
USACE / NAVFAC / AFCEA / NASA UFGS-02 54 21 (February 2010)

Preparing Activity: USACE Superseding
UFGS-02 54 21 (October 2007)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2011

SECTION TABLE OF CONTENTS

DIVISION 02 - EXISTING CONDITIONS

SECTION 02 54 21

BIOREMEDIATION OF SOILS USING WINDROW COMPOSTING

02/10

PART 1 GENERAL

- 1.1 MEASUREMENT AND PAYMENT
 - 1.1.1 Bench-Scale Testing
 - 1.1.2 Field Demonstration
 - 1.1.3 Contaminated Soils Treatment Unit Price
 - 1.1.4 Oversize Materials from Contaminated Areas
- 1.2 REFERENCES
- 1.3 PROCESS DESCRIPTION
- 1.4 DESIGN REQUIREMENTS
 - 1.4.1 Composting Treatment Pad
 - 1.4.1.1 Treatment Pad Sizing
 - 1.4.1.2 Other Work Area Surfaces
 - 1.4.2 Contact Water Management System and Design Storm
 - 1.4.2.1 Perimeter Berms
 - 1.4.2.2 Storage Volume
 - 1.4.2.3 Reuse, Treatment, and Disposal
 - 1.4.2.4 Irrigation Equipment
 - 1.4.3 Weather Cover
 - 1.4.4 Stockpiles
 - 1.4.5 Amendment Storage Facilities
 - 1.4.5.1 Paved Storage Area
 - 1.4.5.2 Unpaved Storage Area
 - 1.4.6 Accuracy of Measurement Equipment
- 1.5 PERFORMANCE REQUIREMENTS
 - 1.5.1 Treatment Criteria and Criteria for Reuse of Composted Soil
 - 1.5.1.1 Treatment Criteria for Composted Soil
 - 1.5.1.2 Criteria for Reuse of Composted Soil
 - 1.5.2 Treatment Criteria for Contact Water
 - 1.5.3 Treatment Criteria for Other Waste
- 1.6 COMPOSTING WORK PLAN
- 1.7 OTHER SUBMITTALS REQUIREMENTS
- 1.8 PREVIOUSLY CONDUCTED TREATABILITY STUDIES
- 1.9 SUBMITTALS
- 1.10 QUALIFICATIONS
- 1.11 PROJECT/SITE CONDITIONS

PART 2 PRODUCTS

- 2.1 STANDARD PRODUCTS
- 2.2 WATER SUPPLY
- 2.3 AMENDMENTS
- 2.4 SYNTHETIC OR MANUFACTURED ADDITIVES

PART 3 EXECUTION

- 3.1 AMENDMENT TESTING AND BENCH-SCALE TESTING
 - 3.1.1 Amendment Test
 - 3.1.2 Bench-Scale Test
 - 3.1.3 Bench-Scale Test Report
- 3.2 MOBILIZATION
- 3.3 EMISSIONS AND DUST CONTROL
- 3.4 FIELD DEMONSTRATION
 - 3.4.1 Sampling Locations
 - 3.4.2 Monitoring
 - 3.4.3 Field Demonstration Report
- 3.5 SOIL PRE-PROCESSING
- 3.6 OPERATION, MAINTENANCE AND PROCESS MONITORING
 - 3.6.1 Amendment Storage
 - 3.6.2 Windrow Construction
 - 3.6.3 Mixing
 - 3.6.4 Moisture Control
 - 3.6.4.1 Moisture Content and Field Capacity Testing
 - 3.6.4.2 Irrigation
 - 3.6.4.3 Contact Water Testing
 - 3.6.5 Temperature
 - 3.6.5.1 Temperature Probe Calibration
 - 3.6.5.2 Temperature Monitoring
 - 3.6.6 Compost pH
 - 3.6.7 Odor Control
 - 3.6.8 Oxygen
 - 3.6.9 Non-Standard Sampling and Analysis
 - 3.6.10 Sampling and Analysis for Contaminants of Concern
 - 3.6.10.1 Sampling Frequency and Locations for Pre-Compliance Testing
 - 3.6.10.2 Pre-Compliance Testing
 - 3.6.10.3 Confirmation of Attainment of Treatment Criteria
 - 3.6.11 Post-Treatment Procedure
 - 3.6.12 Procedure for Non-Attainment of Treatment Criteria
 - 3.6.13 Curing and Storage
 - 3.6.14 Post-Treatment Screening
- 3.7 DISPOSAL
- 3.8 DEMOBILIZATION

-- End of Section Table of Contents --

USACE / NAVFAC / AFCEA / NASA UFGS-02 54 21 (February 2010)

Preparing Activity: USACE Superseding
UFGS-02 54 21 (October 2007)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2011

SECTION 02 54 21

BIOREMEDIATION OF SOILS USING WINDROW COMPOSTING 02/10

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

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

PART 1 GENERAL

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

This guide specification was developed based on the use of composting to treat explosives-contaminated soil. The same process is believed to be applicable for treatment of some other types of organic contaminants in soil (see paragraph Treatment Criteria and Criteria for Reuse of Composted Soil, below). Bioremediation processes, such as composting, are usually considered innovative technologies, and may satisfy CERCLA/SARA

considerations of innovation in remediation.

An edited version of this Section may be used to solicit a request for proposal (RFP). Use of an RFP approach may prevent the contract from being awarded to a Contractor that is not technically qualified.

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 pad and run on/runoff controls, 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.

1.1.1 Bench-Scale Testing

NOTE: Lump sum pricing is recommended for this item; however, bidders should 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. The following reference should be used to prepare the Bench-Scale Test Plan: EPA 540/R-93-519a, Guidance for Conducting Treatability Studies Under CERCLA, Biodegradation Remedy Selection, 1993.

Payment for bench-scale testing will be a lump sum price for proper completion of specified tests. The price shall 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 used in the compost shall be included in the unit price for treatment.

1.1.1.2 Field Demonstration

NOTE: Prior to planning the field demonstration, bench-scale testing should be performed to arrive at a suitable recipe of amendments, and to determine if the contaminants of concern are amenable to composting 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 on 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 proper completion of approved tests]. The price shall 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 used in the compost shall be included in the unit price for treatment.

1.1.1.3 Contaminated Soils Treatment Unit Price

NOTE: Except for equipment usage costs (e.g, rental), other equipment costs are not included as a component of the unit price for treatment in this paragraph; testing for chemical data is also not included in the unit price. The contract price schedule should include separate, unit price items for testing for chemical data.

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% 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.

Payment for composting treatment of contaminated material shall 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 shall 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 used in the compost shall be included in the unit price for treatment. After each batch has been treated, the quantity of material that does not meet treatment criteria shall be reported and subtracted from the quantity of material comprising the batch, when determining payment for treatment. Payment will not be made for material 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 shall 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 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, rubble, and construction debris.

Payment for [disposal] [and 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 shall 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 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.

The solicitation package should provide prospective Contractors with a means to acquire any references that are not included with the contract documents, and are not publicly available. The BIOCYCLE reference shown below is only a few pages and should be included with the solicitation package to provide information on self-heating tests, and compost stability testing. It is also recommended that copies of USAEC CETHA-TS-CR-93043, and USAEC SFIM-AEC-ET-CR-96184 be made available to prospective Contractors to provide descriptions of the intended treatment process.

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.

BIOCYCLE, JOURNAL OF COMPOSTING AND RECYCLING (BIOCYCLE)

BIOCYCLE (Article - Nov 1995, Vol 36, Issue 11)
Standardized Test for Evaluation of
Compost Self-Heating; Briton, W.F.Jr, et.
al.

NATURAL RESOURCE, AGRICULTURAL AND ENGINEERING SERVICE (NRAES)

NRAES 54 (1992) On-Farm Composting Handbook

U.S. ARMY (DA)

DA PAM 385-64 (1999) Ammunition and Explosives Safety
Standards

U.S. ARMY ENVIRONMENTAL CENTER (USAEC)

USAEC CETHA-TS-CR-93043 (1993) Windrow Composting Demonstration
for Explosives-Contaminated Soils at the
Umatilla Depot Activity (NTIS PB95-200119)

USAEC SFIM-AEC-ET-CR-96184 (1996) Cost Report: Windrow Composting to

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

29 CFR 1910

Occupational Safety and Health Standards

1.3 PROCESS DESCRIPTION

NOTE: Requirements for a specific method of treatment are provided below. If the use of a process other than windrow composting 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.

Treatment process shall provide a safe, reliable method to treat contaminated material conforming to the following paragraphs and based on the composting process described in USAEC CETHA-TS-CR-93043 and USAEC SFIM-AEC-ET-CR-96184.

1.4 DESIGN REQUIREMENTS

1.4.1 Composting Treatment Pad

NOTE: Siting of the treatment facility should be in accordance with regulatory requirements. The prevailing wind direction and the potential for odor generation should also be taken into consideration. The design of the treatment pad and weather cover should include provisions for control of storm water and contact water, and should take into account the expected wheel loads of material handling equipment. Concrete pads are typically more expensive, though less permeable than asphalt pads. Asphalt pads have been used for hazardous waste composting projects. It may also be necessary to construct asphalt pads for the following areas: soils pre-processing area; and the amendment and soil blending area.

Pavement of the treatment pad shall be in accordance with Sections [32 12 16 HOT-MIX ASPHALT (HMA) FOR ROADS.] [03 30 00.00 10 CAST-IN-PLACE CONCRETE.] The treatment pad shall be designed to withstand operation of material handling equipment, and to prevent infiltration of contact water. The slope of the surface of the treatment pad shall be not less than [2 percent] [____]. Water collection channels shall be incorporated into the paved treatment pad, and the pad shall drain, by gravity, to collection sumps. The water collection system and sump shall be in accordance with

paragraph Contact Water Management System and Design Storm, below. Sloping, placement of collection channels, and sump shall be sufficient to prevent ponding in the treatment pad area.

1.4.1.1 Treatment Pad Sizing

NOTE: The dimensions of the treatment pad should be based on the amount of time required to reach cleanup goals for each batch of compost (including laboratory turn-around time for compliance testing), the amount of time allotted for treatment of the contaminated soil (within the contract schedule), the "per-batch amount" of material that will be composted, the bulk density of the compost and soil, windrow dimensions and spacing, and the type of material handling equipment that will be used. A batch is defined as that amount of material, including soil and amendments, for which treatment is initiated at the same time during full-scale operations. After cleanup goals have been met for contaminants of concern, it may be necessary to continue to cure the compost (see paragraph Curing and Storage, in PART 3). The compost may be moved to a separate area for curing. On a previous composting project for explosives, each batch required about 4 weeks on the treatment pad (about 2 weeks treatment time, plus about 2 weeks to receive laboratory data from confirmation samples). Curing was not required on this project.

Formulas for the areas of typical windrow cross sections are provided in NRAES-54. The bulk density of compost will vary depending on what amendments are used and the proportions of soil and amendments (see paragraph Amendments, in PART 2). See paragraph Windrow Construction, in PART 3 for information on windrow dimensions. Use of long, narrow treatment pads may allow windrow mixing equipment to process a greater volume of material using a minimal number of turn-arounds. Thus long, narrow treatment pads may result in a more efficient operation than a wider treatment pad. It may be economically advantageous for the Contractor to divide the treatment pad into separate areas, so that mixing equipment does not set idle: on a portion of the pad, daily mixing of windrows may continue until definitive field analysis indicates that the compost is ready for compliance testing; on the other portion of the pad, the windrows may be allowed to set static while waiting for laboratory data from compliance testing.

The treatment pad shall be located within the area indicated on the drawings. The treatment pad shall be sized to avoid constricting other parts of the composting operations that must be conducted within the designated area available for composting operations.

1.4.1.2 Other Work Area Surfaces

NOTE: It may be necessary to require paving in areas designated for handling contaminated material, and operation of heavy equipment (e.g., front-end loaders).

The soils pre-processing area, and the area designated for blending soil and amendments shall be located within the area indicated on the drawings; and shall be constructed and paved in accordance with paragraph Composting Treatment Pad, above.

1.4.2 Contact Water Management System and Design Storm

NOTE: If 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.

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; and runoff water from storage, preprocessing and treatment areas. The design storm shall be the [24] [_____] hour duration storm with a return interval of [25] [_____] years, based on data from [_____] . The collection, conveyance, storage, treatment and disposal system shall remove all contact water from the design storm in not more than [24] [_____] hours.

1.4.2.1 Perimeter Berms

NOTE: Use of barriers constructed from interlocking concrete blocks may, for some applications, be an acceptable substitute for berms.

Berms shall be constructed around the perimeter of the following work areas: [treatment,] [stockpiling,] [storage areas,] [and] [_____] . The perimeter berms shall be sized to prevent flood water run-on from the [25] [_____] year flood, and to contain runoff from the design storm. A minimum of [0.3] [_____] meter [1] [_____] foot shall be maintained from the top of the berm to the surface inside of the work area, and from the top of the berm to the surface outside of the work area.

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 windrows. If this approach is applied, 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 runoff water from storage, preprocessing and treatment areas. If the storage, preprocessing, and treatment areas are properly covered, then the amount of contact water resulting from precipitation events should be limited.

Contact water storage facilities shall be sized to contain [30] [_____] percent above that required for the design storm, and [the maximum volume that will be held in storage for reuse] [_____] . The design storm is defined above.

1.4.2.3 Reuse, Treatment, and Disposal

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

Contact water shall 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 shall be tested in accordance with paragraph Contact Water Testing, in PART 3 and shall meet the requirements of paragraph Water Supply, in PART 2. Prior to disposal, contact water that cannot be applied to contaminated soil or compost shall 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) shall be treated to meet the requirements of paragraph [Treatment Criteria for Other Waste, below] [Treatment Criteria for Composted Soil, below] [_____] .

1.4.2.4 Irrigation Equipment

NOTE: Water may be added at many different points

in the process: to the raw materials prior to blending; during blending of amendments, before soil has been added; during the initial blending of compost; and during turning of the compost windrows. Mixing equipment may be equipped with spray nozzles for applying water. Timely irrigation of compost is critical during thermophilic stages of composting, when the highest rates of evaporation occur. In arid climates, water usage rates will obviously be higher than in non-arid climates.

Irrigation equipment shall be capable of providing at least [2.9] [_____] liters of water/cubic meter [1.0] [_____] gallons of water/cubic yard of compost per day, and meeting the requirements of paragraph Moisture Control, in PART 3.

1.4.3 Weather Cover

NOTE: Although "breathable", water resistant cover material is available, direct contact between the covering material and the compost should be avoided. 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 3-310-04, maximum and minimum ambient air temperatures. The interior of the weather cover should be suitable for a high water-vapor environment. Metal surfaces may be subject to corrosive conditions. If the composting will be conducted 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 composting. Ammonia gas is commonly generated as well. It is also possible for methane to be generated, if anaerobic conditions are allowed to develop. To ensure that proper and consistent ventilation requirements are specified, this section should be coordinated with other sections; e.g., Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM, edited accordingly.

Weather covers, or appropriate structures, shall be used to prevent precipitation from coming into contact with windrows, and shall be designed in accordance with Section [13 34 19 PREENGINEERED METAL BUILDINGS] [_____] . Covers shall allow for free exchange of gasses between the atmosphere and the compost. Weather covers shall be sized to allow unimpaired maneuvering of [front-end loaders,] [windrow mixing equipment,] [and] [_____] ; openings in weather covers shall be sized to allow for entry and exit of [front-end loaders,] [windrow mixing equipment,] [and] [_____] . Ventilation of the composting facility shall be in accordance

with Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS.

1.4.4 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 composting 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 shall be constructed for storing [contaminated material,] [oversize material,] [treated material that has not been fully cured,] [treated material that has been fully cured,] [and] [_____]. Stockpiles shall 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 shall be in accordance with Section 02 56 13 WASTE CONTAINMENT GEOMEMBRANE.
- b. An impermeable geomembrane cover with a minimum thickness of [0.25] [_____] mm [10] [_____] mils to prevent precipitation from entering the stockpile.
- c. Berms surrounding stockpiles in accordance with paragraph Perimeter Berms, above.

1.4.5 Amendment Storage Facilities

NOTE: Some types of amendments should be kept covered to prevent contact with precipitation. However, in very arid climates covers may not be necessary. Usually, synthetic membranes are used as covers. To ensure that stored material can be removed from stockpiles and blended with other compost ingredients in subfreezing conditions, it may be necessary to store a portion of some materials at above 0 degrees C (32 degrees F).

To prevent undesired infiltration, some types of amendments (e.g., manure) should be stored in containers, or on a paved surface (e.g., asphalt pad) with containment walls. However, if the amendment is delivered directly to a blending vessel, use of storage facilities may not be necessary. See paragraph Amendment Storage, PART 3 regarding controls for insects and rodents.

The following amendments shall be covered to prevent contact with precipitation: [____]. Covers will not be required for [woodchips] [____]. Frames, or other materials, shall be used to prevent contact between covers, and the following amendments: [manure,] [and] [____]. The storage area shall be designed to withstand operation of material handling equipment, and to minimize infiltration of contact water. The slope of the surface of the storage area shall be not less than [2 percent] [____]. Water collection channels shall be incorporated into the surface of the storage area, and the storage area shall drain, by gravity, to collection sumps. The water collection system and sump shall be in accordance with paragraph Contact Water Management System and Design Storm, above. Sloping, placement of collection channels, and sump shall be sufficient to prevent ponding in the storage area.

1.4.5.1 Paved Storage Area

The following amendments shall be stored on a paved surface with perimeter berms: [manure,] [potato waste,] [and] [____]. Pavement of the paved storage area shall be in accordance with Sections [32 12 16 HOT-MIX ASPHALT (HMA) FOR ROADS.] [03 30 00.00 10 CAST-IN-PLACE CONCRETE.] Berms surrounding the paved storage area shall be in accordance with paragraph Perimeter Berms, above.

1.4.5.2 Unpaved Storage Area

The following amendments may either be stored on a paved surface with containment walls, or stockpiled in accordance with paragraph Stockpiles, above: [manure,] [potato waste,] [and] [____]. Geomembrane liners will not be required for storage of the following amendments: [sawdust,] [alfalfa,] [wood chips,] and [____].

1.4.6 Accuracy of Measurement Equipment

Measuring devices shall be accurate to at least [25] [____] percent of the unit used as the basis for measurement and payment. A check of calibration of measuring equipment shall be performed prior to initial use, and once every [7] [____] calendar days.

1.5 PERFORMANCE REQUIREMENTS

Sampling and analyses shall be performed in accordance with Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL.

1.5.1 Treatment Criteria and Criteria for Reuse of Composted Soil

NOTE: Some types of nonvolatile and semi-volatile organic contaminants are believed to be amenable to composting, including some explosives, polynuclear aromatic hydrocarbons (PAHs, as found in creosote), and some pesticides and herbicides (see Engineering Bulletin, Composting, EPA 540/S-96/502; also, see The Science of Composting, by Epstein, 1997). Since temperatures may exceed 65 degrees C (150 degrees F) during composting, the volatility of contaminants of concern should be taken into consideration (see paragraph Temperature in PART 3).

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 composting (see paragraph Criteria for Reuse of Composted Soil, below). Treatment criteria, and criteria for reuse should be in accordance with Federal, state and local regulations. Prior approval by regulatory representatives should be acquired for treatment criteria values.

For those parent compounds for which partial breakdown products (intermediates) have been defined and analytical standards are readily available, it may be necessary to include testing for key intermediates. A compound should not be targeted for analysis unless there is a defensible basis for including the compound. This paragraph should be coordinated with Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL to ensure that required analyses are included in the specified analytical methods.

1.5.1.1 Treatment Criteria for Composted Soil

NOTE: Paragraph Confirmation of Attainment of Treatment Criteria, in PART 3 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. The treatment criteria shown below are only examples. This paragraph should be edited to include site-specific criteria.

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

TABLE 1 - TREATMENT CRITERIA FOR ORGANICS	
ORGANIC CONTAMINANT	TOTAL CONCENTRATION IN COMPOST
2,4,6,-trinitrotoluene (TNT)	[_____] mg/kg
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	[_____] mg/kg
Octahydro-1,3,5,7-tetranitro-1,3,5,7,	[_____] mg/kg
N,2,4,6-tetranitro-N-methylaniline (tetryl)	[_____] mg/kg
4-amino-2,6-dinitrotoluene	[_____] mg/kg
1,3,5-trinitrobenzene (TNB)	[_____] mg/kg
1,3-dinitrobenzene (DNB)	[_____] mg/kg
2,4-dinitrotoluene (2,4-DNT)	[_____] mg/kg
2,6-dinitrotoluene (2,6-DNT)	[_____] mg/kg
Total Polynuclear Aromatic Hydrocarbons (PAHs)	[_____] mg/kg
Total cPAHs (carcinogenic PAHs)	[_____] mg/kg
[_____]	[_____] mg/kg

1.5.1.2 Criteria for Reuse of Composted Soil

NOTE: The land application or beneficial use of the compost 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 - Standards for the Use or Disposal of Sewage Sludge (i.e. 40 CFR 503.13 - Pollutant limits) may be useful in evaluating beneficial use alternatives, the designer is cautioned that the scope of this standard is for domestic sewage sludge. Composted materials 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 finished compost 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 dilution (through addition of amendments), composting is usually not considered a treatment process for inorganics. However, depending on regulatory requirements and intended end use, it may be necessary to require testing for some inorganic parameters, for pathogens, and to include requirements to ensure that the compost has been properly cured (see paragraph Curing and Storage, in PART 3). Toxicological testing of treated and untreated material was previously performed as part of a treatability study (see Characterization of Explosives Processing Waste

Decomposition Due to Composting AEC TIC #4078,
 prepared for USATHAMA by Oak Ridge National
 Laboratory, Nov. 1991); however, toxicity testing is
 usually not required during full-scale operations.
 The treatment criteria shown below are only
 examples. This paragraph should be edited to
 include site-specific criteria.

Prior to final disposition, the compost shall meet the following criteria to determine if it has been properly cured: 1) Minimum and maximum pH [5.0] [_____] and [7.6] [____], respectively. 2) The increase in temperature observed during the Dewar self-heating test shall be not more than [15] [____] degrees C above the ambient temperature; and the ambient temperature shall not be greater than 25 degrees C. 3) The soluble salt concentration (conductivity) of the finished compost shall be less than [20] [____] mmhos per centimeter. 4) Dewar self-heating testing, and conductivity testing shall be performed in accordance with paragraph Non-Standard Sampling and Analysis, in PART 3. 5) The treated material shall meet the criteria shown in Table 2.

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

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. It is possible for petroleum, oils and lubricants (POLs) and other fluids from material handling equipment to be spilled onto compost 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.

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

TABLE 3 - WATER DISPOSAL/DISCHARGE CRITERIA	
PARAMETER	MAXIMUM CONCENTRATION
2,4,6,-trinitrotoluene (TNT)	[_____] mg/kg
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	[_____] mg/kg
Octahydro-1,3,5,7-tetranitro-1,3,5,7, -tetrazocine (HMX)	[_____] mg/kg
N,2,4,6-tetranitro-N-methylaniline (tetryl)	[_____] mg/kg
2-amino-4,6-dinitrotoluene	[_____] mg/kg
4-amino-2,6-dinitrotoluene	[_____] mg/kg
1,3,5-trinitrobenzene (TNB)	[_____] mg/kg
1,3-dinitrobenzene (DNB)	[_____] mg/kg
2,4-dinitrotoluene (2,4-DNT)	[_____] mg/kg
2,6-dinitrotoluene (2,6-DNT)	[_____] mg/kg
Chromium	[_____] mg/L
Copper	[_____] mg/L
Arsenic	[_____] mg/L
Lead	[_____] mg/L
TPH	[_____] mg/L
Nitrate	[_____] mg/L
Total phosphates	[_____] mg/L
Ammonia	[_____] mg/L
Total Kjeldahl nitrogen	[_____] mg/L
Total suspended solids	[_____] mg/L
5 Day BOD	[_____] mg/L
minimum pH	[_____]
maximum PH	[_____]
[_____]	[_____]

1.5.3 Treatment Criteria for Other Waste

NOTE: Other waste may include: excess amendments, sludge resulting from treatment of contact water, oversize material, and manufactured material. Treatment may not be required for some wastes. Treatment criteria should be provided if treatment will be conducted onsite. One treatment scenario for each type of waste should be clearly defined. 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".

The following materials shall be treated prior to disposal: [excess manure and vegetable wastes, sludge resulting from treatment of contact water, and oversize material that has been separated from contaminated soil] [____]. Treatment shall be in accordance with regulatory requirements.

1.6 COMPOSTING 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.

Requirements for sampling and analysis for chemical data may be provided as part of submittals described in Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL. Sampling and analysis requirements for parameters not covered under Section 01 35 45.00 10 (i.e., non-chemical data) should be included in the Composting Work Plan. To avoid duplications in submittal requirements, submittals in this Section should be coordinated with other sections of the contract (e.g., 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL, 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.

Submit a Composting Work Plan not more than [200] [____] calendar days after notice to proceed. A period of not less than [30] [____] calendar days shall be allowed for in the schedule for Government review. Include copies of the permits, permit equivalents and certifications with the Composting Work Plan. The composting work plan shall include, but shall not be limited to, the following:

- a. Schedule. The schedule shall specify dates and durations for: excavation, hauling, stockpiling, start and completion of mobilization, treatment pad 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 shall also be provided: intended hours of operation, routine maintenance downtime, other scheduled downtime, anticipated time to reach cleanup goals for each batch of soil and amendments, anticipated laboratory turn-around time to receive data from compliance samples.

- b. Project Organization and Personnel. An organization chart, including subContractors, shall be provided; the chart shall include the names, responsibilities, education, and resume of the key project personnel. Key personnel shall include, but shall not be limited to: project managers, quality control personnel, supervisory operators and technicians, and engineering staff. Responsibilities of each individual in the organization shall 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.
- c. Selection of Amendments. Description of, and preferred sources for each proposed amendment; including at least one alternative source for each category of amendment. Locations of each source, and distances from the site shall be included. Amendment categories shall include: manure, vegetable waste, alfalfa hay, and wood materials. For amendments that are only available on a seasonal basis, a plan for substituting alternative types of amendments shall be provided. The proposed amount of each amendment that will be added to each cubic m yard of contaminated soil shall be included.
- d. Emissions, Dust and Odor Control. For each stage of operations, the plan shall include, but shall not be limited to: the sources of emissions, dust and odors during each stage of operations, and proposed control measures. The stages of operation shall include, but shall not be limited to: construction of paved surfaced, soil preprocessing; treatment, transport, and disposal of oversize material; blending of soil and amendments; during the composting process, including during mixing; transport of compost; storage of compost; disposal of compost. The plan shall specifically address odor control during the following activities: amendment delivery and storage; blending of soil and amendments; during the composting process, including during mixing; transport of compost; storage of compost; and disposal of compost. If air monitoring will be required, the following shall 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.
- e. Operations and Process Monitoring. A detailed description of the proposed operation shall be provided. The description shall 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, soil and constructing windrows; initial volumes of soil and amendments to be treated in each batch; methods for measuring quantities of soil, amendments, and compost; treatment pad area required for each batch; water management plans; parameters that will be monitored during composting, curing and storage; frequency of monitoring, mixing, and irrigation during each stage of operations;

locations of each windrow sampling station shown from plan view; sampling locations shown on a diagram depicting a cross-section of a windrow; the number of sampling stations per each batch of compost; windrow moisture and temperature monitoring locations shall also be shown; and plans for storage of treated materials.

- f. Protocol for Compliance Testing. A detailed, chronological description of the sequence of procedures and tests that will be used to determine whether the compost has met treatment criteria. The locations of each windrow sampling station shown from plan view; the number of sampling stations per each batch of compost; sampling locations shown on a diagram depicting a cross-section of a windrow; the number of samples that will be collected and tested for each type of test performed as a part of compliance testing; and laboratory turn-around-time.
- g. Protocol for Determining if Compost Meets Criteria for Disposal and/or Reuse. A detailed, chronological description of the sequence of procedures and tests that will be used to determine whether the compost has met criteria for disposal and/or reuse; including: the location of each sampling station shown from plan view; the number of sampling stations per each batch of compost; sampling locations shown on a diagram depicting a cross-section of a compost pile; and the number of samples that will be collected and tested for each type of test performed.
- h. Non-Composting Treatment Processes. A detailed description of the procedures for treatment of solid and liquid wastes that will be treated by a process other than composting; including: treatment criteria for oversize material and other wastes; testing parameters; sampling locations; number of samples; monitoring frequency; and laboratory turn-around-time.
- i. Equipment and Servicing. A detailed description of the proposed treatment equipment shall be provided. For each proposed piece of equipment, the description shall include, but shall not be limited to: 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 onsite during each stage of operations. Equipment described shall include, but shall not be limited to: mixing devices; windrow turning equipment; pumps, valves and other in-line devices; irrigation equipment; moisture and temperature control instrumentation; and sampling and testing devices for process monitoring. For equipment that will be in contact with explosives-contaminated material, a copy of the explosives hazard analysis report for each piece of equipment shall be provided; this includes equipment used to homogenize and/or grind samples. Explosives hazard analysis reports shall be in accordance with DA PAM 385-64. Plans for servicing equipment shall also be provided, and shall explain how material handling and windrow mixing will be accomplished during servicing of equipment, and during unanticipated breakdown of machinery.
- j. Process Material Tracking Schedule. The proposed schedule shall be used to record the quantities of the contaminated materials treated. The dates and duration of the following activities shall also be provided for each batch of contaminated material: initiation of composting; completion of composting; reprocessing of any treated materials that failed to meet treatment criteria; storage of treated material; disposal of treated material.

- k. 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 shall 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 shall include, but shall not be limited to: finished compost, other treated material, oversize materials, contact water, and other solid and liquid wastes generated during the project.
- l. Mobilization and Demobilization. A mobilization and demobilization plan to include, but not limited to: transport of personnel, material, and equipment; decontamination and disposal of materials and equipment brought to the site; decontamination and disposal of the treatment pad and other paved surfaces. The demobilization plan shall include a Post-Treatment Cleanup and Sampling Plan for areas where there was contact with contaminated materials.

1.7 OTHER SUBMITTALS REQUIREMENTS

Submit the following:

- a. The amendment test plan not more than [21] [_____] calendar days after notice to proceed. A period of not less than [30] [_____] calendar days shall be allowed for in the schedule for Government review. This plan shall address, but shall not be limited to: the source of each amendment; testing parameters; and the number of samples. Proposed procedures for shipping amendments to the laboratory shall also be provided, including: type of containers; and the maximum time periods between shipping, laboratory receipt, and initiation of testing. Other sampling and analysis requirements for amendment testing shall be covered by submittals specified in Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL.
- b. The bench-scale test plan not more than [90] [_____] calendar days after notice to proceed. A period of not less than [30] [_____] calendar days shall be allowed for in the schedule for Government review. This plan shall address, but shall not be limited to: location of test facility; amendment selection rationale; the source of each amendment; test parameters, number of samples, and sampling locations that will be used to determine the source of soil; the proposed proportions of amendments and soil in each recipe; the number of replicate tests for each selected recipe; procedure for mixing soil and amendments; types of containers that will be used; frequency of mixing; testing and monitoring parameters; number of samples; monitoring frequency; length of monitoring period; and laboratory turn-around-time. Proposed procedures for shipping amendments to the laboratory shall also be provided, including: type of containers; and the maximum time periods between shipping, test facility receipt, and initiation of testing. Test methods, and other sampling and analysis requirements for the bench-scale test shall be [covered by submittals specified in Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL] [_____] .
- c. A field demonstration plan not more than [150] [_____] calendar days after notice to proceed. A period of not less than [30] [_____] calendar days shall be allowed for in the schedule for Government

review. This plan shall address, but shall not be limited to: target levels of contaminants in soil that will be treated; test parameters, number of samples, and sampling locations that will be used to determine the source of contaminated soil; sources of amendments; the proposed amount of each amendment that will be added to each cubic m yard of contaminated soil; irrigation water source; plan for physical and chemical monitoring; laboratory turn-around-time; plan for maintaining proper temperatures, and moisture contents; irrigation and mixing equipment specifications; and waste disposal plan. Test methods, and other sampling and analysis requirements for the field demonstration test shall be [covered by submittals specified in Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL] [____]. For equipment that will be in contact with explosives-contaminated material, a copy of the explosives hazard analysis report for each piece of equipment shall be provided. Explosives hazard analysis reports shall be in accordance with DA PAM 385-64.

- d. The field demonstration report not more than [120] [____] calendar days after completion of the field demonstration. The report shall document relevant data including, but not limited to: characterization test results for each amendment; the source of each amendment; the proportions of amendments and soil in each recipe tested; chronological table showing all materials added to each windrow, amount added, date of addition, and each mixing, precipitation, irrigation and sampling event. The report shall also include: physical and chemical monitoring data from before, during and after treatment; degradation rates; final disposition of wastes and treated material; conclusions; recommendations; and proposed recipe of soil and amendments for full-scale operations. In addition, the day-to-day log of operations and adjustments shall be included in an appendix.
- e. An odor control plan not more than [48] [____] hours after being notified by the Contracting Officer. A period of not less than [14] [____] calendar days shall be allowed for in the schedule for Government review. The submittal shall include: a written description of what measures were taken to control odors, at which locations, and when the measures were implemented; and a plan for future odor control measures.
- f. Copies of records for treated or processed materials which have been disposed of not more than [45] [____] calendar days after disposal of each batch of materials. The following shall be included for each batch of treated material: disposal location; date of transport to disposal location; volume or weight of material; and chemical data reports. Cross-references to submittals specified in Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL may be provided in lieu of chemical data reports. Cross-references to the submittal specified in Section 02 81 00 TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS, which includes the manifests, shall be provided for materials disposed of offsite. For non-manifested materials disposed of offsite, the following information shall also be provided: address, phone number, and point of contact for each receiving offsite disposal facility.
- g. The amendment test report not more than [60] [____] calendar days after completion of amendment testing. Report shall include: characterization test results for each amendment; the source of each amendment; the date that each amendment was shipped, received and tested by the laboratory; procedure used to ship each amendment (including type of containers and temperature); if amendments were

stored for any period of time, the temperature of storage; testing methods used; and proposed recipes of soil and amendments for bench-scale testing.

- h. The bench-scale test report not more than [90] [_____] calendar days after completion of the bench-scale test. Report shall include: characterization test results for each amendment; the source of each amendment; the proportions of amendments and soil in each recipe tested; the date that each amendment was shipped and received by the laboratory; procedure used to ship each amendment (including type of containers and temperature); if amendments were stored for any period of time, the temperature of storage; the date that the bench scale test was initiated; physical and chemical monitoring data; and proposed recipes of soil and amendments for the field demonstration. Graphs of temperature versus time shall be provided for each self-heating test performed. Both ambient temperatures and compost temperatures shall be provided.
- i. Reports shall be furnished weekly for the first [10] [_____] weeks, and every [2] [_____] weeks, thereafter. The report shall be kept at the facility during the [field demonstration] [and] [full-scale operation]. The following information shall 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, contaminated soil, and compost on site; and the quantity at each location. The location and quantity of each type of material shall be recorded on a map or diagram of the site. This information shall 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 shall also be provided. The reports shall 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 (e.g., Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL) may be provided to prevent duplicate information in separate submittals.
- j. Material safety data sheets (MSDSs), certificates of analysis, and product performance data not more than [45] [_____] calendar days after notice to proceed. MSDSs shall be in accordance with 29 CFR 1910 Section 1200 (g).

1.8 PREVIOUSLY CONDUCTED TREATABILITY STUDIES

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

The methods employed in the 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. Treatability studies are a necessary part of each composting project. Bench-scale tests and field demonstrations should be performed to determine which recipes of soil and amendments are most likely to fulfill the treatment criteria.

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 to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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.

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" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation 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

Composting Work Plan[; G][; G, [____]]
Amendment Test[; G][; G, [____]]

Bench-Scale Test[; G][; G, [____]]
Field Demonstration[; G][; G, [____]]
Odor Control[; G][; G, [____]]
Treatment Completion Records[; G][; G, [____]]

SD-06 Test Reports

Amendment Test[; G][; G, [____]]
Bench-Scale Test Report[; G][; G, [____]]
Field Demonstration Report[; G][; G, [____]]
Operations Report

SD-07 Certificates

Synthetic or Manufactured Additives[; G][; G, [____]]
Composting Work Plan

1.10 QUALIFICATIONS

NOTE: The majority of composting projects completed to date have involved treatment of soil contaminated primarily with TNT. For sites with unusual, or difficult to treat, contaminants of concern (e.g., exceptionally high levels of HMX or RDX), the designer should consider including a requirement that the Contractor have completed a field demonstration or full-scale project where explosives-contaminated soil was successfully treated. However, including such a requirement may limit the number of qualified bidders, and drive up the price of the contract.

- a. Have successfully completed at least [1] [____] windrow composting project that required processing of a volume of compost comparable to the estimated volume of compost that will be generated 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 shall 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 shall also be provided, if applicable: dates for initiating and completing treatment; amount of time required to treat each batch of contaminated soil; volume of amendments added per unit volume of contaminated soil; final volume of finished compost; concentrations of contaminants of concern in soil (before treatment), day zero (in compost), during treatment, and after treatment.
- b. 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, shall be included.

- c. Drawings. Project drawings shall include, but shall not be limited to: layout of the facility; dimensions of amendment storage areas, preprocessing areas, and treatment pad; dimensions and volumes of contaminated soils stockpiles, treated materials stockpiles, and waste stockpiles; locations, dimensions, and volume of collection sumps and any ancillary water storage facilities; dimensions, volumes and cross sections of windrows; 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, utilities, 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 in not more than [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
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

NOTE: It may be necessary to perform an explosive hazard analysis on equipment used to process explosives-contaminated material (see DA PAM 385-64). Equipment used on previous composting projects may already have been subject to an explosives hazard analysis (see Hazard Review of KW Windrow Composter, March 1992, in Appendix E of USAEC CETHA-TS-CR-93043).

Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall 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; used decontamination water; and runoff from precipitation; see paragraph Storage Volume. For most composting operations, spontaneous combustion is an unlikely occurrence. However, if large quantities of very dry materials (e.g., leaves) will be used as amendments, it may be necessary to include provisions for fire detection and/or fire protection (see paragraph Moisture Control). If there are susceptible structures nearby, it may be necessary to ensure that the local water distribution system is adequate to prevent a fire from spreading. It may also be necessary to coordinate this Section with Section 28 31 00.00 10 FIRE DETECTION AND ALARM SYSTEM, DIRECT CURRENT LOOP or 28 31 64.00 10 FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE. This Section does not include provisions for fire protection.

Water for irrigation shall 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 shall 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: Factors driving selection of amendments should include: seasonal availability, proximity of sources to the site, costs, amenability to storage and handling, moisture content, odor potential, texture and porosity, carbon-to-nitrogen (C:N) ratio, previous experience with using an amendment, and variability in the quality of an amendment. Amendment mixtures that have been successfully used for previous projects, involving treatment of hazardous-waste-contaminated soil, should be given primary consideration.

Theoretically, the C:N ratio of the compost recipe should be between 20:1-40:1. The C and N contents of candidate amendments can be estimated using literature values (see Appendix A of the On-Farm Composting Handbook). Laboratory testing, for moisture and ash content, may also be used to determine carbon content. By subtracting the ash content from the dry weight, the organic matter content can be determined. The carbon content is usually determined by dividing the organic matter content by 1.8. Other amendment selection considerations are provided in paragraph Amendment Testing and Bench-Scale Testing, in PART 3.

If the bulk density of the amendment recipe (not including soil) is greater than 640 kg per cubic meter (40 lbs per cubic foot), the recipe may not be sufficiently porous. Wood chips may be used to increase the porosity of a compost recipe; however, depending on plans for end-use, large-diameter materials may have to be separated from the finished material (see paragraphs SOIL PRE-PROCESSING, Curing and Storage, and Disposal in PART 3). It becomes more difficult to maintain aerobic conditions in the windrow as the porosity decreases, and as the moisture content increases (see paragraph Moisture Control in PART 3). Use of amendments with a extremely high moisture content (e.g., liquid

manure) should be avoided. The moisture content of the soil and amendments will control the initial moisture content of the compost. If the initial moisture content is too high, the windrow may not heat up properly, and the process may fail.

The following amendment mixture has been successfully used for full-scale treatment of explosives-contaminated soil: 30% soil, 17.5% sawdust, 17.5% hay, 21% cow manure, 10.5% chopped potato waste, 3.5% chicken manure (as reported in USAEC CETHA-TS-CR-93043). Based on previous, successful composting projects for explosives-contaminated soil, the following recipe of soil and amendments is recommended:

- a. 30% Contaminated Soil. It may be necessary to reduce the soil percentage if clayey soils are being treated.
- b. 15 - 20% Saw Dust/Wood Chips. It may be advantageous to substitute all or a portion of the sawdust with wood chips. Wood chips provide for greater porosity in the compost. Use of cedar chips, or other aromatic wood chips, should be avoided.
- c. 15 - 17% Alfalfa Hay. The quality of the hay may be marginal. Moldy alfalfa hay has been found to perform satisfactorily, and it is usually less expensive than feed quality hay.
- d. 10 - 20% Potato Waste. Chopped potatoes are better than whole potatoes. It may be possible to use other starch sources in lieu of potatoes.
- e. 15 - 25% Manure. Must be fresh (not dried). Although chicken manure has a higher nitrogen content, satisfactory results have been obtained using only cow or steer manure. Manure from ruminant animals (e.g., cows) is thought to be the best source of microbial inoculum.

Representative samples from the first shipment of [manure, and potato waste (or other vegetable waste)] [_____] shall be tested for: conductivity, and moisture content. The concentration of glass, plastic, and other foreign materials in each shipment of amendment shall not exceed [5] [_____] percent, by dry weight. Asbestos containing materials shall not be used as amendments. The initial soluble salt content (conductivity) of the compost (including soil and amendments) shall not exceed [20] [_____] mmhos per centimeter. The initial moisture content of the compost (including soil and amendments) shall not exceed [60] [_____] percent of the moisture content at field capacity (or water holding capacity).

2.4 SYNTHETIC OR MANUFACTURED ADDITIVES

NOTE: It is usually unnecessary to include

synthetic or manufactured additives (e.g.,
surfactants or microbial inoculum) in compost
recipes. This paragraph should be deleted if
synthetic or manufactured additives will not be used.

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

PART 3 EXECUTION

3.1 AMENDMENT TESTING AND BENCH-SCALE TESTING

NOTE: If a proven recipe will be used, testing of amendments may not be necessary (see paragraph Amendments). However, if a type of amendment has been proposed for which there is no previous experience, the following tests may be warranted: bulk density, moisture content, field capacity (or water holding capacity), free carbonate, organic matter content (or volatile solids), ash content, pH, conductivity, and total Kjeldahl nitrogen. These paragraphs, and the corresponding submittal descriptions, should be deleted if amendment testing and bench-scale testing were performed prior to awarding this contract.

3.1.1 Amendment Test

Prior to the bench-scale test, samples of amendments shall be collected and tested for: [moisture content, pH, and conductivity] [____]. For each type of amendment, [2 composite samples] [____] shall be tested. The following amendments shall be included in testing: [manure, and potato waste (or other vegetable waste)] [____].

3.1.2 Bench-Scale Test

NOTE: The testing described below is closely related to the Dewar self-heating test that is used to determine the maturity of compost. However, the testing described below requires more intensive monitoring, a larger volume of material, and more time than a standard Dewar self-heating test.

Self-heating tests are typically performed using insulated containers (e.g., Dewar flasks), and may be used to assess whether recipes of soil and amendments are suitable for composting; a recipe may be suitable if it heats up, and remains at a sufficiently high temperature for an extended period of time. Self-heating tests may also be used to determine if an organic contaminant that has not previously been treated via composting, is amenable to composting.

It is possible to use containers with a volume of less than 4 liters (1 gallon) for self-heating tests; however, a minimum volume of 4 liters (1 gallon) is recommended for the following reasons: to more accurately simulate conditions of a compost windrow (height of about 1.5 m (5 feet)); and to reduce the chances of using soil samples that are not representative of site conditions.

After completion of amendment testing, review the test results, and submit the proposed recipes of soil and amendments to be included in the bench-scale testing. At least [three, replicate] [_____] self-heating tests shall be performed simultaneously for each selected recipe. Prior to testing, each recipe shall be homogenized and divided into replicate volumes. The volume of material (including soil and amendments) included in each container for the self-heating tests shall be not less than [[4] [_____] L [1] [_____] gal] [_____]. Self-heating tests shall be performed for a period of not less than [28 days] [_____], during which temperature monitoring shall be performed [daily] [_____].

3.1.3 Bench-Scale Test Report

After completion of bench-scale testing, review the test results, and propose the recipes of soil and amendments to be included in the field demonstration. The proposal for the field demonstration shall be included in the Field Demonstration submittal.

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 shall result in no additional costs. Equipment which may have previously come into contact with contaminated material shall 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, blending amendments, blending amendments and soil, construction of windrows, mixing windrows, transport of compost, disposal of finished compost, and reuse

of finished compost (e.g., land application). There may be an increased potential for human exposure to ammonia gas and mold spores (e.g., Aspergillus fumigatus) during composting.

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

3.4 FIELD DEMONSTRATION

NOTE: The field demonstration requirements are a function of the uncertainty of the materials to be treated. For well defined wastes that are known to be amenable to composting, optimization testing (performed using full-scale equipment and facilities) may be adequate. If the amenability of the contaminated material to composting 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 recipe of soil and amendments used in the field demonstration will be based on the results of the bench-scale test. To prevent scale-up problems between the field demonstration and full-scale operations, the batch size used for the field demonstration should be at least 23 cubic meters (30 cubic yards), and not less than 5% of the proposed batch size for full-scale operations. A batch is defined as that amount of material, including soil and amendments, for which treatment is initiated at the same time during full-scale operations.

Prior to full scale composting operations, a field demonstration shall 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 shall be processed, using properly modified operating conditions, until satisfactory results are obtained. Any treated materials that failed the field demonstration shall be kept segregated and returned to the contaminated materials stockpile area for processing during full-scale remediation. The volume of each windrow, including soil and amendments, included in the field demonstration shall be not less than [23] [_____] cubic meters [30] [_____] cubic yards. Separate windrows, spaced to prevent intermingling of contaminated material, shall be provided for each recipe and/or condition being tested. Recipes and/or Conditions to be tested shall include: [_____]. The field demonstration shall be conducted using the same windrow dimensions, and similar irrigation and mixing methods as proposed for the full scale operations. The field demonstration shall 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 material used for the field demonstration shall 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 shall be tested in accordance with the Field Demonstration Plan to determine if it contains the following minimum levels of contamination: [____].

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 content, and field capacity 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. 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 allow each contaminant of concern to reach asymptotic levels. Also, the amount of sampling and analysis for contaminants of concern should be sufficient to assess the degree of variability in the final concentrations; so that it can be determined if cleanup goals will be reached.

During the field demonstration, sampling and analysis shall be performed as indicated under paragraph OPERATION, MAINTENANCE AND PROCESS MONITORING, below; in addition to these requirements, the following processing monitoring requirements shall be implemented: [____]. The field demonstration shall not exceed [60] [____] days from the initial blending of soil and amendments until completion of composting.

3.4.3 Field Demonstration Report

After completion of field demonstration, review the data from the field demonstration. Proposed changes in Operations, Maintenance and Process Monitoring shall be included in the Field Demonstration Report submitted to

the Contracting Officer for review.

3.5 SOIL PRE-PROCESSING

NOTE: Soil pre-processing may include stockpiling, screening, and blending of contaminated materials. The maximum recommended particle diameter for compost mixing equipment can range from 2.5 to 10 cm. However, the end use for the compost may dictate that the maximum particle diameter not exceed 13 mm (0.5 inch) (see paragraph Curing, Storage and Disposal); and that the concentration of glass, plastic, and other foreign materials in soil not exceed 5 percent, by dry weight. Although it may be possible to include relatively large particles in compost, an additional screening step may also be necessary to remove the large particles prior to disposal. This paragraph should be coordinated with paragraph Amendments. If explosives-contaminated soil will be treated, it may be necessary to require that an explosives hazard analysis be performed on the material handling equipment (see DA PAM 385-64; and Hazard Review of KW Windrow Composter, March 1992, in Appendix E of USAEC CETHA-TS-CR-93043).

The maximum particle size in soil shall be [compatible with approved material handling equipment] [_____]. Oversize materials shall 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 treatability studies and the field demonstration; and historical data from projects with similar soils, amendments, and contaminants. Diligent process monitoring (e.g., monitoring temperature and controlling moisture content) is fundamental to successful composting. 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 1 Section of some contracts.

Some requirements for sampling and analysis are included below. These paragraphs should be coordinated with Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL to ensure consistent requirements.

Full-scale composting operations shall not be initiated until the Composting Work Plan has been approved, and written approval has been received from the Contracting Officer.

3.6.1 Amendment Storage

NOTE: Manure and vegetable wastes are the primary sources of objectionable odor during composting. After blending manure and vegetable wastes with amendments, objectionable odors will usually dissipate after about 7 to 14 days. It may be allowable to relax the maximum holding time for manure and vegetable wastes, if the site is remotely located and odor control is not an issue.

Depending on amendment selection and other site-specific factors, controls may be necessary to prevent insects and rodents from infesting the amendment storage area.

To minimize odor generation, manure and vegetable wastes shall be delivered to the site not more than [24 hours] [_____] prior to blending of soil and amendments. Any excess manure and vegetable wastes, not blended with soil, shall either be removed from the site not more than [24 hours] [_____] after blending was initiated; or shall be blended with other excess amendments and composted onsite. Excess manure and vegetable wastes shall be disposed of in accordance with regulatory requirements.

3.6.2 Windrow Construction

NOTE: Initial homogenization may be accomplished by layering the raw materials into the shape of a windrow, and then mixing with windrow turning equipment. However, it may be possible to achieve a more thorough mix of the soil and amendments if they are blended in a separate vessel prior to forming windrows. The percentage of soil in the compost mixture should be based on previous composting projects, or preferably bench-scale testing and a field demonstration.

Typical dimensions for compost piles created by self propelled windrow turners are: 1.2 to 2.7 meters (4 to 9 feet) high, and 3.0 to 6.1 meters (10 to 20 feet) wide. However, sufficient temperatures may not be reached unless the initial height of the windrows is at least 1.5 meters (5 feet). The height of the windrows will decrease during treatment.

The following measures shall be taken to prevent freezing of contaminated soil that is scheduled to be composted during sub-freezing conditions: [_____] . The initial height of compost windrows shall be not less than [1.5] [_____] m [5] [_____] feet.

3.6.3 Mixing

NOTE: If irrigation and turning are performed separately, mixing should be performed soon after irrigation to provide for more uniform distribution of moisture.

The frequency of mixing should be related to temperature monitoring. When temperatures exceed 65 degrees C (150 degrees F), mixing may be implemented to cool the pile. If excessively high temperatures cannot be controlled through turning, then the size of the compost windrows may have to be reduced. Low temperatures may indicate that oxygen levels in pore spaces within the pile are insufficient, and that the pile should be mixed. However, excessive mixing may impede the pile from reaching optimal temperatures. Isolated hot or cool spots may indicate the location of incompletely mixed pockets. After optimal temperatures have been maintained for about 10 days, it may be possible to reduce the frequency of mixing without adversely affecting the process. However, frequent and thorough mixing should result in more homogenous compost, and should reduce the variability of chemical data. On a previous project, daily windrow mixing was discontinued after definitive field analysis indicated that cleanup goals had been met. Thus, after about 12 days of mixing, the windrows were allowed to set static until after data from compliance samples was received. Even if mixing is discontinued, temperature and moisture content monitoring should continue.

Unless otherwise indicated, the compost pile shall be thoroughly mixed each day. Mixing shall be performed at least once per day, for at least [10] [_____] days. Additional mixing may be required in response to process monitoring; for example, to control temperature, odor and to provide additional aeration.

3.6.4 Moisture Control

NOTE: The potential for spontaneous combustion will increase as the moisture content falls below optimum levels. The water content at saturation will vary depending on what raw materials were used in the compost. 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. The recommended moisture content for composting is between 40 and 65 percent of the moisture content at field capacity.

The procedure shown in USAEC CETHA-TS-CR-93043 has been used to determine the field capacity of compost for previous projects. Because the field capacity will change as the compost matures, periodic testing for field capacity should be required. Finally, a crude indicator of proper moisture content has been described as follows: the compost should feel moist, but not so moist that free water is released when squeezed by the hand.

3.6.4.1 Moisture Content and Field Capacity Testing

Immediately after initiating treatment of each batch of compost, a minimum of one representative, composite sample per each [69] [_____] cubic meters [90] [_____] cubic yards of compost shall be tested to determine percent moisture (by weight), the moisture content at field capacity. Field capacity testing shall be performed every Monday for the first [4] [_____] weeks and [every two weeks] [_____] , thereafter. Testing for moisture content shall be performed every Monday, Wednesday, and Friday the first [4 weeks] [_____] and [every Monday and Friday] [_____] thereafter.

3.6.4.2 Irrigation

NOTE: Factors influencing irrigation water requirements include the initial moisture content of the soil and amendments, and the climate. A tank truck or a water storage tank may be necessary if a local water source (e.g., surface water body) is not available; see paragraph Storage Volume.

When testing indicates that the moisture content is below [40] [_____] percent of the moisture content at field capacity, the moisture-deficient portions of each windrow shall be irrigated. The water application rate shall be measured. The application rate, duration of the irrigation period, and volume of water applied shall be recorded. Sufficient irrigation shall be provided to bring the moisture content to within the acceptable limits in not more than [48] [_____] hours. Irrigation and mixing shall be synchronized so that water is distributed uniformly throughout the windrows. Irrigation shall be immediately ceased if ponded water is observed near any windrow; the time, date, and location of the ponded water shall be recorded in the [Operations Report](#), and the ponded water shall be removed.

3.6.4.3 Contact Water Testing

Contact water, to be reused as irrigation water, shall be tested for pH and conductivity on the [first,] [second,] [_____] and [fourth] [_____] week after initiating treatment of each batch of compost. 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 shall 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 shall be withdrawn from the contact water holding vessel, or the water in the holding vessel shall be directly tested by immersing the instrument probe in the contact water.

3.6.5 Temperature

NOTE: Temperature is indicator of microbial activity, and one of the most important parameters for monitoring the composting process. The temperature of windrows should be monitored immediately before and after mixing. The temperature range for the thermophilic stage of composting is usually considered to be between 43 and 65 degrees C (110 and 150 degrees F), preferably between 54 and 60 degrees C (130 and 140 degrees F). When temperatures continue to increase past 71 degrees C (160 degrees F), microbes become dormant or die. See paragraph Mixing regarding control of excessively high temperatures. The temperature of a compost pile will gradually stratify after mixing. The highest temperatures may be observed in the outer layer of the pile.

3.6.5.1 Temperature Probe Calibration

Temperature probes shall have a range from [0] [] to at least [100] [] degrees C [32] [] to at least [212] [] degrees F. Probes shall be calibrated by taking readings in an ice bath, and in boiling water. Each temperature probe shall be uniquely marked for identification, and calibrated prior to use. Readings from each probe shall be recorded with each calibration event, before and after calibration, and the identifier on the temperature probe shall also be recorded.

3.6.5.2 Temperature Monitoring

The temperature of the windrows shall be tested each day immediately before and after mixing. The temperature shall be monitored at a minimum of [2] [] locations, per [23] [] cubic meter [30] [] cubic yard section of compost. The temperature, time, and monitoring location shall be recorded during each monitoring event. The depth and location of each temperature reading shall be recorded. Ambient air temperatures in the treatment area, and the time of monitoring shall be recorded daily.

3.6.6 Compost pH

NOTE: The pH should usually be maintained between 5.5 and 9, preferably between 6.5 and 5.5 standard units. Excessive volatilization of ammonia may result if the pH exceeds 5.5. However, it is usually unnecessary to adjust the pH during composting; and use of pH adjusting agents (e.g., lime) may be detrimental to the process.

At a minimum, the pH of the compost shall be tested each Monday and Friday on the [first, second, and third] [] week after initiating treatment of each batch of compost, and [each Monday] [] thereafter until treatment criteria has been met for contaminants of concern. Testing the pH of compost shall be performed in accordance with paragraph Non-Standard Test Requirements for Composting.

3.6.7 Odor Control

NOTE: Odor is an important indicator of the condition of a compost pile. Strong putrid odors usually indicate that anaerobic conditions are present, and that mixing (aeration) may be necessary for the pile from which odors are arising. Strong odors may also indicate that the pile, or a portion of the pile is too wet. Excessive ammonia odors may indicate that the C:N ratio of the compost recipe is too low, and/or that the pH is too high. Odors will usually be generated during the following activities: amendment delivery and storage; blending of soil and amendments; and during the composting process, including during mixing. See paragraph Amendment Storage for more information.

The presence or absence of odors in the treatment facility shall be monitored and recorded [each day] [____], for not less than [5] [____] days of each week. If objectionable odors are detected, the following shall 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, described and recorded the odor. If, in the opinion of the Contracting Officer, there is a persistent problem with objectionable odors that has not been properly addressed, the Contractor will be notified to implement measures to reduce odor levels. Odor control measures shall be implemented not more than [24] [____] hours after notification from the Contracting Officer.

3.6.8 Oxygen

NOTE: The concentration of oxygen in the air spaces within the compost pile should typically be greater than 5% by volume (the concentration of oxygen in air is approximately 21% by volume). Oxygen levels will continually decrease after each mixing event as aerobic microorganisms consume oxygen. If used, oxygen monitoring should be performed at regular intervals, after each mixing event. Usually, temperature monitoring is adequate to control the composting process, and oxygen monitoring is unnecessary.

Regularly scheduled monitoring of interstitial oxygen levels will not be required. However, oxygen monitoring may be used as a diagnostic, or trouble-shooting tool. If oxygen monitoring is performed, the monitoring location, the time of the last mixing event, and the time of each oxygen monitoring event shall be recorded.

3.6.9 Non-Standard Sampling and Analysis

NOTE: Analytical methods for other testing should be specified in Section 01 35 45.00 10 CHEMICAL DATA

QUALITY CONTROL. This paragraph only contains methods for relatively uncommon tests, and tests that are unique to composting. Field capacity may also be determined via ASTM D 6836 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.

As alternatives to the Dewar self-heating test, respiration tests may be used to determine the maturity of compost. The text, The Science of Composting, by Epstein, 1997, provides compost stability index values for respiration testing (both for oxygen uptake, and carbon dioxide evolution). ASTM D 5975 also uses oxygen consumption to assess compost maturity. Depending on the planned end use for the compost, some tests shown in this paragraph may not be necessary and should be deleted.

Testing compost for field capacity (or water holding capacity) shall be performed in accordance with section 3.8.1 (Moisture Monitoring) of USAEC CETHA-TS-CR-93043. Testing compost for pH and conductivity (soluble salts) shall be performed in accordance with NRAES 54, Chapter 3 (Raw Materials), the Saturated Paste Method. [The Dewar self-heating test for compost maturity shall be performed in accordance with BIOCYCLE] [_____].

3.6.10 Sampling and Analysis for Contaminants of Concern

NOTE: Under some conditions, it may be more cost-effective to use definitive field analysis (e.g., immunoassay or colorimetric methods), than to require laboratory analysis for all contaminants of concern. However, it may also be necessary to develop a site-specific correlation between data from field, and laboratory analysis. Pigmented materials present in extracts from compost samples may cause interferences in colorimetric, definitive field analysis. For more information see EPA 540 R-97/501, Field Sampling and Selective On-Site Analytical Methods for Explosives in Soil. Laboratory analysis should be required on a minimum percentage of samples to verify data from definitive field analysis.

Collecting samples from the edges and outer surface of the pile should be avoided, since these locations may not be representative of the bulk of the pile. The strategy for sampling and analysis should be consistent with the regulatory requirements for the data. States may impose more restrictive sampling requirements than those under Federal regulations. Compliance testing requirements are usually project specific, and based on negotiations with regulatory officials.

Sampling and analysis shall be in accordance with Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL. Results from each sampling event shall be furnished to the Contracting Officer not more than [24] [_____] hours after data is recorded by the Contractor, or released by the laboratory.

3.6.10.1 Sampling Frequency and Locations for Pre-Compliance Testing

NOTE: This is an example of a pre-compliance testing protocol used during a previous composting project, and should be applicable to projects where definitive field analysis will be used.

At a minimum, sampling shall be conducted two times during treatment of each batch: (1) immediately after initial blending of soil and amendments; and (2) at the estimated time at which the cleanup levels will have been met (based on the results of the field demonstration). To determine locations of sampling stations, the windrows shall be divided into sections. Each section shall be a maximum [23] [_____] cubic meters [30] [_____] cubic yards. Each section shall include one sampling station. Sampling stations shall be represented by vertical planes that transverse the width of the windrow. Samples shall be collected from a minimum of [4] [_____] , separate locations within each sampling station. Samples from each sampling station shall be [composited prior to testing] [_____] .

3.6.10.2 Pre-Compliance Testing

NOTE: Definitive field analysis methods have been used for pre-compliance testing during previous composts projects.

Testing for the following analytes shall be performed during pre-compliance testing: [_____] . Testing shall be conducted using the method specified in Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL for pre-compliance testing.

3.6.10.3 Confirmation of Attainment of Treatment Criteria

NOTE: Various methods of statistical analysis may be used to determine if treatment criteria has been attained. For example, after treatment of each batch is completed, the Contractor may be required to show that the mean of the data for each batch is below a specified value, and/or that the upper 95th percentile of the data for each batch is below a specified value. Although the following EPA reference describes procedures for determining whether a specified percentile of material is less than a cleanup standard (EPA 230/02-89-042, Methods of Evaluation and Attainment of Cleanup Standards), it may not be practical to implement this type of requirement. One alternative is to establish "ceiling" values for each contaminant of concern. Thus, in addition to requiring that the mean of the

data for each batch be below a specified value, there may be a requirement that "single-sample" values shall not exceed a pre-determined ceiling value. Use of ceiling values may eliminate the need for statistical analysis of data by construction QA representatives. There should be a statistical basis for ceiling values, and the basis for establishing ceiling values should be proposed early-on in design (e.g., in the design analysis report). Establishing ceiling values for contaminants of concern should be project specific, and based on negotiations with regulatory officials. The contract should be written so that the Contractor has a clear and consistent basis for determining the amount of sampling and analysis that will be required. See the following reference for more information on sampling and analysis: EM 200-1-3, Requirements for the Preparation of Sampling and Analysis Plans.

Treatment criteria should be specified on a "per-batch basis" so that the Contractor will be free to proceed with treating subsequent batches after the data from each batch has been received. This paragraph should be coordinated with paragraph, Treatment Criteria for Composted Soil. This is only an example of compliance testing requirements, based on a contract from a previous composting project.

After pre-compliance testing indicates that a batch of compost has met treatment criteria, and written approval has been received from the Contracting Officer, compliance sampling shall be performed. To determine sampling locations, the windrows shall be divided into sections. Each section shall be a maximum [23] [] cubic meters [30] [] cubic yards. Two discrete samples, collected from randomly selected locations within each section, shall be tested. If the samples collected for analysis contain rock or gravel, this material shall be separated from the rest of the sample. The rock and gravel shall be crushed to the appropriate size, recombined with the rest of the sample (using a sample splitter to assure sample homogeneity), and the entire sample shall be homogenized. Testing shall be conducted using the method specified in Section 01 35 45.00 10 CHEMICAL DATA QUALITY CONTROL for compliance testing. The mean of the data for each batch of compost shall be less than the level shown for each contaminant, in paragraph Treatment Criteria for Composted Soil. Submit Treatment Completion Records as specified.

3.6.11 Post-Treatment Procedure

NOTE: If treatment criteria for contaminants of concern have been met, but criteria for re-use (see paragraph Treatment Criteria and Criteria for Reuse of Composted Soil, in PART 1) have not been met, the compost should either remain on the treatment pad, or be moved to a curing/storage area.

After compliance test data indicates that treatment criteria have been met,

and written approval from the Contracting Officer has been received, the treated material may be removed from the treatment pad, at the Contractor's option.

3.6.12 Procedure for Non-Attainment of Treatment Criteria

If the treatment criteria is not achieved, implement corrective action at no additional cost. The corrective action may include: additional sampling to provide more data points for statistical analysis; or continued treatment. If there are portions of compost 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 portions of the compost. The report shall 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 portions of the compost where treatment criteria were not met. Obtain written approval from the Contracting Officer prior to implementing measures that deviate from the Composting Work Plan. Continue monitoring (at no additional cost, and in accordance with paragraphs OPERATION, MAINTENANCE AND PROCESS MONITORING, above), until the treatment criteria is attained.

3.6.13 Curing and Storage

NOTE: The dimensions of the curing and storage area should be based on the amount of time required for curing, the amount of time that cured compost will remain in storage, and the dimensions of curing and storage piles. The volume of treated material will usually be less than the initial volume of the compost (see paragraph Disposal, below). The compost is usually allowed to cure until after the following has been observed: the high temperature (43 to 65 degrees C) stage of the process has been completed; the temperature has fallen back to about 38 degrees C or less; and the windrows no longer heat-up after turning. The On-Farm Composting Handbook recommends curing for at least one month. Immature, or improperly cured compost may be detrimental to plants. Properly cured compost should have no objectionable odor. Although it is usually unnecessary to turn compost during curing, the compost should remain aerobic. Thus, the size of the piles should be limited. During curing and storage, the potential for spontaneous combustion and development of anaerobic conditions (or souring) increases as the dimensions of the compost piles increase. On a previous composting project, a cellulose tackifying agent was used to prevent the wind from dispersing treated compost. Only readily biodegradable tackifying agents should be used.

The slope of the surface of the areas for curing and storage shall be not less than [2 percent] [_____]. The surfaces of areas for curing and storage shall be well drained, and kept free of standing water at all times. If anaerobic conditions develop during curing or storage, the compost shall be remixed, spread on a covered, dry surface, and allowed to

aerate for at least 24 hours before reforming the piles.

3.6.14 Post-Treatment Screening

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

Wood chips or other materials whose size exceeds the maximum acceptable size for the intended end use shall be separated from the finished compost prior to disposal.

3.7 DISPOSAL

NOTE: Depending upon the characteristics and quantities, the potential disposal scenarios for wastes may include: onsite treatment and backfilling; partial onsite backfill and partial offsite disposal; and offsite disposal. Asphalt surfaces may be removed and sent offsite for recycling. One disposal scenario for each type of waste should be clearly defined.

After treatment, a volume decrease of approximately 50% may be observed for compost that originally contained 30% soil and 70% amendments. If the compost will be applied as a soil amendment, the following indices should meet quality guideline standards: pH, the Dewar self-heating test, conductivity, maximum particle size, foreign material content, and the levels of heavy metals. In addition, the plan for final disposition of the compost should take into account the conductivity, maximum particle size, foreign material content, and the levels of heavy metals in the untreated soil to assess if the final product will be suited for the desired end use. See the On-Farm Composting Handbook for more on quality guidelines for different end uses of compost; also, see paragraph Treatment Criteria and Criteria for Reuse of Composted Soil, in PART 1. According to the On-Farm Composting Handbook, if the end use for compost will be as a soil amendment, the compost application rate should not exceed 3 cubic meters per 92.9 square meters (4 cubic yards per 1000 square feet).

Compost that has met treatment criteria [and criteria for reuse] shall be disposed of in accordance with regulatory requirements. The following materials shall be treated, if necessary, and disposed of on-site: [oversize materials] [sludge resulting from treatment of contact water] [excess amendments] [and] [_____]. The following materials shall be treated, if necessary, and disposed of off-site: [spent personal protective equipment] [spent granular activate carbon] [and] [_____]. Offsite disposal of hazardous material shall be in accordance with Section

3.8 DEMOBILIZATION

NOTE: A separate table should be prepared if criteria for soils below the treatment pad, or other areas of the treatment facility, differs from criteria in Tables 1 and 2. This paragraph should be edited appropriately if it is desired to retain portions of the composting treatment facilities after project completion. This paragraph should also be coordinated with Division 1 Sections of the contract.

Demobilization shall restore the site to its initial state, prior to the construction and operation of the composting treatment facilities. Demobilization shall not commence until written approval is received from the Contracting Officer. Demobilization shall include, but shall not be limited to: [removal of structures and materials used to house or cover the compost piles,] [disconnecting of utility service lines,] [decontamination and removal of equipment and materials,] [disposal of decontamination wastes,] [disposal of any residual wastewater,] [removal of unused amendments and other materials,] [removal of material overlying liners,] [removal of liners,] [regrading and removal of berms,] [demolition and disposal of the treatment pad, other foundation slabs, and paved surfaces,] [_____]. [Post-treatment testing of soils below work area surfaces shall be performed (after the liners or pavement have been removed), to verify that the area is not contaminated. These soils shall meet the following criteria: [treatment criteria in accordance with paragraph Treatment Criteria for Composted Soil.] [_____]].

-- End of Section --