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USACE / NAVFAC / AFCEC / NASA **UFGS-02 54 19.13 (February 2021)**

Preparing Activity: USACE **Superseding without Revision**
UFGS-02 54 20 (February 2010)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2021
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SECTION 02 54 19.13

BIOREMEDIATION USING LANDFARMING
02/21

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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. Other terms that have been used in place of "landfarming" include "land treatment" and "prepared bed bioreactors".

Adher 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: Special requirements for handling RCRA wastes are not included in this guide specification. However, landfarming may be appropriate for treatment of some types of RCRA hazardous waste.

An edited version of this Section may be used to solicit a request for proposal (RFP). The RFP approach is often used as a selection tool, to distinguish between the qualifications of prospective Contractors.

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.
****

1.1 MEASUREMENT AND PAYMENT

****
NOTE: These paragraphs should be edited based on whether the contract will use lump sum, or unit prices. If there is a separate Measurement and Payment Section, edited versions of these paragraphs should be inserted in that section.

If the quantities of contaminated soils are well defined, payment may be based upon a lump sum 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 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 Bench-Scale Testing

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NOTE: Lump sum pricing is recommended for this item. The lump sum 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 testing will be a lump sum price for completion of specified tests. The price must include the cost of labor, materials, equipment usage, utilities, and fuel for: [preparation of the Bench-Scale Test Plan] [collecting samples,] [sample shipment,] [pre-processing,] [process monitoring (including testing for chemical data),] [disposal of treated material,] [ancillary waste treatment and disposal,] [preparation of the Bench-Scale Test Report,] [and] [_____]. Costs for procurement and handling of amendments must be included in the unit price for treatment.

1.1.2 Field Demonstration

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NOTE: Prior to planning the field demonstration, bench-scale 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 lump sum item, 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 will 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: [excavation,] [hauling,] [stockpiling,] [pre-processing,] [operation, maintenance and process monitoring (not including testing for chemical data),] [disposal of treated material,] [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.

1.1.3 Contaminated Soils Treatment Unit Price

****
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. Payment may also be based on ex-situ volume, after the oversize materials have been separated from the soil. Because of the bulking which usually occurs during excavation of soil, ex-situ volume will usually be about 30 percent greater than the in-situ volume. If there is a substantial volume of oversize material, or if a substantial volume of excavated material will not require treatment, it may be advantageous to use ex-situ volume as the basis for payment.

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 must be by the contract unit price schedule for each cubic [meter yard] [_____] based on [ex-situ volume, after separation of oversize material] [_____]. This unit price must include the cost of labor, materials, equipment usage, utilities, and fuel for: [excavation,] [hauling,] [stockpiling,] [pre-processing,] [operation, maintenance and process monitoring (not including testing for chemical data),] [disposal of treated material,] [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 below, 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.

1.1.4 Oversize Materials from Contaminated Areas

****
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.
****

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

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 D2974	(2020; E 2020) Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
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

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-1913	(2000) Engineering and Design; Design and Construction of Levees

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/R-96/084	(2000) Guidance for Data Quality Assessment: Practical Methods for Data Analysis EPA QA/G-9, QA00 version

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

29 CFR 1910	Occupational Safety and Health Standards

1.3 PROCESS 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.

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Treatment process must provide a safe, reliable method to treat contaminated material conforming to paragraph PERFORMANCE REQUIREMENTS below, and must be based on the landfarming process described next.

1.4 DESIGN REQUIREMENTS

1.4.1 Landfarming Treatment Cell

****

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.

****

The treatment cell must be located 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. The water collection system and sump must be in accordance with paragraph Contact Water Management System and Design Storm, below.

1.4.1.1 Treatment Cell Sizing

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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.

****

The treatment cell must be located [within the area indicated on the drawings] [_____]. The treatment cell must be sized 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. 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. Sizing of the treatment cell must be 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: [_____].

1.4.1.2 Porous Drainage Layer

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NOTE: 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.
****

The porous drainage layer must be designed to facilitate drainage of free water and to prevent entry of contaminated soils. The porous drainage layer must be at least [0.3] [_____] meters [1.0] [_____] feet thick. The gradation limits of the porous drainage layer must be compatible with the grain size distribution of representative samples of contaminated soil, and must be selected in accordance with Appendix D of EM 1110-2-1913. The minimum compacted hydraulic conductivity of the porous drainage layer must be [1 x (10 to the minus 2 power)] [_____] cm/s [3.28 x (10 to the minus 4 power)] [_____] feet/s.

1.4.1.3 Leachate Controls and Collection

****
NOTE: 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 consist 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.
****

Slots in drainage collection piping must be appropriately sized for the porous drainage layer in accordance with Appendix D of EM 1110-2-1913. Drainage water must be routed to a lined, gravel sump [as shown on the drawings].

1.4.1.4 Geomembrane and Clay Liners

****
NOTE: Liners usually consist of 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. Lysimeters may 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 capitol and 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 currrent 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 x (10 to the minus 7 power)] [_____] cm/s [3.28 x (10 to the minus 9 power)] [_____] 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] [_____].

1.4.2 Contact Water Management System and Design Storm

****

NOTE: In accordance with regulatory requirements, excess contact water may be discharged to NPDES storm water discharge outfalls, 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 Technical Paper No. 40, Rainfall Frequency Atlas of the United States, for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years, US Dept. of Commerce, May 1961.

It is recommended that the surface of the treatment cell 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.

****

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.

1.4.2.1 Perimeter Berms

Berms must be constructed around the perimeter of the following areas: [treatment cell,] [contact water storage,] [stockpiling,] [laydown and storage areas,] [and] [_____]. The perimeter berms must be sized 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. Berms constructed around the [treatment cell and contact water storage facility] [_____] must be keyed into the underlying liners of these areas, [as shown on drawings] [_____]. Berms constructed around the [treatment cell, stockpiling, and laydown and storage areas] [_____] must include ramps to permit vehicle access inside these areas.

1.4.2.2 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 PPE; 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] [_____].

1.4.2.3 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.
****

Contact water must be reused to the maximum extent in order to minimize the need for new makeup water and to limit the treatment, discharge and offsite disposal of wastewater. Prior to reuse, contact water must be tested in accordance with paragraph Contact Water Testing in PART 3, and must meet the requirements of paragraph Water Supply in PART 2. Prior to disposal, contact water that cannot be applied to contaminated soil must be collected and tested in accordance with paragraph Treatment Criteria for Contact Water, below. Process sludge (resulting from the removal of suspended material in the contact water) must be treated to meet the requirements of paragraph [Treatment Criteria for Soil, below] [_____].

1.4.3 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.
****

Irrigation equipment must be capable of providing at least 0.7 L/s/1000 m2 40 gpm/acre distributed uniformly over the surface of the treatment cell. The irrigation system must be designed to minimize interference with tilling of the treatment cell. Flood or overland flow irrigation methods must not be used.

1.4.4 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 PREENGINEERED METAL BUILDINGS), should include the design snow load, maximum wind speed, soil bearing capacity, seismic parameters in accordance with UFC 3-301-01, 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 PREENGINEERED METAL BUILDINGS] [_____]. Covers must allow for free exchange of gasses between the atmosphere and the soil. Weather covers must be sized to allow unimpaired maneuvering of [front-end loaders,] [soil mixing equipment,] [and] [_____]; openings in weather covers must be sized to allow for entry and exit of [front-end loaders,] [soil mixing equipment,] [and] [_____]. Ventilation of the covered facility must be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

1.4.5 Stockpiles

****

NOTE: The requirements outlined in this paragraph are the typical, minimum criteria the Contractor should use to prepare the stockpile design. However, 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. This paragraph should be edited based on site-specific factors and regulatory requirements.

****

Stockpiles must be constructed for storing [contaminated material,] [oversize material,] [treated material] [and] [_____]. Stockpiles must be constructed to include:

a. An impermeable HDPE geomembrane liner with a minimum thickness of 1.0 mm 40 mils. Subgrade preparation; and installation, testing, inspection, and protection of the liner must be in accordance with Section 02 56 13.13 GEOMEMBRANE WASTE CONTAINMENT.

b. An impermeable geomembrane cover with a minimum thickness of [0.25] [_____] mm [10] [_____] mils to prevent precipitation from entering the stockpile. Ancillary materials to keep the cover anchored during windy conditions.

c. Berms surrounding stockpiles in accordance with paragraph Perimeter Berms, above.

1.4.6 Other Work Area Surfaces

****
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].

1.4.7 Accuracy of Measurement Equipment

****
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.
****

Measuring devices, such as scales, must be accurate to at least [15] [_____] percent of the unit used as the basis for measurement and payment. A check of calibration of measuring equipment must be performed prior to initial use, and once every [7] [_____] calendar days. The requirements of this paragraph do not apply to measurement of chemical data.

1.5 PERFORMANCE REQUIREMENTS

Perform sampling and analyses in accordance with [_____].

1.5.1 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, pentachlorophenol (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 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 Leachate Procedure (SPLP) or EPA Toxicity Characteristic Leachate 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.
****

1.5.1.1 Treatment Criteria for Soil

****
NOTE: Paragraph Confirmation of Attainment of Treatment Criteria for Contaminants of Concern should be coordinated with this paragraph, and reviewed for guidance on adding a separate set of "ceiling values" for each contaminant of concern to this paragraph.

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. The treatment criteria shown below are only examples. This paragraph should be edited to include site-specific criteria.
****

The treated material must meet the criteria shown in Table 1.

TABLE 1 - TREATMENT CRITERIA FOR ORGANICS	
ORGANIC CONTAMINANT	MAXIMUM TOTAL CONCENTRATION IN SOIL
Pentachlorophenol	[_____] mg/kg
Total Polynuclear Aromatic Hydrocarbons (PAHs)	[_____] mg/kg
Total cPAHs (carcinogenic PAHs)	[_____] mg/kg
Total Petroleum Hydrocarbons (TPH)	[_____] mg/kg
Oil and Grease	[_____] mg/kg
[_____]	[_____] mg/kg

1.5.1.2 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 top soil.

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 this standard is for domestic sewage sludge. Soils treated via landfarming may not meet this 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. The treatment criteria shown below are only examples. This paragraph should be edited to include site-specific criteria.

****

Prior to final disposition, the treated material must meet the criteria shown in Table 2.

TABLE 2 - TREATMENT CRITERIA FOR INORGANICS	
INORGANIC CONTAMINANT	MAXIMUM TOTAL CONCENTRATION IN SOIL
Chromium	[_____] mg/kg
Copper	[_____] mg/kg
Arsenic	[_____] mg/kg
Lead	[_____] mg/kg
Barium	[_____] mg/kg
[_____]	[_____] mg/kg

1.5.1.3 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 can not 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, clumps of soil must be reduced in particle size 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.

1.5.2 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. The treatment criteria shown below are only examples. This paragraph should be edited to include site-specific criteria.
****

Contact water must meet the criteria shown in Table 3 at the time of [discharge] [offsite disposal] [_____].

TABLE 3 - WATER DISPOSAL/DISCHARGE CRITERIA

PARAMETER	MAXIMUM CONCENTRATION
Chromium	[_____] mg/L
Copper	[_____] mg/L
Arsenic	[_____] mg/L
Lead	[_____] mg/L
TPH	[_____] mg/L
Oil and Grease	[_____] mg/L
Nitrate	[_____] mg/L
Total phosphates	[_____] mg/L
Ammonia	[_____] mg/L
Total Kjeldahl nitrogen	[_____] mg/L
Total suspended solids	[_____] mg/L
5 Day Biochemical Oxygen Demand (BOD)	[_____] mg/L
minimum pH	[_____]
maximum pH	[_____]

TABLE 3 - WATER DISPOSAL/DISCHARGE CRITERIA	
PARAMETER	MAXIMUM CONCENTRATION
[_____]	[_____]

1.5.3 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. 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.

****

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

1.6 LANDFARMING WORK PLAN

****

NOTE: 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.

Sampling and analysis requirements for parameters i.e., non-chemical data should be included in the landfarming Work Plan. To avoid duplications in submittal requirements, submittals in this Section should be coordinated with other sections of the contract (e.g., 01 45 00.00 10 QUALITY CONTROL, and 01 32 01.00 10 PROJECT SCHEDULE).

If a request-for-proposal contract is being prepared, this paragraph and the Submittals paragraph should be edited and used to form the basis for Contractor proposals. The sub-paragraph titled, Contractor Experience, should be omitted if the Contractor has been pre-selected.

****

Submit a Landfarming Work Plan not more than [480] [_____] calendar days after notice to proceed. A period of not less than [30] [_____] calendar days must be allowed for in the schedule for Government review. The Plan must include, but not be limited to, the following:[

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.]

1.6.1 Schedule

The schedule must specify dates and durations for: excavation, hauling, stockpiling, start and completion of mobilization, treatment cell construction, separation of oversize materials, field demonstration, full-scale treatment of contaminated materials, storage of treated material, disposal of treated material and other wastes, and demobilization. The following details must also be provided: 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.

1.6.2 Project Organization and Personnel

An organization chart, including subContractors, must be provided; the chart must include the names, responsibilities, education, and resume of the key project personnel. Key personnel must include, but must not be limited to: project managers, quality control personnel, supervisory operators and technicians, and engineering staff. Responsibilities of each individual in the organization must be clearly defined 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.

1.6.3 Selection of Amendments

Rationale for use of each proposed amendment. Description of, and sources for, each amendment; including at least one alternative source for each category of amendment. Locations of each source, and distances from the site must be included. For amendments that are only available on a seasonal basis, a plan for substituting alternative types of amendments must be provided. For organic amendments, such as manure or wood products, the plan must state the intended freshness of the amendment; or the length of the planned period of aging, prior to incorporating the amendment into soil. The proposed amount of each amendment that will be added to each cubic m yard of contaminated soil must also be included.

1.6.4 Emissions, Dust and Odor Control

For each stage of operations, the plan must include: the sources of emissions, dust and odors during each stage of operations, and proposed control measures. The stages of operation must include, but must not be limited to: construction of treatment cell; soil pre-processing; treatment, transport, and disposal of oversize material; material handling during landfarming operations, including tilling; transport and storage of treated soil; disposal of treated soil. If air monitoring will be required, the following must also be included: type and locations of monitoring devices; 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.

1.6.5 Operations and Process Monitoring

A detailed description of the proposed operation must be provided. 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.

1.6.6 Protocol for Compliance Testing

A detailed, chronological description of the sequence of procedures and tests that will be used to determine whether the soil has met treatment criteria. The locations of each sampling station shown from plan view; the number of sampling stations per each lift of soil; sampling locations shown on a diagram depicting a cross-section of the treatment cell; the number of samples that will be tested for each type of test performed as a part of compliance testing; and laboratory turn-around-time.

1.6.7 Protocol for Determining if Soil Meets Criteria for Disposal

A detailed, chronological description of the sequence of procedures and tests that will be used to determine whether the soil has met criteria for disposal; including: the location of each sampling station shown from plan view; the number of sampling stations per each lift of soil; sampling locations shown on a diagram depicting a cross-section of the treatment cell; and the number of samples that will be tested for each type of test performed.

1.6.8 Non-Landfarming Treatment Processes

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; testing parameters; sampling locations; number of samples; monitoring frequency; and laboratory turn-around-time.

1.6.9 Equipment and Servicing

A detailed description of the proposed treatment equipment must be provided. For each proposed piece of equipment, the description must include: 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; sampling and testing devices for process monitoring; and moisture and temperature monitoring devices. Plans for servicing equipment must also be provided, and must explain how material handling and tilling will be accomplished during servicing of equipment, and during unanticipated breakdown of machinery.

1.6.10   Process Material Tracking Schedule

The proposed schedule must be used to record the quantities of the contaminated materials treated. The dates and duration of the following activities must also be provided 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.

1.6.11   Disposal and Reuse of Wastes

A detailed description of the plans for disposal of solid and liquid wastes. For each type of waste that will be generated, the following must be provided: origin and description of waste; estimated total quantity of waste; method of transport to disposal location; disposal location; 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.

1.6.12   Mobilization and Demobilization

A mobilization and demobilization plan must include: transport of personnel, material, and equipment; decontamination and disposal of materials and equipment brought to the site; decontamination and disposal of the treatment cell and other paved surfaces. The demobilization plan must include a Post-Treatment Cleanup and Sampling Plan for areas where there was contact with contaminated materials.

1.7   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 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 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.

****

The following must also be submitted as specified:

a. The bench-scale test plan not more than [30] [_____] calendar days after notice to proceed. A period of not less than [30] [_____] calendar days must be allowed for in the schedule for Government review. This plan must include: location of test facility; minimum, initial levels of contaminants in the soil to be used for the study; locations that will serve as the source of soil for the study; test parameters and number of samples that will be used to confirm that the soil meets criteria for the study; rationale for use of each proposed amendment; and the source of each amendment. For organic amendments, such as manure or wood products, the plan must state the intended freshness of the amendment; and the length of the period of aging, prior to incorporating the amendment into soil. For each test condition, the amount of each amendment that will be added per unit volume of soil; temperatures under which testing will be performed; the number of replicate tests for each test condition; description of containers that will be used; procedure for mixing soil; frequency of mixing; testing and monitoring parameters; number of samples; monitoring frequency; length of monitoring period; and laboratory turn-around-time. Test methods, and other sampling and analysis requirements for the bench-scale test must be [_____].

b. A field demonstration plan not more than [270] [_____] calendar days after notice to proceed. A period of not less than [30] [_____] calendar days must be allowed for in the schedule for Government review. This plan must include: location for performing the field demonstration; minimum, initial levels of contaminants in the soil to be used for the demonstration; 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; rationale for use of each proposed amendment; and the source of each amendment. For organic amendments, such as manure or wood products, the plan must state the intended freshness of the amendment; and the length of the period of aging, prior to incorporating the amendment into soil. For each test condition, the amount of each amendment that will be added to each cubic m yard of contaminated soil; anticipated temperatures under which the field demonstration will be performed; irrigation and tilling equipment specifications; irrigation water source; plan for operation, maintenance and process monitoring; and laboratory turn-around-time. Test methods, and other sampling and analysis requirements for the field demonstration test must be [_____].

c. Copies of records for treated or processed materials which have been disposed of not more than [45] [_____] calendar days after disposal of each batch (or lift) of material. The following must be included for each batch (or lift) of treated material: disposal location; date of transport to disposal location; volume or weight of material; and chemical data reports. Cross-references to the submittal specified in Section 02 81 00 TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS, which includes the manifests, must be provided for materials disposed of offsite. For non-manifested materials disposed of offsite, the following information must also be provided: address, phone number, and point of contact for each receiving offsite disposal facility.

d. The soil and amendment test report not more than [120] [_____] calendar days after notice to proceed. Report must include: the source of each amendment; characterization test results for each amendment; the locations from where soil for the bench-scale test was collected; the quantity of soil collected from each location; and characterization test results for soil for the bench-scale test.

e. The bench-scale test report not more than [60] [_____] calendar days after completion of the bench-scale test. Report must 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; the date that the bench scale test was initiated; chronological table showing all materials added, amount added, date of addition, and each mixing, irrigation and sampling event. For organic amendments, such as manure or wood products, the report must 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. Recommendations for the field demonstration must also be provided in the report.

f. The field demonstration report not more than [60] [_____] calendar days after completion of the field demonstration. The report must 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, the report must 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. Recommendations for full-scale operations must also be provided in the report. In addition, the day-to-day log of operations and adjustments must be included in an appendix.

g. During the [field demonstration,] [and] [full-scale operations,] reports must be furnished weekly for the first [10] [_____] weeks, and every [2] [_____] weeks thereafter. Copies of the reports must be kept at the facility. The following information must be recorded and maintained until closure of the facility: description (including sources) of contaminated soil and amendments on site; the dates of receipt, storage, treatment, and disposal of contaminated soil and amendments; the location of all amendments and contaminated soil on site, and the quantity at each location. The location and quantity of each type of material must be recorded on a map or diagram of the site. This information must include cross-references to specific manifest document numbers, if the waste was accompanied by a manifest. Summary reports and details of all incidents that require implementing contingency plans, or corrective action measures must also be provided. The reports must also include: date and time of each monitoring or testing event; results from each monitoring or testing event; monitoring procedure, or test method used; individual performing the monitoring or testing, and other individuals present; and remarks. Cross-references to submittals specified in other sections may be provided to prevent duplicate information in separate submittals.

h. Safety data sheets (SDSs), certificates of analysis, and product performance data not more than [45] [_____] calendar days after notice to proceed. SDSs must be in accordance with 29 CFR 1910 Section 1200 (g).

i. Copies of the permits, permit equivalents and certifications with the Landfarming Work Plan.

1.8 PREVIOUSLY CONDUCTED TREATABILITY STUDIES

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

The methods employed in previous treatability studies may not be the same as those proposed by the Contractor. Documentation of the previous treatability studies should include the same information shown in the following sub-paragraphs: Bench-Scale Test Report and Field Demonstration Report, in PART 3. Treatability study reports should be prepared to provide prospective Contractors with sufficient information to prepare a responsive bid, or proposal, for the contract.
****

The treatability study report, appended to the technical specifications (Appendix [_____]), is for information purposes only.

1.9 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, Air Force, and NASA 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.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

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.][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-03 Product Data

Bench-Scale Test; G[, [_____]]
Field Demonstration; G[, [_____]]
Landfarming Work Plan; G[, [_____]]
Treatment Completion Records; G[, [_____]]

SD-06 Test Reports

Soil and Amendment Test Report
Bench-Scale Test Report; G[, [_____]]
Field Demonstration Report
Operations Reports

SD-07 Certificates

Synthetic or Manufactured Additives
Landfarming Work Plan

1.10 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.

This paragraph should be omitted if the Contractor has been pre-selected.
****

Have successfully completed at least [1] [_____] 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 [1] [_____] full-scale project, that required handling and transport of soil contaminated with a [RCRA hazardous constituent, or CERCLA hazardous substance] [_____]. For each project, the following must be provided: site name, location, the names of the Contractor's key personnel; key points of contact and phone numbers (including government representatives, and other parties involved in the project); dates of mobilization/demobilization; contaminants of concern; and the volume of contaminated soil handled or treated. The following must also be provided, if available: dates for initiating and completing treatment; amount of time required to treat each lift of contaminated soil; volume of amendments added per unit volume of contaminated soil; initial volume of soil, and final volume after treatment; concentrations of contaminants of concern in soil (before treatment), during treatment period, and after treatment.

a. Permits and Certifications. Obtain the permits, permit equivalents and certifications; and meet the substantive regulatory requirements necessary for the installation, operation and closure of the project. For any of the above-listed items requiring a longer time frame, copies of applications, and scheduled dates for receiving final approval, must be included.

b. Drawings. Project drawings must include: limits of planned excavations; layout of the facility; dimensions of amendment storage areas, pre-processing areas, and treatment cell; details of treatment cell liner and sumps; dimensions and volumes of stockpiles for contaminated soils, oversize materials, and treated materials; locations, dimensions, and volume of collection sumps and any ancillary water storage facilities; plan view and cross sections of perimeter berms and collection sumps; ancillary water storage facilities; size of contact water conveyance devices and structures; piping and instrumentation diagrams; and process flow diagrams.

1.11 PROJECT/SITE 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 and indicate where data gaps exist. 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.

****

The physical conditions indicated on the [drawings] [and] [specifications] are the result of site investigations. The nature and extent of contamination are [summarized in Table 4] [shown in an appendix to the specifications] [_____]. 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.

TABLE 4 - NATURE AND EXTENT OF CONTAMINATION				
CONTAMINATED MATERIALS				
CONTAMINATED ZONE (1)	AREA (2)	AVERAGE DEPTH (3)	VOLUME (4)	CONTAMINANTS OF CONCERN

TABLE 4 - NATURE AND EXTENT OF CONTAMINATION				
Zone 1	[_____]	[_____]	[_____]	[_____]
Zone 2	[_____]	[_____]	[_____]	[_____]
Zone 3	[_____]	[_____]	[_____]	[_____]
(1) Contaminated zones are defined in [Drawings] [Appendix [_____]]				
(2) Area in [square meters feet] [_____]				
(3) Depth in [meters feet] [_____]				
(4) Volume in [cubic meters yards] [_____]				

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 5.

TABLE 5 - IRRIGATION WATER CRITERIA	
PARAMETER	REUSE CRITERIA
maximum conductivity	[_____] micro-mho per cm
minimum pH	[_____] standard units
maximum pH	[_____] standard units
[_____]	[_____]

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 innoculum. 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 As 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, in PART 3). 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 may contain CCA (chromated copper arsenate), PAHs (from creosote), pentachlorophenol, or other contaminants. 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.
****

Amendments must be 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. Asbestos containing materials must not be used as amendments.

2.4 SYNTHETIC OR MANUFACTURED ADDITIVES

Commercial fertilizers are an example of a synthetic or manufactured additive. A certificate of analysis must accompany each shipping unit of synthetic or manufactured additive supplied by the vendor. Additives must be shipped in properly labeled containers with instructions for handling and storage. The instructions must be strictly adhered to.

PART 3 EXECUTION

3.1 SOIL AND AMENDMENT TESTING AND BENCH-SCALE TESTING

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NOTE: Bench-scale 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 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 Soil And 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, in PART 2).

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 initiating the bench-scale 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 study should not be initiated until it can be ascertained that the soil that has been collected meets the desired criteria.

****

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. Contaminated soil for the bench-scale test must be obtained from the following locations: [_____]. After soil has been collected for the bench-scale test, the soil must be homogenized and tested to determine if the soil is representative of the contaminated zone, and if the levels of contaminants are within the desired range. The soil must contain the following minimum levels of contaminants: [_____]. A minimum of [2 composite samples] [_____] must be tested. Also a physical description of each soil sample, prepared by a geologist, must to provided to demonstrate that soil-type is representative of the contaminated zone.

3.1.2 Bench-Scale 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 testing.

****

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

3.1.3 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 MOBILIZATION

Do not mobilize to the site until written approval is received from the Contracting Officer. Delays caused by the Contractor's failure to acquire permits, meet other regulatory requirements, or fulfill other contract requirements must result in no additional costs. Equipment which may have previously come into contact with contaminated material must be decontaminated before being brought to the site.

3.3 EMISSIONS AND DUST CONTROL

****

NOTE: See EP 1110-1-21, Air Pathway Analysis for the Design of Hazardous, Toxic and Radioactive Waste (HTRW) Remedial Action Projects, to determine the need for perimeter air monitoring and air emission control requirements. If necessary, perimeter air action levels, and meteorological monitoring and air emission control requirements, should be included in this Section. If perimeter air monitoring, and emission control requirements are not necessary, this paragraph should be deleted.

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.

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The following measures must be implemented to control emissions, and dust: [_____].

3.4 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 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.

3.4.1 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.
****

Contaminated soil for the field demonstration must be obtained from the following locations: [_____]. Prior to performing the field demonstration, [3 composite samples] [_____] of the material to be used for the field demonstration must be tested to determine if the soil is representative of the contaminated zone, and if the levels of contaminants are within the desired range. The soil must contain the following minimum levels of contaminants: [_____]. Also a physical description of each soil sample, prepared by a geologist, must to provided to demonstrate that soil-type is representative of the contaminated zone.

3.4.2 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 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, MAINTENANCE AND PROCESS MONITORING, in PART 3; 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.

3.4.3 Field Demonstration Report

After completion of field demonstration, compile the data and submit the Field Demonstration Report. Proposed changes in full-scale operations plans must be included in the Field Demonstration Report.

3.5 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. 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, in PART 2.

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.
****

The maximum particle size in the contaminated soil matrix must be [compatible with approved material handling and tilling equipment, and not greater than 80 mm] [_____]. Oversize materials must be separated from contaminated soil prior to mixing soil with amendments.

3.6 OPERATION, MAINTENANCE AND PROCESS MONITORING

****
NOTE: Operation and monitoring requirements should be based on: applicable literature references; knowledge gained from bench-scale 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.

Some requirements for sampling and analysis are included below.
****

Full-scale operations must not be initiated until the Landfarming Work Plan has been approved, and written approval has been received from the Contracting Officer. Operation of the landfarm must proceed continuously, through the term of the contract, except as described below. When soil temperatures fall below [5 degrees C, and written approval has been received from the Contracting Officer,] [_____] operation of the landfarm may be suspended for the season. Operation of the landfarm must resume when soil temperatures remain above [5 degrees C, and written approval has been received from the Contracting Officer] [_____]. See paragraph, Temperature Monitoring, below. Operations Reports must be submitted as specified.

3.6.1 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.

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.
****

Each time soil within the treatment cell has been removed down to within [30.5] [_____] cm [12] [_____] inches of the granular layer, the geomembrane liner must be inspected for damage or penetrations. If the geomembrane liner is damaged or appears to have been penetrated, the granular material must be removed in that vicinity so that the geomembrane liner may be inspected for damage. Any damage to the geomembrane liner must be repaired in accordance with Section 02 56 13.13 GEOMEMBRANE WASTE CONTAINMENT. The depth of the granular layer must be restored to the originally approved depth.

3.6.2 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 must be accomplished using a [rotary tiller, with tines attached to a rotating shaft] [_____]. The direction of tilling must be alternated between lengthwise, crosswise, and diagonal. Tilling must not be conducted within [24] [_____] hours of a rainfall or irrigation event which saturates the soils. A light irrigation event, prior to tilling, may be used as a dust control measure. The soil in the treatment cell must be tilled at least once every [14] [_____] days, unless monitoring indicates that soil gas oxygen levels are greater than [2 percent] [_____], by volume. Additional tilling may be required in response to process monitoring; for example, to provide additional aeration.

3.6.3   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.

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3.6.3.1   Field Capacity

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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][_____].

3.6.3.2 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 capitol 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.

****

The moisture content must be quantitatively tested using a field method (for example, electronic field instrument) at least every [Mon, Wed and Fri] [_____] for the first [6] [_____] weeks, and every [Mon and Thur] [_____] thereafter. The field method may involve the use of an instrument that correlates moisture content to electrical conductivity. Samples must be collected for laboratory analysis, and tested in accordance with ASTM D2974 to determine moisture content, according to the following schedule: [a minimum of 2 samples per week, for the first 4 weeks; and a minimum of 2 samples, once every 8 weeks thereafter] [_____]. These samples must be collected immediately after testing using the field method, and from the same location as the samples tested using the field method.

3.6.3.3 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; see paragraph Storage Volume, in PART 1.
****

When testing indicates that the soil moisture content is below [40] [_____] percent of the field capacity, the treatment cell must be irrigated. The rate of application must not exceed [13] [_____] mm [1/2] [_____] inches per hour. Sufficient irrigation must be provided to bring the moisture content to within the acceptable limits within [24] [_____] hours. Irrigation must be immediately ceased if ponded water is observed in the treatment cell, or if irrigation water is observed running off the treatment cell. A water meter must be used to measure the application rate. The application rate, duration of the irrigation period, and volume of water applied must be recorded. The quantity of water from each precipitation event must also be measured and recorded each weekday.

3.6.3.4 Contact Water Testing

Contact water, to be reused as irrigation water, must be tested 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] [_____] inches of precipitation in a 24 hour period, the pH and conductivity of the contact water must be tested after water from the precipitation event has collected in the contact water storage facility. Each time testing is performed, either one representative sample must be withdrawn from the contact water holding vessel, or the water in the holding vessel must be directly tested by immersing the instrument probe in the water.

3.6.4 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.

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 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.
****

Within the [first 2 weeks] [_____] of initiating treatment of each new lift of contaminated soil in the treatment cell, the levels of nitrogen and phosphorous must be tested. Subsequent nitrogen and phosphorous testing must be performed 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. A minimum of one representative, composite sample per each 1000 cubic meters 1308 cubic yards must be tested. 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, fertilizer must be applied to restore nitrogen levels. One time applications of nitrate and ammonia must not exceed 0.18 kg 0.31 lbs of N per cubic meter cubic yard. When the levels of phosphorous fall below [5] [_____] mg/kg as P, phosphorous-containing fertilizer must be applied. Each time fertilizer is applied, the product name, quantity, and N:P:K content must be recorded. Take necessary precautions to prevent the release of chemicals, such as nitrate, to the vadose zone and groundwater.

3.6.5 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.

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.

****

The temperature of the soil in the treatment cell must be measured [once every 4 weeks at the following times: 800 hours, 1200 hours, and 1600 hours] [_____]. The temperature must be monitored at a minimum of [3] [_____] locations, in the treatment cell. Monitoring must be performed at the same locations during each event, and at a depth of at least 76 mm 3 inches below the surface of the soil. The temperature, time, depth and location of each temperature reading must be recorded during each monitoring event. Ambient air temperatures at the time of monitoring must also be recorded.

3.6.6 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.
****

At a minimum, the pH of soil in the treatment cell mut=st be tested [each Monday of the first, second, fourth, and eighth week after initiating treatment of each new lift of contaminated soil, and every 6 weeks thereafter] [_____]. A minimum of one representative, composite sample per each 1000 cubic meters 1308 cubic yards must be tested. The first [3] [_____] times pH testing is performed, a minimum of [2] [_____] samples must be tested 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, soil samples must be sent 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, the local soil testing laboratory must be notified regarding the contaminants that are present in the soil, and to determine if they can accept such samples. Samples must be tested 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. Additional pH adjustment must not be performed 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, the soil pH must be tested before and after adding the pH adjustment product. Also the product name, quantity, and supplier of the pH adjustment product used must be recorded after each application. Aqueous caustics, such as sodium hydroxide, must not be used as pH adjusting agents.

3.6.7   Odor Control

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NOTE: 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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If objectionable odors are observed, the following must be recorded in the Operations Report: locations where the odors are the strongest; description of the odors; the times and dates when the odors were detected; and the name of individual who observed, and recorded the odor. If, in the opinion of the Contracting Officer, there is a persistent problem with objectionable odors that has not been addressed, the Contractor will be notified to implement measures to reduce odor levels. Odor control measures must be implemented not more than [24] [_____] hours after notification from the Contracting Officer.

3.6.8   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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3.6.8.1 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 pentachlorophenol (PCP) degrading microorganisms, a defined media which includes PCP as the sole carbon source would be used.

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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).

3.6.8.2 Field Respiration Testing

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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 0.001 gal 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)

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Soil gas monitoring must be performed at least once every [7] [_____] days for the first [6] [_____] weeks of treatment, and every [2] [_____] weeks thereafter. Soil gas monitoring must be performed at not less than [5] [_____] randomly selected locations in the treatment cell. Soil gas must be tested 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 not less than [200] [_____] mm [7.9] [_____] inches, and the volume of air withdrawn for the sample must not be greater than [10] [_____] mL [0.61] [_____] cubic inches. Field measurements of soil temperature and moisture must be performed at the same time and location of each soil gas measurement. When soil gas monitoring is performed the following information must be recorded: 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.

3.6.9 Sampling and Analysis for Contaminants of Concern

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NOTE: Definitive 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: http://dqo.pnl.gov/VSP/Index.htm

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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Sampling and analysis must be in accordance with [_____]. Results from each sampling event must be furnished to the Contracting Officer not more than [24] [_____] hours after data is recorded by the Contractor, or released by the laboratory.

3.6.9.1 Pre-Compliance Sampling Design

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NOTE: In the sample design shown 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 http://dqo.pnl.gov/VSP/Index.htm).

The grid size shown in this example was arbitrarily set at a maximum of 1000 square meters (i.e., 4 grids per acre). 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.

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To determine pre-compliance sampling locations, the treatment cell must be divided into grids of equal area. The treatment cell must divided into a minimum of [8] [_____] grids. Each grid must be a maximum [1000] [_____] square meters [10890] [_____] square feet. Samples must be collected from [4, 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.

3.6.9.2 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 confirmation 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) confirmation testing.

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Approved field analysis methods may be used for pre-compliance testing. Sampling must be performed at least two times 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.

3.6.9.3 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).

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Testing for the following analytes must be performed during pre-compliance testing: [_____]. Testing must be conducted using the [field analysis] [_____] method for pre-compliance testing.

3.6.9.4 Confirmational 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 confirmational sampling locations, the treatment cell must be divided into grids of equal area. The treatment cell must divided into a minimum of [8] [_____] grids. 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)] [_____]. Samples must be collected from [4, 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.

3.6.9.5 Confirmation of Attainment of Treatment Criteria

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NOTE: 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.

Oversite 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 coordination with regulatory officials.
****

After pre-compliance testing indicates that a lift of soil has met treatment criteria, and written approval has been received from the Contracting Officer, compliance sampling must be performed. Compliance sampling must be performed in the presence of the Contracting Officer. Testing must be conducted using the method specified in [_____]. 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 paragraph Treatment Criteria for Soil, in PART 1. Data must be analyzed [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 applying 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] [_____].

3.6.10 Post-Treatment Procedure

****
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.
****

After compliance test data indicates that treatment criteria have been met, and written approval from the Contracting Officer has been received, the treated lift of soil may be [removed from the treatment cell] [_____].

3.6.11 Procedure for Non-Attainment of Treatment Criteria

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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.
****

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 OPERATION, MAINTENANCE AND PROCESS MONITORING, above), until the treatment criteria is attained. Submit Treatment Completion Records as specified.

3.6.12 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.

3.7 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, in PART 1.

****

Treated soil that has met treatment criteria [and criteria for reuse] must be disposed of in accordance with regulatory requirements. After it has been demonstrated that they meet disposal criteria, the following materials must be disposed of on-site: [oversize materials] [sludge resulting from treatment of contact water] [excess amendments] [and] [_____]. The following materials must be treated, if necessary, and disposed of off-site: [spent personal protective equipment] [spent granular activated carbon] [and] [_____]. Offsite disposal of hazardous material must be in accordance with Section 02 81 00 TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS.

3.8 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 the table, 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.

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Do not commence demobilization until written approval is received from the Contracting Officer. 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 the liner on 2.0 meter 6.6 ft centers across the length and width of the cell, re-seeding the treated soil.] 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,] [_____]. [Post-treatment testing of soils below work area surfaces must be performed, 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, in PART 1.] [_____]].

-- End of Section --