Go to Table of Contents

Using Compost as a Soil Amendment (Post-Construction Soil BMP)

Compost is the product resulting from the controlled biological decomposition of organic materials that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth. It is an organic matter resource that has the unique ability to improve the chemical, physical, and biological characteristics of soil.

1. Key Considerations

Healthy, undisturbed soils provide important stormwater management functions including efficient water infiltration and storage, adsorption of excess nutrients, filtration of sediments, biological decomposition of pollutants, and moderation of peak stream flows and temperatures. In addition, healthy soils support vigorous plant growth that intercepts rainfall, returning much of it to the sky through evaporation and transpiration. Common development practices include removal of topsoil during grading and clearing, compaction of remaining soil, and planting into unimproved soil or shallow depths of poor quality imported topsoil. These conditions typically produce unhealthy plants that require excessive water, fertilizers and pesticides, further contaminating runoff.

To maintain the natural soil qualities, impacts to undisturbed soils should be avoided and minimized during the construction process. When impacts are unavoidable and soils have been compacted or otherwise disturbed, compost can be used as an amendment to regain some of the characteristics of undisturbed soils.

Figure 1 shows the effect that compaction of soils has on infiltration of water into sandy and clay soils. Uncompacted sandy soils will infiltrate up to 12 inches of water per hour. When compacted, the infiltration rate decreases to 1 inch or less per hour or a 90% reduction in the infiltration of water. Uncompacted clay soils are able to infiltrate up to 9 in per hour. However, when compacted, the infiltration rate drops to less than a ½ inch per hour or a 95% reduction in the infiltration of water. This illustrates how compacted soils contribute a significantly greater volume of runoff to the storm water system. Later discussion shows how compost can help to off-set the effect of compaction.

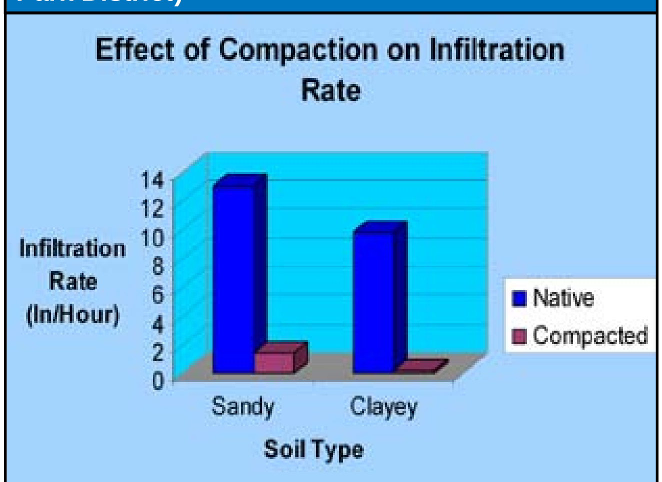
Establishing soil quality and depth regains greater stormwater function in the post development landscape, provides increased treatment of pollutants and sediments that result from development and habitation, and minimizes the need for some landscaping chemicals, thus reducing pollution through prevention. Establishing a minimum soil quality and depth is not the same as preservation of naturally occurring soil and vegetation. However, establishing a minimum soil quality and depth will provide improved onsite management of stormwater flow and water quality.

1.1. Benefits:

Compost can be used as a soil amendment to:

- Increase infiltration
- Reduce runoff
- Improve soil porosity
- Increase soil moisture holding capacity (reduce water demand of lawns and landscaping)
- Reduce erosion
- Absorb certain pollutants (increase cation exchange capacity)
- Reduce fertilizer needs

Figure 1. Comparison of Soil Infiltration after Compaction (*from John Barten, Three Rivers Park District*)



Dormant seeding a compost blanket at a Two Harbors site in late November.

The same Two Harbors site in early spring. Compost blanket on left, seeded straw mat on right.

The Two Harbors site in late summer shows the relative success of the two methods.

- Reduce pesticide and herbicide needs

2. Material Specifications

When amending disturbed soils with compost, it is important to use a compost product that fits the specific situation. In Minnesota, compost is made from a variety of feed-stocks, including yard and leaf debris, residential or commercial food residuals, and animal manure. Each type of feedstock produces a slightly different compost. Examples would be, a yard and leaf compost is low in nutrients (N-P-K) and the particle size is generally a little more coarse than a manure compost which is higher in

Figure 2. Guide to Developing a Soil Management Plan

Step 1 - Determine soil conditions
- Soil type
- Organic and moisture content
- Degree of compaction

Step 2: Develop site and grading plans, which:
- Minimize limits of grading
- Minimize construction limits
- Minimize compaction and construction disturbance
- Minimize soil cut and filling
- Maximize green space
- Maximize preservation of soils with high infiltration rates

Step 3 – Develop soil management plan that determines:
- Areas where native soil and/or vegetation will be retained in place;
- Areas where topsoil or subsoil will be amended in place;
- Areas where topsoil will be stripped and stockpiled prior to grading for reapplication, and;
- Areas where imported topsoil will be applied.

Step 4: Identify available material source

Step 5: Select amendment options & application

Step 6: Calculate application volumes

Step 7: Specify as-built testing procedures

Go to Table of Contents

N-P-K and has a finer, more uniform particle size. These are important factors, as a yard - leaf compost would be more appropriately used when applying compost to a project site that is close to a water source. In addition, yard – leaf compost is more coarse and is a better choice for a blanket, filter sox or berm to control erosion.

Both yard – leaf compost and the manure compost could be used for turf applications. However, if using manure compost, the fertilizer application may need to be adjusted downward so as to not over fertilize the turf and inadvertently create nutrient runoff.

Compost maturity is another important factor. Using compost that has been properly aged as a post-construction soil amendment promotes healthy root and plant growth and will prevent damage to turf and plantings. When immature compost is applied to soils it continues to decompose and the process of decomposition robs nitrogen from the plants and stunts plant growth, possibly even killing the plant.

To facilitate the creation of consistent compost products throughout the United States, the U.S. Composting Council (USCC) created the Seal of Testing Assurance Program (STA). This voluntary program requires participating compost facilities to perform a uniform set of tests on their compost products. Composters who are STA participants are required to furnish test information to compost buyers. This gives the purchaser of the compost the agronomic information needed (such as pH, particle size and test results from a number of other parameters) to successfully use the compost.

3. Turf Establishment or Incorporation in Soil as an Amendment

When purchasing compost to be used for turf establishment or incorporation into soil as a post-construction soil amendment, look for the specifications listed in Table 1.

3.1. Application Guidelines

The goal in amending compacted soils with compost is to reach or exceed the stormwater management benefits of naturally occurring soil and vegetation. Compost amended soils will improve on-site stormwater management and reduce long term operation and maintenance costs for off-site water treatment best management practices. Developing a Soil Management Plan is an important first step in minimizing and mitigating impacts to native soils and maximizing onsite stormwater

Warning

Immature compost will not provide the benefits of mature compost. When immature compost is applied to soils it will continue to decompose and the process of decomposition and the by-products it creates and nutrients it demands may be harmful to plants growing in the soil (Garland and Grist, 1995). These effects may be eliminated by adding additional fertilizer, thereby supplying the nitrogen needed for the continued decomposition of the compost and plant needs.

Application of compost blanket roadside County Road 41 in Carver County.

County Road 41 roadside in Carver County after application of compost blanket.

Go to Table of Contents

Table 1. When purchasing compost to be used for turf establishment or incorporation into soil as a post-construction soil amendment, look for these specifications

Parameter	Parameter Definition	Range (Provided by G. Black, MPCA, 2007)
Source Material/ Nutrient Content	Compost typically comes from biosolids/animal manure or yard wastes. Compost made from biosolids and animal manure typically contains more nutrients.	N: 0.5 – 3 P: 0.5 - 1.5 K: 0.5 - 1
Maturity	Maturity refers to the level of completeness of the composting process. Composts that have not progressed far enough along the decomposition process may contain phytotoxic compounds that inhibit plant growth.	Seed Emergence and Seed vigor =n Minimum 80% relative to positive control
Stability	Compost stability refers to the biological activity in the composted material. Unstable composts may use available nitrogen in the soil and stunt plant growth.	CO2 Evolution rate: < 8 mg CO_2-C/g OM/day
pH	pH is a measure of acidity/alkalinity. Amending soil with compost can alter soil pH, which in turn can improve plant growth.	5.5 – 8.5
Soluble salts	The term "soluble salts" refers to the amount of soluble ions in a solution of compost and water. Because most plant nutrients are supplied in soluble form, excess non-nutrient soluble salts can inhibit plant growth.	Varies widely according to source materials for compost, but should be < 10 dS/m (mmhos/cm)
Organic matter	Organic matter is a measure of the amount of carbon-based materials in compost. There is no ideal range of organic matter for compost, but knowing the amount of organic matter in compost may help determine application rates for specific applications.	30-65% dry weight basis
Particle size	It is helpful to know the size of particles in a compost product. There is no ideal range, but particle size does influence the usability of a compost product for a specific application.	Pass through 1-inch screen or less.
Biological contaminants (weed seeds and pathogens)	Biological contaminants consist of pathogens (disease causing organisms) and weed seeds. High temperatures will inactivate both types of biological contaminants. Minnesota State composting rules require commercial composting operations to hold temperatures over 55 degrees C over an extended period of time to destroy pathogens. In addition, compost operations must monitor the process to prove that these conditions have been met.	Meet or exceed US EPA Class A standards, 40 CFR §503.32(a) levels
Physical contaminants (inerts)*	Inerts are man-made materials (like pieces of plastic or glass) that do not decompose. There is no ideal range but they may be aesthetically unpleasing and add no value to the compost.	< 1% dry weight basis
Trace metals	Trace metals are elements that can be toxic to humans, animals, or plants at elevated concentrations.	Meet or exceed US EPA Class A standards, 40 CFR §503.32(a) levels

* Inert material should not be present in adequately screened, vegetated waste compost. Caution should be used when the compost originates as mixed municipal or unscreened compost.

Compost grouting on Highway 61.

Highway 61 roadside after application of compost grouting.

management benefits.

In areas where remaining topsoil or subsoil will be amended in place, it is important that, at a minimum, certain soil quality and depth improvements are achieved, as follows:

Soil Quality: For soils in planting areas, a minimum dry weight organic matter content of 10% is recommended. For soils in turf areas, a minimum dry weight organic matter content of 5% is recommended. Soil pH should range from 6.0 to 8.0 or match the pH of the original topsoil (WDOE, 2005).

Depth: Within the construction limits, a minimum, uncompacted depth of 12 inches is recommended (Kunz and Jurries, 2001, WDOE, 2005). In high traffic areas, a minimum uncompacted depth of 18 inches is recommended. Table 1 summarizes how to achieve these depths in planting areas and turf areas.

3.2. Nutrient Precaution

When leaching of nutrients could be harmful to a receiving water, is it important to take the compost source into consideration. Because compost made from biosolids or animal manure tends to be higher in nutrients, there is the possibility of nutrient leaching. In general, adequately composted tree and grass material presents less of a problem than animal waste or mixed municipal compost. These types of compost are less appropriate for certain uses in areas in close proximity to water bodies. Note that the use of potential nutrient leaching compost

Table 2. Application Guidelines

	Planting areas	Turf areas
High-traffic areas	(18 inch uncompacted depth) Incorporate 3 inches of compost into the top 5 inches of compacted soil to create a topsoil layer with a minimum depth of 8 inches. Soils below the top soil layer should be scarified to at least 10 inches.	Incorporate 1.75 inches of compost into the top 6.25 inches of compacted soil to create a topsoil layer with a minimum depth of 8 inches. Soils below the top soil layer should be scarified to at least 10 inches.
Construction limits	(12 inch uncompacted depth) Incorporate 3 inches of compost into the top 5 inches of compacted soil to create a topsoil layer with a minimum depth of 8 inches. Soils below the top soil layer should be scarified to at least 4 inches.	Incorporate 1.75 inches of compost into the top 6.25 inches of compacted soil to create a topsoil layer with a minimum depth of 8 inches. Soils below the top soil layer should be scarified to at least 4 inches.

as a filter material in such things as compost socks or filter bags should be avoided whenever excess nutrient (see previous section on Materials Specification) content of water flowing through the filter and into a receiving water would cause a problem. Specification of compost without extractable phosphorus is recommended in cases when nutrients are a receiving water concern.

4. Other Benefits and Emerging

Uses of Compost

In addition to improving the stormwater management functions of compacted soils, compost has several other beneficial uses. The first part of this Fact Sheet addressed soil compost for uses as a post-construction BMP. Because there are so many benefits for compost, its use in construction runoff control is also discussed in the following paragraphs. Many of the uses of compost

Table 3. Product Parameters: Compost Blanket

Parameters[1,4]	Reported as (units of measure)	Blanket Media to be Vegetated	Blanket media to be left Un-vegetated
pH[2]	pH units	6.0 - 8.5	N/A
Soluble Salt Concentration[2] (electrical conductivity)	dS/m (mmhos/cm)	Maximum 5	Maximum 5
Moisture Content	%, wet weight basis	30 – 60	30 – 60
Organic Matter Content	%, dry weight basis	25 – 65	25-100
Particle Size	% passing a selected mesh size, dry weight basis	- 3” (75 mm), 100% passing - 1” (25mm), 90% to 100% passing - 3/4” (19mm), 65% to 100%passing - 1/4” (6.4 mm), 0% to 75% passing - Maximum particle length of 6” (152mm)	- 3” (75 mm), 100% passing - 1” (25mm), 90% to 100% passing - 3/4” (19mm), 65% to 100%passing - 1/4” (6.4 mm), 0% to 75% passing - Maximum particle length of 6” (152mm)
Stability[3] Carbon Dioxide Evolution Rate	mg CO_2-C per g OM per day	< 8	N/A
Physical Contaminants (man-made inerts)	%, dry weight basis	< 1	< 1

1 Recommended test methodologies are provided in Test Methods for the Examination of Composting and Compost (TMECC, The US Composting Council)

2 Each specific plant species requires a specific pH range. Each plant also has a salinity tolerance rating, and maximum tolerable quantities are known. When specifying the establishment of any plant or turf species, it is important to understand their pH and soluble salt requirements, and how they relate to the compost in use.

3 Stability/Maturity rating is an area of compost science that is still evolving, and as such, other various test methods could be considered. Also, never base compost quality conclusions on the result of a single stability/maturity test.

4 Landscape architects, plant specialists and project (field) engineers may modify the allowable compost specification ranges based on specific field conditions and plant requirements.

Go to Table of Contents

certainly overlap and can serve both construction and post-construction purposes.

4.1. Erosion Control and Storm Water Management Uses of Compost

4.1.1 Compost Blanket Application

If you are considering using compost as a "blanket" to reduce or prevent erosion (See Table 3), the soil blanket should be a composted, weed free organic matter source derived from: agricultural, food, or industrial residuals; yard trimmings; or source-separated or mixed solid waste. Particle size shall be as described below in the product parameters table. The compost shall possess no objectionable odors, will be reasonably free (< 1% by dry weight) of foreign matter and will meet the product parameters outlined below.

Well-composted product will provide the best planting medium for grass, wildflower, legume seeding or ornamental planting. Very coarse composts may need to be avoided if the slope is to be landscaped or seeded, as it will make planting and crop establishment more difficult. Composts containing fibrous particles that range in size produce a more stable mat.

A. Construction Requirements:

Compost mulch shall be uniformly applied to a depth described below. Areas receiving greater precipitation (see Table 4), possessing a higher erosivity index, or which will remain unvegetated, will require greater application rates.

The compost should be spread uniformly on up to 1:2 slopes, then track (compact) the compost layer using a bulldozer or other appropriate equipment, if possible. Alternatively, apply compost using a pneumatic (blower) or slinger type spreader unit. Project compost directly at soil surface, thereby preventing water from moving between the soil-compost interface. Apply compost layer approximately 3 feet beyond the top of the slope or overlap it into existing vegetation. On highly unstable soils, use compost in conjunction with appropriate structural, stabilization and diversion measures. Follow by seeding or ornamental planting if desired.

4.1.2 Compost Filter Berm Application or Sediment Control

A. Description:

This work consists of constructing a raised berm of compost on a soil surface to contain soil erosion, control the movement of sediment off site, and to filter storm water.

B. Materials:

Filter berm media should be a composted, weed free organic matter source derived from: agricultural, food, or industrial residuals; yard trimmings; source-separated or mixed solid waste. Particle size may vary widely. The compost shall possess no objectionable odors, will be reasonably free (< 1% by dry weight) of man-made foreign matter and will meet the product parameters outlined below.

Where seeding of the berm is planned, use only well composted product that contains no substances toxic to plants. Avoid coarse composts if the berm is to be seeded, as it will make establishment more difficult.

The Landscape Architect/Designer shall specify the berm dimensions depending upon specific site (e.g., soil characteristics, existing vegetation) and climatic conditions, as well as particular project related requirements. The severity of slope grade, as well as slope length, will also influence compost application.

Table 4. Construction Requirements: Compost Blanket Application

Annual Rainfall/ Flow Rate	Total Precipitation & Rainfall Erosivity Index	Application Rate For Vegetated* Compost Surface Mulch	Application Rate For Unvegetated Compost Surface Mulch
Low	1-25", 20-90	½ - ¾ " (12.5 mm – 19 mm)	1" – 1 ½" (25 mm – 37.5mm)
Average	26-50", 91-200	¾ - 1" (19 mm – 25 mm)	1 ½" – 2" (37 mm – 50 mm)
High	51" and above, 201 and above	1-2" (25 mm – 50 mm)	2-4" (50mm – 100mm)

*These lower application rates should only be used in conjunction with seeding, and for compost blankets applied during the prescribed planting season for the particular region.

Go to Table of Contents

C. Construction Requirements

Parallel to the base of the slope or other affected areas, construct a berm of compost to the size specifications outlined in Table 6.

In extreme conditions and where specified by the Landscape Architect/Designer, a second berm shall be constructed at the top of the slope or silt fencing shall be installed in conjunction with the compost berm. Where the berm deteriorates, it shall be reconstructed. Do not use filter berms in any runoff channels (concentrated flows).

Table 5. Product Parameters: Compost Filter Berm Application for Sediment Control

Parameters[1,4]	Reported as (units of measure)	Filter Berm to be Vegetated	Filter Berm to be left Un-vegetated
pH[2]	pH units	6.0 - 8.5	N/A
Soluble Salt Concentration[2] (electrical conductivity)	dS/m (mmhos/cm)	Maximum 5	N/A
Moisture Content	%, wet weight basis	30 – 60	30 – 60
Organic Matter Content	%, dry weight basis	25 – 65	25-100
Particle Size	% passing a selected mesh size, dry weight basis	- 3" (75 mm), 100% passing - 1" (25mm), 90% to 100% passing - 3/4" (19mm), 70% to 100%passing - 1/4" (6.4 mm), 0% to 75% passing Maximum: - particle size length of 6" (152mm) (no more than 60% passing 1/4" (6.4 mm) in high rainfall/flow rate situations)	- 3" (75 mm), 100% passing - 1" (25mm), 90% to 100% passing - 3/4" (19mm), 65% to 100%passing - 1/4" (6.4 mm), 0% to 75% passing Maximum: - Particle size length of 6" (152mm) (no more than 50% passing 1/4" (6.4 mm) in high rainfall/flow rate situations)
Stability[3] Carbon Dioxide Evolution Rate	mg CO_2-C per g OM per day	< 8	N/A
Physical Contaminants (man-made inerts)	%, dry weight basis	< 1	< 1

[1] Recommended test methodologies are provided in Test Methods for the Examination of Composting and Compost (TMECC, The US Composting Council)

[2] Each specific plant species requires a specific pH range. Each plant also has a salinity tolerance rating, and maximum tolerable quantities are known. When specifying the establishment of any plant or turf species, it is important to understand their pH and soluble salt requirements, and how they relate to the compost in use.

[3] Stability/Maturity rating is an area of compost science that is still evolving, and as such, other various test methods could be considered. Also, never base compost quality conclusions on the result of a single stability/maturity test.

[4] Landscape architects, plant specialists and project (field) engineers may modify the allowable compost specification ranges based on specific field conditions and plant requirements.

Go to Table of Contents

4.2. Other Uses

In addition to improving the stormwater management functions of compacted soils, compost has several other beneficial uses.

4.2.1 Soil Reclamation

Compost can be used to reclaim highly disturbed and low quality soils on sites of old factories, landfills, and brownfields. Application rates in such situations often range from 25 to 175 tons per acre, much higher than typical compost application rates. Benefits include improved soil quality and enhanced plant establishment (Alexander, 1999).

4.2.2 Wetland Construction

Due to its similar physical and chemical properties to certain wetland soils, compost is being used to mimic hydrology, soil properties and plant community composition wetland functions.

4.2.3 Pollution Remediation

Compost has been shown to be effective in degrading or immobilizing several types of contaminants, including hydrocarbons, solvents, and heavy metals (Alexander, 1999).

4.2.4 Pollution Prevention

Compost has been included as a component of biofilters and bioswales to treat contaminated air and water with great success (Alexander, 1999). Compost treated areas have also be shown to be effective at reducing erosion and stormwater runoff (Glanville, et. al., 2003). Because contaminants adhere to soil particles, this limits the amount of sediment and contaminants reaching water bodies.

5. Additional Information

Clean Washington Center. http://www.cwc.org/organics.htm

Minnesota Pollution Control Agency. http://www.pca.state.mn.us/waste/compost.html

Washington Department of Ecology. 2005. Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13.

Soils for Salmon (Oregon). http://www.soilsforsalmonoregon.org/

Soils for Salmon (Washington). http://www.soilsforsalmon.org/index.htm

U.S. Composting Council. http://www.compostingcouncil.org/index.cfm

U.S. Composting Council Seal of Testing Assurance Program. http://www.compostingcouncil.org/section.cfm?id=35

USEPA, Construction Site Storm Water Runoff Controls; Compost Blankets and Berms: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=4

USEPA, Bioretention Cells and Green Roof: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=124

6. References

Alexander, R. 1999. Compost Markets Grow with Environmental Applications. BioCycle Vol. 40, No. 4, pp. 43-48.

Garland, G. and Grist, T.1995. The Compost Story: From Soil Enrichment to Pollution Remediation. BioCycle , Vol. 36, No. 10, pp. 53-56.

Glanville, T., Richard, T., and Persyn, R. 2003. Impacts of Compost Blankets on Erosion Control, Revegetation, and Water Quality at Highway

Table 6. Construction Requirements: Compost Filter Berm

Annual Rainfall/ Flow Rate	Total Precipitation & Rainfall Erosivity Index	Dimensions for the Compost Filter Berm (height x width)
Low	1-25", 20-90	1'x 2' – 1.5' x 3' (30 cm x 60 cm – 45 cm x 90 cm)
Average	26-50", 91-200	1'x 2' - 1.5' x 3' (30 cm x 60 cm – 45 cm x 90 cm)
High	51" and above, 201 and above	1.5'x 3' – 2' x 4' (45 cm x 90 cm – 60cm x 120 cm)

Go to Table of Contents

Construction Sites in Iowa. Iowa State University.

Kunz, D. and Jurries, D. 2001. Restoring Soil Health. Oregon Department of Environmental Quality.

McDonald, D. 2005. Soil Restoration with Organics Enters Mainstream of Storm Water Practices. BioCycle, Vol. 46, No. 4, pp. 20-22.

Washington Department of Ecology. 2005. Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13.

7. Literature Review

Alexander, R. 1999. Compost markets grow with environmental applications. BioCycle 40(4): 43-48. Summarizes uses of compost: erosion control, revegetation and reclamation of marginal and low quality soils, biofilters and bioswales, bioremediation, wetlands construction. The benefits of amending soil with compost include improved soil quality, reduced erosion, enhanced plant establishment, immobilization of toxic metals and supplying microbes.

Alexander, R. 2003. Landscape Architect Specifications for Compost Utilization. The LASCU, developed for the Clean Washington Center and the US Composting Council is a guide that give specifications for specific uses of compost. Topics include turf establishment (page 40-41), planting bed establishment, backfill mix, mulch, compost blanket for erosion control (pages 48-19), and compost filter berms for sediment control (pages 40-51).

Composting Council Research and Education Foundation. 2001. Compost Use on State Highway Applications. CCREF/USCC. Document focuses on compost use on state and local 'roadside' applications. Defines compost as "the product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth. Compost bears little physical resemblance to the raw material from which it originated. Compost is an organic matter resource that has the unique ability to improve the chemical, physical, and biological characteristics of soils or growing media" (p. 2) The addition of compost to soil provides the following benefits: improved structure, moisture management, modifies and stabilizes ph, increases cation exchange capacity, provides nutrients, provides soil biota, suppresses plant diseases, binds contaminants (p. 3). Includes info on State DOT compost specifications and a "Model DOT Compost Specification." Common specification parameters include pH, particle size, soluble salts, organic matter, moisture content, stability/maturity, pathogens, heavy metals, inerts (p. 55).The importance of each parameter is discussed on p. 61-62.

Garland, G. and Grist, T.1995. The compost story: From soil enrichment to pollution remediation. BioCycle 36(10): 53-56. Defines compost as "a recycled product made from the organic portion of municipal solid waste" (p. 2). Compost is NOT peat or mulch. As organic wood mulch decays it tends to use the nitrogen already in the soil, reducing the amount available for plants. This lack of available nitrogen can retard the growth of young plants. Immature compost is nothing more than an organic mulch and does not provide the benefits of mature compost.

Beneficial uses of compost: soil enrichment (adds organic bulk, increases earthworm populations, humus, and cation exchange capacity), pollution prevention, and pollution reduction.

Ge, B., McCartney, D., and Zeb, J. 2006. Compost Environmental Protection standards in Canada. Journal of Environmental Engineering Science 5: 221-234. Canadian standards typically consider maturity, trace element (heavy metals), time-temperature requirements, microbial pathogens, and foreign matter.

Defines stability as "the rate or degree of organic matter decomposition" (p. 223). Stability can be determined by microbial activity and/or substrate availability (examples include microbial respiration and energy release).

Defines maturity as "the degree of decomposition of phytotoxic organic substances produced during decomposition" (p. 223). Can be determined by a plant biotest.

Maturity and stability are important considerations because "immature compost applied to the soil will continue to decompose and may produce odorous products and are often toxic to plants.

A trace element is a chemical element present in compost at a very low concentration (p. 224). States that there are three approaches to developing trace element standards: no net degradation, risk-based, and best achievable technology.

Microbial pathogens: Four major categories of pathogens: bacteria, enteric viruses, protozoa, and helminthes. Some pathogens may survive in finished compost if the compost is immature or if thermophilic conditions are not achieved throughout the composting mass.

Foreign matter: Defined as "any matter over 2 mm in dimension that results from human intervention and has organic or inorganic components such as metal, glass, synthetic polymers" (p. 230). Excludes mineral soil, woody material, and pieces of rock.

Glanville, T., Richard, T., and Persyn, R. 2003. Impacts of Compost Blankets on Erosion Control, Revegetation, and Water Quality at Highway Construction Sites in Iowa. Iowa State University. The primary objective of this research project is to compare the performance of compost treated and conventionally treated roadway embankments. Performance was measured using the following parameters: runoff quantity, runoff quality, rill and interrill erosion, and seasonal growth of planted species and weeds.

Study tested 3 types of compost: fine-textured biosolids compost, a coarse-textured mulch-like yard waste compost, and a medium-textured bio-industrial compost derived from paper mill and grain processing sludge (selected because of wide-spread availability in Iowa). Compost types were spread as blankets at 2 depths (5 cm and 10 cm) and were not incorporated into the underlying soil.

Results:

- Compost treated areas produced equal amounts of plant material when compared to topsoil or compacted subsoils
- Compost treated areas produced 1/3 of the weed biomass found on conventionally treated areas
- Compost treated areas produced 0.2 mm of runoff or less during the first ½ hour of intense rainfall (compared to 0.15 mm runoff from conventionally treated areas)
- Blanket depth had a significant affect on the amount of runoff – areas treated with 5 cm of compost had 1.5 times the runoff of areas treated with 10 cm of compost
- Total mass of eroded material in runoff from composted plots was less than 0.02% of that in runoff from conventionally treated plots

Kunz, D. and Jurries, D. 2001. Restoring Soil Health. Oregon Department of Environmental Quality. This document explains the link between land use planning, and building and road construction, and degraded surface water. It summarizes current research on the benefits of amending soil with compost and provides information on technical specifications for using and applying compost to building and road construction projects.

Suggests "tilling in about 4" of compost is a simple, cost-effective way to restore organic health to a site" (p. 5). Construction activities can increase stormwater runoff by compacting soil (p. 8). Discusses impacts of human activity on soils including compaction and degraded soils and suggests compost amendments to be a solution to the problems associated with compact and degraded soils. Compost amendments can increase the porosity of the soil and add beneficial organisms and nutrients back to the soil. Recommend applying four inches of compost on the surface and tilling it in to a depth of eight inches of compacted soil for a total depth of twelve inches (p. 13).

McDonald, D. 2005. Soil Restoration with Organics Enters Mainstream of Storm Water Practices. BioCycle 46 (4): 20-22. Features the Soils for Salmon project. The project promotes BMPs for protecting native soil and vegetation where possible, and for restoring soil functions on disturbed sites through the incorporation of organic amendments. Amending the soil with compost provides the following benefits: "increases stormwater infiltration, reducing damaging runoff, and also helps filter out urban pollutants (oils and metals from roads, pesticides and fertilizers from landscapes) while creating more successful landscapes that need less chemicals and less summer irrigation" (p. 20).

Musick M, and Stenn, H. 2004. Best Management Practices for Post-Construction Soils. BioCycle 45 (2): 29. Summarizes new guidelines for soil quality and depth BMPs in Washington State Stormwater Manual. Benefits of undisturbed soils include: water infiltration and storage, nutrient and sediment adsorption, and pollutant biofiltration. Top priority is given to preservation of existing soils. For sites that must be cleared and graded, guidelines require that all disturbed and compacted soils shall be amended to mitigate for lost moisture infiltration and moisture holding capacity. Guidelines call for a

Go to Table of Contents

minimum of 8 inches of topsoil over subsoil scarified to a depth of 4 inches.

Noble, R., and Coventry, E. 2005. Suppression of soil-borne plant diseases with composts: A review. Biocontrol Science and Technology 15(1): 3-20. Reviews several studies that show the suppressive effect of compost on soil-borne diseases.

Pitt, R., et al.1999. Infiltration Through Disturbed Urban Soils and Compost-Amended Soil Effects on Runoff Quality and Quantity. US EPA. Article examines the effects of urbanization on soil structure and how compaction affects infiltration of rainwater. Also looks at the effectiveness of using compost as a soil amendment to increase infiltration and reduce runoff. Found a "generally beneficial effect of the compost amendment in regards to nutrient content as well as soil physical properties known to affect water relations in soils" (p. 4-1). Found that "the use of compost amended soil resulted in significantly increase infiltration rates compared to soil alone" (p. 4-2). Found that "the growth rates of turf were also greater for the amended sites" (p. 4-4).

Risse, M. and Faucette, B. 2001. Compost Utilization for Erosion Control. Cooperative Extension Service, The University of Georgia college of Agricultural and Environmental Science. Defines composting as "the controlled biological process of decomposition and recycling of organic material into a humus rich soil amendment known as compost. Mixed organic materials (Example: manure, yard trimmings, food waste, biosolids) must go through a controlled heat process before they can be used as high quality, biologically stable and mature compost (otherwise it is just mulch, manure or byproduct)" (p. 1). Focuses on benefits of compost for erosion control such as increasing water infiltration, reducing runoff and soil particle transport in runoff, increasing plant growth and soil cover, reducing soil particle dislodging, increasing water holding capacity of soil, which reduces runoff, buffering soil ph which can increase vegetation establishment and growth, alleviates soil compaction by increasing soil structure, new vegetation can be established directly into compost (p. 3)

Includes recommended compost specifications for several parameters including particle size, moisture content, soluble salt, organic matter, ph, nitrogen content, human made inerts, application rate/size, maturity.

Russell, S. and Best, L. 2006. Setting the Standards for Compost. BioCycle 47(6): 53-56. Summarizes UK standards for compost (feedstocks, stability tests, monitoring procedures, and certification methods). Includes guidelines for pathogens, potentially toxic elements, stability/maturity, plant response, weed seeds and propagules, physical contaminants, stones (see page 55).

Zabinski, C., et al. 2002. Restoration of Highly Impacted Subalpine Campsites in the Eagle Cap Wilderness, Oregon. Restoration Ecology 10(2): 275-281. Tested the use of compost in the restoration of highly impacted campsites in the Eagle Cap Wilderness. Plotes as four campsites were scarified, amended with compost, and planted to native species. Assessed the degree to which campsite activity altered soil chemical and microbial properties relative to undisturbed soils and the degree of recovery after compost application. Found that three years after compost amendments were applied, levels of total carbon, PMN, and microbial carbon utilization profiles on campsites were equivalent to those under vegetation on undisturbed sites. Compost amendments also supplied "a slow release of macro and micronutrients, improved water-holding capacity, reduced albedo, and increased heat absorption in the spring" (p. 279).

Go to Table of Contents

Green Roofs

Green roofs consist of a series of layers that create an environment suitable for plant growth without damaging the underlying roof system. Green roofs create green space for public benefit, energy efficiency, and stormwater retention/ detention.

Courtesy of The Green Institute - Minneapolis, MN

Design Criteria

Structural load capacity, how much weight the roof can hold, is a major factor in determining whether the green roof is "extensive" or "intensive" (see next page). Vegetation selection is based on numerous factors including, growth medium depth, microclimate, irrigation availability and maintenance.

A leak detection system is recommended to quickly detect and locate leaks. Modular products can increase installation and repair efficiency.

Benefits

- Reduce, delay, and cool stormwater runoff.
- Insulate buildings and lower energy consumption and costs.
- Provide habitat for birds and insects.
- Increase longevity of traditional roofing systems by protecting from ultra-violet rays.
- Reduce carbon dioxide levels and heat island effect.

Limitations

- Cost is higher than traditional roofing systems – can be significant for retrofits.
- Leaks can cause significant damage and can be hard to locate and repair without an electronic leak detection system.
- Conditions can be harsh for vegetation establishment.
- Maintenance needs can be higher than traditional roofing system.

MANAGEMENT SUITABILITY

High	Water Quality (V_{wq})
Med.	Channel Protection (V_{cp})
Low	Overbank Flood Protection (V_{p10})
Low	Extreme Flood Protection (V_{p100})
Low	Recharge Volume (V_{re})

Note: Pollution removal percentages apply to volume of runoff treated, and not to volume by-passed

MECHANISMS

	Infiltration *with appropriate soil & conditions
X	Screening/ Filtration
X	Temperature Control
	Settling
X	Evaporation
X*	Transpiration *if vegetated
X	Soil Adsorption
X	Biological/ Micro. Uptake

Runoff Volume Minimization

POLLUTION REMOVAL

90%	Total Suspended Solids
100%/ 20%	Nutrients - Total Phosphorus/ Total Nitrogen
80%	Metals - Cadmium, Copper, Lead, and Zinc
65%	Pathogens - Coliform, Streptococci, E. Coli
NA	Toxins - Hydrocarbons, Pesticides

Note: Pollution removal percentages apply to volume of runoff treated, and not to volume by-passed

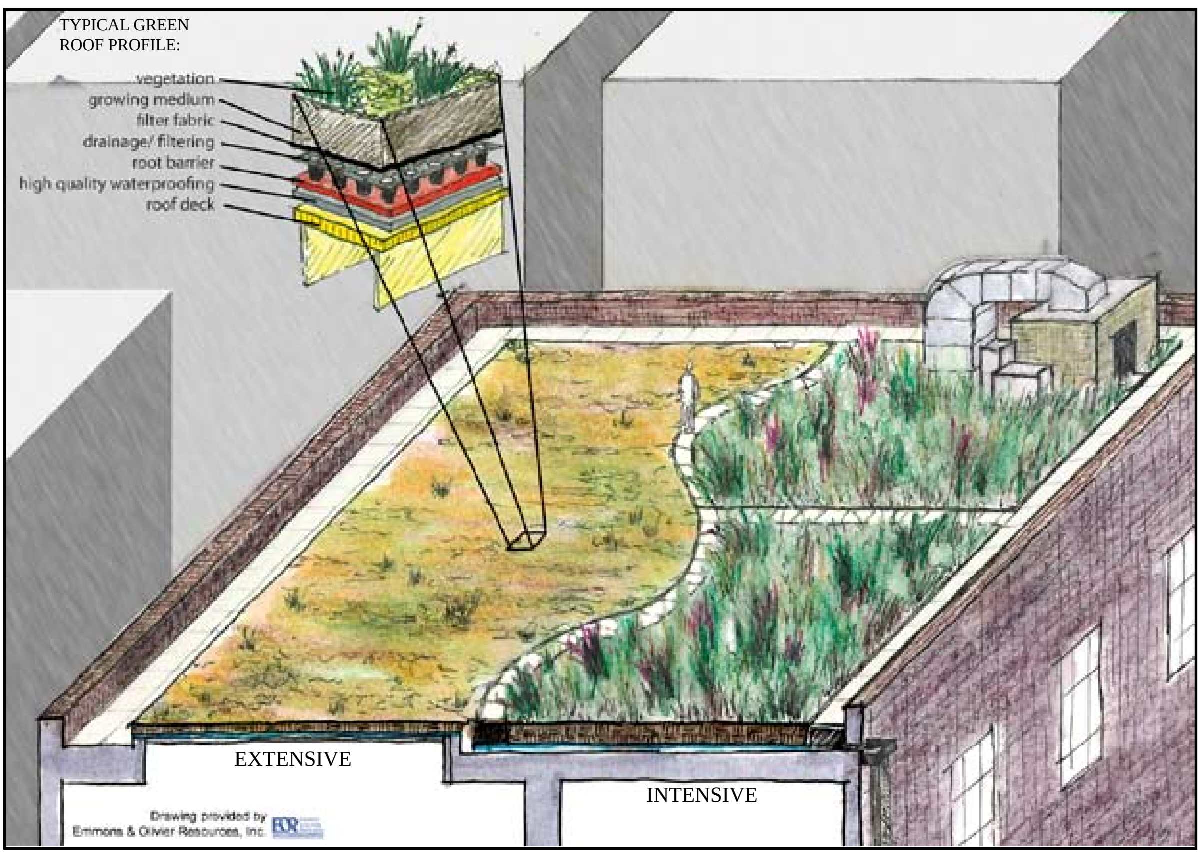
SITE FACTORS

Rooftop	Drainage Area
NA.	Max. Slope
NA	Min. Depth to Bedrock
NA	Min. Depth to Water Table
NA	SCS Soil Type *can be used in C&D soil types with modifications (e.g. underdrains)
Good	Freeze/ Thaw Suitability
Suitable	Potential Hotspot Runoff *requires impermeable liner

Description

There are two systems of green roofs, extensive and intensive, composed of the same system of layers. Extensive systems are lighter, typically have 4 inches or less of growing medium, use drought tolerant vegetation, and can structurally support limited uses (such as maintenance personnel). Intensive systems are heavier, have a greater soil depth, can support a wider range of plants, and can support increased pedestrian traffic.

Rainfall is initially intercepted by vegetation, held on foliage, or soaked up by plant roots. Any remaining runoff filters through the growing medium and is drained away from the roof's surface by the drainage layer. Some drainage systems use small depressions to store excess water for uptake during drier conditions (RCWD 2005), while others provide an overflow for larger rainfall events.



Courtesy of Rice Creek Watershed District

Pervious Pavement

Pervious pavements reduce the amount of runoff by allowing water to pass through surfaces that would otherwise be impervious. Water can either infiltrate into the ground, if soil permeability rates allow, or be conveyed to other BMPs or a storm water system by an under-drain.

Design Criteria

- Pervious pavement is typically used in low traffic areas including overflow parking areas, emergency vehicle lanes, and pedestrian areas.
- In-situ soils should have field-verified minimum permeability rates greater than 0.3 in./hr. Contributing runoff from offsite should be limited to a 3:1 ratio of impervious area to pervious pavement area.
- The selected systems load bearing surface should be suited to maximum intended loads.
- Design storms should be infiltrated within 48 hours.

Grasspave® at Bradshaw Celebration of Life Center - Stillwater, MN

Benefits

- Good for highly impervious areas – particularly parking lots.
- Reduces need for other storm water BMPs by reducing runoff.
- Construction costs of some systems are less than traditional paving.
- Soil-enhanced turf systems resist compaction, increase infiltration, and provide soils for healthier vegetation.

Limitations

- Construction costs of some systems are more expensive than traditional paving
- Use depends on infiltration rates of underlying soils.
- Maintenance costs are higher than conventional paving.
- Not recommended for high traffic areas because of durability concerns.

Description

Pervious pavements can be subdivided into three general categories: 1) Porous Pavements – porous surfaces that infiltrate water across the entire surface (i.e. porous asphalt and porous concrete pavements); 2) Permeable Pavers – impermeable modular blocks or grids separated by spaces or joints that water drains through (i.e. block pavers, plastic grids, etc.); 3) Amended Soils - Fiber or artificial media added to soil to maintain soil structure and prevent compaction. There are many different types of modular porous pavers available from different manufacturers.

Pervious pavement systems reduce runoff from impervious surfaces by allowing stormwater to pass through the load bearing surface and infill that are selected based upon the intended application and required infiltration rate. Runoff is stored in the stone aggregate base course/ storage layer, if present, and allowed to infiltrate into the surrounding soil (functioning like an infiltration basin), or collected by an under-drain system and discharged to the storm sewer system or directly to receiving waters (functioning like a surface sand filter).

Regular maintenance of pervious pavements is necessary to ensure long-term effectiveness. Annual or semi-annual sweeping or vacuuming of surface debris (litter, sediment, etc.) is STRONGLY RECOMMENDED for pavement or pavers. If clogging occurs, the filtration media below the surface may need to be replaced. Manufacturers should be consulted for specific maintenance requirements.

Currently, the MPCA will allow site designers to reduce the water quality volume sizing when using pervious pavement, up to a maximum of ½ acre of new impervious surface. The MPCA will not allow pervious pavements as a replacement for water quality treatment BMPs, such as infiltration or filtration practices.

Go to Table of Contents

Runoff Volume Minimization

MANAGEMENT SUITABILITY

High/ Med.	Water Quality (V_{wq})
Med.	Channel Protection (V_{cp})
Low	Overbank Flood Protection (V_{p10})
Low	Extreme Flood Protection (V_{p100})
High/ Med.	Recharge Volume (V_{re})

MECHANISMS

X*	Infiltration *with appropriate site conditions
X	Screening/ Filtration
X	Temperature Control
	Settling
	Evaporation
X*	Transpiration *if vegetation present
X	Soil Adsorption
X	Biological/ Micro. Uptake

POLLUTION REMOVAL

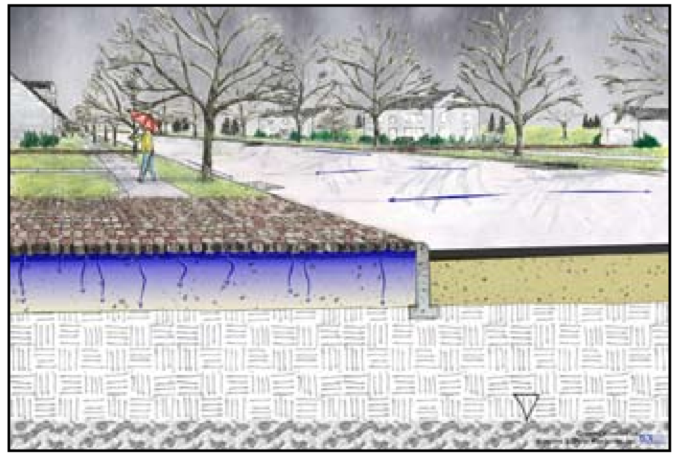
NA*	Total Suspended Solids *pretreatment for TSS is recommended if adjacent areas drain to pervious pavement
80%/ 80%	Nutrients - Total Phosphorus/ Total Nitrogen
90%	Metals - Cadmium, Copper, Lead, and Zinc
NA	Pathogens - Coliform, Streptococci, E. Coli
NA	Toxins - Hydrocarbons, Pesticides

SITE FACTORS

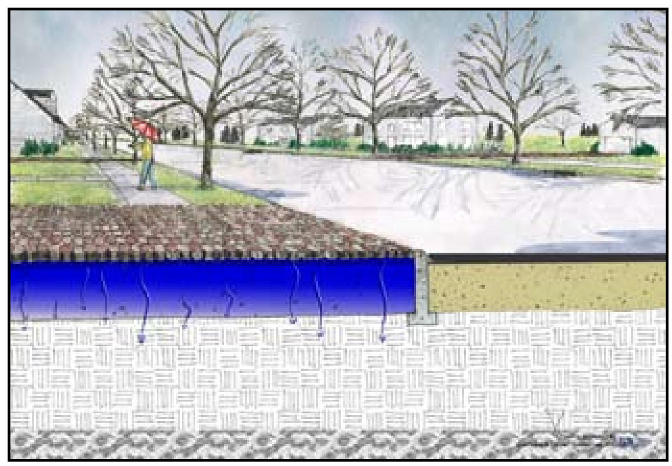
NA	Drainage Area
2% Max.	Max. Slope
3 ft	Min. Depth to Bedrock
3 ft	Min. Depth to Water Table
A,B	SCS Soil Type *can be used in C&D soil types with modifications (e.g. underdrains)
Good	Freeze/ Thaw Suitability *with adequate sub-grade
Yes	Potential Hotspot Runoff *requires impermeable liner if identified in hotspot area

Note: Pollution removal percentages apply to volume of runoff treated, and not to volume of runoff bypassed

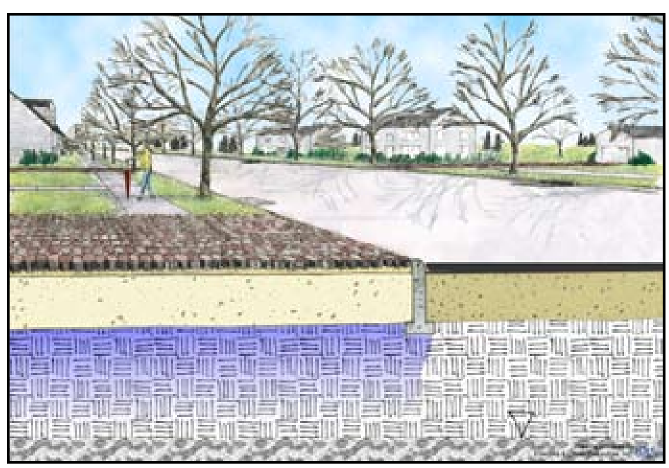
STORM SEQUENCE



Start of Storm Event - Initial runoff & storage



Duration of Storm Event - Storage & filtration/infiltration



Courtesy of Rice Creek Watershed District

Following Storm Event - Remaining storage draw-down

Go to Table of Contents

Rainwater Harvesting

Rain water harvesting is the practice of collecting rain water from impermeable surfaces, such as rooftops, and storing for future use. There are a number of systems used for the collection, storage and distribution of rain water including rain barrels, cisterns, evaporative control systems, and irrigation.

Design Criteria

- The system should be watertight, have a smooth interior surface, be located on level and stable ground, have a tight-fitting lid, good screens on the inlet and outlet and have an emergency overflow device.
- To prevent the breeding of mosquitoes, empty the water in less than 5 days or place a fine screen over all openings.
- Material can withstand the pressure of water over long periods of time.
- Disconnect and drain rain barrels and cisterns in the winter to prevent freezing and deformation of the rain water harvesting system.

Residential rain barrel - Stillwater, MN

MANAGEMENT SUITABILITY

High*	Water Quality (V_{wq})
Med.	Channel Protection (V_{cp})
Low	Overbank Flood Protection (V_{p10})
Low	Extreme Flood Protection (V_{p100})
High*	Recharge Volume (V_{re})

POLLUTION REMOVAL

100%*	Total Suspended Solids
100%*	Nutrients - Total Phosphorus/ Total Nitrogen
100%*	Metals - Cadmium, Copper, Lead, and Zinc
100%*	Pathogens - Coliform, Streptococci, E. Coli
100%*	Toxins - Hydrocarbons, Pesticides

MECHANISMS

X*	Infiltration
X*	Screening/ Filtration
X	Temperature Control
X	Settling
X	Evaporation
X*	Transpiration
X*	Soil Adsorption
X*	Biological/ Micro. Uptake

SITE FACTORS

Rooftop	Drainage Area
NA	Max. Slope
NA	Min. Depth to Bedrock
NA	Min. Depth to Water Table
NA	SCS Soil Type *can be used in C&D soil types with modifications (e.g. underdrains)
Poor	Freeze/ Thaw Suitability
Suitable	Potential Hotspot Runoff

**Assuming water is drained to a vegetated pervious area. Does not apply to volume of runoff that bypasses the system*

Go to Table of Contents

Benefits

- Protects water supplies by reducing use during peak summer months.
- Mimics the natural hydrology of the area by infiltrating a portion of the rain water falling on the site.
- Reduces volume of storm water being delivered to downstream waterbodies.
- Results in cost savings by reducing municipal water bill.

Limitations

- Not suitable for the following roof types: tar and gravel, asbestos shingle and treated cedar shakes.
- Depending on the design, requires a certain amount of operation and maintenance.
- Proprietary systems can be expensive.

Description

Rain water harvesting can be accomplished using rain barrels and/or cisterns. Rain barrels are typically located at the downspout of a gutter system and are used to collect and store rainwater for watering landscapes and gardens.

The simplest method of delivering water is by the force of gravity. However, more complex systems can be designed to deliver the water from multiple barrels connected in a series with pumps and flow control devices.

Cisterns have a greater storage capacity than rain barrels and may be located above or below ground. Due to their size and storage capacity, these systems are typically used to irrigate landscapes and gardens on a regular basis reducing the strain on municipal water supplies during peak summer months. Again, cisterns may be used in series and water is typically delivered using a pump system.

The storage capacity of a rain barrel or cistern is a function of the catchment area, the depth of rainfall required to fill the system and the water losses. A general rule of thumb in sizing rain barrels or cisterns is that one inch of rainfall on a 1,000 square foot roof will yield approximately 600 gallons of runoff.