Guidelines for Landscaping with Compost-Amended Soils

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Executive Summary

The *Guidelines for Landscaping with Compost-Amended Soils* provide direction for the incorporation of compost as a soil amendment prior to vegetation establishment. Primary focus is placed on amending soil types found in the City of Redmond and the Puget Sound Area, and planting this amended soil with turf. Turf establishment was focused on because most landscapes in these urban and suburban areas primarily consist of turf. Turf areas are a major contributor to stormwater runoff with high concentrations of fertilizers and pesticides, and also have a high summer irrigation demand.

Amending a soil with compost increases the soil's permeability and water holding capacity, thereby delaying and often reducing the peak stormwater run-off flow rate, and decreasing irrigation water requirements. Amending soils will also enhance the lawn's long-term aesthetics while reducing fertilizer and pesticide requirements.

The benefits of increasing a soils organic content have previously been established through research, however, traditional lawn installation procedures continue in new developments. As a means to promote the use of soil amendments, the *Guidelines for Landscaping with Compost-Amended Soils* were developed. These guidelines:

(1) address the benefits associated with turf grown on compost-amended soil,
(2) describe factors to be considered and the procedures to be followed,
(3) provide a cost analysis of compost amending over traditional lawn installation procedures,
(4) project the payback-period for turf grown on compost-amended soil, and
(5) address how compost-amendment improves soil quality.

To maximize the benefits of compost addition, these guidelines set an amended soil organic content goal of between eight and thirteen percent, by weight. As a general rule of thumb this goal can be achieved by incorporating two units of loose soil with one unit of loose compost (a 2:1 ratio). Final depth of amended soil will be between eight and ten inches, dependent upon the equipment used.

The projected payback periods have been calculated for turf grown on compost-

amended soil versus the most common variations of lawn installation methods currently practiced. The calculations were performed with an economic model that used projected City of Redmond peak summer water rates, fertilizer, and turf installation costs. Additional environmental benefits achieved by soil-amending were excluded from the model. Results show that turf grown on tilled compost-amended soil by hydroseed application (*TCT*–seed) pays for itself:

(1) Between the fifth and sixth year when compared to topsoil-seed,
(2) During the first year when compared to topsoil-sod,
(3) Between the sixth and seventh year when compared to minimum-seed, and
(4) Between the second and third year when compared to minimum-sod.

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Chapter I: Introduction

I.A Introduction

This report has been prepared on behalf of the City of Redmond Public Works. It provides guidance for the incorporation of compost as a soil amendment for turf establishment and landscaping. Furthermore, this report: (1) addresses the benefits associated with turf grown on compost-amended soil, (2) describes the installation process, (3) examines the direct costs of compost amendment, (4) projects the payback-period for turf grown on compost-amended soil, and (5) addresses the soil quality issues associated with compost-amended soil

Compost-amended soil has many potential benefits when instituted with establishment of turf and landscaping, including: (1) increased water conservation, (2) increased nutrient retention, (3) better turf aesthetics, (4) reduced need for chemical use, (5) improved stormwater retention, and (6) cost-savings to the private landowner, and, the City of Redmond.

Compost is aerobically decomposed organic waste and it has a long history of use as an agricultural soil amendment. Now, as urban and suburban communities are taking up more of the landscape, compost is being reassessed as a tool for improving the overall soil quality within these environments.

The quantity of compost to be incorporated into as site is determined by the final organic content goal for the soil. These guidelines are established based on an organic content goal between eight and thirteen percent. Although these guidelines specifically address soil amending for turf establishment, other landscaping vegetation would benefit from these procedures.

I.B Geologic History of Redmond, Washington; Soil Compaction, and Organic Matter

The most recent glaciation in the Puget Sound occurred approximately 15,000 years ago. The glaciers were massive sheets of ice with a thickness of more than 5,000 feet. As the glaciers advanced, the topsoil in the region was scoured away, while the phenomenal weight of the glaciers compacted the remaining soil. The remaining soil, which extends beneath 60 to 70 percent of the Redmond area, is called glacial till. Glacial till contains little organic matter and is nearly impermeable. The soil profile predominantly composed of till is called an Alderwood soil series; it is generally found on slopes from 0 to 70 percent in elevations of 100 to 800 feet. The upper three feet of the soil profile soils have naturally developed into gravely sandy loam with an organic content of four to six-percent. The gravely sandy loam layer, however, is usually removed during construction practices to expose the underlying layer of compacted glacial till.

Glacial tills possess physical properties that are poor for turf establishment and plant livability. These soils are often compacted with a high bulk density (expresesed as the dry weight of soil per the *in situ* volume of soil) exceeding 2700 pounds per cubic yard (1.6 grams per cubic centimeter). A typical non-glaciated (therefore non-compacted) sandy soil often has a bulk density of 2020 pounds per cubic yard (1.2 grams per cubic centimeter) and provides a much superior medium for turf establishment. Compacted soils restrict root penetration, impede water infiltration, and contain few macropore spaces needed for adequate aeration.

Incorporation of organic matter such as compost improves the structure (tilth) of the till and any other soil types, with the exception of soils that are already highly organic. For example, in till soils compost will keep the micro and macro pores open until allowing roots to penetrate and air and water to circulate. In sandy soils, compost increases the water holding capacity and nutrient retention. Therefore, the physical and chemical properties of most Redmond soils can be significantly improved by blending in compost as described in Chapter II.

I.C Water Conservation

The term "moisture holding capacity" indicates the amount of water a soil can hold, while the term "moisture retention capacity" refers to the length of time a soil can retain water (Epstein *et al.* 1976). Both properties are greater in soils with large amounts of organic matter or clay particles. Water is held in the soil by capillary force and is released as a result of forces such as gravity, root uptake and evaporation. Numerous studies have found an increase in the moisture holding capacity and moisture retention capacity of soil as a result of compost applications (Hortenstine and Rothwell, 1972; Bengston and Cornette, 1973; Epstein *et al.*, 1976). Therefore, the incorporation of compost into the soil of turf sites will reduce the need to irrigate. Water savings resulting from compost-amendment vary from location to location due to the many variables associated with turf including soil type, grass species, slope, aspect, climate, wind exposure and irrigation practices at each site. Typical water savings potentials have been estimated from experienced landscapers in the Redmond area. This data has been used in an economic model (Chapter IV) to project the payback period for turf grown on compost-amended soil. For instance, on a typical site in Redmond with little slope, and little wind, turf grown on compost-amended soil can reduce peak summer irrigation needs by 60% when compared to sites with unamended topsoil.

I.D Fewer Fertilizer Applications

Compost is more valuable as a source of organic matter than as a source of nutrients. However, compost can supply all of the nutrients necessary for turf growth and development for an entire year and possibly longer (Landshoot, 1996). More importantly for long-term turf health is organic soil amendments to increase a soil's ability to retain applied fertilizer. Organic matter has a high cation (ions with positive charge) exchange capacity, or ability to bond with positively charged nutrients. While some composts may not contain large quantities of nutrients essential for plant growth, compost amended soils require less fertilization in order to attain the same aesthetic appeal As more fertilizer is added to an unamended-soil, increases in nutrient runoff occur (Harrison *et al.,* 1996).

Finally, compost-amended turf requires less water than unamended-soils due to the higher moisture retention of the organic matter. Reduced water application can result in less nutrient leaching. Conversely, unamended-soils require more water and fertilizer resulting in an increase in nutrient runoff.

I.E Improved Aesthetics

Observing turf plots grown on compost amended and non-amended glacial till soils, Harrison *et al.* (1996) noted that turf grown on compost-amended soil "greened up" more quickly than on unamended-soil during initial turf establishment. He also observed that 100% turf coverage occurred more rapidly in compost amended plots. Furthermore, the long term aesthetic appeal of an amended-soil lawn is sustained naturally by the increased biological activity of biota living within the soil. These life forces in the soil work 24 hours a day providing aeration, material decomposition, and nutrient conversion.

I.F Decreased Pesticide Needs

Given the same growing conditions (light, water), turf grown on compost-amended soil is typically healthier than turf on unamended-soil. The better aeration, reduction of soil compaction, deeper rooting depth, and improved soil structure helps fight undesired turf problems. Healthier turf is generally more tolerant to diseases, weeds insects, and fungus, which should resultin an overall reduction in pesticide utilization (Stahnke, 1997).

I.G Stormwater Retention

Compost-amended turf increases the stormwater retention capacity of a lawn. Typical lawns in the Redmond area provide minimal stormwater retention and act as relatively impervious surfaces for detention facility sizing calculations. Demonstration plots at the University of Washington's Center of Urban Horticulture have shown turf grown on compost-amended-soil reduced peak and total water discharge. Thus, if the future compost-amended soil is used throughout a typical residential development, stormwater runoff from the development, and the subsequent environmental degradation, would be reduced.

I.H Significant Cost-Savings

Turf grown on compost-amended soil has proven to have less summer irrigation demand, improved stormwater retention, improved quality, and improved aesthetics when compared to traditional lawn installation.

Also, turf grown on compost-amended soil is anticipated to yield environmental benefits which havenot been incorporated into an economic model. These benefits include reducing pesticide and fertilizer use and run off, consequently reducing degradation of water quality in Lake Sammamish, other receiving water bodies, and area ground water aquifers. Further research must be conducted in the Redmond area to address these issues (See Chapter V – Soil Quality Issues).

I.I Conclusion

In conclusion the proven benefits in Redmond resulting from compost-amended soil versus glacial till-based soil include:

(1) reduced summer irrigation demand,
(2) reduces stormwater runoff, thereby reducing erosion
(3) improved soil quality, and
(4) improved turf aesthetics.

Other potential environmental benefits of turf grown on compost-amended soil versus till-grown turf include:

(1) reduced pesticide use and run off,
(2) reduced fertilizer consumption and runoff,
(3) reduced-degradation of water quality in Lake Sammamish and other water bodies,
(4) reduced-degradation of ground water aquifers,
(5) reduced degradation of watersheds,
(6) cost-savings to homeowners and the City of Redmond.

Chapter II: Installation of Soil Amendments

This chapter provides details for amending a soil with compost. Lawns established by this process are termed *Tilled Compost-Amended Turf (TCT).* A *TCT* is set apart from other lawns because it results in a eight to ten-inch soil base having an organic content between 8 and 13 percent, by weight. Organic content is defined as the weight of organic matter divided by the weight of mineral soils. This report will discuss the proposed soil amending and turf establishment procedures and site preparation.

The *TCT* procedure is also recommended for use in other landscaped features such as ornamental vegetation and flowerbeds. The maximum benefits of incorporating compost are achieved by amending the entire site, regardless of the vegetation to be planted. Nutrient requirements for non-turf vegetation, however, may be different than those identified in these turf establishment guidelines.

II.A Site Plan Preparation

Prior to soil preparation and lawn installation, a site evaluation must be made. Of primary importance is documenting the presence of natural features such as steep slopes, large vegetation, stream corridors wetlands, and shaded areas. The landscape practitioner must establish any special precautions that are necessary for these concerns. Estimates of the change in soil depth are necessary to determine grading elevations. Recommendations and guidelines for frequently experienced situations follow.

II.A.1 Potential Concerns: Poorly Draining Sites and Steep Slopes

Increasing the organic content of a soil increases the ability of the soil to hold moisture. Concern has been expressed, however, that the increased water holding capacity of an amended lawn could have a potential drawback if the site's underlying soil does not drain well, or the area to be landscaped is on a steep slope.

II.A.1.a Poorly Draining Sites

Readily draining soil is necessary for turf to survive in amended or non-amended soils. If the site being considered for turf establishment is does not drain well, an alternative to planting a lawn should be considered. If the site is acceptable for traditional lawn installation, however, a compost-amended soil lawn will also drain equally well, if not better, presuming the landscape professional provides a drainage route (see II.C Subsurface Collection Systems).

At the University of Washington's Center for Urban Horticulture, post-storm-event monitoring of glacial till plots which were amended with varying degrees of compost has demonstrated enhanced drainage of amended soil compared to non-amended soil (Burges, 1997). Kolsti (1995) observed the high degree of saturation in compost amended plots is not sustained once the precipitation has stopped. These plots, which are on a five-percent slope, suggest that drainage problems would not be a problem in freely draining amended soil.

If the site is not freely draining, and turf placement is still being attempted, compost addition in excess of 30 percent by volume should not be incorporated. This upper limit is suggested in the Pacific Northwest because winter's extended saturated conditions may create water logging of the lawn (Stahnke, 1997). Saturated soils are easily compacted loosing aeration, and creating a poor rooting environment reversing any desired improvements.

II.A.1.b Steep Slopes

With regard to steep slopes, increased soil instability could potentially result from the increasing the moisture content of amended soils. Observations of amended sites, however, indicate that this concern presents minimal risk. The Washington State Department of Transportation (WSDOT) has been incorporating compost-amendment to almost all of its vegetated sites since 1992. Even at the steepest end of the slopes that they amended (33% slope) they have not experienced problems created by the increased moisture holding capacity of compost amended soils. This observation includes all types of soils encountered in the Puget Sound Lowlands (Bennett, 1997).

In turf areas the slope angle should be minimized to the greatest extent possible, for both stability and lawn maintenance concerns. Geotechnical engineers suggest a maximum slope of 30-percent, provided the site is freely draining. Terracing is recommended to minimize steep slope angle. If the site slope can be altered with retaining walls less than 3 to 4 feet in height, geo-technical engineers are generally not needed. (Retaining walls in excess of 4 feet should always be approved by an engineer.) Any slope that is to remain in excess of this 30-percent threshold should be planted with deep rooting vegetation to aid slope stability. Slopes equal to or in excess of 40 percent with a vertical rise more than ten feet are zoned as sensitive areas by King County's Sensitive Areas Ordinance; geotechnical engineers should always be consulted before any land development in these areas. Rototilling may want to be avoided on these slopes, as erosion becomes a problem.

To provide for a freely draining site, the engineer or landscape practitioner must determine the drainage pattern of the slope and furnish controlled drainage at the outfall of these areas. A subsurface collection system should be installed at the base of each terrace to redirect water away from the retaining structure, if applicable. Subsurface collection systems may also be necessary in low depressions of a non-uniform site, although it is recommended to eliminate these depressional areas through site grading if possible. An appropriate receiving area for the water collected and concentrated by the subsurface drainage system must be provided.

Although few long-term problems are expected as a result of incorporating amendments, extra precaution must be taken in the steeper sloped areas during the soil work and turf installation. Work at these sites should be done during dry weather and early enough in the year to allow vegetation establishment prior to the onset of the wet season and colder temperatures. Non-saturated conditions are desired not only for erosion concerns but also because working with saturated soil is difficult and time consuming as well as destructive to the soil structure, which, in turn, may be detrimental to plant viability by the means mentioned above.

II.A.2 Tree and Shrub Root Considerations

A landscape practitioner must determine how close to a tree or shrub base, and to what depth soil amendment can be performed without root damage. Many landscape practitioners can easily make these determinations based on the tree or shrub type; others, however, may not be as familiar with the vegetation's root structure in which case a professional horticulturist should be consulted.

There are feeder, transport, and stabilization roots. Feeder roots, which uptake the water and nutrients, often lie within the top two to three inches of the soil. The sturdier transport and stabilization roots, that are one-quarter to one-inch in diameter, are usually located four to twelve inches below the soil, spreading radially around the tree or shrub. In many tree species, both of these types of roots extend well beyond the outer limits of the branches, or drip-line; root-spread twice the diameter of the drip-line is not uncommon.

Site development will have some deleterious effect on existing trees and shrubs. As a general rule, avoid disturbance to the soil within the plant's drip-line. Landscape practitioners, however, frequently perform rototilling between the drip line and the outer perimeter of the root-spread area. Although tree or shrub health may initially impacted, most species are able to recover when disturbances are minimal. For soil amendment within three-feet of the drip zone, compost should be worked into the upper three to four-inch depth of the soils, just short of the transport roots, with a hand-tiller or similar tool. Because of the reduced depth of incorporation, amendment quantity will need to be reduced proportionately (see Section II.D.3: Estimating Compost Quantities for guidance). For sites that are being amended with large equipment, smaller sized shrubs are sometimes dug up, the site amended, and then the shrubs replanted.

II.A.3 Estimating Soil Depth and Height Changes

After determining the elevation to which a site must be graded for drainage and other reasons, estimation of the changes in soil depth and height need to be calculated. A final grade of the soil desired ranges between one-half and two inches below the elevation of sidewalks, driveways and other permanent site.

The difference in volume of the dense versus the loose soil condition is determined by the "fluff factor" of the soil. The fluff factor of compacted subsoils in the Puget Sound Area tends to be between 1.3 and 1.4. Rototilling typically penetrates the upper 6 to 8-inches of the existing soil. Assuming only a 6-inch depth is achieved, this depth adjusted by the fluff factor will correspond to a 7.8 to 8.4-inch depth of loose soil. This loose volume will then be amended at a 2:1 ratio of loose soil to compost, corresponding to an imported amendment depth of approximately four inches for this example. In the loose state, both the soil and compost have a high percentage of pore spaces (volume of total soil not occupied by solids). The resulting change in elevation must account for compost settling into void spaces of the loose soil. (Calculations presented in Table II-1 assume 15-percent of the soils' void spaces become occupied by compost particles.) After compost incorporation, the amended site will undergo some degree of compaction by the rolling procedure and the weight of the soil itself Calculation presented below used a compression factor of 1.15 for soils with a 1.3 fluff factor, and 1.2 for soils with a 1.4 fluff factor. The resulting change in elevation for a site amended to a 6-inch depth will be approximately three inches. Additional calculations performed following these same guidelines indicate a site elevation change between 75% and 80% of the imported compost loose depth. Therefore make the finish grade three inches lower than desired final finish grade.

Table II-1: Estimating Soil Depth and Height Changes

Procedure	Calculation	Relative Elevation, Inches
Beginning Elevation		0
Rototill soil to a depth of **6-inches**[a], assuming a **1.4-inch** fluff factor of the soil	Depth achieved by machinery x fluff factor of soil: (**6** x **1.4**) = 8.4 8.4 - 6 = 2.4	+2.4
Add compost, 2 units soil to 1 unit compost, by loose volume	Depth of soil ÷ 2: 8.4 ÷ 2 = 4.2	+4.2
Filling of pore spaces	Depth of loose soil x percentage of pore space filled by compost addition: 8.4 x (-.15) = -1.3	-1.3
Rototill compost into soil and roll site to compact soil, assuming compression factor of **1.2**	(Amended soil depth ÷ compression factor) – amended soil depth: [(11.3 ÷ **1.2**) - (11.3)] = -2.1	-2.1
RESULTING ELEVATION CHANGE	Sum	+3.2
Addition of turf, as sod	½ to ¾ of an inch	+0.5
Addition of turf, as hydroseed	0	0

[a] **Bold** values will change according to individual site conditions.

The actual degree of expansion or compaction exhibited is a function of both existing soil and imported compost properties so it will vary from site to site. If the desired final grade is not met at the fixed points (sidewalk, driveway, etc.) , soil can be redistributed in a mounding fashion to other areas of the lawn as necessary (Survey, 1996).

II.B Installation Schedule Considerations

Grass seed germination requirements often place major constraints on a landscape installer's schedule. However, this is not the only time constraint placed upon the landscaper. The client, either developer or homeowner, also has to consider other time constraints such as the completion of building construction.

II.B.1 Turf Germination Period

The turf establishment period takes between nine and twelve weeks and is determined predominantly by species, soil temperature and moisture conditions. The critical seed germination period of this window, however, is the first two to three weeks. Grass seeds will not germinate if saturated or dry for extended periods, or if the soil or air temperatures are too cold. Seeding is suggested in the Puget Sound Lowlands between April 1 and October 1, dependent upon grass type. Spring applications have the advantage of a decreased watering frequency, but cool evening temperatures result in an extended germination period. Mid-summer applications offer an increased growth rate as a result of the long periods of sunshine, but the need for watering is increased. Late summer seeding has the advantages of the warm ground temperatures, adequate moisture from scattered showers and evening dew, and reduced weed problems.

September is considered the ideal period to seed and establish a lawn for the above mentioned reasons, and also because a September application allows for the longest established lawn growth prior to the time of highest stress to the lawns, July and August. For sites where no irrigation system is to be installed, seeding should be performed between April 1 to April 15, or between August 15 to October 1. Again, September is the preferred month for seeding.

Soil amending can be done almost any time but is discouraged unless immediately followed by turf establishment. Otherwise, rain and wind erosion control measures will be necessary to hold the amended soil in place until it can be vegetated. Additionally, soil amending should not be performed during saturated or frozen soil conditions due to the destruction of the soil structure that occurs.

II.B.2 Site Development Considerations

In residential and commercial developments, the building construction completion date is the primary factor in determining the landscape installer's schedule. Driveways and sidewalk installation generally follow building construction, followed by yard landscaping. Often these two processes overlap.

Landscape practitioners follow a general sequence of events, shown in Table II-2. The first step involves site grading. The construction crew usually performs a rough site grading, but the landscape practitioner is responsible for additional site grading. Grading must accommodate landscaping features, such as ornamental ponds, planting beds, sidewalks, and final grade elevations (see Section II.A.3). Following grading, underdrain systems are usually installed. Irrigation system installation follows soil amending to avoid the potential damage to irrigation heads by rototilling practices.

Table II-2: Landscape Practitioner's Installation Schedule Considerations

Procedure
Initial Site Grading and Building Construction
Driveway and Sidewalk Installation
Site Landscaping
Site Grading to accommodate landscape features
Soil Sample Collection for Analysis
Underdrain and/or other utilities Installation
Soil Development Sequence (See Table II-4)
Irrigation System Installation
Lawn Seeding or Sod placement

Once all site development considerations have been accounted for, the resulting dates of soil work in new developments allows minimal flexibility. The seasonal conditions apparent at the onset of landscaping work will determine if the desired lawn installation schedule can be maintained. As discussed above, the primary seasonal scheduling constraint of lawn installation is the growing conditions needed for seed germination.

II.B.3 Retrofit of existing lawns

The beneficial properties offered by an amended soil are not reserved to new site development only; soil amendment can be utilized when replacing an existing lawn. Retrofitting existing lawns allows more flexibility to the landscape practitioner because the site is not subjected to the same time constraints discussed above for new development. The ideal months for lawn installation, early September or May, should be the target date of lawn retrofits.

There are two methods of dealing with existing grass and moss prior to incorporation of a composted amendment: removal from the site, or incorporation into existing soil. Removing the turf from the site is recommended procedure. The grass or moss can be removed from the site most efficiently by using a sod cutter, which is a piece of equipment specifically designed for removing turf; most equipment rental locations rent sod cutters. Atleast two weeks before cutting the sod, grass should be sprayed with nonselective herbicide. Once the grass is removed, amending the soil should proceed as if installing a lawn at a new site. The other option for lawn retrofits, incorporating the grass or moss into the soil, will require approximately 8 weeks prior to reseeding the site because of the time required to decompose the incorporated material. If there is a significant thatch layer on the site, however, the existing lawn should not be incorporated into the soil.

II.C Subsurface Collection Systems

Subsurface drainage systems are costly but are necessary for turf establishment in some sites. A landscape practitioner usually determines the necessity of underdrains by visually assessing the site conditions. Factors such as European crane fly (*Tipula paludosa*) problems, thin turf cover, moss, and standing water can all indicate the necessity of underdrains (overwatering can also result in these problems). Standing water, however, is the conclusive sign that drainage problems exist. Wherever possible, the site should be graded to a smooth-surfaced slope, minimum of 2 percent, eliminating areas of ponding water and directing the excess soil moisture to one location in the site. Grading the site in this manner will limit the area where underdrains are necessary.

Should an underdrain system be required, a French drain configuration is most commonly constructed (Survey, 1996). The drainage trench is usually excavated 12 to18 inches in depth, dependent upon soil conditions. The minimum depth of 12 inches is necessary so soil placed above it can be tilled during soil preparation without damaging the drain or equipment. The width of the trench is generally 12 inches. Following excavation, one of two procedures is commonly utilized. The trench is lined with a filter fabric, filled partially with pea gravel, then perforated piping is placed at a minimum slope of 2-percent, and then the remainder of the pea gravel is placed. In the second option, lining the trench is substituted with piping wrapped with filter fabric. These systems should be connected to the municipal storm drainage system or to roof and footing drains. If a direct connection to the municipal storm drain is necessary, timing must be coordinated with obtaining any necessary permits, and sidewalk placement.

Drainage is enhanced initially by the subsurface collection system, but its effectiveness decreases with time. After periods as short as four years many underdrains become inoperable and must be replaced if the turfgrass is to survive. The problem is usually a result of the pea gravel or filter fabric clogging with fine sediments. Field observations suggest the filter fabric clogs more readily than pea gravel. For this reason, the filter fabric is often omitted in hopes of extending the subsurface collection system's operability period (Survey, 1996). If a filter cloth is not used a layer of newspaper will help reduce system clogging.

System operation can be enhanced by several other means. High quality construction materials should be purchased and inspected on site. Four-inch diameter perforated PVC piping is suitable. The drainage rock should be washed pea gravel. Cleanouts or yard catch basins should be utilized to reduce problems with system clogging.

If underdrains are determined to be necessary after turf establishment, installation procedures will be slightly modified. Remove established turf with a sod cutter and store the sod on site. Once the impacted lawn areas have the turf removed, underdrain installation procedures can continue in their usual manner. Sod can then be reinstalled.

II.D Soil and Site Preparation

A site visit is necessary to evaluate the soil to be amended and existing conditions at the site. The schedule of activities is given in Table II-3.

Table II-3: Landscape Practitioner's Planning Schedule Considerations

Procedure Considered	**Section Discussed**
Reuse of on-site soils	II.D.1
Weed control	II.D.2.a
Soil testing, existing soil and amendment	II.D.2.b
Use of a ripper to break up sub-surface soils	II.D.2.c
Ordering Compost	II.E.3

II.D.1 Use of On-site Soils

A determination of the soil that is being amended is the first step of soil preparation. Some developers sell the soil removed during site clearing and then import topsoil for landscaping. The reason stated for this practice is a minimal quantity of good quality soil found at the site (Survey, 1996). Undisturbed sites in the Puget Sound Lowland area, however, are comprised of up to 3.5-feet of what is termed forest duff soil. This native topsoil usually has an organic content from four to six percent, significantly higher than the average subsoil organic content of less than one percent. In light of this variance, the value of existing soil on the site must be considered on a site-by-site basis.

When using stockpiled soils, screen it to remove unwanted debris. Determination of compost quantity to be incorporated should be based on the organic content goal described in Section II.E.3. Amendment addition to the excavated soil can occur prior to soil distribution, or after in the same manner as amending subsoils.

Tilling the distributed soil into, at minimum, the upper 2 inches of the existing subsoil, will ensure a suitable soil transition. Standard machinery used for mixing has a maximum depth of penetration between 6 and 8-inches. Because of this limitation, if the depth of distributed soil will exceed 5 inches, distribution of the native soil or soil compost mix should be done in lifts, or incorporation of the amendment in stages. (For example, distributing three inches of amendment and tilling it could be the first lift. Then distributing the remaining two inches of amendment and tilling it would be the second lift). The first lift consists of distributing and integrating one-third to one-half of the imported soil. The remainder of the soil is distributed and mixed in the second lift.

II.D.1.a Use of Native Topsoil

Reusing existing topsoil can be advantageous for the proposed goal of increasing soil organic content to 8 to 13-percent by weight. Redistribution of the native soils can decrease the amount of compost and nutritional amendments required on-site. For this reason, the costs of stockpiling, screening and redistributing the existing topsoil may be justified at locations where there is a suitable quantity of decent quality native topsoil.

II.D.1.b Use of Excavated soils

Excavated soil may be obtained from the site of construction, within the same subdivision, or from an off-site source. Excavated soil from off-site have the potential to import an invasive weed problems Additionally, excavated soils generally have a low organic content, such as the glacial till described in Section I.B. It is likely that excavated soils will require comparable amendment quantities as the existing subsoils. If this is the case, redistribution soils excavated from the site may not warrant the cost.

II.D.2 Pre-Amendment Soil Evaluation

Prior to soil amendment, the soil samples must be collected. After this site visit the landscaper can use the soil analyses to determine amendment quantities (guidelines are given in Section II.E.3) and plan the amending process (described in Section II.E), and materials ordered.

II.D.2.a Weed Control

Open soil areas allow weed seeds to blow in and dormant weed seeds to sprout. Integration of compost into the soil will uproot the weeds and kill most of them. If the weeds are perennial grasses, however, they need to be killed prior to rototilling or they will be broken into small propagates throughout the soil. Following integration the site should be watered to encourage the growth of remaining weed seeds. Shallow tilling or raking, about ½ -inch in depth, performed two or three times over a four to six week period is an effective means of diminishing weed invasion in young turf. If the existing weed problem is not severe, one shallow tilling or one Round-Up™ application prior to hydroseed or sod application should be sufficient to control weed problems during the turf germination period. Mowing the site may also be sufficient to kill the weeds. If a pesticide is used, it should be done only as necessary and according to label recommendations.

II.D.2.b Soil Sampling

The soil to be amended, either existing subsoil or redistributed native soil, needs analysis to determine amendment quantities. The compost-amendment to be incorporated will also need to be sampled. Sample collection procedures, analysis considerations and costs are described in Section II-H. Sample analysis turn-around time is usually between 15 and 30 days in the Puget Sound Area.

II.D.2.c Use of a Ripper

Soil sampling also allows the landscaper to generally estimate the ability of standard equipment to till the soil. If the soil is too dense for hydraulic tillers or shaft driven tillers, a preliminary step of breaking open the soil with a ripper or similar type of machinery will be necessary. As a general rule of thumb, a ripper is necessary when a standard pick or s3hovel cannot penetrate the soil beyond a 6-inch depth. At these sites the ripper will break the upper 12 to 18 inches of the dense soil into large aggregates, at which point the tiller can further break-up the soil as in other sites.

II.E Amendment Quantities

Amendments include nutrients, lime, gypsum and compost. The optimum quantities for each of these amendments must be determined to receive the maximum benefits from compost amending.

II.E.1 Nutrient and Lime Requirements

In addition to incorporating compost into existing soils, whether intact subsoils or previously excavated soils, nutritional deficiencies and unsuitable alkalinity levels must be corrected. Readily leached nutrients are often deficient. Micronutrients, the nutrients needed by vegetation in small quantities, will be supplied by the addition of compost with the possible exception of boron (Landschoot, 1996). The need for macronutrients, the nutrients needed by vegetation in large quantities, should be expected. Nitrogen and sulfur are the most commonly deficient macronutrients in Puget Sound Lowland soils. Potassium, phosphorous, magnesium and calcium levels are sometimes also insufficient for grasses. Soil analysis will determine optimum quantities of the various nutrients.

If the soil pH is below 6.0, incorporating pelletized dolomite lime into the soil during the amendment process is recommended, additionally providing the benefit of correcting calcium and magnesium shortages. Application rates of lime will be in the range of 50 to 100 pounds per 1000 square feet. Nitrogen requirements range from 2 to 8 pounds per 1000 square feet on an annual basis. Applications of slow release, water-insoluble forms of nitrogen, such as sulfur-coated urea (SCU) or polycoated fertilizers, is the preferred means of supplying this nitrogen. Urea formaldehyde (UF) is not suggested due to the low soil temperatures in pacific northwest soils; the UF breaks down too slowly in low temperatures so it is not of much use in turf establishment (Stanke, 1997). Incorporation of compost, however, may limit the need for nitrogen application during the first year after lawn establishment, although a starter fertilizer is recommended for turf establishment (Landschoot, 1996). Sulfur quantity required, as elemental sulfur, ranges between 2 and 5 pounds per 1000 square feet on an annual basis (Stahnke, 1996; Muntean, 1997). Boron deficiencies will be much lower, it is recommended at only one-tenth of an ounce elemental boron per 1000 square feet per year (Muntean, 1997).

II.E.2 Use of gypsum

Gypsum, hydrated calcium sulfate ($CaSO_4 2H_2O$), is used for three primary purposes in soil: the addition of calcium and sulfur without increasing the pH, the displacement of sodium ions in extremely salty soils, and the binding of clay particles to enhance macropore abundance. Gypsum is not generally needed in the Puget Sound Lowlands; the low pH necessitates calcium carbonate (lime) addition to neutralize the soil pH, which corrects calcium deficiencies present. In areas where soil is calcium deficient and the pH is above 5.5, lime addition is favored over gypsum addition because of its pH stabilization effects. If the soil is sulfur deficient, it can be added to the soil independently.

Gypsum enhances clay's soil structure by adding chemicals required to bind clay particles together. There is not a consensus among soil scientist that gypsum addition to clay soil in the Puget Sound Lowlands is necessary. According to Washington State University's (WSU) Extension Service in Puyallup , clay soils in the Puget Sound Lowlands do not lack the chemical parameters necessary for soil structure. Cogger (1997) indicates that clay soils are missing the physical parameters (such as macropores) which are not enhanced by gypsum addition. Cogger additionally stated the addition of well-degraded compost will provide the physical requirements necessary for soil structure. Contrary to Cogger, Unterschuetz (1997) and Muntean (1997) believe that 50 to 100 pounds of gypsum per 1000 square feet should be applied to heavy clay soils at the same time as compost incorporation. Since the addition of gypsum does not present any negative side effects, its utilization is at the discretion of the landscape practitioner.

II.E.3 Estimating Compost Quantities

A final organic content of amended soil between 8 percent and 13 percent by soil weight is the target of the proposed soil amendment procedure. The organic content of all existing subsoils exposed during site construction is expected to be less than one percent. Compost typically has a 45-60% organic content, and is used to supply almost all of the organics to the soil profile. As a general rule of thumb, a 2 to 1 ratio of existing soil to compost, by loose volume, will achieve the desired organics level. The optimum benefits are achieved by utilizing a 7/16- inch well-degraded compost (Kolsti, 1995). Acceptable compost criteria are suggested in Appendix A.

To maximize the benefits of compost incorporation, a minimum of the top six inches of soil should be amended. To determine the loose soil volume which is to be amended, the fluff factor discussed previously in Section IIA.3 must again be considered. Assuming a fluff factor of 1.4, amending the top six inches of a soil will result in 8.4 inches of soil to be amended. The depth of amendment applied should therefore be 4.2 inches, or 13 cubic yards per 1000 square feet. In areas where tree root considerations or other natural features limit the maximum depth of incorporation, compost quantities should be adjusted. For example, if feeder roots are observed at a 3.5-inch depth, only the top three inches of the soil should be amended. (This three inches corresponds to 2.1 inches of compost amendment.)

Calculations for the various amendment quantities can be kept simple by the following conversion: one inch of material spread over 1000 square feet is equivalent to about three cubic yards. If this one inch is a typical yard debris compost, with an organic content of 50% and bulk density of 1000 pounds per cubic yard, it will increase the organic content of the soil by approximately 2.5 to 3.5 percent when incorporated into the loose eight-inch soil depth.

Assume a four-inch depth of native soil, with an organic content of five percent, is redistributed and incorporated throughout the site. Only a 2.5-inch depth of compost throughout the site would be necessary to get a final organic content between eight and thirteen percent, once both soils are incorporated. For precise calculations, volume, bulk density and organic content of both soil and compost are necessary.

Once the quantity of compost has been determined, the supplier should be contacted to establish compost availability and quality. Compost may need to be ordered two weeks in advance in the spring. On the other hand, ample quantities of compost are generally available in the fall, but they are frequently delivered before the product has completely decomposed. If space is available at the site, having the compost delivered up to eight weeks in advance of use is suggested. The composting process can then be completed on-site by keeping the compost moist.

II.F Incorporating the Compost

Once the necessary amendment quantities of compost and nutrients have been determined and materials ordered, soil preparation can be executed. Suggested procedure for soil amendment incorporation is to rototill or rip and rototill the subgrade, remove rocks, distribute compost, spread lime and nutrients, rerototill soils several times in perpendicular directions, fine grade or “float”, and hand roll the site. Ripping of the subgrade is only necessary when a soil’s high density requires it, as discussed in Section II.D.2.*c*. Ripping soil breaks dense soil into large clumps that will be further processed by other equipment. Multiple passes with a rototiller will uniformly break-up the top six to eight inches of the subsoil. Following soil integration, the soil should be watered and allowed to settle for one week. Depressions and other irregularities throughout the site can then be filled and graded until a uniform surface is achieved.

Table II-4: Site Preparation Using Soil Amendment

Procedure	Soil Amending Guidelines
Initial soil disturbance	For highly compacted sites, performed with a ripper
Uniformly break-up subsoil	2-passes with rototiller

Rock removal	Performed with a rock rake, rock hound, or hand
Distribution of imported compost	Predetermined depth of a well-composted product
Lime and Fertilizer application	Rates determined by soil analysis
Soil Integration	2-passes with rototiller
Grading and rolling of site	To achieve a uniformly smooth site surface.

If compost delivered to the site is immature, and there is not time to complete the composting process on site as described in section II.E.3, the landscape practitioner may want to modify the above procedure. The settling period should be extended two to five weeks to allow the soil to fully settle prior to the final grading and rolling of the site. This time frame may allow weed seeds to blow in or latent weed seeds to sprout. If weeds are observed refer to Section II.D.2.a for weed removal procedures. If seeding or sod placement cannot be delayed, thin areas can be overseeded the following spring or fall.

To ensure that sites are developed in the best manner, individuals with professional credentials should be hired for landscape and turf installation work (Survey, 1996). Such professionals could be Washington State Nursery and Landscape Association (WSNLA) certified (Washington Certified Landscapers), Washington Association of Landscape Professionals certified (Certified Landscape Technicians), or other certified landscape professionals. These certifications are industry-sponsored to compensate for the lack of mandated testing for contractor licensing in Washington State.

II.G Turf Establishment

II.G.1 Turf Installation

Turf is provided in new developments by hydroseeding or sod placement. Hydroseeding is the preferred method of establishing turf on an amended site. The reason for this preference is the greater depth of root penetration observed in hydroseeded lawns over sod lawns, possibly due to the soil interface problem associated with sod placement (Survey, 1996). Standard seeding results in a lawn similar to a hydroseeded site, but hydroseeding is generally preferred because the increased ease of seed application. A full lawn is generally achieved within 60 to 90 days after hydroseeding or seed application. Accelerated growth mixes are also available when time limitations warrant their increased cost.

The type of grasses utilized should be based on the site’s degree of shading, but a blend of perennial rye and improved fine fescue varieties developed for the Northwest is suggested. Perennial ryegrasses are a durable thin blade that will adapt to the sunny portions of the lawn, whereas fine fescue is drought resistant and adapted for shaded areas as well as full sun areas. For more information on lawn seeding refer to WSU’s publication “Home Lawns” (1993) or consult a reputable local seed dealer.

II.G.2 Startup Irrigation

Desiccation, or drying, of the seed or sod mulch is the most frequent problem with lawn installation, as seed germination and subsequent root growth are halted without an adequate water supply. To ensure grass survival, landscape practitioners generally determine the optimum watering schedule and educate the site's owner about these practices (Survey, 1996). The critical period for lawn establishment is the first two to three weeks. Watering during this period should be light and frequent.. To achieve this environment, watering may be performed two to three times per day, distributing water to approximately a one-half to one-inch depth with each irrigation cycle. Actual watering duration will vary depending on the type of irrigation system, but 10 to 15 minutes is the average time requirement.

After root establishment has begun, over-watering must be avoided because it inhibits the ability of oxygen to reach the roots and can promote diseases. The goal of watering during this period is to maintain moist conditions throughout the root establishment zone. As the seeds continue to grow, watering duration is increased, encouraging a deep root zone by allowing for moisture penetration beyond the full depth of roots. By week seven, one watering per day, of about a 2-inch depth is usually sufficient. Approximately ten weeks after the lawn has been installed watering is reduced to 2 times per week. By the end of the third month the lawn is fully established and watering is performed on an as needed basis.

II.H Soil Testing Considerations

Prior to amending soil, the compost and the soil will need analyses for chemical and physical properties. This analysis will reveal necessary proportions of nutrients, soil amendment and soil. There are two options for submitting samples: soil and compost separately, or a combined sample. A combined sample is preferable, consisting of the same proportions to be used in the field (Landschoot, 1996). The analyzing laboratory will provide recommendations for fertilizer, lime and compost requirements. Allow a one-month time window for analysis and reporting.

For the site soil analysis, a composite sample of one quart by volume should be submitted for analysis. This is a composite of fifteen to twenty sub-samples obtained at locations evenly distributed throughout the site, each reaching an 8-inch depth. Analyses suggested of the composite sample are detailed fertility, sulfate, bulk density and percent organic matter. Detailed fertility consists of moisture holding capacity, pH, sodium, salinity, nitrate-nitrogen, ammonium-nitrogen, phosphate phosphorus, potassium, calcium, magnesium, copper, zinc, manganese, iron, and boron levels.

Compost analysis consists of total and available macro and micronutrients, percent organic matter, pH, sodium, salinity, moisture content, bulk density, particle size distribution, and estimated carbon to nitrogen ratio. Since this type of testing is routinely performed by the compost manufacturer, results of a current compost analysis should be sufficient for determining amendment needs. If recent analyses are not available, a sample should be obtained from the compost manufacturer prior to its delivery.

Once the compost product is delivered to the site, compost maturity must be determined to ensure the material is well decomposed. This can be accomplished in approximately four hours with a simple compost maturity test manufactured by Woods

End Research Laboratory, Inc[1]. An experienced professional can forgo the testing kit and establish compost maturity by evaluating the composts for dark color, moderate heat generation, and emissions of earthy-odors (not foul odor). Guidelines for determining compost maturity are outlined by EA Environmental Consultants (1994). If the delivered product is determined not to be mature, adjustments to the installation process may be desired, as described in Section II.F.

The organic content of compost coupled with a compost maturity test is a measure of compost's relative benefit to the surrounding soil and plants. For example, a low organics and immature compost reading indicates lots of clay and silt fines mixed with manure (which is bad on a nitrogen and microporosity basis). A high percentage of organics and mature compost indicates the soil is better suited for root growth and nutrient and water exchange.

II-I Local Agency Inspection

In areas where soil amending is regulated, local agency inspection will be performed (At the time of this publication, however, no areas are requiring soil amendment). Upon completion of the lawn installation the landscape practitioner will be required to submit a synopsis of the work which has been performed to the regulating agency. Required information is site size, compost type and quantity purchased, compost maturity rating, the procedure followed, and the depth of amendment achieved. Documentation of the compost purchase must also be attached.

On-site inspection by the local agency will document the depth of amendment achieved and sample for final organic content. Upon receiving the analysis results for the organic content, the local agency will determine if compliance with the given regulation has been achieved.

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[1] Woods End Research Laboratory, Inc., box 297, Mount Vernon, Maine 04352, 207-293-2457. E-mail: infor@woodsend.org

Chapter III. Comparative Costs of Soil Amendment

This chapter provides the comparative cost associated with the benefits of compost-amended soil, which were addressed in Chapter I. A comparative dollar evaluation of initial installation procedures for both traditional and the proposed site preparation are shown. Dollar values were obtained between 1996 and 1997 when inflation rates were less than three-percent. Installation procedures vary widely, as do hourly wages and equipment costs; this information provides a method for cost-benefit analyses at future site developments.

Installation costs of a *Tilled Compost Turf (TCT)* are higher than that of standard lawn installation procedures. However, *TCT* can potentially lower site development costs in residential subdivisions by reducing the size of stormwater detention facilities. Long term cost comparisons, factoring in the homeowner savings resulting from reduced watering and maintenance requirements of a *TCT* lawn, are discussed in Chapter IV.

III.A Costs for Standard Turf Installation

This section reviews the costs for traditional lawn establishment as customarily done at new residential and commercial developments. A traditional lawn is considered as one in which the grass roots are confined to a shallow soil depth between one and three inches, underlain by nutrient and organic deficient subsoil. Traditional lawns have low water and nutrient infiltration rates and low moisture-holding capacities.

Traditional soil preparation procedures are influenced by the homeowners or builder's budget, developer time constraints, traditional landscaping procedures and, sometimes, lack of proper procedural knowledge. Developers, who are trying to minimize costs, are interested in beautiful lawns during the sale of the residences, but are generally not concerned with long-term aesthetics or maintenance requirements. Individuals who purchase these homes usually have little input to the site landscaping, unless a retrofit of their property is being performed.

Lawns without proper soil preparation have the minimum installation costs desired by developers, but they usually require higher maintenance by the homeowner to retain an acceptable appearance. Applications of pesticides could be more prevalent. The low moisture-holding capacity necessitates frequent watering during dry summer months, a practice that is discouraged as water conservation continues to be a growing concern. During rain events, lawns without proper soil preparation offer little stormwater-holding capacity. The downstream effects of fertilization and herbicide practices are also a concern, but they are not factored into this cost analysis.

III.A.1 Soil and Site Preparation

As described in Chapter II, the primary site preparation procedures include soil preparation, subsurface drainage collection, and irrigation system installation. To aid in the comparison between the different soil preparation methods, the economic costs of these processes were researched and are provided below. A description of traditional site preparation processes and the associated materials used in these lawns is also provided.

III.A.1.a Soil Preparation

There are two general sequences that are followed for soil development. They are referred to in these guidelines as *Topsoil Amended Turf (TAT)* and the *Minimum Input Turf (MIT).*

The ***Topsoil Amended Turf*** method consists of the following:

- scarification of subsoil and rock removal
- importation and even distribution of additional topsoil
- fertilizer and lime application
- integration of soil layers by rototilling
- grading and rolling of soil
- seed, sod, or hydroseeding application.

The final depth of topsoil applied ranges between two and five inches when the subsoil is derived from glacial till. Variation in the average depth of topsoil applied significantly affects the cost of soil preparation work. For the calculations shown in Table III-6, an average depth of 3.5 inches is used. The resulting cost of *TAT* soil preparation, omitting the sod or hydroseeding application, is $0.49 per square foot for large sites (greater than 5000 square feet of lawn area) and $0.51 per square foot for small sites (less than or equal to 5000 square feet of lawn area). For example, a lot with 5000 square feet of lawn would cost approximately $2550. Table III-6 provides detail on how the author derived these costs. The variation in cost between large and small sites is a factor of the equipment that can be used on the site. The relatively high cost of this type of soil work limits its use to residential housing projects with substantial landscape budgets, and individual owners who are willing to pay the extra cost to receive the benefits of a deep soil base. These lawns still do not offer the same benefits achieved by *TCT*, in that the topsoil used is of a highly variable organic content and quality, and vegetation root depth is still confined within the upper few inches of the soil.

A more frequent procedure found in both residential and commercial development is *Minimum Input Turf* development.

The ***Minimum Input Turf*** soil preparation consists of

- some rock removal and grading
- even distribution of imported topsoil
- fertilizer and lime application
- grading and rolling of the soil
- seed, sod or hydroseeding application.

When hydroseeding is to be used, the fertilizer step is often omitted on the assumption that the fertilizer mix in hydroseed slurry will be sufficient. Depth of distributed topsoil in the *MIT* procedure is 1 to 3 inches; a 2-inch average depth is used for determining cost. Associated costs for *MIT* soil preparation is $0.25 per square foot for large sites and $0.27 per square foot for small sites.

Table III-1: Comparison of *TAT* versus *MIT* Soil Preparation

Procedure	***Topsoil Amended Turf***	**Minimum Input Turf**
Scarify Subsoil	provided by rock removal equipment	Not performed
Rock removal	thorough, using a "rock hound"	Minimal, using a "rock rake"
Distribution of imported soil	2 to 5 inches, 3.5 inches used for calculations	1 to 3 inches, 2 inches used for calculations
Fertilizer and lime application	Performed*	Performed*
Soil Integration	1 pass with hydraulic rototiller	Not performed
Grading and rolling of soil	Performed	Performed
Average cost per square foot	$0.49 / $0.51	$0.25 / $0.27

*Sometimes fertilizer is added only during hydroseeding application.

An itemized listing of procedures and the associated costs are shown in Table III-6. *Minimum Input Turf* and *Topsoil Amended Turf* procedures stated are generalizations of current practices in an effort to establish standard soil development costs. Many variations of these processes exist. For example, topsoil may be spread in lifts with the first lift being incorporated into the existing soil, fertilizer may be applied before or after topsoil and may or may not be incorporated into the existing soil, and rolling between steps may be used.

III.A.1.b Subsurface Collection Systems

When conditions warrant, subsurface collection systems are installed. As described in Chapter II, systems consist of a drainage ditch lined with a filter fabric in which a perforated pipe is placed and surrounded by gravel bedding. Drainpipe suggested is four-inch perforated PVC pipe with cleanouts; a one hundred-foot length will cost approximately $53. Corrugated plastic piping, which comes in 100-foot coils for about $38, is sometimes used but is not suggested due to associated problems of pipe clogging. Gravel used is specified as pea-gravel, approximately $25 per cubic yard. Filter fabric, sold in 3'X 300' rolls, can be purchased for $63. Installation price will vary considerably from site to site, averaging around $2.50 per lineal foot.

III.A.1.c Irrigation System Installation

Irrigation system installation is another integral part of site preparation work. Irrigation systems are priced according to type of system desired (standard or low volume) and number of sprinkler heads. Sprinkler head requirements are a function of coverage desired, number of irrigation zones, gallons per minute and dynamic water pressure available in each zone, and size and location of planted beds. Minimal pressure zone irrigation systems costs between $0.50 and $0.75 per square foot for sites larger than 5000 square feet. At minimum, expect a $1800 base cost for any residential irrigation system (Survey, 1996). A water efficient irrigation system is encouraged when selecting the type of system for purchase.

III.A.2 Top Soil Haul and Application

Topsoil used by contractors is usually a manufactured three-way mix. "Three-way mixes" are described as a sandy loam, compost, and sawdust blend. The quality of these mixes varies considerably between suppliers. "Sandy loam" is screened excavation dirt; the true texture will depend upon the native soil of the given excavation site. Compost, usually processed through a 5/8-inch screen, is either wood or animal derived. When purchasing by the truckload, average cost of three-way soil delivered to Redmond is $12 per cubic yard (Survey, 1996).

Topsoil is applied in two steps. First the soil is distributed throughout the site into large piles using a bucket loader on a tractor or bobcat, or with a wheelbarrow when site conditions restrict the use of large machinery. These soil piles are then uniformly spread. Again site conditions will determine the equipment chosen for the spreading process; tractors, backhoes and hand tools are most commonly used. The cost of topsoil application varies according to the equipment utilized, refer to Table III-6 for values obtained from local sources.

III.A.3 Sod: Production, Purchase, and Installation

If construction delays the installation of turf until the end of the growing season, or there is only a short timeframe before homeowners are moving onto the property, sod use may be specified by the developer. Seed mixes vary from a 100 percent perennial rye mix to a 50% perennial rye, 30% Kentucky bluegrass and 20% fine fescue mix. Kentucky bluegrass is used for its rich color and texture in addition to its ability for rapid recovery of divots and grooves due to rhizome development. Many cultivars of Kentucky bluegrass, however, do not do well on this side of the Cascades due to the lack of freezing climate periods. It commonly thins out within the first few years and requires overseeding.

The soil base used in this area for sod mixtures is advertised as a sandy loam, but sometimes higher percentages of clay are visible in the delivered product. This variance in sod subsoil is due to the differences in soil particle size distribution throughout the sod farm acreage. Sandy loam soil base should be specified upon ordering and confirmed by on-site inspection.

Delivered prices of sod have a narrow range in cost: $0.17 to $0.22 per square foot, as shown in Table III-3 (Survey, 1996). Deposits of $8 to $11 per pallet are also required; each pallet holds 500 square feet of sod resulting in an additional refundable charge of about $0.02 per square foot (this cost is not included in the cost analysis).

Prior to sod placement, a starter fertilizer is applied. Prices quoted in this analysis include the even distribution of starter fertilizer application; however, some landscapers recommend distribution of only 50-percent of fertilizer prior to sod application and the other 50-percent after the sod has been laid. Transfer and unrolling of the sod onto the site is then performed. Sod is delivered fresh the day that it is to be installed and should be lightly irrigated within thirty minutes of placement onto the soil. Installation is completed by soaking the lawn with water to an eight-inch depth, base soil conditions permitting. In a typical residence, between 300 to 350 square feet of sod is placed in one hour, resulting in an average installation cost of $0.07 per square foot. At larger sites up to 500 square feet of sod can be placed in an hour, averaging $0.06 per square foot (Survey, 1996).

Table III-2: Sod Costs, per Square Foot

Purchased Quantity, square feet	Price Range of Delivered Sod	Average Price of Delivered Sod	Average Installation cost of Sod	Average Total Installed Cost of Sod
≤ 5,000	0.18 - 0.22	$0.20	$0.07	$0.27
5,000-10,000	0.17 - 0.21	$0.19	$0.06	$0.25
Quantity ≥ 10,000	0.17 - 0.19	$0.18	$0.06	$0.24

III.A.4 Hydroseed Application

Hydroseeding is a process of applying a grass seed mix in slurry containing wood fiber mulch, fertilizer, tackifier and water in addition to seed mix. In Western Washington standard seed mix consists of 70 to 80-percent perennial rye blend and 30 to 20-percent fine fescue blend. Prices quoted are for this type of mix.

Application costs are influenced by a variety of factors, with site size being most predominant. Ease of access and water supply are also important considerations. As shown in Table III-3, application cost per square foot decreases as site size increases. Minimum costs fluctuate between hydroseeding companies and time of year, ranging from $200 to $325 per site. When demands for applications are at their peak, generally in the fall, the minimum costs reach the high end of the scale (Survey, 1996).

Table III-3: Hydroseeding Cost Estimates

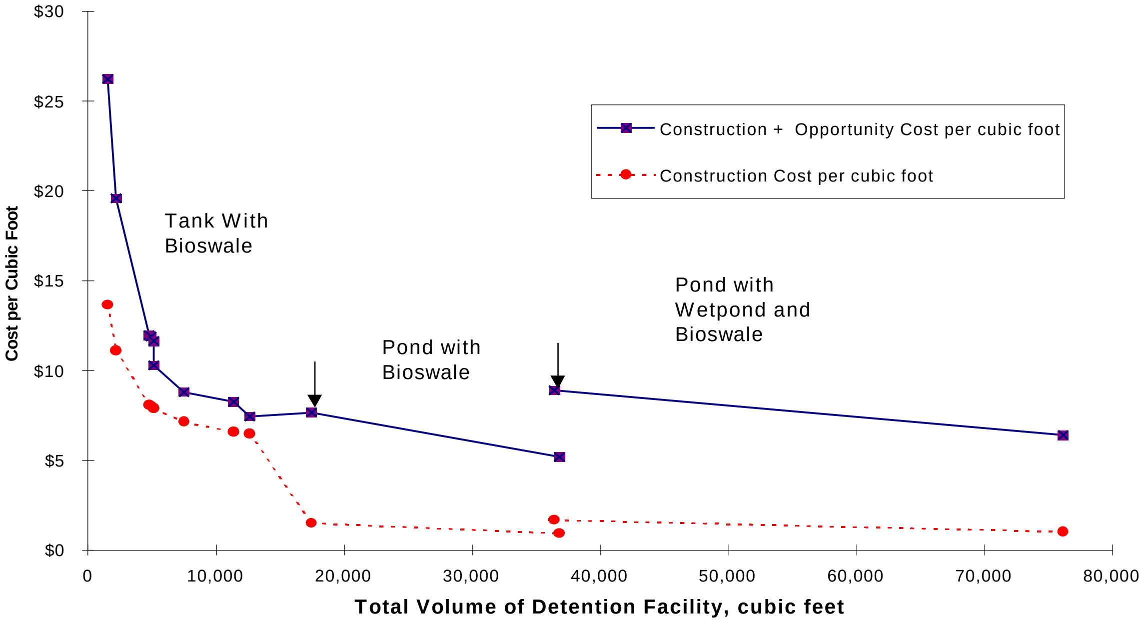
Site Size (square feet)	Range of Costs (square foot)	Average Cost (square foot)
≤ 3,000	0.09-0.13	.10
≤ 5,000	0.07-0.09	.078
≤ 7,000	0.062-0.08	.07
≤ 10,000	0.057-.07	.065
≤ 15,000	0.05-0.065	.06
> 15,000	0.05-0.065	.055

III.A.5 Detention Facility Costs

The *TAT* and *MIT* lawns described above offer little stormwater holding capacity, therefore stormwater runoff is created from even minor and intermediate storm events. Regulations require detention facilities to control runoff flows when a predetermined area of impervious surface is created. For both Redmond and King County, the flow control threshold is 5,000 square feet of impervious area, equating to development areas of approximately 10,000 square feet or more. As the development size increases, more impervious area is created, resulting in larger volumes of runoff. The actual amount of runoff generated will be a function of the storm event's magnitude, the permeability of the soils, and the antecedent (prior to rain event) soil saturation conditions.

Detention facility construction costs are substantial; therefore, methods to decrease runoff volume could provide substantial savings to the developer. The following graph compares the cost of various sized stormwater facilities. Cost saving estimates from reduced stormwater facility sizing shown in Table III-5 were determined using this graph.

Figure III-1: Detention Facility Costs per Cubic Foot Detention Volume Required



after Johnson 1996, King County Surface Water Management Division, Seattle, Washington

Opportunity cost reflects lost revenue from land that would have been developed for residential use, but instead is used for stormwater facilities. Opportunity costs used in this analysis are based on a study by Johnson (1996), in which opportunity costs were found to be $5.95 per square foot in the King County area. This value was adjusted for the Redmond area and found to be $6.15 per square foot, which is reflected in the graph above.

III.B Cost Associated with Soil Amending

Enhancement of existing soil with well composted derived from yard debris compost or biosolid amendment to form a *Tilled Compost-Amended Turf* (*TCT*) will have higher soil preparation costs than that of *TAT* or *MIT* procedures. *TCT* practices will require a larger volume of material to be delivered to the site and more extensive site preparation procedures to ensure the amendment is well mixed with the existing soil. Additional soil analyses will be required to determine the optimum quantities of the various soil amendments. The following sections address the costs of *TCT*.. Cost savings and benefits provided by *TCT* practices are long term and it is difficult to assign dollar values to some. Long-term costs are addressed in Chapter IV.

III.B.1 Soil and Site Preparation

The amendment process will not affect the subsurface collection and irrigation system aspects of site preparation. Soil preparation for amended turf, however, has several additional steps compared to the *TAT* and *MIT* procedures. Soil preparation on sites that are accessible by large machinery will cost approximately $0.59 per square foot, while sites requiring all hand work will cost approximately $0.63 per square foot (See Table III-6 for details). As shown in Table III-6, breaking up of the soil accounts for the majority of cost escalation. If the subsoil density prohibits the initial use of standard equipment, a ripper must be utilized raising site preparation costs by an additional $0.11 per square foot.

III.B.2 Delivered Curb Costs of Soil Amendments

Mature 7/16-inch screened yard debris compost or biosolid product is specified for the amendment process (refer to Appendix A for compost specifications). The delivered cost of this type of product is comparable to the cost of standard soil delivery. Land developers in the Redmond area most frequently use the products listed below. Cedar Grove, a yard debris compost manufacturer, has generally been preferred due to their product consistency and routine testing. Pacific Garden Mulch is also yard debris compost. GroCo, a biosolid product, has been associated with nitrogen depletion and the associated lawn “yellowing”, as well as sealing or hardening the soil when excess quantities are applied. However, when utilized properly GroCo also produces a similar quality lawn as lawns amended with other compost varieties (Survey, 1996). Location and phone numbers for these compost suppliers are listed in Appendix B.

Table III-4: Delivered Curb Costs of Soil Amendments

Quantity, Cubic Yards	Soil Amendment Cost per Cubic Yard			
	Cedar Grove Fine	**GroCo**		**Pacific Garden Mulch**
		Delivered	Blower Applied	
6 - 10	N / A	$17.20 - $14.20		$20.00
≥ 10	$14.50	$13.45		$16.00

≥ 15	$13.00			$14.00
≥ 20			$14.70	$13.00
≥ 25	$12.00	$10.95	$13.95	
≥ 30	$11.50			
≥ 40				$12.00

Blower application of Groco requires two on-site crew workers to direct the distribution hose. Application of a full 25 cubic yard truckload takes about 1.25 hours. If GroCo is the compost product used, blower application will save $0.04 per square foot over standard distribution and spreading techniques.

III.B.3 Sod and Hydroseeding Applications

Turfgrass and hydroseeding application cost will be the same for amended and nonamended sites. Hydroseeding applications are preferred over sod applications because depth of root penetration is increased due to the lack of soil interface problems. Macronutrient proportions can be determined by on-site soil and compost analyses. Hydroseeding companies surveyed indicated a willingness to alter their standard fertilizer for such applications.

III.B.4 Detention Facility Costs

Compost amended soils have an increased moisture holding capacity. Therefore, they are able to delay and often reduce the peak stormwater run-off flow rates. Furthermore, compost amended soil hold more moisture in winter, when precipitation in the Northwest is most abundant (Stanke, 1997). The change in flow rates between amended and non-amended glacial till soils are illustrated in Figure III-2 (Fig 4-3 of Kolsti, 1995). The amended plot (plot 2) was incorporated with a 7/16-inch well-composted yard debris compost on a two-unit soil to one-unit compost basis. The amended plots generated 53 to 74-percent of the runoff volume produced by unamended plots under unsaturated conditions (Hielema, 1996).

The lawn's storage capacity may allow for reduced detention facility sizing requirements in the future. Computations were performed to determine estimated storage volume reductions and the respective reduced detention facility sizing assuming a 6-month stormwater holding capacity of amended soils. The 6-month 24-hour stormwater holding capacity was chosen to perform this hypothetical scenario. This scenario is based on the professional judgment of City of Redmond Stormwater Utility staff. Runoff volumes were calculated for areas of two different subsoil compositions that were not amended, identified by their curve numbers (CN). The curve number of 78 represents soils having a higher percentage of sand than the soils with a curve number of 84, which are denser. Runoff volumes were then recalculated for the same hypothetical subdivisions, assuming all conditions were identical except for soil preparation. The same curve numbers were used for the amended soils, the only variable which changed in the calculations was the water

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Place holder for Figure III-2: Comparison of Hydrologic Responses from Amended and Non-amended Plots holding capacity of the soils. Calculations were performed using the hydrology software Water Works, which incorporates the Santa Barbara Urban Hydrograph method (Kong, 1996). Values shown in Table III-5 depict the changes in detention facility volumes and costs as a result of soil amending.

Detention facilities represented in Table III-5 are sized to release storm flow at the 100-year predeveloped rate in Redmond; a 100-year storm event in Redmond is currently equivalent to 3.7-inches of rainfall in a 24-hour period. For example, a 11.5-acre development with a 3.168-acre pervious area having a curve number of 84 was calculated to require a 19,227 cubic foot detention facility. Recalculating the stormwater runoff from this development, assuming the soils were amended to a 10-inch depth, resulted in a detention volume of 18,147 cubic feet, 93.38 percent of the original detention facility volume. Estimates of opportunity and construction costs were obtained from Graph III-1. The reduction in stormwater facility volume of 1080 cubic feet for this example equates to a potential reduction in cost of $8,640, or approximately $0.05 per square foot of amended lawn. As shown in the table below, potential cost savings range from $0.02 to $0.21 per square foot of amended lawn area. The largest benefits are exhibited by development sites less than or equal to one acre.

Table III-5: Potential Stormwater Detention Cost Savings from *TCT*

Nominal Size, acres	Curve number (CN)	Impervious Area, acres	Pervious Area, acres	Change in Detention Volume, %[a]	Opportunity Costs Savings per square foot[b]	Construction Cost Savings per square foot[b]	Total Savings per square foot[b]
0.75	84	0.537	0.213	97.5	$0.03	$0.14	$0.17
	78	0.537	0.213	99.52	$0.00	$0.02	$0.02
1	84	0.48	0.52	85.8	$0.03	$0.18	$0.21
	78	0.48	0.52	90.99	$0.02	$0.12	$0.15
5.5	84	3.985	1.515	94.38	$0.02	$0.02	$0.04
	78	3.985	1.515	94.56	$0.02	$0.03	$0.04
6	84	2.88	3.12	94.56	$0.01	$0.06	$0.07
	78	2.88	3.12	94.3	$0.01	$0.01	$0.02
11.5	84	8.332	3.168	93.38	$0.01	$0.04	$0.05
	78	8.332	3.168	92.18	$0.02	$0.03	$0.05
12	84	5.67	6.24	92.18	$0.01	$0.02	$0.03
	78	5.67	6.24	92.96	$0.01	$0.01	$0.02

a Values determined by Kong (1996)

b Preliminary savings estimates

Detention facility sizing represented by these calculations are only preliminary estimates. The software used for calculations is single storm event based. Future modeling with a continuous storm event model such as King County Run Time Series (KCRTS) would provide more accurate detention volume estimates. However, there are currently no parameters available from which to base soil conditions throughout a storm event.

III.B.5 Inspection and Testing Costs

Soil analyses and associated costs from local soil laboratories are as follows: detailed fertility, $40; sulfate, $8; organic matter, $12; bulk density, $15. The total cost, including the $40 report fee, is $115. The compost analysis is $125, and the report fee is $50. The compost manufacturer, however, will usually provide the compost analysis. Post amendment organic content analysis costs $12 per sample.

Non-composted amended sites usually have existing soil analyzed for fertility, for a total fee of $80, including report. The increased testing required by *TCT* sites therefore would only be $35 for existing soil, and $12 for post amendment testing.

III.C Cost Comparisons between *TAT, MIT* and *TCT*

Soil preparation costs increase substantially from *TAT* and *MIT* to *TCT*, up to $0.12 and $0.36 per square foot, respectively. Comparing the total site development costs, however, reduces the gap between the procedures. As shown in Table III-8, a *MIT* site that uses sod provides savings of only $0.15 per square foot over the hydroseeded *TCT* site. The increased installation cost may be compensated by future stormwater regulations, once *TCT* stormwater holding capacity has additional documentation. The reduced detention facility costs could save a developer up to $0.21 per square foot. The increase cost of *TCT* site development can be justified without changes to detention facility sizing, however, by the reduced maintenance cost of *TCT* as will be discussed in Chapter IV.

Chapter IV: Payback Period For Tilled Compost-Turf

IV.A Assumptions

An economic analysis has been conducted that predicts payback periods for the various soil preparation methods discussed earlier. Estimates of water and fertilizer savings have been used to predict the payback period of *Tilled Compost Turf (TCT)* by hydroseed application (*TCT* –seed) compared to that of the four other most common lawn installation approaches. These other installation procedures are variations of the traditional lawn installation procedures described previously. They include: (1) *Topsoil Amended Turf* by hydroseeding application(topsoil-seed), (2) *Topsoil Amended Turf* by sod placement (topsoil-sod), (3) *Minimum Input Turf* by hydroseed application (minimum-seed), and (4) *Minimum Input Turf* by sod placement (minimum-sod). For more description of each approach, see Chapters II and III.

The economic model uses the projected peak summer water rates for the City of Redmond supplied by Financial Consulting Solutions (Cebron and Seat 1996, Sullivan 1997). Financial Consulting Solution's model assumes that Seattle Public Utilities Water may increase it's summer peak water fees to the City of Redmond by approximately 10% annually, which in turn will inflate the City of Redmond's water rates by approximately 6% annually (See Table IV.1). (Higher increases are scheduled in 1999 due to several Capital Improvement Projects being implemented by SPU.)

Table IV-1: Projected Summer Peak City Of Redmond Water Rates for 100 Cubic Feet of Water

	1997	1998	1999	2000	2001	2002
Percent increase	0%	5.28%	12.04%	4.74%	5.25%	5.23%
Summer Peak Water Rate for 100 ft^3	$1.94	$2.04	$2.29	$2.40	$2.52	$2.65

The model created to determine the payback period for a *TCT*-seed assumes a 14-week summer watering period where *TCT*-seed receives between 0.67 to 0.75-inches of water per week, topsoil-amended turf receives 1.25-inches of water per week, and minimum-input turf receives 2-inches of water per week (See Figures IV-1, IV-2, IV-3, IV-4, and Table IV-2).

Furthermore the model assumes fertilizer applications of 2-pounds of nitrogen per year in compost-amended turf, 4-pounds of nitrogen in topsoil-amended turf, and 6-pounds of nitrogen per 1000 square feet in minimum-input turf. These application rates are based on the experience of landscape professionals (Survey, 1996).

IV.B Variables Excluded from Model

A great deal of scientific literature exists documenting: (1) that organic matter increases the water holding capacity of soil and (2) that organic matter increases the ability of soil to retain fertilizer (Brady and Weil, 1996). However, there is only anecdotal evidence that turf grown on tilled-compost soil reduces the need for herbicide, insecticide, and fungicide applications. Thus, these variables were excluded from the model. Finally, while minimum-input turf soils are typically compacted (requiring more aeration and thatch removal treatments than *TCT*-seed), this variable was also excluded.

IV.C Projected Payback Period

The projected payback periods have been calculated using the previously mentioned assumptions. Table IV-2 summarizes payback periods for *TCT* –seed.

Table IV-2: Payback Period of *Tilled Compost Turf* by hydroseeding Versus the Following Turf Installation Practices

Alternative Turf Installation Practice	Years for Payback
Topsoil-seed	5 to 6
Topsoil-sod	0
Minimum-seed	6 to 7
Minimum-sod	2 to 3

Table IV-3: Average Projected Cumulative-Cost of 1000 Square Feet of Turf

	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
TCT-seed (0.67" water/week)	$667	$685	$705	$726	$747	$770	$794	$818	$847
TCT-seed (0.75" water/week)	$669	$689	$711	$734	$758	$784	$810	$838	$869
topsoil-seed (1.25" water/week)	$582	$616	$654	$693	$733	**$776****	$821	$867	$920
topsoil-sod (1.25" water/week)	**$767****	$801	$839	$878	$918	$961	$1006	$1052	$1105
minimum-seed (2" water/week)	$391	$445	$504	$566	$631	$698	$769	**$844****	$927

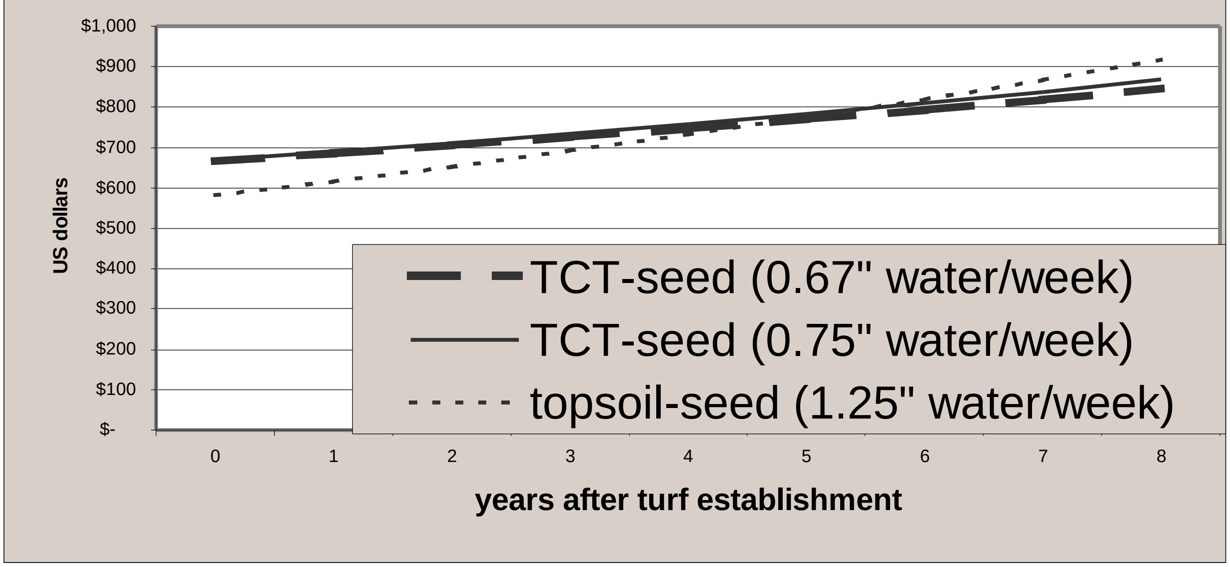
minimum-sod (2" water/week)	$586	$640	$699	**$761****	$826	$893	$964	$1039	$1122

BOLD** = Payback year

IV.D *TCT*-seed versus Topsoil-Seed

Topsoil-seed is a common practice in the Redmond area. Typically 4 to 6-inches of topsoil are distributed over a relatively compacted soil (with a bulk density over 1.6 grams per cubic centimeter) with less than 2 percent organic matter. This soil depth then compacts to approximately a 2-inch soil depth. The main problems with topsoil-seed are: (1) the turf establishes shallow roots that can not penetrate the compacted subsoil below and (2) excess water that comes in contact with the compacted till moves laterally as runoff resulting in loss of water, fertilizer, and pesticides. The result is that topsoil-seed requires approximately 1.25-inches of water per week during the summer months (Hawn 1997), while *TCT*-seed requires 0.67 to 0.75 inches of water per week (Hawn 1997). Thus the model predicts that the payback period for tilled compost versus topsoil-seed is between 5 to 6-years (Figure IV.1).

Figure IV-1: Payback Period For Installation, Water, and Fertilizer of *TCT* -seed vs. Topsoil-Seed



IV.E *TCT*-seed versus Topsoil-Sod

Topsoil-sod is a very common turf establishment practice in the Redmond area due to the short-term ease of establishing an instant lawn. However, TCT-seed turf looks more aesthetically pleasing than sod within three to five years. Furthermore, in areas where an adequate soil interface layer is not established, sod establishes shallow roots, has a fuzzy unnatural look, and promotes unhealthy thatch buildup. And just as with topsoil-seed in the Redmond area, topsoil-sod is typically established on compacted impervious subsoil resulting in the lateral runoff of water, fertilizer, and pesticides. Topsoil-sod required approximately 1.25-inches of water each week during the summer months, while tilled compost requires approximately 0.67 to 0.75-inches of water per week during the summer months. TCT-seed is projected to provide cost-savings of approximately $100 per 1000 square feet in the very first year (See Figure IV.2).

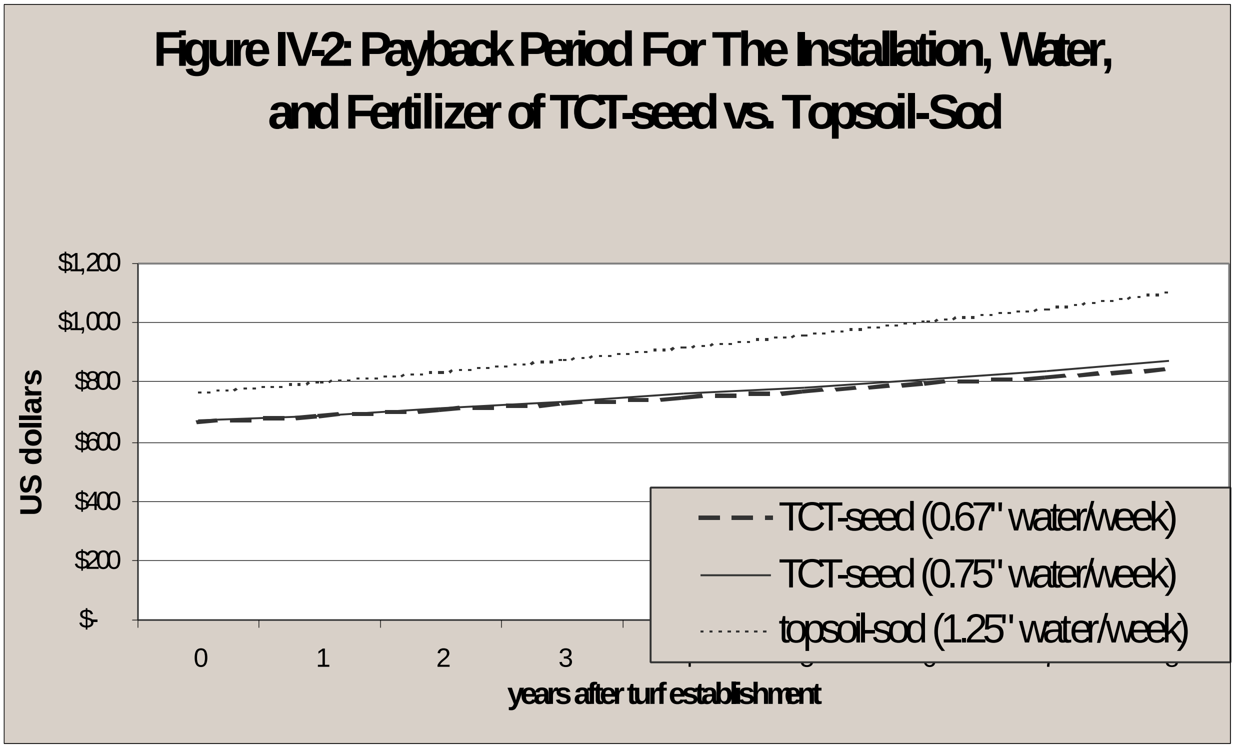


Figure IV-2: Payback Period For The Installation, Water, and Fertilizer of TCT-seed vs. Topsoil-Sod

IV.F TCT-seed versus Minimum-Seed:

Minimum-seed turf in Redmond is often located on compacted soils with very little organic matter (less than 2 percent). While sandy soils without organic matter drain and desiccate most rapidly, clay soils without organic matter are typically impervious with slow water infiltration rates, inducing heavy run-off and poor drainage. Thus the economic model estimates that if a landowner wishes to maintain a green minimum-input lawn during the summer months, between 2 to 2.5-inches of water will have to be applied each week. On the other hand TCT-seed with high porosity and moisture holding capacity often requires only 0.67 to 0.75-inches of water per week (Hawn 1997). Thus the model predicts a payback period for TCT-seed versus minimum-seed is approximately 6 to 7-years (See Figure IV-3).

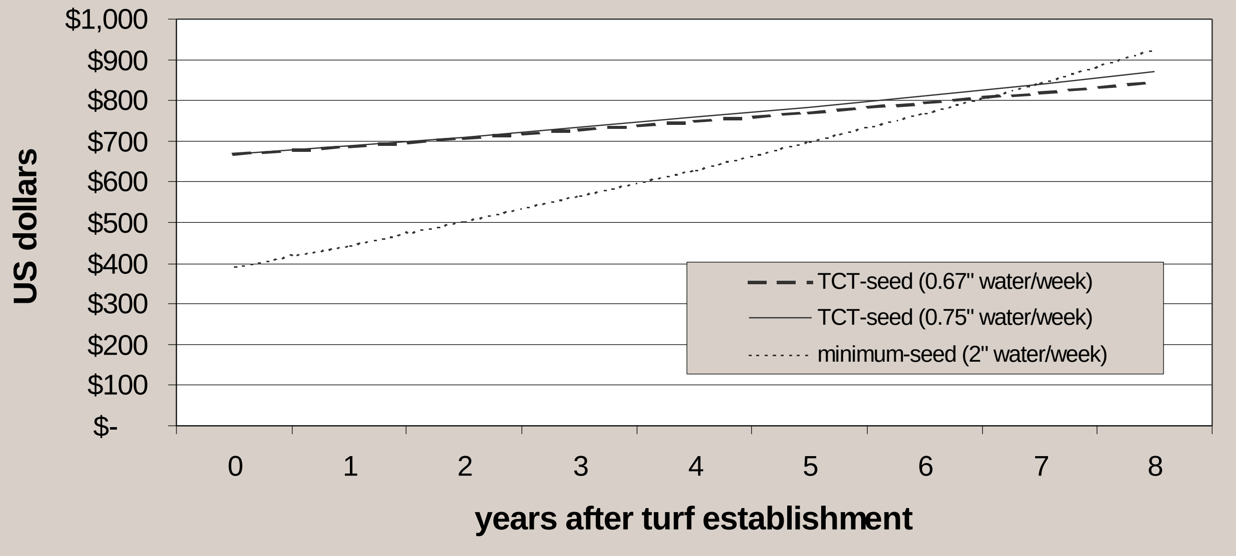
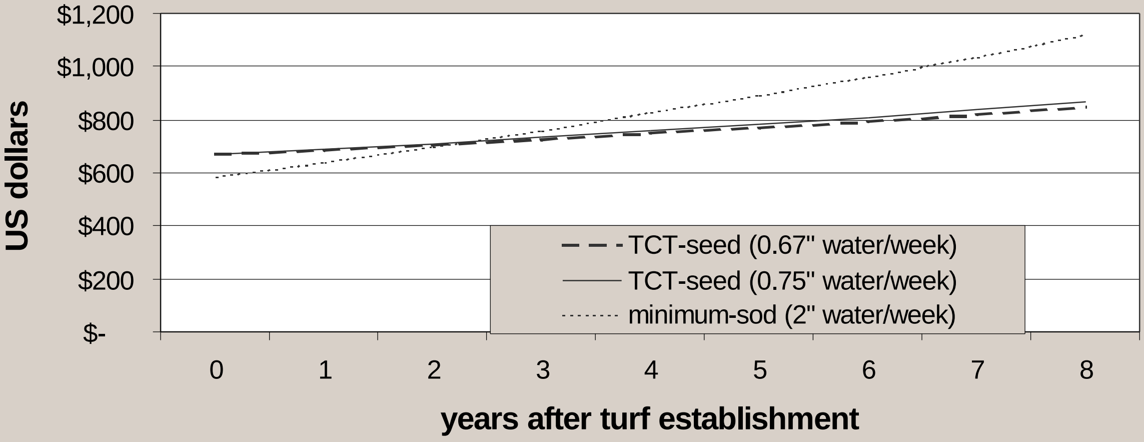


Figure IV-3: Payback Period For The Installation, Water and Fertilizer of TCT-seed vs. Minimum-Seed

IV.G TCT-seed versus Minimum-Sod

In the worst case scenario individuals simply lay sod down upon compacted soil with very little organic matter. In order for the sod to retain sufficient nutrients to look aesthetically appealing, minimum-sod must be fertilized with 6 to 8-pounds of nitrogen annually , as opposed to the 2 to 4-pounds of nitrogen applied to turf grown on compost-amended soil. Each of these 6 annual nitrogen applications is usually accompanied by a proportional quantity of phosphorous, as well as a several of other fertilizers. Furthermore, “sod-on-cement” type turf typically requires between 2 to 2.5-inches of water a week in order to stay green during the entire summer (Hawn 1997). The frequent fertilizer applications and enormous leaching potential of continuous watering results in significant off-site nutrient run off degrading the water quality in Lake Sammamish and local groundwater aquifers. Finally the model predicts that the payback period for minimum-sod versus TCT-seed is approximately 2 to 3-years (See Figure IV.4).

Figure IV-4: Payback Period For The Installation, Water, and Fertilizer of TCT-seed vs. Minimum-Sod



IV.H Conclusion

In conclusion, turf grown on compost-amended soil can save homeowners, residences, and businesses money on water and fertilizer when compared to the other types of turf. TCT-seed seeded-turf pays for itself: (1) in year-5 to 6 when compared to topsoil-seed, (2) in year-0 when compared to topsoil-sod, (3) in year-6 to 7 when compared to minimum-seed, and (4) in year-2 to 3 when compared to minimum-sod.

There are several external costs that can be alleviated by compost-amended soil that have not been put into the economic model. These external costs have not been quantified, however compost-amended soil can potentially reduce pesticide and fertilizer runoff into local streams and groundwater aquifers. Finally, by adopting the compost-amended soil programs in the Puget Sound area, the general population will save money on water and fertilizer, and the environment may benefit from improved soil quality (See Chapter V – Soil Quality Issues).

Chapter V: Soil Quality Issues

V.A Soil Quality Issues

Compost-amended-soil can benefit the City of Redmond by improving the soil quality and thus the environmental health of Redmond's urban and suburban landscapes. Soil quality is defined as "the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health." The three major components that define soil quality include (Doran *et al,* 1994):

(1) **Productivity-** The ability of soil to enhance biological productivity.
(2) **Environmental quality-** The ability of soil to attenuate environmental contaminants, pathogens, and offsite damage.
(3) **Biota health**- The interrelationship between soil quality and plant, animal, and human health.

V.B Turf grown on Compost-Amended Soil Is More Productive

Turf grown on compost-amended soil is more productive (or produces more biomass) than turf on unamended soils. Typically compost amended turf possesses (1) larger individual grass blades resulting in a thicker more healthy looking lawn, and (2) deeper grass roots resulting in a more spongy and resilient lawn. Compost amended soil is more productive due primarily to the physical and chemical characteristics of compost itself.

As noted earlier, proper incorporation of compost into a typical Redmond glaciated soil will increase the soil organic matter to eight to thirteen percent by weight. Compost increases the moisture holding capacity and moisture retention capacity of a soil (Hortenstine and Rothwell, 1972; Bengston and Cornette, 1973; Epstein *et al.,* 1976), thus the soil can hold onto more water for a longer period of time than an unamended soil. During the dry summer months, water is a limiting factor for turf productivity, and any increase in available water will increase productivity.

Furthermore, compost itself contains slow-release nutrients. Soil organisms slowly decompose the compost releasing nutrients into the soil environment over several years. Compost also increases the cation exchange capacity of a soil (or the ability of a soil to retain positively charged nutrients such as NH4+, Ca2+, Mg2+, and K+). Thus compost-amended soil typically contains more available nutrients which can increase net photosynthesis and starch and protein production.

V.C Turf grown on Compost-Amended Soil Improves Environmental Quality

Turf grown on compost-amended soil is typically healthier than turf grown on unamended-soil due to the better aeration, reduction of soil compaction, deeper rooting depth, and improved soil structure. Healthier turf is generally more tolerant to insect, disease, weed invasion and fungal attack, resulting in an overall reduction in pesticide and herbicide utilization (Stahnke, 1997).

Over the counter fertilizer-with-herbicide products commonly used in the Puget Sound area (e.g., “weed and feed”) contain 2,4-D mecoprop, and dicamba. Researchers applied herbicides and fertilizer to turf in Georgia, and found that 10% of applied 2,4 D, 14% of the mecoprop, and 15% of the dicamba washed off mildly-sloped green turf after two days following two inches of simulated rain. However 26% of applied 2,4 D, 24% of the mecoporp, and 37% of the dicamba washed off a mildly-sloped dormant turf in the same experiment (Kenna, 1995). Furthermore, Kenna (1995) found that 16% of nitrate fertilizer washed off the mildly-sloped green-turf in two days, and 64% of the nitrate fertilizer washed off a mildly sloped dormant-turf in two days. Thus one can deduce that actively growing turf absorbs more nutrients and herbicides than dormant turf.

An increasing portion of these fertilizers and pesticides are getting out into the streams and lakes in the Puget Sound Region. In September of 1997, Lake Sammamish suffered from an algal bloom. Phosphorus is usually the limiting nutrient for algae, although nitrogen is sometimes the limiting nutrient.It appears that fertilizer runoff and sediment (from development in the watershed) are supplying sufficient quantities of these limiting nutrients to deteriorate the local water quality.

In 1992 and 1993 the Washington State Department of Ecology sampled eleven local sites for some common pesticides. In 1992 nine pesticides including glyphosate (Roundup), diazinon, and 2,4-D were detected in both Thorton and Mercer Creeks. Resampling of Mercer Creek in 1993 found the aquatic contamination to have increased to fifteen pesticides. While all identified pesticides were at levels below one part per billion (ppb), the increase in pesticides indicate further degradation of the Puget Sound Region aquatic environment. If compost-amended-soil increases turf health and reduces the need for pesticide applications, the water in the Puget Sound Region may become less contaminated over time.

V.D Compost-Amended-Soil Improves Biota Health

Compost can increase the available microhabitats necessary for beneficial predatory insects and soil microorganisms, thus increasing the biodiversity in the soil ecosystem. Earthworms, soil arthropods, and soil microorganisms improve the soil structure by recycling recalcitrant difficult-to-decompose organic debris, such as thatch, back into nutrients needed for turf production. Predacious invertebrates use the improved soil structure of compost-amended soil as habitat, and consume herbivorous insects that cause damage to turf. On the other hand soils with little organic matter have low moisture holding capacities and lack microhabitats necessary for beneficial predatory insects, earthworms and soil microorganisms (Paul and Clark, 1996).

Compost-amended-turf is generally healthier than unamended-turf requiring less fertilizer and pesticides (Sthanke, 1997). Overapplication of fertilizers which reduce soil pH and some pesticides can reduce turf earthworm populations, and grass vigor resulting in thatch buildup (King and Dale, 1977).

Furthermore, soils rich in organic matter (e.g., compost) typically have more microbial biodiversity than soils without organic matter. This is mainly due to the fact that microorganisms require a carbon substrate for reproduction. And microorganisms can decompose soil contaminants such as hydrocarbons and pesticides. Hence, increased concentrations of organic matter in soil can result in faster degradation (or chelation) of toxic compounds (Paul and Clark, 1996).

V.E Conclusion

Compost incorporation into Redmond soils typically improves the overall soil quality by increasing soil productivity, possibly improving environmental quality, and increasing soil biodiversity. Compost-amendment improves turf productivity by increasing the amount and duration of available water, available nutrients and aeration, and the rooting depth of turf. Compost can improve environmental quality by reducing the amount of fertilizer and pesticides used on turf, and by potentially reducing the amount of pesticide and fertilizer runoff from turf. Compost can increase the biodiversity of the soil environment by increasing available carbon substrate for microorganisms and microhabitats for predatory insects.

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Appendix B: Individuals and Businesses Surveyed

Contact	Company	Phone	Street Address	City
LANDSCAPE CONTRACTORS				
Scott	Attractive Landscape	(253)838-1215	8302 Chambers Creek Rd. W.	Tacoma
Charles Martin	Beowulf Landscaper	(206)440-0067	1121 NE Perkins Way	Shoreline
Mike Freedman	Benchmark Land Management	(425)880-4578	P.O. Box 1078	Fall City
Tom Berg	Berg's Landscaping	(425)483-0717	P.O. Box 1628	Woodinvi
Leon Hussey	Classic Nursery	(425)885-5678	12526 Avondale Rd.	Redmond
Mitch Fergeson	Clifford Qualtiy Landscaping	(253)527-1284	11814 23d Ave SE	Seatac
Dan Defreece	Defreece Landscape Services, Inc.	(425)481-6889	23010 E. Echo Lake Rd.	Snohomis
Jerry Gorton	Gorton's Landscaping	(425)228-8719	955 Edmonds NE, Apt. D	Renton
Lauren Stouhish	The Highridge Corporation	(425)587-0249	P.O. Box 260	Issaquah
Ladd Smith	In Harmony Landscaping	(425)486-2180	P.O. Box 755	Woodinvi
Joel	Mohoric Landscaping Inc	(206)775-0659		
Monti	Pro Grass	(425)486-4799	1734 211th Way NE	Redmond
Pat Hunsaker	Shamrock Landscaping	(206)271-6568	11335 Durland Pl. NE	Seattle
Mike Palmer	Star Nurserys	(253)241-2115	13916 42nd S.	Tukwilla
Dave	Terrain Co	(206)839-4295		
Michael	Thomas Catworks	(206)946-9449		
Tim Goss	Tim Goss Landscape Design	(206)842-8664	353 Wallace Way NE, #17	Bainbridg
Ross Fletcher	Teuful	(425)482-1112	6303 200 33d Pl. SE	Woodinvi

Company	Phone	City

SOD & HYDROSEEDING COMPANIES

Agrow-Tech Hydroseeding	1-800-605-4446	Marysville
Briargreen	1-800-635-TURF	Kent
Choice Turf	(206)487-1240	Snohomis
Country Green Turf Farms	1-800-300-1763	Olympia
Emerald Turfgrass Farms	(206)641-0608	Sumner
Grass Masters	1-800-859-4727	Redmond
Green Valley Turf Farm	1-800-237-3884	Sumner
Hydroseeding Inc.	1-800-870-0242	Puyallup
JB Instant Lawn	(206)821-0444	Redmond

COMPOST DISTRIBUTORS

Cedar Grove Composting Inc	(206)521-9439	Maple Val
GroCo	(206)622-5141	Seattle
Pacific Topsoil	(425)522-7180	Bothell

OTHER CONTACTS

Contact	**Company**	**Profession**	**Street Address**	**City**
Rod Bailey	Evergreen Services Corporation	Landscape Management	12010 SE 32nd St.	Bellevue
Phillip Unterschuetz	Integrated Fertility Management	Soil Scientist	333 Ohme Gardens Road	Wenatche
Dirk Muntean	Plant and Soil Science	Soil Scientist	P.O. Box 1648	Bellevue