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USACE / NAVFAC / AFCEC **UFGS-02 54 19.13 (February 2025)**

Preparing Activity: USACE **Superseding**
UFGS-02 54 19.13 (February 2021)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2025
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BIOREMEDIATION USING LANDFARMING

02/25

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SECTION 02 54 19.13

BIOREMEDIATION USING LANDFARMING
02/25

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NOTE: This guide specification covers the requirements for reduction of the concentrations of organic contaminants in soils by bioremediation using landfarming systems..

Adhere to UFC 1-300-02 **Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.**

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR)**.**
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PART 1 GENERAL

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NOTE: An edited version of this Section may be used to solicit a request for proposal (RFP). Use of an RFP approach may prevent the contract from being awarded to a Contractor that is not technically qualified. This guide specification was developed based on the use of landfarming to treat contaminated soil. Other terms that have been used in place of "landfarming" include "land treatment" and "prepared bed bioreactors." The same process is believed to be applicable for treatment of some other types of organic contaminants in soil. Bioremediation processes, such as landfarming, are usually considered innovative

technologies, and may satisfy CERCLA/SARA considerations of innovation in remediation.

According to Landfarming guidance from the Federal Remediation Technologies Roundtable (FRTR), Landfarming typically applies to treat aerobically biodegradable compounds including nonhalogenated volatile organic compounds, nonhalogenated semivolatile organic compounds, oily sludge, wood-preserving wastes (e.g. pentachlorophenol [PCP] and creosote), and fuels. Landfarming does not effectively degrade chlorinated and nitrate-containing compounds due to the need for anaerobic conditions. Other conditions should be considered when selecting Landfarming. A large amount of space is required and debris greater than 8 3 inches in diameter typically should be removed prior to processing. Very high contaminant concentrations and heavy metals can be toxic to microorganisms. Local regulatory requirements should also be taken into consideration since some volatile contaminants may evaporate during aeration instead of being biodegraded. These constituents may be required to be trapped and treated to avoid release to the atmosphere. This specification section presumes that the project team has confirmed landfarming is generally a feasible remedy for the site before the specs and contract are prepared.

Please also note that "Contracting Officer" mentioned throughout this document is intended to be an umbrella term for anyone, including the Contracting Officer, designated by the Contracting Officer.

Recommended references for design and operation of landfarming facilities include:

1. Bioremediation of Contaminated Soils, Agronomy Monograph no. 37, American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, 1999. This includes the following chapter titles: "Prepared Bed Bioreactors", Sims, J. L., et al., and "Landfarming of Petroleum Contaminated Soils", Sims, R. C. and Sims, J. L.

2. Bioremediation Using the Land Treatment Concept, EPA/600/R-93/164, Pope, D. F., and Matthews, J. E.

3. Guidelines for Land Treating Petroleum Hydrocarbon-Contaminated Soils, Journal of Soil Contamination, 3(3):299-318, Huesemann, M. H., 1994.

4. How To Evaluate Alternative Cleanup Technologies For Underground Storage Tank Sites, U.S. Environmental Protection Agency, EPA 510-B-17-003, October 2017 (see Chapter V within, titled Landfarming, dated October 1994)

5. Aerobic Biodegradation of Oily Wastes, A Field Guidance Book For Federal On-scene Coordinators Version 1.0, October 2003, U.S. Environmental Protection Agency, Region 6 South Central Response and Prevention Branch

6. Website: Center for Public Environmental Oversight, Webpage: Land Farming, http://www.cpeo.org/techtree/ttdescript/lanfarm.htm>http://www.cpeo.org/tech accessed December 2023 .

7. Website: Federal Remediation Technologies Roundtable, Webpage: Landfarming, https://www.frtr.gov/matrix/Landfarming/>https://www.frtr.gov/matrix/Landfar Accessed July 2024.

A systematic project planning approach should be employed when developing sampling procedures to demonstrate the performance of the landfarming treatment process, ideally through implementation of the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP). A specific landfarming work plan documented the sampling procedures is also acceptable and can be an appendix of a UFP-QAPP or a standalone document, depending on the project.

The landfarming treatment considered in this guide specification starts with the raw contaminated material; a treatment cell is constructed; contaminated soils are pre-processed, placed into the treatment cell, and amended with various treatment agents; contaminated soils are tilled, aerated, and moisture controlled as necessary; testing is conducted to confirm treatment performance; and ends with final disposition of the treated material (either left in-place, moved to an on-site designated permanent storage unit, or transported off-site for final disposal). As applicable, refer to Section 02 61 13 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL for requirements related to excavation and stockpiling of the contaminated materials; Section 31 00 00 EARTHWORK for placement of treated materials in on-site permanent storage; and Section 02 81 00 TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS for requirements relevant to offsite transportation and disposal.
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1.1 MEASUREMENT AND PAYMENT

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NOTE: Edit this paragraph based on whether the Contract will use a single job price or unit prices. If Section 01 20 00 PRICE AND PAYMENT PROCEDURES is in the project, move these paragraphs to that Section for editing. The project team should involve their Contracting Office to determine the best way to create a payment schedule/milestone

for their Contract or Task Order.

If the project includes Section 02 61 13 EXCAVATION AND HANDLING OF CONTAMINATED MATERIALS, coordinate measurement and payment methods and contaminated material handling and stockpiling between this Section and Section 02 61 13 EXCAVATION AND HANDLING OF CONTAMINATED MATERIALS.

If the quantities of contaminated soils are well defined, payment may be based upon a single job price structure. However, it is usually more cost-effective to use a unit price structure when there is a significant degree of uncertainty in the amount of contaminated material. When the amount of contaminated material is inadequately defined or uncertain, a data gap investigation is generally advised before any landfarming activity begins. When specifying a unit price structure for treatment, separate items should be provided in the Contract Price Schedule to cover any other work required. Other work items include, but are not limited to: preparation of submittals, mobilization and demobilization, site preparation, construction of the treatment cell and run on/runoff controls, water storage facilities, contact water treatment and disposal, sampling and testing, implementing health and safety requirements, and utilities. Inclusion of separate items in the Contract Price Schedule for the above work tasks should result in a lower unit price for treatment.

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1.1.1 Unit Prices

1.1.1.1 Field Demonstration

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NOTE: Prior to planning the field demonstration, bench-scale treatability study testing should be performed to determine if the contaminants of concern are amenable to landfarming in the site-specific soil matrix. The field demonstration may either be conducted prior to the construction of the full-scale facilities, or conducted using the full-scale facilities and equipment. Payment for the field demonstration should be covered by a separate single job price, or by a unit price that is separate from the unit price for full-scale treatment. Because more intensive monitoring is usually required during the field demonstration, the unit price for the field demonstration will usually be higher than the unit price for full-scale treatment. Testing for chemical data is not included as a component of the price in this paragraph. The contract price schedule should include separate, unit price items for testing for chemical data.

If the results of the field demonstration indicate that an extended treatment period (or other special measures) will be required to meet cleanup goals, it may become necessary to modify the bid item that covers treatment pricing for full-scale operations.
****

Payment for the field demonstration must be[by the Contract unit price schedule for each[cubic meter yard][_____] treated during the field demonstration][a lump sum price for completion of approved tests]. The price must include the cost of labor, materials, equipment usage, utilities, and fuel for: [pre-processing,][operation, maintenance and process monitoring (not including testing for chemical data),][ancillary waste treatment and disposal,][preparation of Field Demonstration Report,][and][_____]. Costs for procurement and handling of amendments must be included in the unit price for treatment.

1.1.1.2 Contaminated Soils Treatment Unit Price

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NOTE: Testing for chemical data is not included in the unit price. The contract price schedule should include separate, unit price items for testing for chemical data.

Unit price payment may either be based on weight or volume (in-place or ex-situ). This paragraph uses ex-situ volume as the default unit.

If unit price payment will be based on weight, dry weight should be specified and requirements should be included for moisture content testing so that dry weight can be determined. However, surveys are usually required before and after excavation of contaminated material, so that excavation and backfilling can be paid for on the basis of in-place volume. Thus, in some cases, it may be advantageous to pay for processing and treatment of soils using in-place volume as the pricing unit.

If the size of the site is well-known, it may be reasonable to simplify contracting and subsequent billing, performance verification and payment by awarding the project as a fixed single job price. If flexibility is desired, additional volume or additional weight may be contracted at fixed unit rates, however additional surveying or other performance verification will be needed for the additional effort beyond the single job price effort.

This paragraph should be coordinated with the treatment criteria and sampling requirements paragraphs so that it will be possible to distinguish between soil that passes, and does not pass, treatment criteria.
****

[Payment for treatment of contaminated soil will be by the contract unit price schedule for each cubic meter yard of contaminated soil that is treated based on [ex-situ volume, after separation of oversize material][_____].

][Payment for treatment of contaminated soil will be by the contract unit price schedule for each metric ton ton of contaminated soil that is treated. Use a properly calibrated weighing system to accurately measure the gross (bulk) weight of the contaminated material. Convert the measured gross (bulk) weight of the contaminated materials to be treated to dry weight based on the[percent moisture content of representative contaminated material samples. Determine the percent moisture content in accordance with[ASTM D2216][ASTM D4643][ASTM D4959][_____]. Determine moisture content[daily][for every[500][_____] metric tons tons of contaminated material that is treated]][_____].

]This unit price must include the cost of labor, materials, equipment usage, utilities, and fuel for: [pre-processing,][operation, maintenance and process monitoring (not including testing for chemical data),][ancillary waste treatment and disposal,][preparation of operations reports,][and][_____]. Costs for procurement and handling of amendments must be included in the unit price for treatment. After each lift of soil has been treated, the quantity of soil that does not meet treatment criteria must be reported and subtracted from the quantity of soil comprising the lift, when determining payment for treatment. See paragraph TREATMENT CELL SIZING for a definition of "lift of soil". Payment will not be made for soil that does not meet treatment criteria. If additional tests, or additional processing and testing, are necessary to show that material meets treatment criteria, the additional costs must be borne by the Contractor.

1.1.1.3 Oversize Materials from Contaminated Areas

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NOTE: This paragraph should be deleted if payment for treatment and disposal of oversize materials will be included as part of the unit price item for treatment of contaminated soil. Payment for disposal of oversize materials may be by weight or volume, depending on the nature of the materials. Oversize materials may include brush, trees, roots, rocks, rubble, and construction debris.

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Payment for[treatment][and][disposal] of oversize material separated from contaminated soil will be by the Contract unit price schedule for each[kilogram pound][_____]. Separate soil, free water, and other extraneous materials from oversize materials prior to measuring quantities.

1.1.2 Single Job Prices

[1.1.2.1 Bench-Scale Treatability Study Testing

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NOTE: Single job pricing is recommended for each bench-scale treatability study testing run. The single job price should include the cost for testing for chemical data. However, bidders should also be required to provide a unit cost amount for testing for chemical data. This will provide a basis for

payment for additional analytical costs, if it is determined that more testing will be required.
****

Payment for bench-scale treatability study testing will be a single job price for completion of specified tests. Include in the price the cost of labor, materials, equipment usage, utilities, and fuel for:

[a. Preparation of the bench-scale treatability study test plan.

][b. Collecting samples.

][c. Sample shipment.

][d. Pre-processing.

][e. Process monitoring (including testing for chemical data).

][f. Disposal of treated material and waste.

][g. Ancillary waste treatment and disposal.

][h. Preparation of the bench-scale test treatability study report.

][i. [_____]].

Costs for procurement and handling of amendments must be included in the unit price for treatment.

]1.1.2.2 Other Work Items

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NOTE: Coordinate this paragraph with Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS. Temporary utility connections are covered in Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS.
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Payment for work items not included above must be included in the payment for the base bid for treatment of the contaminated materials. The other work items include submittals related to mobilization and demobilization, site preparation in the treatment cell, manufacturers' field services, environmental compliance monitoring, health and safety monitoring and controls, and utilities required for the landfarming treatment if approved by the Government as necessary for the project.

1.2 REFERENCES

****
NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of

the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D2216	(2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2974	(2020; E 2020) Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
ASTM D4643	(2017) Standard Test Method for Determination of Water Content of Soil and Rock by Microwave Oven Heating
ASTM D4959	(2016) Determination of Water (Moisture) Content of Soil by Direct Heating
ASTM D4972	(2018) Standard Test Methods for pH of Soils
ASTM D6836	(2016) Standard Test Methods for Determination of the Soil Water Characteristic Curve for Desorption Using a Hanging Column, Pressure Extractor, Chilled Mirror Hygrometer, and/or Centrifuge

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(2018) Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 505-B-04-900A	(2005) Intergovernmental Data Quality Task Force - Uniform Federal Policy for Quality Assurance Project Plans: Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs Part 1: UFP-QAPP Manual
EPA 600/R-96/084	(2000) Guidance for Data Quality Assessment: Practical Methods for Data Analysis EPA QA/G-9, QA00 version

EPA SW-846	(Third Edition; Update VII) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods
UFP-QAPP WKSTS	(2012) Intergovernmental Data Quality Task Force - Uniform Federal Policy for Quality Assurance Project Plans, Optimized UFP-QAPP Worksheets

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.1200	Hazard Communication

[1.3 PRECONSTRUCTION MEETING

****
NOTE: Delete this paragraph if the requirements are included in Section 01 30 00 ADMINISTRATIVE REQUIREMENTS, Section 01 32 01.00 10 PROJECT SCHEDULE, or other Specification Section.

Appropriate facility personnel should be present at the pre-installation meeting if siting of the treatment facility and other associated work areas will be discussed.
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Arrange and conduct a preconstruction meeting at the jobsite[at least five business days prior to the start of operations on the project][_____]. The preconstruction meeting must follow the written preconstruction meeting agenda submitted [_____] days prior to the meeting. The purpose of this meeting is to review the requirements of this Section and the associated plans. The following individuals must attend this meeting: [Contractor's project manager,][site foreman,][and Contracting Officer].

Record preconstruction meeting minutes and publish via email within 48 hours to the attendees. Re-publish the meeting minutes within 48 hours via email pending subsequent comments from the attendees.

]1.4 SYSTEM DESCRIPTION

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NOTE: Requirements for a specific method of treatment are provided below. If the use of a variation on landfarming process described will be allowed, this paragraph should be revised to indicate that a process, other than described in this Section, may be proposed by the Contractor; that the Contractor's approved submittals must demonstrate equivalent capabilities; and that such approval will not relieve the Contractor of responsibility for meeting specified requirements for safety, reliability, and performance.
****

Perform treatment using a safe, reliable method to treat contaminated material conforming to paragraph PERFORMANCE REQUIREMENTS. Requirements for a specific method of treatment are provided below.[The Contractor may propose an alternative treatment method. Government approval of a Contractor-proposed plans does not relieve the Contractor of responsibility for meeting specified requirements for safety, reliability, and performance.]

1.4.1 DESIGN REQUIREMENTS

1.4.1.1 Landfarming Treatment Cell

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NOTE: Siting of the treatment facility should be in accordance with regulatory requirements. The prevailing wind direction and the potential for dust generation should also be taken into consideration. The design of the treatment cell should include provisions for control of storm water and contact water, and should take into account the expected wheel loads of material handling equipment.

In-situ applications of landfarming are usually not recommended due to the potential for spreading contamination into the vadose zone and groundwater. Typically, treatment of contaminated soil is performed in a lined treatment cell. Lined treatment cells usually include a composite clay or geomembrane liner with a leachate collection system.

Care should be used when applying standards established for landfill liner systems, to avoid requiring over-conservative and costly designs.
****

Locate the treatment cell in an area where seasonal, high water table level is at least [1.5][_____] meters [5.0][_____] feet below the lowest level of the liner. The treatment cell must be designed to support the load of material handling and tilling equipment. Provide the water collection system and sump in accordance with paragraph CONTACT WATER MANAGEMENT SYSTEM AND DESIGN STORM.

1.4.1.1.1 Treatment Cell Sizing

****
NOTE: The dimensions of the treatment cell should be based on the amount of time required to reach cleanup goals for each lift of soil (including laboratory turn-around time for compliance testing), the volume of soil and amendments that can be held in the treatment cell, the configuration of the irrigation system, and the type of material handling equipment that will be used. A pie-shaped, or semi-circular, treatment cell lends itself well to the use of a center-pivot irrigation system. Laboratory turn-around time is usually about 2 to 4 weeks. The depth to which soil can be treated (i.e., lift depth) is limited by the practical depth of tilling (usually about 300 mm 1 foot).

Traditionally, new lifts of contaminated soil were

placed in the treatment cell after treatment of preceding lifts were completed. However, material handling requirements may be decreased by placing the entire volume of contaminated soil onto the treatment cell at once. Under the latter scenario, treated lifts are successively removed after they have been shown to meet clean-up goals. One-time placement of all the contaminated soil onto the treatment cell may also eliminate the need to establish a contaminated soil stockpile area.
****

Locate the treatment cell [within the area indicated on the drawings][_____]. Size the treatment cell to hold at least [_____] cubic meters cubic yards of soil per lift, based on a lift depth of [0.3][_____] meters [1][_____] foot. A lift is a single layer of contaminated soil contained within the treatment cell which can be mixed to it full thickness by tilling. Active treatment occurs primarily in the uppermost lift of soil in the treatment cell. Traditionally, a new lift of contaminated soil is placed in the treatment cell after treatment of the preceding lift has been completed. Alternatively, the entire volume of contaminated soil may be placed onto the treatment cell at once; then treated lifts are successively removed after they have been shown to meet clean-up goals. Size the treatment cell based on completing treatment of the estimated, total volume of contaminated soil in [_____] months from initiating treatment of the first lift, assuming treatment is initiated on the following date: [_____].

1.4.1.1.2 Porous Drainage Layer

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NOTE: Specification of the drainage layer is deferred to Section 33 46 16 SUBDRAINAGE PIPING. The remaining information is provided for consideration when preparing that specification section. The gradation limits of the porous drainage layer should be compatible with the grain-size distribution of the contaminated soil. Gradation limits should be determined as shown in EM 1110-2-1913, Engineering and Design - Design of Construction Levees (see Appendix D Filter Design). The slot width of the leachate drainage piping (or pore size of filter fabric around the drainage piping) must also be compatible with the gradation limits of the porous drainage layer.

Geotextiles may be incorporated into the porous drainage layer to help prevent fines from migrating into the leachate collection system. Due to the potential for clogging, use of geotextiles could pose a problem for a treatment cell that is designed for long-term operation. Geotextiles provide attachment sites for microorganisms. Growth of biomass may lead to reductions in the permeability of the geotextile material. However, experience at Region 8 EPA landfarming operations for treatment of creosote-contaminated soil indicates that clogging of geotextile has not been observed at projects that were completed within about 5 years.

To protect the drainage piping, a minimum distance should be maintained between the top of the drainage piping and the top of the porous drainage layer (e.g., 203 to 254 mm 8 to 10 inches). Use of low-profile piping, such as panel pipe for highway edge drains, laid flat against the geomembrane will allow the thickness of the porous drainage layer to be minimized.

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Provide a porous drainage layer in accordance with Section 33 46 16 SUBDRAINAGE PIPING. Design the porous drainage layer to facilitate drainage of free water and to prevent entry of contaminated soils.

1.4.1.1.3 Leachate Controls and Collection

****

NOTE: Specification of the drainage layer leachate controls and collection is deferred to Section 33 46 16 Subdrainage Piping. The remaining information is provided for consideration when preparing that specification section. Lined landfarm units should have a granular drainage layer to allow free water to drain from the soil layer, and a leachate collection system to remove drainage. Some problems unique to landfarming applications are:

a. Exposure to equipment traffic (e.g., applying soil, tilling, and removing soil), can damage drainage layers and liners.

b. Removing lifts of treated soil requires scraping and shoveling the treated lift from the treatment cell, typically with a front-end loader. To protect the leachate collection and geomembrane layers, an armoring layer (gravel or crushed stone) is often used to indicate over-excavation to the equipment operator. The armoring layer is usually positioned immediately above the porous drainage layer.

Slotted piping generally has more area available for water to flow into the pipe than perforated piping, and is less susceptible to clogging and fouling than filter fabric covered piping. Thus slotted piping should be considered for treatment cells that are designed for long-term operation, or where clogging or fouling is a strong concern.

Perforated piping is generally less expensive than slotted. The combination of perforated piping within a geotextile (filter fabric) sleeve has been used with success in landfarm drainage layers. The pore size of the geotextile must be compatible with the grain-size distribution of the porous drainage layer. Installing a layer of geotextile across the entire area of a treatment cell is not recommended because it would require substantially more material than using only geotextile sleeves around the

collection piping, and geotextile sheets would be susceptible to damage during removal of lifts of treated soil.

Leachate drainage lines are routed to a sump, which is usually placed below the treatment cell. The sump usually consists of a lined depression in the impermeable layer packed with gravel. Water holding facilities outside of the treatment cell are commonly used for additional water storage capacity. When the gravel sump reaches a set level, water is pumped from the sump to the outer water holding facility. Options for water storage facilities outside of the treatment cell include: an above-ground storage tank, a reinforced concrete basin, vertical caisson piping, or a lined earthen pit.

See U.S. Army Corps of Engineers, CPD-74B, Hydrologic Modeling System HEC-HMS, Technical Reference Manual, March 2000 for additional information on runoff issues relevant to landfarming.
****

Provide leachate controls and collection in accordance with Section 33 46 16 SUBDRAINAGE PIPING.

1.4.1.1.4 Geomembrane and Clay Liners

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NOTE: Liners usually consist of high density polyethylene (HDPE) geomembrane or recompacted clay. It is atypical to require a composite liner system for a temporary landfarming facility. Options have been provided for HDPE liners and recompacted clay liners.

If granular material in the drainage layer is greater than 13 mm 1/2 inch, a sand or geotextile protective layer should be required between the geomembrane liner and the granular material.

The drawings should provide requirements for sloping of the surface of the liner. Recommended, minimum sloping requirements are as follows: 2 percent from the sides of the treatment cell to the central drainage line, and 1 percent over the length of the central drainage line (from the upslope end to the entry into the gravel sump).

Sections 02 56 13.13 GEOMEMBRANE WASTE CONTAINMENT and 02 56 13.16 CLAY WASTE CONTAINMENT provide some testing requirements for the liner. Additional testing and leak monitoring may be necessary for some projects. Leak monitoring will be more important for projects where the treatment cell is located over an area with clean groundwater and a clean vadose zone.

Monitoring wells, downgradient of the treatment cell, can be used to determine if leaks have occurred in the past. Lysimeters may be installed within and around the perimeter of the treatment cell. If used, lysimeters should be installed before the liner to avoid damage to the liner during placement of lysimeters. Penetrations through the liner must also be properly sealed. Generally there is greater potential for leaks to occur in the sump, than in other locations of the liner. Water may remain in the sump for extended periods if the sump is being used to store contact water.

Leak sensing technologies are described in the following reference, Leak Detection for Landfill Liners, Overview of Tools for Vadose Zone Monitoring, Karen Hix, Technology Status Report Prepared for USEPA Technology Innovation Office under a National Network of Environmental Management Studies Fellowship, Aug. 1998. The reference can be accessed at the following internet site: http://www.clu-in.org/download/char/leaklnfl.pdf

Most of the leak sensing technologies involve installation of leak sensing devices below the liner, prior to placement of the liner. Because of the relatively high capital and operation and maintenance (O&M) costs for leak detection systems, they are usually not installed.

As a relatively inexpensive construction QA measure, the Two Electrode method can be used for leak testing of the sump area. The test can be performed by filling the sump with water (before it has been filled with gravel) for a set period (e.g., 24 hours), and monitoring for passage of current from the inside the sump to the soil outside of the sump area. If current is detected in the electrode placed in the soil outside of the sump area, then the liner is checked for penetrations, repaired, and the test is repeated.

Leak testing, using one of the methods or devices described in the above reference, is highly recommended; especially in the area immediately below the sump.
****

Line the treatment cell with [a chemically resistant, high density polyethylene geomembrane liner with a minimum thickness of [0.1][_____] mm [40][_____] mils.][a recompacted clay liner with a minimum thickness of [0.6][_____] meters [2][_____] feet and a maximum permeability of [1×10^{-7}][_____] cm/s [3.28×10^{-9}][_____] feet/s.] Subgrade preparation and installation, testing, inspection, and protection of the liner, must be in accordance with Section [02 56 13.13 GEOMEMBRANE WASTE CONTAINMENT][02 56 13.16 CLAY WASTE CONTAINMENT]. The surface of the liner must be sloped [as indicated][_____].

1.4.1.1.5   Other Work Area Surfaces

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NOTE: This paragraph should be revised if paved surfaces will not be required. It may be necessary to require paving in areas designated for handling contaminated material and operation of heavy equipment (e.g., front-end loaders). Concrete pads are typically more expensive, though less permeable than asphalt pads. Asphalt pads have been used for hazardous waste composting projects.

****

Locate the soils pre-processing area[within the area indicated][_____], and construct and pave in accordance with Section [03 30 00 CAST-IN-PLACE CONCRETE][_____].

1.4.1.2   Contact Water Management System and Design Storm

****

NOTE: In accordance with regulatory requirements, excess contact water may be discharged to National Pollutant Discharge Elimination System (NPDES) storm water discharge outfalls, publicly owned treatment works (POTW) sewers, facility sewer to onsite treatment systems, or treated and disposed of offsite.

The source of data for the design storm should be referenced. Sources for hypothetical storm information in the United States are referenced in Appendix A of Hydrological Analysis of Ungaged Watersheds Using HEC-1, Training Document No. 15, USACE Hydrologic Engineering Center, April 1982; another source is NOAA Atlas 14. Previous through current versions of the HEC Hydrologic Modeling System (HMS), as well as training materials, are available at https://www.hec.usace.army.mil/software/hec-hms/documentation.aspx

The surface of the treatment cell must be sloped so that surface run-off from high intensity precipitation events and snow melt can be collected and transferred to contact water storage facilities. If too much surface water penetrates the contaminated soil layer, the soil may become waterlogged and contaminant degradation rates may decrease. The degree of slope must be tailored to account for the frequency of the high intensity precipitation events and the wind and humidity patterns at the project site. It is critical that the landfarming cell be able to drain rapidly after high intensity precipitation events.

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Contact water is defined as water that has come into contact with contaminated materials, or other contaminated surfaces. Sources of contact water may include, but are not limited to: water from decontamination of equipment, personnel, and PPE; runoff water from storage and pre-processing areas; and water that leaches through the treatment cell. The design storm must be the [24][_____] hour duration storm with a return interval of [25][_____] years, based on data from [_____]. Water head in the gravel sump (under the treatment cell), in excess of [0.3][_____] meter [1][_____] foot, must be removed within [24][_____] hours of the design storm event. The water head in the gravel sump (under the treatment cell) must be maintained at no more than [0.3][_____] meter [1][_____] foot between storm events. The surface of the top layer of the treatment cell must be sloped, [as shown on the drawings,][_____] to allow surface run-off to be collected and transferred to contact water storage facilities.

1.4.1.2.1 Perimeter Berms

Berms must be constructed around the perimeter of the following areas: [treatment cell,][contact water storage,][laydown and storage areas,][and][_____]. Size the perimeter berms to prevent flood water run-on from the [25][_____] year flood while maintaining a minimum freeboard of [0.3][_____] meter [1][_____] foot. The perimeter berms must also be sized to contain water from the design storm that collects on the surface, inside of bermed areas, while maintaining a minimum freeboard of [0.3][_____] meter [1][_____] foot. Key berms constructed around the [treatment cell and contact water storage facility][_____] into the underlying liners of these areas, [as shown on drawings][_____]. Include ramps to permit vehicle access across berms constructed around the [treatment cell, and laydown and storage areas][_____].

1.4.1.2.2 Storage Volume

****

NOTE: Typically, storage and testing of contact water is required prior to discharge. Thus contact water storage facilities should be sized to contain the peak detention volume for the design storm. In order to minimize treatment and disposal costs, it is often desirable to reuse the contact water to irrigate the treatment cell. Using this approach, the storage volume must be sufficient to retain the volume of water in storage prior to the design storm, and the volume of water generated by the design storm.

Sources of contact water include: water from decontamination of equipment, personnel, and personal protective equipment; and water that drains from storage, pre-processing and treatment areas. If the storage, pre-processing, or treatment areas are covered, then the volume of contact water resulting from precipitation events should be reduced.

****

Size contact water storage facilities to contain [30][_____] percent above that required for the design storm, and [the maximum volume that will be held in storage for reuse][_____].

1.4.1.2.3 Reuse, Treatment, and Disposal

****

NOTE: It is possible for contact water to accumulate compounds (e.g., acids, bases, or salts) at levels which may inhibit microbial activity. However, contact water can usually be applied to contaminated soil with little or no treatment. Water which has accumulated excessive levels of acids, bases or salts may require treatment, or offsite disposal.

****

Reuse contact water to the maximum extent, to minimize the need for new makeup water and to limit the treatment, discharge and offsite disposal of wastewater. Prior to reuse, test contact water in accordance with paragraph CONTACT WATER TESTING and confirm that contact water meets the requirements of paragraph WATER SUPPLY. Prior to disposal, collect and test contact water that cannot be applied to contaminated soil in accordance with paragraph TREATMENT CRITERIA FOR CONTACT WATER. Treat process sludge (resulting from the removal of suspended material in the contact water) to meet the requirements of[paragraph TREATMENT CRITERIA FOR SOIL][_____].

1.4.1.3 Irrigation Equipment

****

NOTE: Irrigation is critical to maintaining optimum moisture content, and maintaining high degradation rates. In arid climates, water usage rates will obviously be higher than in non-arid climates. Drip irrigation systems are generally not recommended for landfarming because they are not designed to distribute moisture uniformly. Center-pivot irrigation systems have been successfully used in conjunction with pie-shaped, or semi-circular, treatment cells.

****

Provide irrigation equipment capable of delivering at least 0.7 L/s/1000 m^2 40 gpm/acre distributed uniformly over the surface of the treatment cell. Design the irrigation system to minimize interference with tilling of the treatment cell. Do not use flood or overland flow irrigation methods.

1.4.1.4 Weather Cover

****

NOTE: This paragraph should be deleted if there will be no requirement for use of a weather cover. Weather covers allow an added measure of control over moisture delivery to the treatment cell, and may also be used to increase soil temperature. Use of a weather cover will also allow the scale of the contact water management facilities to be reduced. Clam-shell buildings, metal buildings, pole barns, large tents, or other prefabricated structures may serve as weather covers. The section containing requirements for the weather cover (e.g., Section 13 34 19 METAL BUILDING SYSTEMS), should include the design snow load, maximum wind speed, soil bearing capacity, seismic parameters in accordance with UFC 3-301-01, and maximum and minimum ambient air

temperatures.

If landfarming will be performed inside of an enclosed structure, adequate ventilation must be provided. A rate of 3 to 6 air changes per hour has been recommended for composting facilities. Carbon dioxide is generated and oxygen may become depleted during landfarming. However, rates of oxygen consumption for most landfarming applications will be significantly lower than that of composting. During material handling operations (e.g., tilling) dust and engine exhaust fumes will accumulate. To ensure that proper and consistent ventilation requirements are specified, this section should be coordinated with Section 23 30 00 HVAC AIR DISTRIBUTION.

****

Use weather covers, or appropriate structures, to prevent precipitation from coming into contact with soil in the treatment cell, and design in accordance with Section[13 34 19 METAL BUILDING SYSTEMS][_____]. Provide covers which allow for free exchange of gases between the atmosphere and the soil. Size weather covers to allow unimpaired maneuvering of [front-end loaders,][soil mixing equipment,][and][_____]; size openings in weather covers to allow for entry and exit of [front-end loaders,][soil mixing equipment,][and][_____]. Provide ventilation of the covered facility in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

1.4.1.5 Stockpiles

****

NOTE: Typical stockpile design requirements are provided in Section 02 61 13 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL. In very arid climates, covers may not be necessary. If operations will continue during subfreezing conditions, it may be necessary to ensure that the Contractor has included provisions to prevent a portion of the contaminated soil stockpile from freezing. The stockpile requirements in that section should be edited based on site-specific factors and regulatory requirements.

****

In accordance with Section 02 61 13 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, prepare areas that will be used to stockpile [contaminated material,][oversize material,][treated material][and][_____].

1.4.1.6 Material Measurement

****

NOTE: This paragraph is primarily intended to ensure that calibrated scales are being used to weigh treated soil, when weight is being used as the basis for measurement and payment.

****

Provide scales, meters, and volumetric measuring devices for measuring oversize materials, feed contaminated materials, reagents, and water which conform to the applicable requirements of NIST HB 44, except that the accuracy must be plus or minus [0.1][_____] percent of the quantity being measured. For scales used to measure weight of material in vehicles, provide scales of sufficient length to permit simultaneous weighing of all axle loads. For any scales used to make measurement for payment, ensure the scale is certified [by an acceptable scales company representative][by an inspector of the State Inspection Bureau charged with scales inspection within the state in which the project is located] prior to weighing any materials. Perform a check of calibration of measuring equipment prior to initial use, and once every [seven][_____] calendar days. The requirements of this paragraph do not apply to measurement of chemical or physical data for purposes of demonstrating compliance with paragraph PERFORMANCE REQUIREMENTS.

1.4.1.7 Utilities

****

NOTE: The locations and details (such as utility point of contact, sizes, capacities, and flows) of the utility hookups should be provided on the drawings for the Contractor's use. Verify the utilities are available on-site before including the second sentence.

****

In accordance with Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS, provide the utilities associated with landfarming including, but not limited to:[telecommunications,][electricity,][water,][gas,][sanitary,][_____,] and solid waste facilities. The [telecommunications,][electricity,][water,][gas,][sanitary,][_____,] and [solid waste facilities] are available at the site.

1.4.2 PERFORMANCE REQUIREMENTS

1.4.2.1 Treatment Criteria and Criteria for Reuse of Treated Soil

****

NOTE: Landfarming is primarily applicable to nonvolatile and semi-volatile organic contaminants, including: low-volatility components of fuels, diesel fuel, kerosine-based fuels, fuel oils, PCP, some polycyclic aromatic hydrocarbons (PAHs, as found in creosote), some pesticides, and some herbicides. Biodegradation of PAHs becomes more difficult as the number of aromatic rings increases. Thus, landfarming is usually not considered to be an efficient process for treating PAHs that contain more than four aromatic rings. Contaminated soil will be aerated during tilling and material handling operations. Thus, the volatility of contaminants of concern should be taken into consideration to ensure that air emissions requirements are not exceeded. Non-weathered, light fuels such as gasoline are not suitable for landfarming since the most toxic components (i.e., BTEX) will readily volatilize.

Depending on regulatory requirements, both total concentration and leachability concentrations for

some compounds may be required. Total concentrations can be used to estimate worst case leachate concentrations. If the contaminated material is classified as characteristic waste, leachability testing will usually be required, and the appropriate leachability test (e.g., EPA Synthetic Precipitation Leaching Procedure (SPLP) or EPA Toxicity Characteristic Leaching Procedure (TCLP)) must be selected. If the treated material will not be disposed of in a landfill, SPLP testing may be appropriate.

Although there are EPA Land Application regulations for metals and pathogens (40 CFR 503 - Standards for Use or Disposal of Sewage Sludge), these regulations are not normally applicable to hazardous waste landfarming.

For compounds whose partial breakdown products (intermediates) have been defined, it may be necessary to include testing for key intermediates. However, it may not be practical to require testing for intermediates if chemical standards are not available. A compound should not be targeted for analysis unless there is a defensible basis for acquiring the data (e.g., if there is strong probability of generating an intermediate with higher toxicity than the parent compound).

Treatment criteria, and criteria for disposal (or reuse) should be in accordance with Federal, state and local regulations. Prior approval by regulatory representatives should be acquired for treatment criteria values.

****

1.4.2.1.1 Treatment Criteria for Soil

****

NOTE: Treatment criteria can be based on the total concentrations of a class of substances particularly if an analytical method exists that outputs only the total, such as for total petroleum hydrocarbons (TPH), however it is more typical that treatment criteria are based on individual substances.

It is possible for petroleum, oils and lubricants (POLs) and other fluids from material handling equipment to be spilled onto soil during process operations. Thus, testing for POLs should be considered.

In some cases attaining a target concentration for the site's contaminants of concern might not be sufficient; landfarming may not completely degrade, or mineralize, the contaminants but rather converts them to a series of complex degradation products which may not be analyzable with regular lab methods, and which will likely not have health based

screening values. These products may bind irreversibly to the soil, indicating that landfarming is a technology that has both degradation and stabilization aspects. In this case it may be necessary to augment the treatment criteria by adding a bacterial assay, such as the Ames Mutagenicity test, to verify the safety of the finished landfarming soils or the safety of the leachate from the finished landfarming. Another factor is that the mixing of the soils with carbon rich amendments, and their bacterial degradation, will change the redox balance of the soil and possibly convert native insoluble metals to mobile forms. This can be detected with TCLP testing of the finished soil. Lastly, there can be the concern that mixing large amounts of amendments with contaminated soil causes dilution of the contaminants, that is, it causes an immediate decrease in contaminant concentration without any landfarming having occurred. It is possible that stakeholders may insist on reducing the soil remedial criteria by this dilution factor, in order that no benefit is provided solely by the amendment mixing step toward attaining those criteria. This paragraph should be edited to include site-specific criteria.

If a statistically based criteria for determining attainment of treatment criteria will be used, the contract should be prepared to allow some flexibility as to the number of samples that will be required for confirmatory sampling.
****

Treat contaminated material to the criteria shown in Table 1A. The mean of the data for [the grids representing the top lift of soil in the treatment cell][_____] must be less than the level shown for each contaminant in Table 1A. Analyze data [using the One-Sample t-Test in accordance with EPA 600/R-96/084 (see p. 3-8 of the reference for an example of this procedure), and apply the following statistical conditions][_____]. The statistical conditions include: [true mean greater than or equal to action level (assume site is dirty) maximum false rejection rate (alpha) = 5 percent; maximum false acceptance rate (beta) = 20 percent; width of grey region (delta) = 15 percent of treatment criteria value][_____].

TABLE 1A - TREATMENT CRITERIA FOR ORGANICS	
CONTAMINANT	MAXIMUM TOTAL CONCENTRATION IN SOIL
[_____]	[_____] mg/kg
[_____]	[_____] mg/kg

1.4.2.1.2 Criteria for Reuse of Treated Soil

****
NOTE: For some projects this paragraph could be combined with the above paragraph, Treatment

Criteria for Soil. For the purposes of this guide specification, this paragraph has been separated to emphasize that a separate set of regulatory criteria may have to be met before treated soil can be incorporated into topsoil.

The land application or beneficial use of treated soil will be largely controlled by existing land disposal restrictions (40 CFR 268), specifically toxicity characteristics for RCRA metals, volatiles, and semi-volatiles and any triggered universal treatment standards (40 CFR 268.48). While the metals loading rates found in 40 CFR 503 (i.e., 40 CFR 503.13 - Pollutant limits) may be useful in evaluating beneficial reuse alternatives, the designer is cautioned that the scope of that standard is for domestic sewage sludge. Soils treated via landfarming may not meet that definition, and therefore would not be excluded from hazardous waste management regulations. The application of ceiling values listed in 40 CFR 503.13 to treated soil not excluded from hazardous waste regulations is not allowed under regulation (40 CFR 503.6).

Although reductions in concentrations of heavy metals may occur due to mixing and dilution effects, landfarming is usually not considered a treatment process for inorganics. Depending on regulatory requirements and intended end use, it may be necessary to require testing for some inorganic parameters. This paragraph should be edited to include site-specific criteria.
****

Prior to final disposition, treat contaminated material to the criteria shown in Table 1B. The mean of the data for [the grids representing the top lift of soil in the treatment cell][_____] must be less than the level shown for each contaminant in Table 1B. Analyze data [using the One-Sample t-Test in accordance with EPA 600/R-96/084 (see p. 3-8 of the reference for an example of this procedure), and apply the following statistical conditions][_____]. The statistical conditions include: [true mean greater than or equal to action level (assume site is dirty) maximum false rejection rate (alpha) =5.0 percent; maximum false acceptance rate (beta) =20.0 percent; width of grey region (delta) =15.0 percent of treatment criteria value][_____].

TABLE 1B - REUSE CRITERIA FOR INORGANICS

INORGANIC CONTAMINANT	MAXIMUM TOTAL CONCENTRATION IN SOIL
[_____]	[_____] mg/kg
[_____]	[_____] mg/kg

1.4.2.1.3   Particle Size Criteria for Treated Soil

****

NOTE: Oversized materials are typically separated from contaminated soil during soil pre-processing. Relatively impermeable oversize materials (e.g., rocks) are often treated by rinsing or pressure washing. However, clods of contaminated soil or other large particle-size materials that are not broken-up during tilling cannot be assumed to be adequately treated by landfarming. If attrition of this chunk-material does not occur with repeated tilling, it may be necessary to perform additional sampling and analysis specifically to determine if chunk-material is being treated.

Particle size criteria may be waived if sampling and analysis of the large particle-size materials demonstrates that treatment criteria is being achieved. A sufficient quantity of large particle-size material should be collected so that samples will be representative of the "chunk-fraction" throughout the treatment cell. The large particle-size material must then be ground-up so that subsamples can be submitted for testing.

If treatment of large particle-size materials cannot be adequately demonstrated, then an additional processing step may be necessary. Equipment such as soil shredders will increase the cost of treatment, but can be used to reduce the particle size and thereby improve the degree of treatment achieved. The goal should be to reduce the particle size of treated soil to approximately 13 to 40 cm 0.5 to 1.5 inches.

****

To achieve uniform treatment, reduce particle size of clumps of soil as necessary by tilling or other mechanical means. The maximum particle size in the treated soil matrix must be not greater than [40][_____] mm [1.5][_____] inches.

1.4.2.2   Treatment Criteria for Contact Water

****

NOTE: Treatment and disposal options for contact water include: onsite treatment and discharge; offsite treatment and disposal; and storage and reuse as irrigation water. It is possible for POLs and other fluids from material handling equipment to be spilled onto soil during process operations. Thus, testing for POLs should be considered. This paragraph should be edited to include site-specific criteria. A State permit under the Clean Water Act may be required for onsite discharge of water, and will include criteria that must be met and documented prior to discharge. The permit may limit discharge of the constituents that are being treated, as well as other constituents introduced in

the amendments or conditions caused by the introduction of the amendments.
****

Contact water must meet the criteria shown in Table 2 at the time of [discharge][offsite disposal][_____]. If a State permit is required for onsite discharge, the water must be documented to have met the criteria in the permit prior to discharge.

TABLE 2 - WATER DISPOSAL/DISCHARGE CRITERIA	
PARAMETER	MAXIMUM CONCENTRATION
[_____]	[_____]
[_____]	[_____]

1.4.2.3 Treatment Criteria for Other Waste

****
NOTE: Other waste may include sludge or sediment resulting from treatment of contact water and oversize material. Treatment may not be required for some wastes. Treatment criteria should be provided if treatment will be conducted onsite. Treatment criteria and methods for porous oversize material such as wood chips may be difficult to develop. A separate table should be developed for the criteria. If treatment criteria already provided in the preceding paragraphs do not adequately cover "Other Wastes", it may be necessary to provide additional criteria, specific to "Other Wastes". Oversize material is often pressure-washed prior to disposal. Sludge or sediment may often be blended with contaminated soil for processing in the treatment cell.
****

Treat the following materials prior to disposal: [sludge or sediment resulting from treatment of contact water, and oversize material that has been separated from contaminated soil][_____]. Treat in accordance with regulatory requirements.

1.4.2.4 Emissions and Dust Controls

****
NOTE: Specifications for emission and dust controls should be provided in Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS. If Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS is not included in the project specifications, emissions, dust, and odor control sources and control activities should be specified here. The remaining text in this note discusses landfarming technology-specific emission and dust control considerations to incorporate into Section 01 57 19. An air pathways analysis should be performed during design in accordance with EP

200-1-24 Air Pathway Analysis for the Design of Hazardous, Toxic and Radioactive Waste (HTRW) Remedial Action Projects. Depending upon the contaminants of concern in the contaminated materials, the unit processes/operations employed in landfarming, the amount of pollutants emitted, and the geographical location of the site, the emission standards and limitations for certain contaminants and dust control can be identified from the following regulations including, but not limited to, National Primary and Secondary Ambient Air Quality Standards, National Emission Standards for Hazardous Air Quality Pollutants, and state and local regulations.

When editing Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS, consider the following: For each stage of operations, an air pollution control plan must include, but not be limited to: the sources of emissions, dust and odors during each stage of operations, and proposed control measures. The stages of operation must include, but are not limited to: construction of paved or lined surfaced, soil preprocessing; treatment, transport, and disposal of oversize material; blending of soil and amendments; during the landfarming process, including during mixing; transport, storage, and disposal of treated material. The plan must specifically address fugitive emissions and odor control during the following activities: amendment delivery and storage; blending of soil and amendments; during the landfarming process, including during mixing; transport of compost; storage of compost; and disposal of compost. If local air pollution regulations require capture and control of specific emissions, the type of collection and treatment equipment should be identified. If air monitoring will be required, the following must also be included: type and locations of monitoring devices, secure retention of the data; and for each stage of operations: frequency of sampling, number of samples from each location, the total number of samples, and the parameters to be monitored. If operations are to occur near occupied areas, consideration must be given to using perimeter air monitoring to generate a defensible record showing that unacceptable air concentrations have not extended past the boundaries of the site .

Based on the regulatory requirements, the proper technologies or apparatus for the emissions control if required can be determined. Upon completion of the design of the landfarming operation, these emission requirements and control technologies should be defined by the design engineer. It may be necessary to implement control measures during the following activities: the field demonstration, excavation, hauling, stockpiling, separation of oversize materials, spreading of amendments,

tilling, and disposal of treated soil.

If a performance specification is prepared, the emissions, dust sources, and contaminants of concern should meet specified requirements based on applicable regulations. Section 01 57 19 should list the emissions criteria for the contaminants of concern for each emission and dust source, and if applicable, monitoring requirements should be specified. The applicable federal, state, and local regulations should also be identified. If the specification is prepared based on detailed design, the technologies or apparatus for controlling the emissions and dust sources should also be specified.
****

Execute the landfarming process to meet the emissions and dust control requirements in [Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS][___].

1.4.3 LANDFARMING WORK PLAN

****
NOTE: To avoid duplications in submittal requirements, submittals in this Section should be coordinated with other sections of the contract (e.g., 01 45 00 QUALITY CONTROL, and 01 32 01.00 10 PROJECT SCHEDULE).

If an RPF contract is being prepared, this paragraph and the Submittals paragraph should be edited and used to form the basis for Contractor proposals.
****

Submit a Landfarming Work Plan [as an appendix of the Uniform Federal Policy Quality Assurance Project Plan (UFP-QAPP)][as a standalone document] not more than [480][_____] calendar days after notice to proceed. [Prepare [draft for Government review][draft-final for [regulatory][_____] review] and final versions of the Landfarming Work Plan. Allow [30][_____] calendar days for [Government] review [and [30][_____] calendar days for regulatory review]. Allow [45][_____] days for comment resolution following each review and preparing the next version of the document.] The plan must include, but not be limited to, the following.

1.4.3.1 Schedule

****
NOTE: Landfarming may rely substantially on the supply of seasonal farm-generated inputs like manure and straw. The seasonal availability of these items must be incorporated into the operating schedule. The seasonality may be lessened by stockpiling these materials; if so this feature must be described in the workplan.
****

Provide a schedule specifying dates and durations for: excavation, hauling, stockpiling, start and completion of mobilization, treatment cell construction, separation of oversize materials, delivery and stockpiling of amendments, field demonstration, full-scale treatment of contaminated materials, storage of treated material, disposal of treated material and other wastes, and demobilization. Provide the following details: intended days and hours of operation; plans for operating, or scaling back operations during winter conditions; routine maintenance down-time for tilling equipment; anticipated time to reach cleanup goals for each lift of soil; and laboratory turn-around time to receive data from compliance samples.

1.4.3.2   Project Organization and Personnel

Provide an organization chart, including subcontractors; include the names, responsibilities, education, and resume of the key project personnel. Key personnel must meet the requirements of this paragraph and paragraph KEY PERSONNEL. Key personnel must include, but must not be limited to: project managers, quality control personnel, supervisory operators and technicians, and engineering staff. Clearly define responsibilities of each individual in the organization in terms of project activities including, but not limited to: project management and coordination; scheduling; quality control and quality assurance; sampling; measurement; field and laboratory analysis; data management; operation and maintenance; and health and safety management.

1.4.3.3   Selection of Amendments

****

NOTE: Options are provided for the Designer to either specify that inoculants will not be allowed, or prompting the Contractor to indicate what inoculants they intend to use. The second option provides more flexibility if the Designer does not have a strong reason to disallow inoculants. With some manure amendments, sufficient bacteria are present to inoculate the landfarming cell without resorting to purchase and introduction of a laboratory or factory grown consortia. Some research indicates that bioaugmentation with inoculants can improve landfarming results.

****

Provide rationale for use of each proposed amendment. [Do not use any inoculants as part of the landfarming amendments.][Include rationale for use of any inoculants that will be used in combination with other landfarming amendments.] Provide a description of, and sources for, each amendment; including at least one alternative source for each category of amendment. Include locations of each source, and distances from the site. For amendments that are only available on a seasonal basis, provide a plan for substituting alternative types of amendments. For organic amendments, such as manure or wood products, state the intended freshness of the amendment; or the length of the planned period of aging, prior to incorporating the amendment into soil. Include the proposed quantity of each amendment that will be added to each cubic meter cubic yard of contaminated soil.

1.4.3.4   Operations and Process Monitoring

Provide a detailed description of the proposed operation in the [UFP-QAPP][the Landfarming Work Plan]. The description must include: plans for pre-processing of contaminated soils; plans for stockpiling materials; plans and schedule for pick-up, transport, delivery and storage of each amendment during operations; plans for mixing amendments into soil; methods for measuring quantities of soil and amendments; treatment cell area required for each lift; contact water management plans; parameters that will be monitored during landfarming; frequency of monitoring, tilling and irrigation during operations; locations of each sampling station shown from plan view; sampling locations shown on a diagram depicting a cross-section of the treatment cell; the number of sampling stations per each lift of soil; moisture and temperature monitoring locations must also be shown; and plans for storage and disposal of treated materials.

1.4.3.5 Non-Landfarming Treatment Processes

Provide a detailed description of the procedures for treatment of air, liquid, and solid wastes that will be treated by a process other than landfarming, including: treatment criteria for oversize material and other wastes.

1.4.3.6 Equipment and Servicing

Provide a detailed description of the proposed treatment equipment. For each proposed piece of equipment, describe: function, design capacity, equipment specifications identifying manufacturer and model number, material of construction, recommended operating conditions, and the number of units that will be present on-site during each stage of operations. Equipment described must include, but must not be limited to: tilling devices; pumps; irrigation equipment. Provide plans for servicing equipment, and explain how material handling and tilling will be accomplished during servicing of equipment, and during unanticipated breakdown of machinery. Decontamination of equipment is as required in the mobilization and demobilization plans included in the UFP-QAPP.

1.4.3.7 Process Material Tracking Schedule

Provide a Process Material Tracking Schedule for recording and managing the quantities of the contaminated materials processed. Provide the dates and duration of the following activities for each lift of contaminated material: initiation of landfarming; completion of landfarming; re-processing of any treated materials that failed to meet treatment criteria; storage of treated material; disposal of treated material.

1.4.3.8 Disposal and Reuse of Wastes

Provide a detailed description of the plans for disposal of solid and liquid wastes. For each type of waste that will be generated, specify: origin and description of waste; estimated total quantity of waste; method of transport to disposal location; disposal location; disposal documentation to be provided by the receiving facility; and schedule showing the anticipated quantities and dates for generation, transport, and disposal of the wastes. Waste types must include: treated soil, oversize materials, contact water, and other solid and liquid wastes generated during the project.

1.4.3.9 Uniform Federal Policy Quality Assurance Project Plan

a. Prepare a UFP-QAPP in accordance with EPA 505-B-04-900A and using the UFP-QAPP WKSTS.

b. Provide a detailed, chronological description of the sequence of procedures and tests that will be used to determine whether the soil has met [treatment][and][or][disposal] criteria, including:

   (1) The location of each sampling station shown from plan view.

   (2) The number of sampling stations per each lift of soil.

   (3) Sampling locations shown on a diagram depicting a cross-section of the treatment cell.

   (4) The number of samples that will be tested for each type of test performed.

   (5) The decision process to be made with the sample results, i.e., whether the results are to be used individually and applied to the individual areas of the lift, or averaged in order to make a volume-average decision for the entire lift.

   (6) If decisions are made based on individual samples instead of lift-wide, the means for reproducibly defining the boundaries of the individual areas within the lift, and the means of segregating out-of-specification soils in one individual area from in-specification soils in another area, and re-treating the out-of-specification soils.

c. Describe any sampling and testing devices for process monitoring; and moisture and temperature monitoring devices that will be used at the landfarming site.

d. For air, liquid, and solid wastes that will be treated by processes other than landfarming, include: testing parameters; sampling locations; number of samples; monitoring frequency; and laboratory turn-around-time.

e. Provide a mobilization and demobilization plan as an attachment to the UFP-QAPP to include, but not be limited to: transport of personnel, material, and equipment; decontamination and disposal of materials and equipment brought to the site; decontamination and disposal of the treatment pad and other paved surfaces; and decontamination of equipment during demobilization. Include a Post-Treatment Cleanup and Sampling Plan in the mobilization and demobilization plan for areas where there was contact with contaminated materials and were disturbed by the Remedial Action/Site Work. Also, discuss the restoration of disturbed areas such as grading, seeding, etc.

f. Submit the UFP-QAPP not more than [480][_____] calendar days after notice to proceed. Prepare [draft for Government review][draft-final for [regulatory][_____] review] and final versions of the UFP-QAPP. Allow [30][_____] calendar days for [Government] review [and [30][_____] calendar days for regulatory review]. Allow [45][_____] days for comment resolution following each review and preparing the next version of the document.

[1.4.3.10 Bench-Scale Treatability Study Test Report

Provide the bench-scale treatability study test report as part of the Landfarming Work Plan and after completion of the bench-scale treatability study test. Include: characterization test results for each amendment;

the source of each amendment; for each condition tested, the quantity of each amendment that was added per unit volume of soil; the date that the bench scale treatability study test was initiated; chronological table showing all materials added, quantity added, date of addition, and each mixing, irrigation and sampling event. For organic amendments, such as manure or wood products, state the freshness of the amendment; and the length of the period of aging, prior to incorporating the amendment into soil. The report must also include: physical and chemical monitoring data from before, and during treatment; degradation rates; final disposition of wastes and treated material; and conclusions. Provide recommendations for the field demonstration in the report.

]1.4.3.11 Materials Data

Provide safety data sheets (SDSs), certificates of analysis, and product performance data. SDSs must be in accordance with 29 CFR 1910.1200(g).

1.4.3.12 Permits, Permit Equivalents, and Certifications

Provide copies of the permits, permit equivalents and certifications with the Landfarming Work Plan. For the above-listed items requiring a longer time frame, include copies of applications and scheduled dates for receiving final approval.

1.4.4 Other Submittal Requirements

****

NOTE: Submittal scheduling should allow for an adequate amount of time for:
1. Preparation and review of submittals.
2. The treatment period of the bench-scale treatability study test and the field demonstration.
3. Receipt of analytical results from the laboratory for samples collected on the last day of the treatment period.

The time periods shown for completing submittals have been sequenced to illustrate this point. Ideally, the Bench-scale Treatability Study Test Report should be completed before the Contractor is required to submit the Field Demonstration Plan, and the Field Demonstration Report should be completed before the Contractor is required to submit the Landfarming Work Plan.

****

Submit the following as specified:

[1.4.4.1 Bench-Scale Treatability Study Test Plan

Prepare [draft for Government review][draft-final for [regulatory][_____] review] and final versions of the Bench-Scale Treatability Study Test Plan. Allow [30][_____] calendar days for [Government] review [and [30][_____] calendar days for regulatory review]. Allow [45][_____] days for comment resolution following each review and preparing the next version of the document. Submit a Bench-Scale Treatability Study Test Plan not more than [30][_____] calendar days after notice to proceed. This plan must incorporate the requirements in paragraph BENCH-SCALE TREATABILITY STUDY TEST and must include:

a. Location of test facility.

b. Minimum and maximum initial levels of contaminants in the soil to be used for the study.

c. Locations that will serve as the source of soil for the study.

d. Test parameters and number of samples that will be used to confirm that the soil meets criteria for the study

e. Rationale for use of each proposed amendment.

f. The source of each amendment. For organic amendments, such as manure or wood products, state the intended freshness of the amendment and the length of the period of aging, prior to incorporating the amendment into soil.

g. For each test condition, provide:

(1) Quantity of each amendment that will be added per unit volume of soil.

(2) Temperatures under which testing will be performed.

(3) The number of replicate tests for each test condition.

(4) Description of containers that will be used.

(5) Procedure for mixing soil.

(6) Frequency of mixing.

(7) Testing and monitoring parameters.

(8) Number of samples.

(9) Monitoring frequency.

(10) Length of monitoring period.

(11) Laboratory turn-around-time.

h. Test methods, and other sampling and analysis requirements for the bench-scale treatability study test must be [_____].

]1.4.4.2 Field Demonstration Plan

****

NOTE: It is important that the field demonstration match the intended implementation as closely as possible in terms of inputs and process. Landfarming is sensitive to a variety of factors like moisture, temperature, chemical conditions, and most critically, the survival and propagation of the bacteria. The difference in scale between the demonstration and the implementation will inevitably introduce changes in the conditions. The conditions in the demonstration need to be measured

to a greater degree than might be initially supposed, such as greater resolution in the temperature and moisture over time and across the volume of soil being treated, so that the differences due to scale can be identified and minimized, and the implementation can reproduce as closely as possible the successful conditions of the demonstration.
****

Submit a Field Demonstration Plan not more than [270][_____] calendar days after notice to proceed. Prepare [draft for Government review][draft-final for [regulatory][_____] review] and final versions of the Field Demonstration Plan. Allow [30][_____] calendar days for [Government] review [and [30][_____] calendar days for regulatory review]. Allow [45][_____] days for comment resolution following each review and preparing the next version of the document. This plan must include:

a. Location for performing the field demonstration.

b. Minimum, initial levels of contaminants in the soil to be used for the demonstration.

c. Locations that will serve as the source of soil for the demonstration. test parameters and number of samples that will be used to confirm that the soil meets criteria for the demonstration.

d. Rationale for use of each proposed amendment and the source of each amendment.

e. For organic amendments, such as manure or wood products, state the intended freshness of the amendment and the length of the period of aging, prior to incorporating the amendment into soil.

f. For each test condition, indicate:

    (1) Quantity of each amendment that will be added to each cubic meter yard of contaminated soil.

    (2) Anticipated temperatures under which the field demonstration will be performed.

    (3) Irrigation and tilling equipment specifications.

    (4) Irrigation water source.

    (5) Plan for operation, maintenance and process monitoring.

    (6) Laboratory turn-around-time.

g. Test methods, and other sampling and analysis requirements for the field demonstration test must be [_____].

1.5 SUBMITTALS

****
NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal

items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy and Air Force projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.
****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Preconstruction Meeting Agenda

Preconstruction Meeting Minutes; G, [_____]

Bench-Scale Treatability Study Test Plan; G, [_____]

Field Demonstration Plan; G, [_____]

Landfarming Work Plan; G, [_____]

SD-05 Design Data

Adjusted Design; G, [_____]

SD-06 Test Reports

Amendment Test Report

Bench-Scale Treatability Study Test Report; G, [_____]

Pre-Operation Examination Report

Preconstruction Equipment Examination Report

Field Demonstration Operations Reports

Treatment Completion Records; G, [_____]

Water Supply Analysis

Operations Reports

Field Demonstration Report; G, [_____]

Bench-Scale Test Report; G, [_____]

SD-07 Certificates

Certificate Of Analysis For Synthetic Or Manufactured Additives

1.6 QUALITY CONTROL

1.6.1 Regulatory Requirements

****

NOTE: Regulatory requirements will be location specific and may include local ordinances and State regulatory requirements. Correspondence from regulatory agencies, and other relevant information, should be attached to the specifications to indicate the level of effort necessary for the Contractor to obtain finalized permits, permit equivalents, certifications and to meet substantive regulatory requirements.

For sites addressed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), administrative permit requirements for on-site activities are not required, though the substantive requirements may need to be met. The permits or permit equivalents may include those addressing air discharges, treated water discharge, well installation and abandonment, underground injection, and possibly others. Permitting requirements known to have substantive requirements should be listed here. If permit requirements are covered in other specifications, delete this section.

****

Obtain the permits, permit equivalents, and certifications; and meet the substantive regulatory requirements necessary for the installation, operation, and closure of the project.[Correspondence from regulatory agencies, and other relevant information, are attached to the specifications to indicate the level of effort necessary to obtain finalized permits, permit equivalents, certifications and to meet substantive regulatory requirements.]

1.6.2   Qualifications

****
NOTE: For sites with unusual, or difficult to treat, contaminants of concern, the designer should consider including a requirement that the Contractor have completed a field demonstration or full-scale project where the same type of contaminants were successfully treated. However, including such a requirement may limit the number of qualified bidders, and drive up the price of the contract. Delete the paragraph if the Contractor has been pre-selected.
****

1.6.2.1   Contractor Experience

Have successfully completed at least[one][_____] landfarming project that required processing of a volume of contaminated soil comparable to the estimated volume that will require treatment during this project. Also have successfully completed at least[one][_____] full-scale project, that required handling and transport of soil contaminated with[a RCRA hazardous constituent, or CERCLA hazardous substance, or petroleum waste][_____]. For each project, provide the following:

a. Site name.

b. Location.

c. Names of the Contractor's key personnel.

d. Key points of contact and phone numbers (including Government representatives, and other parties involved in the project).

e. Dates of mobilization/demobilization.

f. Contaminants of concern.

g. The volume of contaminated soil handled or treated.

Also provide the following, if available:

h. Dates for initiating and completing treatment.

i. Quantity of time required to treat each lift of contaminated soil.

j. Volume and weight of amendments added per unit volume and weight of contaminated soil.

k. Initial volume of soil, and final volume after treatment.

l. Concentrations of contaminants of concern in soil before treatment, during treatment period, and after treatment.

m. The treatment concentration goal.

1.6.2.2   Key Personnel

Provide key personnel with a minimum of[three][_____] years of landfarming field experience. Include system operators, quality control personnel, and supervisory engineering and technical staff involved with the landfarming operation in key personnel. Perform all survey work under the supervision of a registered land surveyor licensed in the [applicable jurisdiction] [State of [_____]].[Perform surveys in accordance with Section:[_____].]

1.6.2.3 Lab Validation

Perform testing by a DoD Environmental Laboratory Accreditation Program (DoD ELAP) accredited commercial testing laboratory[in accordance with [Section 01 45 00 QUALITY CONTROL][_____] and][approved by the Contracting Officer]. Submit testing laboratory validation for the testing to be performed. Do not permit work requiring testing until the Contracting Officer approves use of the testing laboratory.

1.6.3 Drawings

Project drawings must include:

a. Limits of planned excavations.

b. Layout of the facility.

c. Dimensions of amendment storage areas, pre-processing areas, and treatment cell.

d. Details of treatment cell liner and sumps.

e. Dimensions and volumes of stockpiles for contaminated soils, oversize materials, and treated materials.

f. Locations, dimensions, and volume of collection sumps and any ancillary water storage facilities.

g. Plan view and cross sections of perimeter berms and collection sumps.

h. Ancillary water storage facilities.

i. Size of contact water conveyance devices and structures.

j. Piping and instrumentation diagrams.

k. Process flow diagrams.

1.7 DELIVERY, STORAGE, AND HANDLING

Safely transport, store, and handle equipment and raw materials (including reagents). Package and ship these items in compliance with United States Department of Transportation (USDOT) requirements. Store and handle these items onsite in accordance with the manufacturer's recommendations and applicable regulatory requirements.

1.8 PROJECT/SITE CONDITIONS

1.8.1 Environmental Requirements

When soil temperatures fall below[5 degrees C 40 degrees F, remain below that temperature for[[_____] hours][[_____] days], and written approval has been received from the Contracting Officer,][_____], suspend operation of the landfarm for the season. Resume operation of the landfarm when soil temperatures remain above [5 degrees C 40 degrees F for[[_____] hours][[_____] days], and written approval has been received from the Contracting Officer][_____]. Do not conduct tilling within[24][_____] hours of a rainfall or irrigation event which saturates the soils.

1.8.2   Existing Conditions

****

NOTE: The pertinent site characterization data should be placed in the appendices of the technical specifications or on the drawings, and referenced here. If the site contains a significant amount of debris, the available information about its extent and characterization should also be provided. Indicate the detail to which site characterization has been performed. The information should also include: construction limits, property survey, access gates and haul roads available to the Contractor, locations of utilities, water sources, area available for the field demonstration and treatment cell, restricted areas adjacent to the project site, chemical data, geotechnical data, sampling locations, and boring logs. Reference the administrative record locations, whether they are physical or digital, of the site if they exist.

Indicate if there are multiple dissimilar types of contaminated materials that will require different operations. Materials may be considered dissimilar based on possessing different soil properties, types of contaminants, or relative concentrations of contaminants. Determination of dissimilar materials may be based on site investigations and/or previously completed treatability studies.

****

The existing site conditions are presented [in Appendix [_____]][and][on the drawings]. These include [physical configuration][utilities][topography][land uses][geotechnical characteristics of the contaminated materials (including [grain size analysis][total organic content][cation exchange capacity][pH][moisture content][density][porosity]) [hydrogeology]] and [nature and extent of contamination][_____]. The existing conditions presented are the result of site investigations at specific locations; variations in the existing site conditions could occur. Perform an independent interpretation of the site characterization data. Notify the Contracting Officer within [48 hours][_____] if discrepancies between the data provided and actual field conditions are discovered.

[1.8.3   Previously Conducted Bench-Scale Treatability Studies

****

NOTE: This paragraph should be deleted if no previous treatability studies have been conducted.

The methods employed in previous bench-scale treatability studies may not be the same as those

proposed by the Contractor. Documentation of the previous bench-scale treatability studies should include the same information shown in the following sub-paragraphs: BENCH-SCALE TREATABILITY STUDY TEST REPORT and FIELD DEMONSTRATION REPORT. Bench-Scale Treatability study reports should be prepared to provide prospective Contractors with sufficient information to prepare a responsive bid, or proposal, for the contract.
****

Appendix [A][_____] "Bench-Scale Treatability Study Report" is for information purposes only.

]PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Materials and equipment must be the standard products of a manufacturer regularly engaged in the manufacture of such products and must essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment must be supported by a service organization that is, in the opinion of the Contracting Officer, capable of providing service, materials and equipment in an expedient manner.

2.2 WATER SUPPLY

****
NOTE: One important concern for irrigation water is to ensure that salts do not accumulate to levels that inhibit biological activity. Conductivity is an indicator of salt content. Conductivity may be reported in micro-siemen per cm, or micro-mho per cm. Total dissolved solids (TDS) testing may be substituted for conductivity.

Possible water sources include: a nearby pond, or other surface water body; a hydrant, or other connection to a water distribution line; runoff from precipitation; and contact water; see paragraph Storage Volume.
****

Water for irrigation must not contain oils, acids, salts, alkalis, organic matter, solids or other substances at concentrations that could be detrimental to the successful treatment of the contaminated materials. The acceptable ranges, or levels, of the following parameters in the irrigation water must not exceed the criteria established in Table 3.

TABLE 3 - IRRIGATION WATER LANDFARMING CRITERIA CRITERIA	
PARAMETER	REUSE CRITERIA
maximum conductivity	[_____] micro-mho per cm
minimum pH	[_____] standard units

TABLE 3 - IRRIGATION WATER LANDFARMING CRITERIA CRITERIA	
PARAMETER	REUSE CRITERIA
maximum pH	[_____] standard units
[_____]	[_____]

Provide water for irrigation that does not contain contaminants that would persist through the landfarming process and that would thereby cause the landfarmed soil to be considered contaminated and not suitable for reuse. Contaminants must also be avoided that may leach through the project site and contaminate groundwater.[If non-potable water is to be used, the irrigation water must be characterized prior to its use using Table 4. Sufficient numbers of samples must be collected to characterize the irrigation water source. Irrigation water that does not meet the criteria in this table may be treated to these criteria prior to landfarming use. Submit a Water Supply Analysis demonstrating that irrigation water meets requirements.

TABLE 4 - IRRIGATION WATER CONTAMINANT CRITERIA		
Chemical Contaminants		
ANALYTICAL METHOD NUMBER From EPA SW-846	ANALYSIS TYPE	CRITERION TO BE MET
6010 [and 7470A]	Metals [and Mercury]	[Less than Maximum Contaminant Level (MCL)] [_____]
8260	Volatile Organics	
8270	Semi-volatile Organics	
8082	PCBs	
1633	PFAS	
8081	Pesticides	
Within each Analytical Method, only analyze for analytes which have a [MCL] [_____].		

]2.3 AMENDMENTS

****

NOTE: Use of amendments may not be necessary for treatment of some types of soils. Adding amendments such as manure at too high of a rate can change porosity characteristics, and may prevent proper drainage and aeration. Organic contaminants will adsorb onto organic amendments (e.g., wood chips), and may become less available to degrading microorganisms. Adsorption of contaminants can make it appear like the contaminants have been

biodegraded. An in-depth discussion of adsorption and bio-transformation reactions can be found in the chapter titled, "Microbe-Soil-Organic Contaminant Interactions", Haider, K., from the text, Bioremediation of Contaminated Soils, Agronomy Monograph no. 37, American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, 1999.

Factors driving selection of amendments include: seasonal availability, proximity of sources to the site, costs, storage and handling properties, moisture content, odor potential, texture and porosity, carbon-to-nitrogen (C:N) ratio, previous experience with using an amendment, and consistency in the quality of an amendment.

Addition of manure is an inexpensive way to bolster microbial activity, provide nutrients (nitrogen, phosphorous and micro-nutrients), and increase the field capacity of sandy soils. Relative to most other types of manure, chicken manure has a high nitrogen content. Fresh manure will contain higher levels of nitrogen than dried. Nutrients will leach more readily from fresh than from dried manure. Swine manure is not recommended due to the potential for odor problems. Because of the diversity of the bacterial populations within their digestive systems, manure from ruminant animals (e.g., cows) is generally considered to be good source of microbial inoculum. Bedding materials will often be intermixed with manure. These bedding materials may help increase porosity, depending on the soil type. Pope and Matthews previously recommended that manure be applied to each lift at a rate of about 3-4 percent by weight of soil (Bioremediation Using the Land Treatment Concept, EPA/600/R-93/164). Pope currently recommends a 2-4 application rate.

Arsenic-containing compounds are often fed to chicken, turkey and swine as growth promoters. Thus, there is potential for residual levels of arsenic to be present in these types of manure (see "Sources and Practices Contributing to Soil Contamination", Knox, A. S., et al., from the text, Bioremediation of Contaminated Soils, Agronomy Monograph no. 37, American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, 1999.

The C and N contents of candidate amendments can be estimated using literature values, see Appendix A of the On-Farm Composting Handbook (Northeast Regional Agricultural Engineering Service, 1992). Laboratory testing, for moisture and ash content, may also be used to estimate carbon content. By subtracting the ash content from the dry weight, the organic matter content can be determined. The carbon content is usually estimated by dividing the organic matter

content by 1.8.

Carbon in the form of aged wood, or other aged wood products is generally considered to be unavailable. Carbon in manure and other relatively soluble organic materials is generally considered to be available. Amendments with high C:N ratios, and high levels of available carbon, will tend to exert a nitrogen demand. Microorganisms will consume nitrogen as they degrade the organic carbon in the amendment. Use of amendments high in available carbon and with high C:N ratios should be limited; as their use will increase the amount of fertilizer needed to replenish nitrogen.

Wood chips, shredded wood or bark may be used to increase the porosity of soil; however, depending on plans for end-use, large-diameter materials may have to be separated from treated soil. It becomes more difficult to maintain aerobic conditions as the porosity decreases, and as the moisture content increases (see paragraph MOISTURE CONTROL). Organic contaminants will often adsorb and accumulate onto wood products present in the contaminated-soil matrix.

Wood products derived from treated wood should not be used, as this may result in secondary contamination of soil. Treated wood especially older treated wood, may contain CCA (chromated copper arsenate), PAHs (from creosote), PCP, or other contaminants. Even newer treated wood that uses wood preservatives approved by the USEPA in the 2010 or later timeframe should be avoided due to the risk of contamination and inhibition of microbial activity. Types of wood which contain naturally occurring compounds that inhibit microbial activity (e.g., cedar) should be avoided. Freshly processed wood products can also release other organic compounds (e.g., organic acids) that can be detrimental to the treatment process. Wood products should be aged under moist conditions for several months prior to use.

****

Provide amendments that are free of chemicals, such as wood preservatives, which could result in secondary contamination of soil. The concentration of glass, plastic, and other foreign materials in each shipment of amendment must not exceed [5][_____] percent, by dry weight. Do not use asbestos containing materials as amendments.

Analyze manure amendments to verify absence of constituents that would pass unaltered through the landfarming process and possibly accumulate in the product soil. The following table should be used:

TABLE 5 - MANURE AMENDMENT CONTAMINANT CRITERIA		
Chemical Contaminants		
ANALYTICAL METHOD NUMBER From EPA SW-846	ANALYSIS TYPE	CRITERION TO BE MET
6010 [and 7470A]	Metals [and Mercury]	[Less than USEPA Residentional Soil Regional Screening Level if one exists] [_____]
8082	PCBs	
1633	PFAS	
Within each Analytical Method, only analyze for analytes which have a [Residential Soil RegionalScreening Level] [_____].		

2.4 SYNTHETIC OR MANUFACTURED ADDITIVES

Commercial fertilizers are an example of a synthetic or manufactured additive. A Certificate of Analysis for Synthetic or Manufactured Additives must accompany each shipping unit of synthetic or manufactured additive supplied by the vendor.

[2.5 Samples for Bench-Scale Tests

****
NOTE: To reduce the overall risk to the government, it is strongly advised that the project team should require the Contractor to collect samples for the bench-scale treatability study test unless the nature of the site prevents the Contractor to do so. Depending on site conditions and project needs (e.g. site security, access issue, etc.), the Government may provide samples to the Contractor to conduct bench-scale treatability study tests.
****

[The Contracting Officer will provide the required samples to conduct the bench-scale treatability study test.][Select sampling locations and collect representative samples to conduct the bench-scale treatability study test. Consider the existing site conditions presented in paragraph EXISTING CONDITIONS when selecting sampling locations.[Conduct sample collection activity in the presence of Contracting Officer.]] The collected bench-scale treatability study test samples must have contaminant concentration levels [representative of the average concentration of the contaminants identified][and][greater than the action level criteria presented in Table 6]. Otherwise, repeat sampling until the contaminant concentration levels exceed the action level criteria. A minimum of [2 composite samples][_____] must be tested. Also provide a physical description of each soil sample, either prepared by or under the supervision of a licensed geologist, to demonstrate that soil-type is representative of the contaminated zone. Do not commence bench-scale treatability study testing until contaminated material sample results meet the aforementioned concentration criteria.

TABLE 6 - ACTION LEVEL CRITERIA	
PARAMETER	ACTION LEVEL CRITERIA
[_____]	[_____] mg/kg

]PART 3 EXECUTION

[3.1 SOIL AND AMENDMENT TESTING AND BENCH-SCALE TREATABILITY STUDY TESTING

****

NOTE: Bench-scale treatability study tests should be performed to confirm that the landfarming process is capable of meeting treatment criteria for the specific contaminants and soil matrix. For contaminants that are known to be amenable to landfarming in a soil matrix similar to that of the project site, bench scale testing may not be necessary. The following reference should be used to prepare the plan for Bench-Scale Treatability Study Testing: EPA 540/R-93-519a, Guidance for Conducting Treatability Studies Under CERCLA, Biodegradation Remedy Selection, 1993.

These paragraphs, and the corresponding submittal descriptions, should be deleted if amendment testing and bench-scale testing were performed prior to awarding this contract.

****

3.1.1 Amendment Test Report

****

NOTE: If a proven type of amendment will be used, testing may not be necessary. However, if a type of amendment has been proposed for which there is no previous experience, the following tests should be considered: bulk density, moisture content, field capacity (or water holding capacity), conductivity, pH, organic matter content (or volatile solids), ash content, and total Kjeldahl nitrogen (TKN). The field capacity of coarse, sandy soils may be improved by adding an amendment with a high field capacity. Conductivity is an indicator of salt content. High salt levels can be detrimental to microbial activity. Organic matter content, ash content, and TKN can be used to determine C:N ratios (see note under paragraph AMENDMENTS).

Contaminants may be present in an amendment that could affect plans for disposal of treated soil. Testing should be performed if it is suspected that use of an amendment could result in secondary contamination of soil.

****

Prior to the bench-scale test, collect and test samples of amendments for: [moisture content, pH, and conductivity][_____]. For each type of amendment, [2 composite samples][_____] must be tested. Submit the amendment test report along with the Bench-Scale Treatability Study Test Report in accordance with paragraph BENCH-SCALE TREATABILIITY STUDY TEST REPORT. Include the following in the report: characterization test results for each amendment; the source and approximate age of each amendment; the date that each amendment was shipped, received and tested by the laboratory; procedure used to ship each amendment (including type of containers and temperature); if amendments were stored for any period of time, the temperature of storage; testing methods used; certification or laboratory reports showing the amendment is contaminant-free; and proposed recipes of soil and amendments for bench-scale treatability study testing.

3.1.2 Bench-Scale Treatability Study Test

****

NOTE: To reduce the chances of using soil samples that are not representative of site conditions, a minimum volume of 4 liters 1 gallon is recommended for each condition to be tested at the bench scale. Use of large particle-size amendments (e.g., bark chips) makes it all-the-more important to require relatively large soil samples for bench-scale treatability study testing.

Prior to initiating the bench-scale treatability study, the soil to be used in the study should be tested to confirm that the levels of contaminants are within the desired range. If test results indicate that the soil is not representative, or contaminant levels are outside of the desired range, then more soil may need to be collected. The bench-scale treatability study should not be initiated until it can be ascertained that the soil that has been collected meets the desired criteria.

****

Submit the proposed test conditions to be included in the bench-scale treatability study testing. Perform at least [two, replicate][_____] tests simultaneously for each selected test condition. Prior to initiating testing, homogenize and divide the soil into replicate volumes. The volume of contaminated soil included in each soil pan must be not less than [[4][_____] liters [1][_____] gallons][_____]. Bench-scale treatability study testing must be performed for a period of not less than [60 days][_____] or until target levels are reached, whichever is shorter.

3.1.2.1 Bench-Scale Test Report

After completion of testing, compile the data, submit the Bench-Scale Test Report and propose the conditions to be tested in the field demonstration, and include the proposal for the in the Bench-Scale Test Report.

]3.2 PREPARATION

****

NOTE: Section 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES

includes requirements for decontaminating equipment that has been used in contaminated zones. That section should be modified to extend decontamination/cleaning requirements to equipment being brought on-site to cover the requirements of this paragraph.

****

3.2.1 Mobilization

Do not mobilize to the site until [the Landfarming Work Plan][UFP-QAPP] has been approved by the Contracting Officer and the Contractor has received written confirmation. Delays caused by the Contractor's failure to meet regulatory requirements must result in no additional cost to the Government. In accordance with[Section 01 35 29.13 HEALTH, SAFETY, AND EMERGENCY RESPONSE PROCEDURES FOR CONTAMINATED SITES][_____], do not bring rented equipment and equipment previously used for other site remediation to the site until such equipment has been decontaminated and tested.

3.2.2 Pre-Operation Examination

Conduct a pre-operation examination of the on-site infrastructure, utility conduits, monitoring points, and site access constraints. Photographically document, with identifying labels, the existing condition of infrastructure and utilities, particularly for comparison to post-treatment conditions. Verify locations of critical utilities that cannot be disrupted and those utilities that would potentially have significant impacts on treatment and public safety. Submit a Pre-Operation Examination Report documenting the examination activity [before mobilization begins][_____]. Obtain the necessary utility clearances before initiation of subsurface work.

3.2.3 Preconstruction Equipment Examination

Conduct a preconstruction examination of the landfarming equipment for damages, defects, and dilapidation. Submit the Preconstruction Equipment Examination Report to the Contracting Officer [before construction begins][_____]. The Contracting Officer may conduct an independent examination to ascertain the condition and functionality of the equipment. Based on this examination, the Contracting Officer may reject the entire system or damaged, defective, or dilapidated equipment. The cost associated with equipment or control replacement or repair, and delays caused by the rejection must be borne by the Contractor. Routinely and properly inspect and maintain the equipment to provide the operation as required by the Contract schedule. Schedule delays and the associated costs are the responsibility of the Contractor. Provide an alternate or auxiliary power source if sufficiently reliable sources are not available.

3.3 FIELD DEMONSTRATION

****

NOTE: Field demonstrations should be performed to confirm that the landfarming process is capable of meeting treatment criteria in a reasonable time frame.

The field demonstration requirements are a function of the uncertainty of the materials to be treated. For well defined wastes, known to be amenable to

landfarming, optimization testing may be adequate. Optimization testing would typically be performed using full-scale equipment and facilities. If the amenability of the contaminated material to landfarming, has not been established, the field demonstration should be preceded by bench-scale testing. If the process has yet to be demonstrated on a large scale for the specific soil type and contaminants of concern, it may be advantageous to perform the field demonstration prior to construction of full-scale facilities.

The treatment conditions and amendments used in the field demonstration should be based on the results of the bench-scale treatability study test. To prevent scale-up problems between the field demonstration and full-scale operations, the area of each treatment cell used for the field demonstration should be at least 5 percent of the area planned for each full-scale treatment cell.

****

Prior to full scale landfarming operations, a field demonstration must be performed. If the materials treated during the field demonstration do not meet the treatment criteria, an equal quantity of the same type of material that failed must be processed, using modified operating conditions, until satisfactory results are obtained. Any treated materials that failed the field demonstration must be kept segregated and returned to the contaminated materials stockpile area for processing during full-scale remediation. The area of each demonstration treatment cell must be a minimum of [9][_____] square meters [100][_____] square feet. Separate treatment cells spaced to prevent intermingling of contaminated material, must be provided for each condition being tested. Conditions to be tested must include: [_____]. The field demonstration must be conducted using the same lift-depth, and similar irrigation and tilling methods as proposed for the full scale operations. The field demonstration must not be initiated until written approval has been received from the Contracting Officer.

3.3.1 Sampling Locations

****

NOTE: Chemical testing should be performed to verify that the materials to be used for the field demonstration contain the contaminants of concern at high enough concentrations to adequately test the process. Additional testing may be warranted to verify that the physical properties of the materials are representative of site conditions.

****

Obtain contaminated material used for the field demonstration from [the location specified by the Contracting Officer][_____]. Prior to performing the field demonstration, test [three composite samples][_____] of the contaminated material to be used for the field demonstration. Consider the existing site conditions presented in paragraph EXISTING CONDITIONS when selecting sampling locations. The contaminated material samples must have contaminant concentration levels [representative of the average concentration of the contaminants identified][and][greater][than the action level criteria presented in Table 7]. Otherwise, repeat sampling until the contaminant concentration levels exceed the action level criteria. Test samples of contaminated materials intended to be used in the field demonstration in accordance with procedures in paragraph PRE-COMPLIANCE TESTING. Do not commence the field demonstration until soil samples meet the aforementioned concentration criteria. Also provide a physical description of each soil sample, either prepared by or under the supervision of a licensed geologist, to demonstrate that soil-type is representative of the contaminated zone.

TABLE 7 - ACTION LEVEL CRITERIA	
PARAMETER	ACTION LEVEL CRITERIA
[_____]	[_____] mg/kg
[_____]	[_____] mg/kg

3.3.2 Monitoring

****

NOTE: Because a more intensive level of monitoring is usually required during the field demonstration than during full-scale operations, a separate set of Operation, Maintenance and Process Monitoring requirements may need to be prepared. The following differences in monitoring requirements are typical for the field demonstration versus full-scale operations: sampling stations may be spaced more densely; temperature, moisture, and respiration testing may be performed more frequently; and sampling and analysis for contaminants of concern may be performed on a more frequent, and more regular basis. A sufficient number of samples should be tested to assess the heterogeneity of contaminant concentrations. The field demonstration may also provide an opportunity to develop a site-specific correlation between field, and laboratory analysis methods.

A sufficient amount of time,which should be based on the results from the bench-scale treatability study test, should be scheduled for the field demonstration to determine the amount of time it will take to reach cleanup goals during full-scale operations. Degradation rates typically decrease as contaminant levels decrease; e.g., it may take 3 times as long to go from 25 to 10 mg/kg as it takes to from 100 to 25 mg/kg. Thus, trends in contaminant levels should not be extrapolated in an attempt to predict how long it will take to reach cleanup goals.

****

During the field demonstration, sampling and analysis must be performed as indicated under paragraph OPERATION AND FIELD QUALITY CONTROL; in addition to these requirements, the following processing monitoring requirements must be implemented: [_____]. The treatment period of the field demonstration must not exceed [180][_____] days, without written approval from the Contracting Officer.

3.3.3 Field Demonstration Operations Reports

During the field demonstration furnish reports weekly for the first [10][_____] weeks, and every [two][_____] weeks thereafter. Maintain copies of the reports at the facility. Record and maintain the following information until closure of the facility: description (including sources) of contaminated soil and amendments on site; the locations of all amendments and contaminated soil on site, and the quantity at each location; receipt, storage, treatment, disposal date, offsite disposal location, volume, and weight of hazardous and non-hazardous wastes including contaminated and treated soil and amendments; and manifests/proof of receipt from the disposal facility for hazardous and non-hazardous wastes. Dispose of all hazardous materials and wastes in accordance with Section 02 81 00 TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS. Record the location and quantity of each type of material on a map or diagram of the site. Include cross-references to specific manifest document numbers, if the waste was accompanied by a manifest. Provide summary reports and details of all incidents that require implementing contingency plans, or corrective action measures. Also include:

a. Date and time of each monitoring or testing event.

b. Results from each monitoring or testing event.

c. Monitoring procedure, or test method used.

d. Individual performing the monitoring or testing, and other individuals present.

e. Remarks.

Cross-reference to submittals specified in other Sections to prevent duplicate information in separate submittals.

3.3.4 Field Demonstration Report

****

NOTE: If the results of the field demonstration will be used to inform the Landfarming Work Plan, it may be preferred to report the field demonstration results in the Landfarming Work Plan instead of having a separate Field Demonstration Report. Update the Landfarming Work Plan paragraph and delete this paragraph if using that approach.

****

Provide the field demonstration report[not more than [60][_____] calendar days after completion of the field demonstration. Prepare [draft for Government review] [draft-final for [regulatory][_____] review] and final versions of the Field Demonstration Report. Allow [30][_____] calendar days for[Government] review[and [30][_____] calendar days for regulatory review]. Allow [45][_____] days for comment resolution following each review and preparing the next version of the document]. Include: characterization test results for each amendment; the source of each amendment; for each condition tested, the amount of each amendment that was added per unit volume of soil; chronological table showing all materials added, amount added, date of addition, and each mixing, precipitation, irrigation and sampling event. For organic amendments, such as manure or wood products, state the freshness of the amendment; and the length of the period of aging, prior to incorporating the amendment into soil. The report must also include: physical and chemical monitoring data from before, and during treatment; degradation rates; final disposition of wastes and treated material; and conclusions. Provide recommendations for full-scale operations in the report. In addition, include the day-to-day log of operations and adjustments in an appendix.

3.4 SOIL PRE-PROCESSING

****

NOTE: Soil pre-processing may include stockpiling, screening, and blending of soil and amendments. The maximum recommended particle diameter for soil mixing / tilling equipment can range from 25 to 100 mm 1 to 4 inches. Although it is possible to include relatively large particles in the soil matrix during landfarming, an additional screening step may also be necessary to remove the large particles prior to disposal. The end use for the treated soil often governs the maximum allowable particle diameter. More stringent requirements will apply if treated soil will be allowed to be incorporated into top soil. For surficial landscaping purposes, the concentration of glass, plastic, and other foreign materials should not exceed 5 percent, by dry weight. This paragraph should be coordinated with paragraph AMENDMENTS.

Relatively impermeable oversize materials (e.g., rocks) are usually treated by rinsing or pressure washing. For further discussion see paragraph, Particle Size Criteria for Treated Soil.

****

Pre-process contaminated soils as necessary by [screening][blending][shredding][_____] to provide a maximum particle size in the contaminated soil matrix [compatible with approved material handling and tilling equipment][and no greater than 80 mm 3 inches][_____]. Oversize materials must be separated from contaminated soil prior to mixing soil with amendments.

3.5 OPERATION AND FIELD QUALITY CONTROL

****

NOTE: Operation and monitoring requirements should be based on: applicable literature references; knowledge gained from bench-scale treatability studies and the field demonstration; and historical data from projects with similar soils, and contaminants. Aeration of soil (via tilling) and maintaining proper moisture content are fundamental to successful landfarming. Because there will always be exceptions, where the default values provided in these paragraphs do not suit a specific project, the following paragraphs should be edited appropriately. These paragraphs should be

coordinated with Division 1 Sections of the contract; operations, maintenance, and process monitoring requirements are covered in a Division 01 Section of some contracts.

Reference a UFP-QAPP that has been prepared in accordance with DoD and EPA guidance. UFP-QAPPs follow the Data Quality Objectives (DQO) process and are required for DoD environmental restoration work. If a UFP-QAPP has been prepared for the overall project that landfarming is being used on, referencing to the UFP-QAPP for testing requirements avoids potential for conflicting requirements between the UFP-QAPP and the specifications.
****

Do not initiate full-scale operations until the Landfarming Work Plan[and the UFP-QAPP] has been approved, and written approval has been received from the Contracting Officer. Operation of the landfarming must proceed continuously, through the term of the contract, except as described in paragraph ENVIRONMENTAL REQUIREMENTS. The testing specified in the following sub-paragraphs is needed by the Government to generate documentation that the landfarming treatment has been accomplished in accordance with performance requirements listed in the decision document and approved by the government and regulators (e.g. EPA or other state agencies). The results of these tests may be used as part of the Contractor's QC program; however the Contractor must meet the performance requirements specified in this Section. Perform additional testing and measurements to ensure that treated materials meet requirements without rejecting batches, retesting, or reprocessing.

3.5.1 Dissimilar Soils

****
NOTE: Delete the bracketed text item if dissimilar materials are not known to be present at time of preparing project specifications.
****

Do not mix together dissimilar soils if the bench-scale treatability study and/or field demonstration testing results indicate that different operating conditions have to be implemented to achieve effective treatment of these soils.[Materials known to be dissimilar at the site are defined in [paragraph EXISTING CONDITIONS][_____].]

3.5.2 Containment Inspection

****
NOTE: Routine operation of heavy equipment within lined landfarm facilities can result in damage to the geomembrane liner. Periodically, the granular drainage layer and geomembrane liner should be inspected. Use of rubber-tracked equipment may minimize the risk of such damage.

Containment inspection may not be necessary where the mode of operation involves successively placing new lifts of contaminated soil on top of treated lifts of soil.

Electrical leak location may be an alternative to visually inspecting the geomembrane liner. If electrical leak location is specified, the designer should have a good understanding of electrical leak location methods, availability of testing firms to perform the work, and integration into the project schedule. Refer to ASTM D6747 Standard Guide for Selection of Techniques for Electrical Leak Location of Leaks in Geomembranes to determine the appropriate location technique. If electrical leak location is retained, the specification and references must indicate how leaks will be identified and how repairs will be made.
****

Inspect the geomembrane liner when the liner may have been damaged during removal of soil from the treatment cell. This requirement does not apply when completing final disposition of the treatment cell. Reason to suspect damage to the geomembrane liner includes [inadvertent removal of more than [half][_____] the thickness of the drainage layer][observations of potential damage by Contractor or Government QC personnel][_____]. Define the limits of potential damage, remove the porous drainage layer material by hand, and conduct a visual inspection of the geomembrane liner [with the Contracting Officer present]. Repair damages to the geomembrane liner in accordance with Section 02 56 13.13 GEOMEMBRANE WASTE CONTAINMENT. Restore the porous drainage layer to the approved design requirements.

3.5.3 Tilling and Aeration

****
NOTE: Tilling too soon after heavy precipitation or irrigation may lead to the formation of hard clods; especially, for soils with high clay content. Light irrigation prior to tilling will help keep dust down.

The direction of tilling should be alternated to facilitate thorough mixing and uniform treatment of the contaminated material. Thorough tilling will result in more homogenous soil, and should reduce the variability of chemical data.

The goal of tilling is to mix and aerate the soil while minimizing compaction. Tilling too frequently can compromise soil structure (i.e., reduce pore volume, and lead to compaction). Although conventional agricultural plowing methods (e.g., using a disk harrow or chisel plows) can result in some degree of mixing and aeration, they are usually much less effective than rotary tilling equipment. Periodic deep tilling (to a depth of about 500 mm1.6 ft) using subsoil tillers can be used to provide a limited degree aeration at depth, and may hasten treatment of soil below the depth limit of a rotary tiller.

Although most categories of organic contaminants biodegrade most readily under aerobic conditions,

there are some types of contaminants that are more amenable to biodegradation under anaerobic conditions. There are also some contaminants that are most readily biodegraded under alternating conditions (e.g., anaerobic followed by aerobic conditions). It may be necessary to modify tilling requirements to accommodate these types of alternative treatment strategies. Tilling and aeration procedures should be based on the results and recommendations from the Field Demonstration report approved by the government.
****

Till using a [rotary tiller, with tines attached to a rotating shaft][_____]. Alternate the direction of tilling between lengthwise, crosswise, and diagonal. A light irrigation event, prior to tilling, may be used as a dust control measure. Till the soil in the treatment cell at least once every [14][_____] days, unless monitoring indicates that soil gas oxygen levels are greater than [2 percent][_____], by volume, in which case it may be tilled less frequently. Additional tilling may be required in response to process monitoring; for example, to provide additional aeration.

3.5.4 Moisture Control

****
NOTE: The water content at saturation will vary with soil type, and depending on whether amendments were added. Determination of water content as a percent of field capacity (or water holding capacity) provides a more universal indicator of the degree of saturation. Field capacity is determined by saturating a sample, allowing the free water to drain, and then determining the moisture content; field capacity is the mass of water in the sample divided by the dry weight. According to Bioremediation Using the Land Treatment Concept, EPA/600/R-93/164, field capacity can range from 5 percent (for a sandy soil) to 30 percent (for a clay soil). The recommended moisture content for landfarming is between 40 and 80 percent of the moisture content at field capacity. For example, if the field capacity of a soil is determined to be 20 percent, then optimum moisture content would be between 8 and 16 percent.
****

3.5.4.1 Field Capacity

****
NOTE: The following methods may be used as approximate measures of field capacity: ASTM D425 or ASTM D6836.

When using porous-plate or pressure-membrane apparatus, the pressure that should be applied depends on the soil-specific factors such as organic matter content, soil structure, compaction, and percent sand, silt, and clay. As a general

guideline, Methods of Soil Analysis recommends the following pressures for the following soil types: 5-10 kPa 0.7-1.4 psi for coarse-textured, 33 kPa 4.8 psi for medium-textured, and 50 kPa 7.3 psi for fine-textured. If the centrifuge method is used, the centrifuge speed should be adjusted to accommodate differences in soil types (this is analogous to the above guideline for pressure versus soil type).

****

Prior to treating each lift of contaminated material, a minimum of [4][_____] representative composite samples must be tested to determine field capacity (or water holding capacity). Testing soil for field capacity must be performed in accordance with [ASTM D6836][_____].

3.5.4.2 Moisture Content

****

NOTE: Visual/manual methods for estimating moisture content should be used in conjunction with laboratory and field testing. Moisture content should be monitored more frequently than other process parameters. The frequency of monitoring usually depends on the climate and soil type; more frequent monitoring is required in arid climates and for high permeability soils.

ASTM D2974 and ASTM D2216 are equivalent, gravimetric laboratory methods for moisture content testing.

Many moisture monitoring devices used in agricultural applications are not suitable for landfarming because they must be positioned in one location and left undisturbed. Because landfarming involves frequent tilling, moisture monitoring devices that can be inserted into the soil to take immediate readings are preferred.

Several types of electronic moisture sensing devices that provide real-time readings are available. Electrical conductivity moisture sensors are inexpensive but not highly accurate, compared to some of the more sophisticated instruments available. Neutron probes and time domain reflectometry (TDR) moisture sensors offer a higher degree of accuracy, but at a substantially higher capital cost. However, neutron probes are not particularly well suited to landfarming because they are not accurate for measurements less than 180 mm 7 inches from the surface.

****

Quantitatively test the moisture content using a field method (for example, electronic field instrument) at least every [Monday, Wednesday, and Friday][_____] for the first [six][_____] weeks, and every [Monday and Thursday][_____] thereafter. The field method may involve the use of an instrument that correlates moisture content to electrical conductivity.

Collect samples for laboratory analysis, and test in accordance with [ASTM D2216][ASTM D2974][_____] to determine moisture content, according to the following schedule: [a minimum of two samples per week, for the first four weeks; and a minimum of two samples, once every eight weeks thereafter][_____]. Collect these samples immediately after testing using the field method, and from the same location as the samples tested using the field method.

3.5.4.3 Irrigation

****

NOTE: Factors influencing irrigation water requirements include the field capacity of the soil, water holding properties of amendments (if used), and the climate. A tank truck or a water storage tank may be necessary if a local water source is not available.

****

Irrigate the treatment cell when testing indicates that the soil moisture content is below [40][_____] percent of the field capacity. Do not irrigate at a rate greater than [13][_____] mm [1/2][_____] inch per hour. Irrigate sufficiently to bring the moisture content to within the acceptable limits within [24][_____] hours. Immediately cease irrigation if ponded water is observed in the treatment cell, or if irrigation water is observed running off the treatment cell. Measure the application rate with a water meter. Record the application rate, duration of the irrigation period, and volume of water applied. Measure and record the quantity of water from each precipitation event each weekday.

3.5.4.4 Contact Water Testing

Test contact water, to be reused as irrigation water, for pH and conductivity on the [first,][second,][_____][and][fourth][_____] week after initiating treatment of each lift of soil. If there is more than [13][_____] mm [1/2][_____] inch of precipitation in 24 hours, test the pH and conductivity of the contact water after water from the precipitation event has collected in the contact water storage facility. Each time testing is performed, either withdraw one representative sample from the contact water holding vessel, or directly test the water in the holding vessel by immersing the instrument probe in the water.

3.5.5 Nitrogen and Phosphorus Control

****

NOTE: Commercial fertilizers are often used as a source of nitrogen (N) for landfarming operations. In commercial fertilizer specifications, N is the first of the three components listed (i.e., 33:3:3 refers to N:P:K). The N and P (phosphorous) content is usually expressed as weight percent of N and phosphorus pentoxide equivalents (P2O5) in the fertilizer. To determine the percent of P, by weight, the number corresponding to P should be divided by 2.3. The potassium content, expressed as K2O, in commercial fertilizers is much more significant for plants than it is for microbial nutrition. Slow release fertilizers require less frequent application and supply nutrients at a more

constant level. Examples of slow-release, nitrogen fertilizers include: sulfur-coated urea, urea formaldehyde, as well as some organic products (e.g., fish meal, blood meal, etc.). Agricultural spreaders are commonly used to distribute fertilizer across the treatment cell, or it may be dissolved into irrigation water and applied to the cell by the irrigation system.

When measuring nutrients in soils it is important to distinguish between available and total concentrations of N and P. Readily available nutrients are in a form that can be rapidly assimilated by microorganisms. Total nitrogen is usually determined by adding the level of total Kjeldahl nitrogen (TKN) to that of nitrate nitrogen. TKN includes ammonia nitrogen and nitrogen bound to organics. Nitrate and ammonia (inorganic N) represent the most readily available forms of nitrogen.

There are several different methods for determining available phosphorous in soil. Agricultural labs often use the Bray P-1 method (also known as Phosphorous Soluble in Dilute Acid-Fluoride). For highly calcareous soils (greater than 4 percent calcium carbonate), the Olsen P method (also known as Phosphorous Soluble in Sodium Bicarbonate) is recommended. For additional information on test methods see, Methods of Soil Analysis, Part 2 Chemical and Microbiological Properties, American Society of Agronomy and Soil Science Society of America, 1982.

The following information are found in the literature and are for information only. The Contractor can propose different ratios based on the results from the bench-scale treatability study

testing and field demonstration.

A wide range of optimal carbon-to-nitrogen (C:N) and carbon to phosphorous (C:P) ratios for landfarming have been reported in the literature. A C:N:P ratio range of 100:10:1 to 300:10:1 was recommended (Pope & Matthews, EPA/600/R-93/164). C:N ratios between 25:1 and 38:1 have also been recommended (Huddleston, R.L., et al., Land treatment biological degradation processes. p. 41-61. In R.C. Lowhr and J.F. Malina, Jr. (editors) Land treatment: A hazardous waste management alternative. Water Resour. Symposium 13th. Center for Research in Water Resour., Univ. of Texas, Austin, 1986.)

Insufficient nitrogen levels may lead to sub-optimal degradation rates. However, excessive levels of nitrate and ammonia can also reduce hydrocarbon degradation rates (see Huesemann, "Guidelines for Land-Treating Petroleum Hydrocarbon-Contaminated Soils", Journal of Soil Contamination, 3(3):299-318, 1994). Also organic nitrogen is often present in soil before fertilizer has been added, and recycling of nitrogen will occur as microorganisms die-off. According to Huesmann, one-time additions of inorganic N should be limited, and inorganic N levels should be maintained above a threshold level of about 50 mg/kg. Treatment of soil with high levels of organic contaminants usually requires repeated applications of N.

If the Contractor can demonstrate that increasing one-time applications of N to a value higher than the recommendations from the bench-scale testing, field demonstration, or that prescribed below does not adversely affect contaminant degradation rates, then the Contractor should present such data to obtain approval to increase one-time N application rates. However the data should be from the same site, using the same soil type, the same type of N amendment, and treating the same contaminants.

****

Test the levels of nitrogen and phosphorous within the [first two weeks][_____] of initiating treatment of each new lift of contaminated soil in the treatment cell. Perform subsequent nitrogen and phosphorous testing once every [90 days][_____]. Nutrient testing and application of nutrients may be performed as a pre-treatment step, prior to placement of the soil in the treatment cell. Test a minimum of one representative, composite sample per each 1,000 cubic meters 1,300 cubic yards. Nitrogen analysis must include testing for the following parameters: [nitrate, ammonia, and total Kjeldahl nitrogen][_____]. Phosphorous analysis must be performed by testing for [phosphorous soluble in dilute acid - fluoride][_____]. When the sum of the nitrate and ammonia levels fall below [50][_____] mg/kg as N, apply fertilizer to restore nitrogen levels. Do not exceed 0.18 kg 0.31 pounds of N per cubic meter yard during one time applications of nitrate and ammonia. Apply phosphorous-containing fertilizer when the levels of phosphorous fall below [5][_____] mg/kg as P. Each time fertilizer is applied, record the product name, quantity, and N:P:K content. Take necessary precautions to prevent the release of chemicals, such as nitrate, to the vadose zone and groundwater.

3.5.6 Temperature Monitoring

****

NOTE: Control of temperature is usually not practical for large-scale treatment cells. The treatment cell can be covered by a layer of mulch to help insulate the soil. However the mulch layer may reduce the rate of oxygen diffusion from the atmosphere to the soil, and will have to be removed prior to tilling. In cold climates, activity at large-scale landfarming operations is usually seasonal. Follow the recommended effective temperature range in the Landfarming Work Plan and cease landfarming operation when it becomes impractical. The typical effective Soil temperature range is between 10 and 45 degrees C 50 and 113 degrees F for landfarming operation based on the guidance from Federal Remediation Technologies Roundtable (https://www.frtr.gov/matrix/Landfarming/).

For small-scale projects, it may be possible to perform landfarming inside of a heated building or other type of covered structure during the winter. Structures similar to temporary greenhouses have been used to extend the "landfarming season" during cold periods. More than 3 temperature monitoring locations should be required if a cover structure is being used to determine if adequate temperatures are being maintained throughout the treatment cell.

****

Use the recommended low/high temperature range in the approved Landfarming Work Plan for reference, which should also follow the temperature range requirements listed in paragraph ENVIRONMENTAL REQUIREMENTS. Measure the temperature of the soil in the treatment cell[once every four weeks at the following times: 0800 hours, 1200 hours, and 1600 hours][_____]. Monitor the temperature at a minimum of [three][_____] locations, in the treatment cell. Monitor at the same locations during each event, and at a depth of at least 76 mm 3 inches below the surface of the soil. Record the temperature, time, depth and location of each temperature reading during each monitoring event. Record ambient air temperatures at the time of monitoring.

3.5.7 Soil pH

****

NOTE: The optimum pH range for biodegradation of most types of contaminants is between 6.0 and 8.5 standard units. However, where acclimated populations of microbes are present, degradation may proceed at an adequate rate when the pH is as low as 5.0. The pH can influence the availability of N, P, micronutrients, metals and some types of organic contaminants (see Sims, et al., Prepared Bed

Bioreactors, in Bioremediation of Contaminated Soils, Agronomy Monograph no. 37, American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, 1999).

Biological degradation of organic constituents may result in a reduction of the pH of soils. Strong caustics should not be used to adjust the pH of the soil because they can cause large, rapid changes in soil pH, which may inhibit biological activity. Crushed limestone or lime are commonly used to increase the pH. Agricultural lime is available in several particle-size grades. Finely graded material acts faster than coarsely graded product.

Some soils are naturally alkaline and may require downward pH adjustment. Sulfur-based amendments (e.g., elemental sulfur) may be used to decrease the pH of the soil.

The goal of pH adjustment should be to adjust the pH in small increments. If it appears that pH adjustment may be necessary, samples should be sent to a local soils laboratory (after ascertaining that the laboratory can accept soil from a hazardous waste site). Agricultural extension services (e.g., USDA, Natural Resources Conservation Service) possess knowledge of local soil characteristics any may be able to identify site-specific factors that can influence pH, nutrient availability and other considerations.

Test results should be used to calculate how much pH adjustment agent should be added (e.g., lime requirement test, or excess lime test). Amendments used to adjust the pH should be added in conservative, calculated doses.
****

Unless otherwise described in the approved Landfarming Work Plan, at a minimum, test the pH of soil in the treatment cell[each Monday of the first, second, fourth, and eighth week after initiating treatment of each new lift of contaminated soil, and every six weeks thereafter][_____]. Test a minimum of one representative, composite sample per each 1,000 cubic meters 1,300 cubic yards. The first [three][_____] times pH testing is performed, test a minimum of [two][_____] samples in accordance with ASTM D4972 to determine the pH, and to verify the field method. After the field method has been verified, all subsequent testing may be performed in the field. If the soil pH is greater than 8.5, or less than 6.0, send soil samples to a local soil testing laboratory (such as an agricultural extension laboratory) to determine how much pH adjustment product should be added. Prior to sending any samples, notify the local soil testing laboratory regarding the contaminants that are present in the soil, to determine if they can accept such samples. Test samples for [Lime Requirement or Excess Lime][_____]. The first time the pH is adjusted, not more than [one fifth][_____] of the area of the treatment cell must be adjusted. Do not perform additional pH adjustment until after pH adjustment has been demonstrated to result in increased rates of contaminant degradation, and written approval has been received from the

Contracting Officer. Laboratory or field demonstration data may be used to demonstrate that pH adjustment results in increased rates of contaminant degradation. After approval for pH adjustment has been obtained, the pH of stockpiled soil may be adjusted as a pre-treatment step, prior to placement of the soil in the treatment cell. Each time a pH adjustment product is applied, test the soil pH before and after adding the pH adjustment product. Also record the product name, quantity, and supplier of the pH adjustment product used after each application. Do not use aqueous caustics, such as sodium hydroxide, as pH adjusting agents.

3.5.8 Odor Control

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NOTE: If Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS is not included in the project specifications, emissions, dust, and odor sources and control activities should be specified here. To help control odor problems, storage of manure on-site should be avoided. If it is being used as an amendment, manure should be incorporated into soil as soon as possible after delivery to the site.

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Implement odor control requirements as specified in the approved Landfarming Work Plan [and in accordance with Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS][_____].

3.5.9 Microbial Activity

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NOTE: Several categories of tests are available for assessing microbial activity; however, these tests are almost never direct indicators of the rate of biodegradation of the contaminants of concern. If chemical data indicates that the levels of contaminants of concern are steadily decreasing, then there may not be any need to test for microbial activity. In addition to plate counts and respiration testing (as discussed in the following paragraphs), there are a host of other tests that can be used as indicators of microbial activity.

Nucleic acid probes can be used to determine whether a gene coding for an enzyme capable of degrading a specific contaminant of concern is present in soil, or to determine whether a specific strain of microorganisms are present. Use of nucleic acid probes requires that the gene that codes for the specific enzyme be known, or that the nucleic acid sequence of the specific microorganism be known. It is important to note that nucleic acid probes usually measure the potential for expression of a gene. Only messenger RNA (mRNA) probes measure the actual activity of a gene. For additional information on microbial activity assays see, Methods of Soil Analysis, Part 2 Microbiological and Biochemical Properties, Soil Science Society of America, 1994.

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3.5.9.1   Enumeration of Soil Bacteria

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NOTE: It is not uncommon for topsoil to contain greater than 1 X 10 6 colony forming units (CFU) of heterotrophic bacteria per gram of soil. However, enumeration methods that rely on non-selective media (e.g., counts of heterotrophic bacteria) do not target the specific microorganisms responsible for degrading contaminants of concern. Furthermore, enumeration data is generally not well correlated with microbial activity in soil.

Plate counts performed using selective media can be used to enumerate microorganisms capable of degrading specific contaminants of concern. Selective culturing procedures (i.e., enrichment culture methods) require use of defined growth media. For example, to select for PCP degrading microorganisms, a defined media which includes PCP as the sole carbon source would be used.

****

Enumeration of soil bacteria will not be required, but may be used as a diagnostic, or trouble-shooting, tool. Contaminant-specific selective culturing methods (e.g., pentachlorophenol-degrading bacteria), are recommended over non-specific test methods (e.g., total heterotrophic bacteria).

3.5.9.2   Field Respiration Testing

****

NOTE: Depleted oxygen and elevated carbon dioxide levels in soil gas are often used as indicators of microbial respiration. Soil gas testing may be performed in the field, and can provide a real-time indicator of microbial activity. However, respiration tests do not target the specific groups of microorganisms responsible for degrading contaminants of concern. Oxygen is usually considered to be a better indicator than carbon dioxide because carbon dioxide can be released (or consumed) via abiotic reactions. Levels of respiration are dependent on temperature and moisture. Thus, respiration measurements should be accompanied by temperature and moisture measurements.

Oxygen levels will usually decrease gradually after each tilling event as aerobic microorganisms consume oxygen. Oxygen concentrations greater than about 2 percent, by volume, are generally indicative of aerobic conditions. The concentration of oxygen in the atmosphere is approximately 21 percent, by volume. For most types of organic contaminants, rates of biodegradation will be highest under aerobic conditions.

The depth of insertion of the gas probe and the

volume of sample withdrawn must be synchronized to minimize the chances of drawing in air from the atmosphere. For example, assuming an air-filled pore volume of 25 percent, a 4 mL 0.25 cubic inch air sample drawn from a depth of 100 mm 4 inch would theoretically come from a spherical zone with a diameter of about 78 mm 3 inch (from a depth of 61 to 139 mm 2.4 to 5.5 inches)

****

Unless otherwise described in the approved Landfarming Work Plan, perform soil gas monitoring at least once every [seven][_____] days for the first [six][_____] weeks of treatment, and every [two][_____] weeks thereafter. Perform soil gas monitoring at not less than [five][_____] randomly selected locations in the treatment cell. Test soil gas for levels of [oxygen and carbon dioxide][_____]. The soil gas meter must be sensitive to [oxygen and carbon dioxide][_____] levels of at least [0.1][_____] percent, by volume. The depth of insertion for the soil gas probe must be no less than [200][_____] mm [7.9][_____] inches, and the volume of air withdrawn for the sample must not be greater than [10][_____] milliliters (mL) [0.61][_____] cubic inches. Perform field measurements of soil temperature and moisture at the same time and location of each soil gas measurement. When soil gas monitoring is performed record the following information: the monitoring location, soil temperature, soil moisture (by field method), the elapsed time since the last tilling event, and the time of day when monitoring was performed.

3.5.10 Sampling and Analysis for Contaminants of Concern

****

NOTE: Field analysis methods (e.g., immunoassay or colorimetric test kits) are usually much less expensive than laboratory analysis for contaminants of concern. However, a site-specific correlation between data from field and laboratory analysis should be developed. Pigmented materials present in extracts from soil samples may cause interferences in colorimetric, definitive field analysis. Laboratory analysis should be required on a minimum percentage of samples to verify data from definitive field analysis.

The goal of the sampling should be to collect samples that are chemically and physically representative of the soil in the treatment cell. The strategy for sampling and analysis should be consistent with the regulatory requirements for the data.

Sample designs that may be applied to treatment cells include: simple random, ranked set, and systematic grid. Systematic grid sampling is simple to apply, and provides for relatively uniform coverage of the area of interest (i.e., the treatment cell). See the following reference for more information on sampling designs: Guidance on Choosing a Sampling Design for Environmental Data Collection (G-5S), EPA/240/R-02/005, Dec. 2002. Visual Sampling Plan, a useful software program that

can be used to develop sampling designs, can be accessed at the following internet site: https://www.pnnl.gov/projects/visual-sample-plan

The following paragraphs provide an example of sampling and analysis requirements, using a systematic grid sampling approach, with randomly selected sample locations within each grid (also known as unaligned grid). This example also includes a field analysis component for pre-compliance testing. This is only an example of sampling and analysis requirements. Compliance testing requirements are project specific, and usually based on negotiations with regulatory officials.

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Perform sampling and analysis in accordance with the approved UFP-QAPP. Furnish results from each sampling event to the Contracting Officer no more than [24][_____] hours after data is recorded by the Contractor, or released by the laboratory.

3.5.10.1 Pre-Compliance Sampling Design

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NOTE: In the sample design described in these paragraphs, one of the purposes of pre-compliance testing is to determine the variability of the data (i.e., standard deviation). The variability of the data is then used to determine the minimum number of samples (i.e., maximum grid-size) that will be required for confirmatory sampling via the One-Sample t-Test. Typical, default assumptions include: that the data is normally distributed, and that the clean-up goals have not been met (assume site is dirty). An example of using the One-Sample t-Test to determine the minimum, required number of samples is shown on page 3-8 of the following reference: Guidance for Data Quality Assessment, EPA QA/G-9, EPA/600/R-96/084. The same calculation can be performed using the Visual Sampling Plan software program (see https://www.pnnl.gov/projects/visual-sample-plan).

The grid size shown in this example was arbitrarily set at a maximum of 1,000 square meters 10,800 square feet. Grid sizing is a function of the variability of the data, and the statistical criteria that will be used to demonstrate attainment of clean-up criteria. As the grid size increases, the required number of grids (and samples) decrease. Larger grid sizes may be allowable for data that exhibits low variability. An estimate of data variability should be used to arrive at the grid size (and number of samples) for pre-compliance sampling.

Based on landfarming project experience at "wood treater" sites in EPA Region 8, about 10-12 samples

per treatment cell are usually needed to meet the statistical requirements to show that clean-up goals were met. Thus, the default number in this paragraph was set at a minimum of 8 samples. It may be necessary to perform additional sampling and analysis, if the One-Sample t-Test indicates that too few samples were collected.

The default specified by this paragraph is for composite sampling within each grid. Relative to discrete sampling, compositing provides a better measure of the mean contaminant level at a given number of analyses. Discrete sampling is useful for assessing variability within the treatment cell. A round of discrete sampling is recommended during treatment of the first one or two lifts of soil to assess the effectiveness of the Contractor's mixing (i.e., tilling) practices. Discrete sampling would typically involve sampling from one randomly selected location per grid.
****

To determine pre-compliance sampling locations, divide the treatment cell into grids of equal area. Divide the treatment cell into a minimum of [eight][_____] grids. Each grid must be a maximum [1,000][_____] square meters [10,800][_____] square feet. Sample from [four, randomly selected locations][_____] within each grid. Samples from each grid must be [composited][_____] prior to testing. Each sample must include material from the entire depth interval of the top lift of soil in the treatment cell.

3.5.10.2 Sampling Frequency for Pre-Compliance Testing

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NOTE: Another purpose of pre-compliance testing is to determine whether contaminant levels have decreased to the point where compliance testing should be performed. Performing pre-compliance testing using a field analysis method can result in considerable cost savings by avoiding the expense of unnecessary (i.e., premature) compliance testing.
****

Approved field analysis methods may be used for pre-compliance testing. Sampling must be performed at least twice during treatment of each lift of soil in the treatment cell: (1) immediately after initiating treatment of new lift of contaminated soil; and (2) at the estimated time at which the cleanup levels will have been met (based on the results of the field demonstration). Intermediate sampling may be performed to determine if contaminant degradation is occurring according to schedule expectations.

3.5.10.3 Pre-Compliance Testing

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NOTE: Low-cost, definitive field analysis methods are recommended for pre-compliance testing (if they are available for the contaminants of concern).
****

Test for the following analytes during pre-compliance testing: [_____]. Test using the [field analysis][_____] method for pre-compliance testing.

3.5.10.4 Compliance Sampling Design

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NOTE: Compositing samples from each grid is recommended in order to provide a reliable determination of the mean concentration of contaminant levels in the treatment cell while minimizing analytical costs. However, compositing will decrease the variability of the data.

Determination of the minimum number of samples will be dependent on the data variability. Data from discrete samples will usually exhibit a greater degree of variability than data from composite samples. A data set produced from discrete samples may result in more samples being required to demonstrate attainment of treatment criteria, relative to a data set produced from composite samples. Thus, the determination of the required, minimum number of confirmatory samples will be influenced by whether data from discrete (or composite) samples was used.

****

To determine compliance sampling locations [use the same grid divisions from pre-compliance testing][_____]. The required, minimum number of samples must be[based on a statistical analysis of the data from pre-compliance testing, using the One-Sample t-Test in accordance with EPA 600/R-96/084 (see p. 3-8 of the reference for an example of this procedure)][_____]. Sample from [four, randomly selected locations][_____] within each grid. Samples from each grid must be [composited][_____] prior to testing. Each sample must include material from the entire depth interval of the top lift of soil in the treatment cell.

3.5.10.5 Compliance Sampling Collection

****

NOTE: Oversight must be performed to ensure that representative samples are being collected by the Contractor, and to ensure that proper sampling procedures are being followed. The proportion of fines and coarse particles in samples should be nearly the same as that within the treatment cell. Clumps of soil should not be excluded from samples. Clumps of soil present in samples should be crushed before finishing homogenizing the sample. The procedure for excluding other types of particles (e.g., rocks that exceed a maximum diameter) should be established up front, and in accordance with the approved UFP-QAPP/Landfarming Work Plan.

****

Perform compliance testing after pre-compliance testing indicates that a lift of soil has met treatment criteria, and written approval has been received from the Contracting Officer. Perform compliance sampling in the presence of the Contracting Officer. Conduct testing using the method specified in [_____].

3.5.10.6 Government Quality Assurance Testing

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NOTE: The need for quality assurance testing should be considered on a project-by-project basis, and if not considered necessary this paragraph should be deleted. Factors to consider include whether the Government has access to a laboratory that can analyze quality assurance samples in a timely manner to not delay the project execution. Use of quality assurance testing data also needs to be considered. A relatively straightforward data use is to compare quality assurance sample results to the project Performance Requirements, and a failing result would be treated the same way as a failing Contractor test result. A more complicated data use is to compare results from quality assurance samples and contractor quality control samples for the purpose of determining if there is meaningful disagreement between the results. In this case, procedures would need to be developed for determining when there is a meaningful disagreement between quality assurance and quality control sample results; corrective actions for when a meaningful disagreement was identified would also need to be developed. The process of defining procedures for identifying and correcting meaningful differences should be documented in a project-specific UFP-QAPP and referenced in this specification; the process is likely to complex to be adequately defined in this specification.

****

Provide duplicate samples to the Government's quality assurance laboratory for Government quality assurance. Submit samples at a frequency of one set of samples per [10][_____] sets of quality control tests performed. Quality assurance samples will be tested for the same parameters as the parent quality control sample. Provide additional quality assurance samples upon request.

3.5.11 Post-Treatment Procedure

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NOTE: If treatment criteria for contaminants of concern have been met, but criteria for re-use (see paragraph CRITERIA FOR REUSE OF TREATED SOIL, in PART 1) have not been met, the soil should either remain in the treatment cell, or be moved to a storage area.

At one Superfund project, lifts of treated soil were overlain by a new lifts of contaminated material, gradually increasing the height of the treatment cell, as each lift was treated. This decreased material handling requirements, as the treatment cell location served as the final disposal site.

However, such a plan may also require monitoring to determine if contaminants are migrating into and re-contaminating the treated material.

There may be a benefit to purposely leaving a small volume of fully treated soil in the treatment cell to mix with the new lift of contaminated soil. Mixing about 50 mm 2 inches of the treated lift with untreated soil may decrease the treatment time for the untreated lift; i.e., material from the treated lift may act as a "starter culture" for the untreated lift.

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After compliance test data indicates that treatment criteria have been met, and written approval from the Contracting Officer has been received, [remove the treated lift of soil from the treatment cell][_____]. Submit Treatment Completion Records which include, but are not limited to, a summary of the activities performed at the site as part of landfarming, materials and equipment used, and the testing and sampling results.

3.5.12 Procedure for Non-Attainment of Treatment Criteria

****

NOTE: The situation may arise where there are one or two grids that still exhibit substantially higher contaminant levels than other grids (i.e., outlier data points). If the statistical criteria for demonstrating attainment of clean-up criteria can be satisfied based on data from all but the one or two outlier grids, then it may be acceptable to move all of the treated soil (except for the outlier grids) to the disposal location. Soil from the one or two outlier grids should continue to undergo treatment (either by themselves, or via mixing the soil from the outlier grids with the next lift of soil across the entire treatment cell).

If additional sampling is performed to provide more data points for statistical analysis, the Contractor should not be allowed to exclude "selected" data from samples collected during the same time period. Following additional treatment, and more time for biodegradation to occur, data from new samples should be considered separate from pre-existing data sets.

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If the treatment criteria is not achieved, implement corrective action at no additional cost. The corrective action may include: [supplemental sampling and analysis to increase the size of the data set, to allow the statistical analysis to be repeated; or continued treatment followed by additional sampling and analysis][_____]. If there are sections of the treatment cell for which substantial reduction of contaminants of concern was not observed after the end of the estimated treatment period, prepare a report detailing all activities associated with those sections of the treatment cell. The report must include: probable causes as to why significant reductions were not observed; measures that will be implemented to prevent the same problems from recurring; and a proposed plan for continued treatment of those sections of the treatment cell where treatment criteria were not met. Obtain written approval from the Contracting Officer prior to implementing measures that deviate from the Landfarming Work Plan. Continue monitoring (at no additional cost, and in accordance with paragraph OPERATIONS AND FIELD QUALITY CONTROL), until the treatment criteria is attained. Submit Treatment Completion Records as specified.

3.5.13 Post-Treatment Screening

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NOTE: If wood chips or other large diameter particles must be separated from the treated soil prior to disposal, it may be desirable to reuse this material in subsequent lifts of contaminated soil.

Additional sampling and analysis may be required prior to disposal of wood chips. Organic contaminants will often adsorb and accumulate on wood, or other organic materials present in the contaminated-soil matrix. Even though soil may meet clean-up goals, interspersed wood chips may contain relatively high levels of contaminants.

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Wood chips or other materials whose diameter exceeds the maximum acceptable particle size for the intended end use must be separated from the treated soil prior to disposal.

3.5.14 Operations Reports

Submit operations reports weekly for the first [10][_____] weeks, and every [2][_____] weeks thereafter. Requirements of the Operations Reports must be in accordance with paragraph FIELD DEMONSTRATION OPERATIONS REPORT.

3.5.15 Change of Operating Conditions

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NOTE: If adjustment to the landfarming operating conditions is required due to change in contaminated material characteristics, then the Contractor's adjusted operating conditions should be evaluated by the Contracting Officer for the extent of changes from the previous operating conditions. Further, price negotiation may be required based on the extent of changes from the previous operating conditions.

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The following two requirements must be met in order to be considered for change of operating conditions:

a. The physical and chemical characteristics of the contaminated materials are significantly different from the originally defined characteristics.

b. The treatment requirements cannot be met under the current landfarming amendment design and related operating conditions.

When change of operating condition is necessary, notify the Contracting Officer before changes are made to the amendment design and related operating conditions. The Contracting Officer may require the Contractor to perform a field demonstration for significant changes made to the amendment design and related operating conditions in accordance with paragraph FIELD DEMONSTRATION, for approval. If adjustment to the amendment design and/or operating conditions is required due to change in contaminated material characteristics, submit an adjusted design for the extent of changes from the previous design for approval. Further, price negotiation may be required based on the extent of changes from the previous mix design.

3.6 DISPOSAL

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NOTE: Depending upon the characteristics and quantities, the potential disposal scenarios for wastes may include: on-site treatment and backfilling; partial on-site treatment / backfill, and partial offsite disposal; and offsite disposal. Asphalt surfaces may be removed and sent offsite for recycling, or left in place if desired by stakeholders. One disposal scenario for each type of waste should be clearly defined.

If the treated soil will be incorporated into topsoil, the following indices should meet quality guideline standards: pH, conductivity, maximum particle size, foreign material content, and the levels of heavy metals. See the On-Farm Composting Handbook (Natural Resource, Agriculture, and Engineering Service, 1992) regarding quality guidelines for different end uses of compost; also, see paragraph Criteria for Reuse of Treated Soil.

****

Dispose treated soil that has met Treatment Criteria for Soil[and Criteria for Reuse of Treated Soil] in accordance with regulatory requirements and [UFP-QAPP][Landfarming Work Plan]. After it has been demonstrated that the treated soil meets disposal criteria, dispose the following materials on-site: [oversize materials][sludge resulting from treatment of contact water][excess amendments][and][_____]. Treat, if necessary, and dispose the following materials of off-site: [spent personal protective equipment][spent granular activated carbon][and][_____]. Perform offsite disposal of hazardous wastes in accordance with Section 02 81 00 TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS, which includes the preparation and submission of manifests and disposal certificates for materials disposed of offsite.

3.7 DEMOBILIZATION

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NOTE: A separate table should be prepared if criteria for soils below the treatment pad, or other areas of the treatment facility, differ from criteria in paragraph TREATMENT CRITERIA FOR SOIL. This paragraph should be edited appropriately if it is desired to retain portions of the landfarming treatment facilities after project completion. This

paragraph should also be coordinated with Division 1 Sections of the contract.

After treatment of the final lift of contaminated soil, an economical approach for disposition of the treatment cell would involve: leaving the treated lift in-place, puncturing the liner, and re-seeding the treated soil.

The paragraph ENVIRONMENTAL REQUIREMENTS FOR OFF-SITE SOIL in Section 31 00 00 EARTHWORK should be edited to include an appropriate list of chemical testing parameters for off-site soil. Some backfill sources may have chemical testing data already available; the Government should require chemical testing if the backfill chemical testing data is inadequate or does not exist. Off-site backfill should not be tested for only the site contaminants of concern. At a minimum, samples should be analyzed for target contaminant list (TCL) VOCs, TCL SVOCs, target analyte list (TAL) Metals, and Pesticides/PCBs. Additional analyses such as Total Petroleum Hydrocarbons may be appropriate also. Individual States or military installations may require or recommend additional parameters. Typical frequency of sampling would be one sample per 1,900 to 2,300 cubic meters 2,500 to 3,000 cubic yards. However, individual States or military installations may require or recommend more frequent or less frequent sampling.

****

Do not commence demobilization until written approval is received from the Contracting Officer. Follow the approved mobilization and demobilization plan and requirements under paragraph MOBILIZATION AND DEMOBILIZATION. Demobilization must include restoration of the [following areas, as shown on drawings, to their original condition: [_____]]. Disposition of paved surfaces, and subsurface liners must include: [_____]. Disposition of the treatment cell must include: [leaving the last lift of treated soil in-place, puncturing the liner on 2-meter 6.6-foot centers across the length and width of the cell, re-seeding the treated soil[in accordance with Section 32 92 19 SEEDING]]. Demobilization must include, but must not be limited to: [removal of structures and materials used to house or cover the treatment cell,][disconnecting of utility service lines,][decontamination and removal of equipment and materials,][disposal of decontamination wastes,][disposal of residual wastewater,][removal of fertilizer, amendments and other unused materials,][and regrading of berms, as shown on drawings][_____].[Perform post-treatment testing of soils below work area surfaces to verify that the area is not contaminated. These soils must meet the following criteria: [treatment criteria in accordance with paragraph TREATMENT CRITERIA FOR SOIL.][_____]]. If soil excavation is also part of the field activity, excavated areas need to be backfilled and restored to the original condition in accordance with Section 02 61 13 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL and Section 31 00 00 EARTHWORK.[Perform confirmation sampling within the excavated areas in accordance with the UFP QAPP to ensure all contaminated soil above treatment criteria are removed.]

-- End of Section --