# Appendix C

## Soil Amendments

## C.1 General Description

Soil amendment (also called soil restoration) is a technique applied after construction, to deeply till compacted soils and restore their porosity by amending them with compost. This can reduce the generation of runoff from compacted urban lawns and may also be used to enhance the runoff reduction performance of impervious surface disconnections, grass channels, and filter strips.

## C.2 Physical Feasibility & Design Applications

Amended soils are suitable for any pervious area where soils have been or will be compacted by the grading and construction process. They are particularly well suited when existing soils have low infiltration rates (HSG C and D) and the pervious area will be used to filter runoff. The area or strip of amended soils should be hydraulically connected to the stormwater conveyance system. Soil restoration is recommended for sites that will experience mass grading of more than a foot of cut and fill across the site.

Soil amendments are not recommended where:

- Existing soils have high infiltration rates (e.g., HSG A and B), although compost amendments may be needed at mass-graded B soils in order to maintain runoff reduction rates;
- The water table or bedrock is located within 1.5 feet of the soil surface;
- Slopes exceed 10%;
- Existing soils are saturated or seasonally wet;
- They would harm roots of existing trees (keep amendments outside the tree drip line);
- The downhill slope runs toward an existing or proposed building foundation; and
- The contributing impervious surface area exceeds the surface area of the amended soils.

Soil amendments can be applied to the entire pervious area of a development or be applied only to select areas of the site to enhance the performance of runoff reduction practices. Some common design applications include:

- Reducing runoff from compacted lawns,
- Enhancing rooftop disconnections on poor soils,
- Increasing runoff reduction within a grass channel,
- Increasing runoff reduction within a vegetated filter strip, and
- Increasing the runoff reduction function of a tree cluster or reforested area of the site.

## C.3 Design Criteria

### C.3.1 Soil Testing

Soil tests are required during two stages of the compost amendment process. The first testing is done to ascertain pre-construction soil properties at proposed amendment areas. The initial testing is used to determine soil properties to a depth 1 foot below the proposed amendment area, with respect to bulk density, pH, salts, potential drainage problems and determine what, if any, further soil amendments are needed.

The second soil test is taken at least one week after the compost has been incorporated into the soils. This soil analysis should be conducted by a reputable laboratory to determine whether any further nutritional requirements, pH adjustment, and organic matter adjustments are necessary for plant growth. This soil analysis should be done in conjunction with the final construction inspection to ensure tilling or subsoiling has achieved design depths.

### C.3.2 Determining Depth of Compost Incorporation

The depth of compost amendment is based on the relationship of the surface area of the soil amendment to the contributing area of impervious cover that it receives. Table C.1 presents some general guidance derived from soil modeling by Holman-Dodds (2004) that evaluates the required depth to which compost must be incorporated. Some adjustments to the recommended incorporation depth were made to reflect alternative recommendations of Roa Espinosa (2006), Balousek (2003), Chollak and Rosenfeld (1998) and others.

**Table C.1: Short-cut Method to Determine Compost and Incorporation Depths.**

| | Contributing Impervious Cover to Soil Amendment Area Ratio[1] | | | |
|---|---|---|---|---|
| | IC/SA = 0[2] | IC/SA = 0.5 | IC/SA = 0.75 | IC/SA = 1.0[3] |
| **Compost (in)**[4] | 2 to 4[5] | 3 to 6[5] | 4 to 8[5] | 6 to 10[5] |
| **Incorporation Depth (in)** | 6 to 10[5] | 8 to 12[5] | 15 to 18[5] | 18 to 24[5] |
| **Incorporation Method** | Rototiller | Tiller | Subsoiler | Subsoiler |

*1 IC = contrib. impervious cover (sq. ft.) and SA = surface area of compost amendment (sq. ft.)*
*2 For amendment of compacted lawns that do not receive off-site runoff*
*3 In general, IC/SA ratios greater than 1 should be avoided*
*4 Average depth of compost added*
*5 Lower end for B soils, higher end for C/D soils*

Once the area and depth of the compost amendments are known, the designer can estimate the total amount of compost needed using the following estimator equation:

**Equation C.1 Compost Quantity Estimation:**

**C = A * D * 0.0031**

*Where:*

**C** = compost needed (cu. yds.)

**A** = area of soil amended (sq. ft.)

**D** = depth of compost added (in.)

## C.3.3 Compost Specifications

The basic material specifications for compost amendments are outlined below:

- Compost shall be derived from plant material and provided by a member of the U.S. Composting Seal of Testing Assurance (STA) program. See www.compostingcouncil.org for a list of local providers.
- The compost shall be the result of the biological degradation and transformation of plant-derived materials under conditions that promote anaerobic decomposition. The material shall be well composted, free of viable weed seeds, and stable with regard to oxygen consumption and carbon dioxide generation. The compost shall have a moisture content that has no visible free water or dust produced when handling the material. It shall meet the following criteria, as reported by the U.S.

Composting Council STA Compost Technical Data Sheet provided by the vendor:

a. 100% of the material must pass through a half inch screen
b. The pH of the material shall be between 6 and 8
c. Manufactured inert material (plastic, concrete, ceramics, metal, etc.) shall be less than 1.0% by weight
d. The organic matter content shall be between 35% and 65%
e. Soluble salt content shall be less than 6.0 mmhos/cm
f. Maturity should be greater than 80%
g. Stability shall be 7 or less
h. Carbon/nitrogen ratio shall be less than 25:1
i. Trace metal test result = “pass”
j. The compost must have a dry bulk density ranging from 40 to 50 lbs./cu.ft.

# C.4 Construction and Maintenance

## C.4.1 Construction Sequence

The construction sequence for compost amendments differs depending on whether the practice will be applied to a large area or a narrow filter strip, such as in a rooftop disconnection or grass channel. For larger areas, a typical construction sequence is as follows:

**Step 1.** Prior to building, the proposed area should be deep tilled to a depth of 2 to 3 feet using a tractor and sub-soiler with two deep shanks (curved metal bars) to create rips perpendicular to the direction of flow. (This step is usually omitted when compost is used for narrower filter strips.)

**Step 2.** A second deep tilling to a depth of 12 to 18 inches is needed after final building lots have been graded.

**Step 3.** It is important to have dry conditions at the site prior to incorporating compost.

**Step 4.** An acceptable compost mix is then incorporated into the soil using a roto-tiller or similar equipment at the volumetric rate of 1 part compost to 2 parts soil.

**Step 5.** The site should be leveled and seeds or sod used to establish a vigorous grass cover. Lime or irrigation may initially be needed to help the grass grow quickly.

**Step 6.** Areas of compost amendments exceeding 2,500 square feet should employ simple erosion control measures, such as silt fence, to reduce the potential for erosion and trap sediment.

## C.4.2 Construction Inspection

Construction inspection involves digging a test pit to verify the depth of mulch, amended soil and scarification. A rod penetrometer should be used to establish the depth of uncompacted soil at one location per 10,000 square feet.

## C.4.3 Maintenance Criteria

**Maintenance Agreements.** When soil amendments are applied on private residential lots, homeowners will need to be educated on their routine maintenance needs, understand the long-term maintenance plan, and be subject to a deed restriction or other mechanism enforceable by the local stormwater program to ensure that infiltrating areas are not converted or disturbed. The mechanism should, ideally, grant authority for local agencies to access the property for inspection or corrective action. In addition, the GPS coordinates for all amended areas should be provided upon facility acceptance to ensure long term tracking.

A simple maintenance agreement should be provided if soil restoration is associated with more than 10,000 square feet of reforestation. A conservation easement or deed restriction, which also identifies a responsible party, may be required to make sure the newly developing forest cannot be cleared or developed management is accomplished (i.e., thinning, invasive plant removal, etc.). Soil amendments within a filter strip or grass channel should be located in a public right-of-way, or within a dedicated stormwater or drainage easement.

**First Year Maintenance Operations.** In order to ensure the success of soil amendments, the following tasks must be undertaken in the first year following soil restoration:

- *Initial inspections.* For the first six months following the incorporation of soil amendments, the site should be inspected at least once after each storm event that exceeds 1/2-inch of rainfall.
- *Spot Reseeding.* Inspectors should look for bare or eroding areas in the contributing drainage area or around the soil restoration area and make sure they are immediately stabilized with grass cover.
- *Fertilization.* Depending on the amended soils test, a one-time, spot fertilization may be needed in the fall after the first growing season to increase plant vigor.
- *Watering.* Water once every three days for the first month, and then weekly during the first year (April-October), depending on rainfall.

**Ongoing Maintenance.** There are no major on-going maintenance needs associated with soil amendments, although the owners may want to de-thatch the turf every few years to increase permeability. The owner should also be aware that there are maintenance tasks needed for filter strips, grass channels, and reforestation areas.

## REFERENCES

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