# USING COMPOST to Protect Water Resources from Pollutants


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The Iowa Waste Reduction Center, located at the University of Northern Iowa, is a nationally recognized leader in environmental consulting and education. We serve organizations seeking to address their environmental impact through consulting, training and specialized assistance.

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# Introduction

Compost, that magical soil amendment, enriches our soils by improving nutrient content, moisture holding capacity, and soil structure. Compost can also help prevent and remediate contamination of rivers, lakes, and streams from pollutant-laden stormwater runoff. Not only does using compost reduce reliance on traditional fertilizers and improve soil health, compost has the capacity to filter, degrade, and sequester many pollutants found in stormwater that can threaten the quality of our local and regional watersheds. This training guide provides an overview of strategies using compost that can help clean-up your favorite swimming hole or fishing spot.

# Impaired Waters

Did you realize that the Federal Clean Water Act was enacted over 50 years ago with the goal for all waters across our country to be “fishable and swimmable” by 1983 and yet here we are with 50% or 300,000 miles of assessed rivers and shorelines listed as impaired along with 5 million acres of lakes across the nation. The US Environmental Protection Agency (EPA) has estimated that over 200,000 million people in the US live within 10 miles of an impaired waterway. This isn’t great news because the EPA has also stated that only half of US waterways have even been tested for pollutants.

The good news is we can do something about it; we can use strategically-placed compost to help filter-out pollutants BEFORE they enter our rivers and lakes.

## How do water sources become impaired?

Impaired means these waters are not safe for one or more public uses including:

- Swimming
- Fishing
- As a source of drinking water

Stormwater drain

## Wet Deposition

So, how do pollutants end-up contaminating our rivers and lakes? One possible way is called wet deposition which is a process where precipitation, as it falls, binds with air pollution such as particulate matter and chemicals that can include mercury, sulfur, or nitrogen released into the air via industrial processes. Wet deposition helps clean the air, however these pollutants are brought to the ground via precipitation.

## Stormwater Pollution

When precipitation hits the ground, be it a farm field, your backyard, or a concrete parking lot, that water either percolates into the ground or it flows on the surface towards rivers, storm drains, or retention basins. This process is called overland flow. As the water travels along the surface, it picks up pollutants such as oil, grease, metals, and coolants from vehicles, fertilizers, pesticides and other chemicals from gardens and farms, bacteria from pets or livestock waste, or even soap from equipment and car washing. Pollution originates within our cities, industries, commercial entities, and both the residential and agricultural sectors.

## What are the criteria that designates a water source as impaired?

Impaired waters are identified as such for various reasons including:

- Deficits in dissolved oxygen
- Mercury found in fish tissue
- Excess nutrients
- High levels of turbidity
- E. coli
- Fecal coliform
- A lack of presence or diversity of benthic macroinvertebrates
- A lack of presence or biodiversity of fish
- High levels of total suspended solids
- Presence of atrazine, chloride, manganese, iron, dioxin, and/or ammonia

## Environmental and Health Risks

Pollutants impact aquatic recreation as they can indicate a potential health risk for those swimming, wading, and playing in waters. Consuming fish or other aquatic wildlife from impaired waters can also impact human health with detrimental effects from mercury poisoning, E. coli, heavy metals, and fecal coliform as well as the spread of diseases and pathogens found in impaired waters. Excess sediment and nutrients (eutrophication) reduce water clarity and light penetration while increasing potential algae blooms that threaten all aquatic ecosystems; the algae use up available dissolved oxygen from within the water making it unavailable to support other aquatic life.

Glossary:

## Types of Flow

**CONCENTRATED FLOW**
Where water flows comes together into channels, gullies, or small streams

**OVERLAND FLOW**
Water flowing on the land surface rather than infiltrating into the ground

**RUNOFF**
The flow of water originating from rain, snowmelt, or groundwater that does not infiltrate the ground and instead moves across the land surface

**SHEET FLOW**
The movement of water as a continuous layer that spreads out evenly across a surface rather than concentrating into a channel

**STORMWATER**
Runoff water produced after a precipitation event that flows over streets, lawns, and rooftops making its way into a drainage system

# Compost Use to Prevent and Remediate Pollution

Applying compost to lawns, gardens, and farm fields improves soil structure and increases water-holding capacity so that precipitation better infiltrates into the ground. When precipitation infiltrates into the soil, runoff is reduced as is the threat of stormwater carrying eroded soils and pollutants into our water sources. Compost used in lieu of traditional fertilizers also reduces pollutants that can be carried into rivers, lakes, and streams.

## Compost Use for Prevention and Remediation of Pollutants

Compost has the ability to remediate contaminated soil and water. The organic matter that makes up compost is rich with microorganisms such as fungi and bacteria. This microbial activity has proven successful in breaking down pollutants that are not easily biodegradable, such as petroleum, fertilizers, and pesticides. Non-biodegradable inorganics such as heavy metals are captured and bound by the organic matter, allowing the soil to grow healthy plants. When polluted water comes in contact and passes through the compost particles, the contaminants are filtered out, then retained or broken down. Therefore, compost can be an effective yet low cost solution to limiting runoff and preventing both surface water and groundwater contamination.

**Compost is Amazing!**

## Compost Use Strategies to Protect Water Sources

There are several different strategies for using compost to prevent runoff and protect or improve water quality. Choosing the best strategy can depend on the characteristics of the site. The following characteristics should be considered prior to selecting a strategy using compost to prevent and remediate pollutants found in local water sources.

- Topography
- Steepness of the slope
- Size of the local watershed
- Surface type
- Existing storm water inlets
- Seasonal flow rate
- Location of streams, rivers, lakes or other water sources
- Type of pollution
- Budget

## Calculating Your Slope

Many erosion control and water quality conservation practices take into account the slope of the land when determining the best practice to implement. So, how do you calculate the slope of your land? Typically, you calculate Rise divided by Run and then multiply that number by 100 giving you the percent slope.

However there is an easy way to calculate your average slope in the field following the steps below.

**01** Place the board on the sloped ground with the length of the board going up and down the slope at a good location that represents the general slope of your land.

**02** Place your level on the board.

**03** Lift only the lower end of the board up until it's horizontally level according to the indicator in your level.

**04** Measure the distance in inches from the raised end of the board to the ground.

**05** To determine your slope, plug your numbers into the following equation:

$$\frac{\text{Distance from raised end of the board to the ground in inches}}{50 \text{ (length of your board)}} \times 100 = \%\ \text{SLOPE}$$

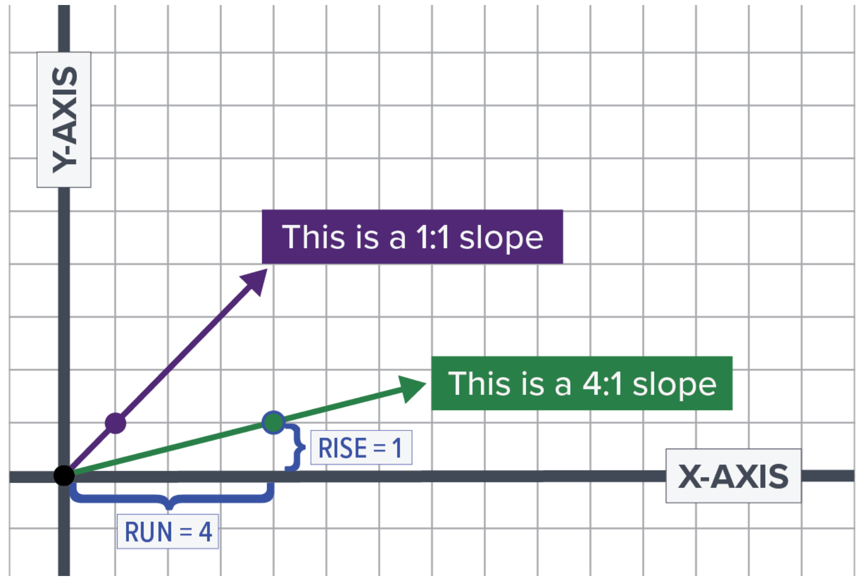
**06** Repeat these steps at various locations throughout your slope and then average all your measurements to get the most accurate % slope.

### All you need is:

- Carpenter's level
- Measuring tape
- One 50-inch board

## Slope as a Ratio

Slope can also be described as a ratio of the horizontal distance versus the vertical distance, or the H:V. The H:V ratio is used intermittently with the term, rise/run (rise divided by run). Rise is the vertical change divided by the Run, or the horizontal change. A slope can also be defined as a simple ratio as seen on the graph to the right. Notice that a 1:1 slope is much steeper than a 4:1 slope.




Converting a slope ratio into a percent slope is fairly straightforward when we calculate rise divided by run. Let's take a look at the 4:1 slope ratio as seen on the graph above in green. Since the rise is the vertical distance from the origin (zero point - where the Y and X axes intersect or the base of your slope in the field) to our green point (top of your slope in the field), the vertical rise is equal to 1. Next the run is the horizontal distance between the origin (bottom of the slope in the field) and our green point (top of the slope in the field) therefore, the run is equal to 4. So we have a rise/run of ¼. Similarly, this is the same as an H:V ratio of 4:1. Simply divide the top number (rise) by the bottom number (run) and then multiply by 100 to get the percent slope. In this scenario, for a slope of 4:1, we have an H:V of 4:1 and a rise/run of ¼, and our slope is 25%.

Now that you understand how slopes are calculated, we can start determining which is the best conservation practice to prevent and slow erosive stormwater based on a variety of characteristics including the slope of the land.

As stormwater rolls over the ground surface it picks up and carries contaminants into rivers and lakes contributing to an array of pollutants that can land a favorite fishing spot on your state's impaired waters list. The good news is that compost can slow and block stormwater from entering rivers and lakes, but it also has the capacity to filter-out and/or degrade these pollutants, helping to remediate contaminated water resources.

# Compost Blankets

**Most Effective For:**
Sheet flow on slopes not greater than a 1:1 slope

**Not Suitable For:**
Areas with ditches, channels or concentrated flow paths

Compost blankets are a layer of compost applied to the soil surface, usually a slope, that protects the area from wind and water erosion while improving the quality of the soil, water holding capacity, and nutrients available to establish quicker and healthier plant growth which further stabilizes the soil from erosion. Compost blankets are the most affordable option since there is no material to collect later and little to no excavating required.

Compost blankets are best used with the following criteria in mind:

- Non-paved sloped surfaces ranging from a gentler slope of 4:1 to a steeper slope of 1:1 where sheet flow occurs
- A range of 1"- 3" thick, with a target of 2" thick, is sufficient for most compost blanket applications
  - The applied thickness and particle size of the compost may need to be greater in areas of high runoff flow, steeper slopes, and higher expected rainfall amounts
- Coarser compost will withstand more water flow while finer compost is better for slopes that are seeded since it allows for more soil to seed contact
- Compost should also be spread 3 feet past the crest of the slope to prevent water from flowing under the blanket
- Compost blankets are the most affordable option since there is no material to collect later and little to no excavating required
- If necessary, placing netting material over the blanket will help hold it in place and prevent the compost from being washed away
  - Using netting or other methods for stabilization will require revisiting the site later for clean up

**Application of seeded compost blanket on a 1:1 Rock Slope**
Photo Credit: Texas Commission on Environmental Quality and the Texas Department of Transportation

## Application Methods of Compost Blanket Installation

There are multiple methods to spread compost on a slope including the following:

- Compost can be applied using a pneumatic blower which is the best application method for steeper slopes or areas that are difficult to reach.
- Compost can be applied by hand.
- Compost can be applied by using a conveyor system.
- Compost can be applied by using a compost spreader.

## Slope and Quality Compost

Slope is an important consideration when installing a Compost Blanket. Steeper slopes such as 1:1 and greater rainfall may require coarser compost applied in a thicker layer as well as another strategy such as filter berms and/or staked-down netting to help increase the success of the compost blanket. It's extremely important to use good quality compost such as the US Composting Council's Seal of Testing Assurance, or STA Certified compost. STA compost has undergone lab testing and is held to high standards. Below are standard compost characteristics suitable for compost blankets, both seeded and unseeded slopes:

| SEEDED COMPOST BLANKET | UNSEEDED COMPOST BLANKET | NOTES |
|---|---|---|
| pH between 6-8.5 | N/A | Adjust soils if necessary prior to seeding according to plant needs |
| Maximum soluble salt content of < 5 dS/m (deciSiemens per meter) | N/A | Higher soluble salt content should be applied at lower rates and "watered-in" well if necessary |
| Moisture content of 30-60% | Moisture content of 30-60% | Ease of application will be impacted if outside these limits |
| Organic matter content of 25-65% | Organic matter content of 25-100% | Beneficial for filtration and bioremediation |
| Maturity >80% | N/A | Indicates % seed emergence and vigor with higher % meaning more mature compost |
| Stability <8 $CO_2$-C per g OM per day | N/A | Lower values indicate more completely composted product |
| Particle size distribution:<br>• 100% passing through a 3" screen<br>• 90-100 % passing through a 1" screen<br>• 65-100% passing through a ¾" screen<br>• 0-75% passing through a ¼" screen | Particle size distribution:<br>• 100% passing through a 3" screen<br>• 90-100 % passing through a 1" screen<br>• 65-100% passing through a ¾" screen<br>• 0-75% passing through a ¼" screen | Important for water to pass through |

## When Not to Use a Compost Blanket

In areas where the runoff is concentrated or channelized, compost blankets are not effective and should either be avoided or used in combination with another practice that is more resistant to concentrated water flow. Also, compost that is applied too thick can promote anaerobic conditions that can work against the intended purpose of the compost blanket.

# Filter Socks

**Most Effective For:**
Construction sites and areas with disturbed soils

**Not Suitable For:**
Concentrated flow areas, perennial or intermittent streams, or below graded slopes that are greater than 10 feet tall.

Filter Socks are an elongated tube of natural fibers filled with compost that allow water to flow through while holding back sediment. Filter socks filled with compost filter pollutants from stormwater and are a proven method to remove gasoline, diesel, oil residues, heavy metals, and some herbicides and pesticides. Filter socks come in various lengths, diameters and pore sizes including 8”, 12”, 18”, and 24” diameters.
Filter socks have many different applications including but not limited to the following uses:

- Sediment control around a perimeter
- As a check dam to mitigate soil erosion in swales, gullies, and ditches
- Protection from pollutants entering storm drains and inlets
- Reducing fecal coliform, e. coli, petroleum hydrocarbons, phosphorus, and heavy metals from stormwater
- Reducing suspended solids and turbidity in stormwater and effluents

Filter socks can be filled with different material that may be more readily available such as wood chips or straw with less than satisfactory results. Socks filled with compost however, are very effective for controlling soil runoff. They are heavy enough to provide more surface area contact than silt fences, straw bales or socks filled with straw. Because they are very flexible, they can maintain the same surface area contact on sites with inconsistent topography. This allows them to be more effective at slowing the flow of water and allowing silt to settle upstream.

**Compost filter sock protects an inlet drain.**
Photo Credit: Texas Commission on Environmental Quality and the Texas Department of Transportation

## Placement of Filter Socks

Compost filter socks must be placed perpendicular to the flow of the water to be effective. Since the socks lay on top of the soil, no trenching is required and therefore no further disturbance of the soil is necessary. To make sure the maximum surface area contact is achieved, it is recommended to mow any vegetation as low as possible where the socks will be placed. Stakes should be driven through the middle of the sock or on the downhill side of the sock to keep it in place. These stakes should be driven into the ground at least 8" and heavy enough to hold the sock in place during heavy rain storm events.

**Comparison between hydro mulch on the left and a compost filter sock on the right.**
Photo Credit: Texas Commission on Environmental Quality and the Texas Department of Transportation

## Protecting Stormwater Drains

Compost filter socks can also be used to encircle a storm drain as a method of final protection against silt, chemicals, petroleum, and heavy metals before entering storm drains and eventually rivers and lakes.

## Compost Quality

To help minimize risk, it is important to always use high quality tested compost to fill the socks such as the US Composting Council's STA Certified compost. Compost that is mature and biologically stable will have been sterilized naturally by reaching the appropriate temperature during the decomposition process and should therefore be lower in excess nutrients and pathogenic organisms. Parameters to look for in a quality compost include the following:

- Free from man made debris such as glass, metal, and plastic (less than 1%)
- Particle size distribution should be varied with the following criteria for the ideal compost is done by "screening" the compost through various mesh sizes including the following:
  - 100% of the compost sifts through a 2" screen
  - 10-30% of the compost sifts through a 0.375" screen
- Moisture content of 30-60%
- Soluble salts <5 dS/m (deciSiemens per meter)
- A pH of 6.0-8.0
- Organic matter content of 25-65%
- Stability measure of <8 mg $CO_2$ - this is important since using compost that isn't mature can cause eutrophication, resulting in oxygen depletion, fish kills, and harm to other aquatic life

## Types of Sock Material

There are primarily two types of sock material used, Polyethylene plastic and burlap. Plastic socks are durable and tear resistant but will need to be removed after soil is stabilized and vegetation is established. The compost can be dumped onsite to be used as fertilizer and the plastic will need to be collected and discarded. Burlap is cheaper and is biodegradable so there is no need to remove it from the site. Once the burlap sock is in place, it can remain there while the undisturbed vegetation benefits from the nutrient rich compost inside the sock. Each type comes in several different diameters and can be trimmed to specific lengths.

## Filling Socks

On a large commercial scale, compost can be filled into the socks by means of a pneumatic blower usually mounted on a truck, or by a mechanical auger. It is difficult to fill socks on a small scale but it could be done on smaller diameter socks by using shovels and a funnel much like the process of filling sand bags.

Pallets of filled socks are available from some landscape and construction supply retailers and can be shipped to your location.

## Where Not to Use Compost Socks

Caution should be used when placing compost socks in the close vicinity of a sensitive water body, as immature compost can have an effect on the water quality of water bodies by introducing nutrients that may be harmful in large amounts, such as excess nitrogen and phosphorus. This process, called eutrophication, results in oxygen depletion, fish kills, and harm to other aquatic life. This caution is the reason the stability measurement is important when selecting quality compost that is mature and the curing phase has concluded.

**Compost filter sock being used as a gate to halt erosive flows.**
Photo Credit: Texas Commission on Environmental Quality and the Texas Department of Transportation

# Filter Berms

**Most Effective For:**
Sheet flow and small concentrated flow where drainage is small and flow rate is fairly low

**Not Suitable For:**
Concentrated high-volume flow, steep slopes,
ditches or waterways or drainage areas exceeding 0.25 acres per 100 foot berm length

A compost filter berm is typically placed perpendicular to sheet flow to help slow and control erosive water flows, spread and dissipate flow, and retain sediment in disturbed areas. Filter berms are generally constructed at the base of a slope on nearly level ground to intercept the flow of runoff and act as a filter to remove sediment and pollution as the water passes through berm material.

**Filter berm working during a rain event.**
Photo Credit: Texas Commission on Environmental Quality and the Texas Department of Transportation

## Filter Berm Dimensions

Compost filter berms require the compost to make direct contact with the soil so removing vegetation is imperative to the success of the berm so it does not easily wash away. Trapezoidal in cross section, the berm does not need to be very large and the size will depend on the amount of flow water passing through as well as the slope of the land and the length of the area being treated. The base should be 2 to 3 times wider than the height with at least 2 feet wide at the top of the berm. Consider the size of the berm as follows:

- Gentler slopes with a horizontal to vertical ratio of 5:1 - 2:1, berm spacing of 50 feet, would need a berm height of 1.3 feet, bottom width of 5.5 feet, and top width of 2 feet.
- Steeper slopes with a horizontal to vertical ratio of greater than 2:1, berm spacing of 25 feet, would need a berm height of 1.5 feet, bottom width of 6 feet and top width of 2 feet.

**Compost blanket in conjunction with multiple filter berms.**
Photo Credit: Texas Commission on Environmental Quality and the Texas Department of Transportation

Steeper slopes may require multiple berms that follow the contours of the land yet are placed perpendicular to the flow of stormwater. When installing multiple berms on a steeper slope, the spacing of berms should be considered along with the size of the drainage area and flow rate. Steeper slopes require berms to be spaced closer together.

- A 5-10% slope indicates berms should be spaced at about 200 feet apart
- A 20% slope indicates berms should be spaced about 50 feet apart
- Drainage area that is less than 0.25 acres per 100 feet berm length
- No more than 1 cubic foot per second flow rate per 8 linear feet
- Maximum flow length to the berm is less than 200 feet

Berms can be used on nearly level ground to slopes of 2:1 or less. They are great for reducing sheet flow but not recommended for channelized or concentrated runoff. If water is flowing too quickly or if the volume is too great the water will breach the berm allowing it to fail. Therefore, placement of the berm should not be immediately at the foot of the slope, but back far enough from the slope to allow the runoff to slow down and dissipate before reaching the berm. The ends of the berm should wrap up the slope so they are higher in elevation than the top of the berm. This will prevent intercepted water from spilling out around the berm reducing the berms effectiveness and possibly causing the berm to wash away. It is important to monitor the berms after each heavy rain event and make repairs as necessary. Filter berms can be vegetated for a more permanent structure or non-vegetated, however without regular maintenance, filter berms are prone to clog with mud so it's imperative to continuously monitor the berm for maintenance needs to keep it functioning properly.

## Compost Quality

The compost used for a filter berm should be of high quality such as the US Composting Council's STA Certified compost. Also, compost parameters depend on if the filter berm will be vegetated by seeding, or if the berm will remain unseeded. Unseeded berms are not permanent and require coarser compost while vegetated berms are permanent and will need finer compost to help establish seedlings. The compost should be clean, free from contaminants such as glass, plastic, and metal, weed seeds, and pathogens. Parameters to be considered also include the following:

| SEEDED AND VEGETATED PERMANENT BERMS | NON-VEGETATED TEMPORARY BERMS | NOTES |
|---|---|---|
| pH between 6-8.5 | N/A | Adjust soils if necessary prior to seeding according to plant needs |
| Maximum soluble salt content of < 5 dS/m (deciSiemens per meter) | N/A | Higher soluble salt content should be applied at lower rates and "watered-in" well if necessary |
| Moisture content of 30-60% | Moisture content of 30-60% | Ease of application will be impacted if outside these limits |
| Organic matter content of 25-65% | Organic matter content of 25-100% | Beneficial for filtration and bioremediation |
| Maturity >80% | N/A | Indicates % seed emergence and vigor with higher % meaning more mature compost |
| Stability <4 $CO_2$-C per g OM per day | N/A | Lower values indicate more completely composted product |
| Particle size distribution:<br>• 100% passing through a 3" screen<br>• 90% passing through a 1" screen<br>• 70% passing through a ¾" screen<br>• 30% passing through a ¼" screen | Particle size distribution:<br>• 100% passing through a 3" screen<br>• 90% passing through a 1" screen<br>• 70% passing through a ¾" screen<br>• 30% passing through a ¼" screen | Important for water to pass through |

After the construction project site (or soil disturbance activity) is completed upstream of the berm and vegetation is established, the berm material can be removed and dispersed as a top dressing to help fertilize the new vegetation. The newly exposed soil then will need to be seeded. In some cases it is acceptable to leave the berms intact and plant vegetation on the berm itself. This practice is sometimes used in natural areas, such as near wetlands.

# Incorporating Compost Into Soils

**Most Effective For:**
Regenerating degraded soils, replacing traditional fertilizer, and to promote drought tolerance

Incorporating compost into soils reduces compaction, creates airspace, adds available nutrients and microbes, helps the soil retain moisture, and helps to prevent contaminants found within soils from entering the groundwater. Compost can be used to help establish a seeded and eventually vegetated slope that will serve to reduce pollution carried by precipitation and to reduce stormwater runoff and erosion; the vegetation aids in the dissipation of water flows and slows stormwater runoff thus causing contaminants to settle before reaching a sensitive water supply.

Degraded soils that no longer have the capacity to support plant or animal life can be effectively treated by adding compost, which in turn adds organic matter and beneficial microbes, improves soil structure and overall soil health. In addition to improving degraded soils, compost also improves sandy soils where infiltration of water occurs quickly and easily migrates towards groundwater. Compost improves sandy soils that lack nutrients and soil structure while slowing the infiltration rate of water that can quickly carry pollutants directly to groundwater aquifers. In clay soils, water does not easily percolate as the soil texture is made up of finer particles. Compost added to clay soils helps create space between the soil particles to allow for more water infiltration. Compost added to soils can serve as a great remediator of many types of pollutants because compost has the capacity to either degrade or sequester pollutants before migrating towards the groundwater. You can incorporate compost into your soil in several different ways.

**Sugar-sand soils before incorporating compost.**

Photo Credit: Texas Commission on Environmental Quality and the Texas Department of Transportation

## Incorporating compost into soils

For new lawns apply 1”- 2”compost before the final preparation before seeding. Work into the ground using a rototiller, or rake. Make sure not to over till the soil. You don't want it to be too fine, just blend the compost into the soil evenly. You can spread the grass seed on top of the compost soil blend and work it in lightly with a rake, or you can spread a thin layer of compost over the grass seed. Make sure not to bury the seed too deep. The seed only has to make contact with the soil and stay in place, so a light dusting of compost over the seed is sufficient. The compost will also help the seed retain moisture for germination.

Compost can be added to an existing lawn as well. This is called top dressing. Late spring and early fall are the best times to top dress an established lawn. It is also a good idea to apply grass seed at this time to create a thicker turf and eliminate bare spots. New grass seeds will germinate when the soil temperature reaches above 60ºF.

Start by mowing the grass low. Remove the clipping with a bagger or a rake. It also helps to dethatch the lawn to expose even more soil and to aerate the soil to reduce compaction and allow more air to get into the soil. Aerating makes room for compost to penetrate into the soil as well. Spread compost ¼” - ½” thick across the lawn and continue to water one to three times per day if necessary until the seeds have germinated.

To incorporate compost into a vegetable garden, start by clearing off the plant material and debris from the previous growing season. If there are large clumps of dirt in the soil, break them up with a shovel or rake. If the garden has never had compost added before, add about 3 to 4 inches. If compost has been added each year then 1 inch of compost is all that is necessary. Add the compost and mix it into the soil prior to planting.

**Sugar-sand soils six weeks after incorporating compost**

Photo Credit: Texas Commission on Environmental Quality and the Texas Department of Transportation

# Rain Garden

**Most Effective For:**
Low-lying areas or depressions prone to standing water or flooding, improving water quality, enhancing aesthetics of property, and/or supporting wildlife

**Not Suitable For:**
Soils with very poor drainage or a high water table, and steep slopes

A rain garden is a low area in a residential lawn or city landscape designed to slow down rain water runoff and allow water to infiltrate the soil and into the groundwater. In addition, the rain garden helps to filter the water that may be contaminated with pollutants and excessive nutrients often picked-up by runoff. Rain gardens are most effective when they are cultivated with ornamental native plants consisting of grasses and forbes. These plants assist in slowing down the flow of water, aerating the soil, and capturing nutrients, thus allowing the rain garden to be even more effective.

In urban landscapes, rain gardens are often placed in areas where water drains from impervious surfaces such as driveways, sidewalks, patios, roofs, and lawns with compacted soils. If not captured by a rain garden, this water picks-up and carries soil, petroleum, nitrogen, phosphorus, salts, and other contaminants into the municipal storm sewer system creating the need for costly treatment.

## Using Compost in a Rain Garden

There are two main reasons to use compost in a rain garden. The first reason is to amend the soil. If the soil is too compacted, is made up primarily of clay, or lacks organic matter, then the infiltration of water through the soil is very slow. This creates standing water or flooding. Another problem occurs when the infiltration rate is too high allowing water to enter the soil too quickly making the rain garden ineffective for filtering out contaminants. This occurs when the rain garden soil contains too much sand and adding compost will help slow infiltration rates.

The second reason to use compost in a rain garden is to provide nutrients for the establishment and growth of the native plants. Compost is rich in nutrients and provides food for the initial growth of roots as well as the continued health throughout the growing season. The more healthy the plants, the more beneficial they are for the uptake of water and excess nutrients carried in by runoff.

As compost helps to control the movement of water through the soil, it also filters out contaminants to prevent them from polluting the groundwater. Compost promotes the essential microorganisms that transform these contaminants into inert organic matter. When a rain garden is placed properly in the watershed of a storm drain, stream, river, or lake, it can help in reducing hazardous chemicals in the water supply.

## Where to Place a Rain Garden

Areas where rain gardens are placed should have good infiltration rates. Sites with frequent standing water can indicate the low area is already too close to the groundwater table for a rain garden to be effective.

Make sure the rain garden is not placed in an area where it can interfere with public utilities, such as water lines, natural gas lines, electrical cable, and telecommunication wires. It is always necessary to call the utility locators hotline before digging. Additionally, rain gardens should be placed away from trees that can interfere with water flow and more than 10 feet away from buildings to avoid seepage into foundations and basements.

Rain gardens are recommended for sites with a watershed under 5 acres. Residential rain gardens can range from 100 - 300 square feet with ponding depths that can range from 4-8 inches at the top. Larger watersheds may require a bioretention cell, which works in a similar way to a rain garden but are usually larger in size with engineered water control structures and are capable of treating significantly more water flow.

## Measuring Impervious Areas

The first step to planning your rain garden is to identify and measure the impervious areas that will be treated in square feet, meaning the measurements need to include the entire impervious areas where water will flow from and into your rain garden including calculating the area of your roof, driveway, sidewalk or other impervious surfaces like extremely compacted soil. Square feet is calculated by multiplying length by width of impervious areas and then adding all of the areas together. If your rain garden will be treating water from a roof, simply measure the roof width and multiply this by the length of your roof.

When measuring the roof, to increase the accuracy of your measurements, identify the number of total downspouts on the building versus the number of downspouts that will be draining into your rain garden. As an example, let's say your building has a total of 4 downspouts, but your rain garden will only be treating water from 1 downspout. To increase accuracy you can estimate that only 25% of your roof will drain into your rain garden. Therefore when calculating the impervious surface of your roof, only include measurements equal to 25% of your roof.

Add up all the impervious surfaces that will be draining into your rain garden.

**Rain garden ponding depth full after storm event**

Photo Credit: MA Watershed Coalition via US EPA website

## Infiltration Rate Test

Soil infiltration rate testing can be done to determine the infiltration rate and how well water will drain. This is done by digging two or three holes in different areas of the proposed rain garden area. Dig these with a shovel or a clam-shell post hole digger. The holes should be about two feet deep. Using a tape measure as a reference, fill the hole with 12” of water. After 24 hours, measure the depth and record the amount that has drained. Measure again at 24 hours and record the amount that has drained. Divide the amount drained by the number of hours and that is the infiltration rate of that hole. Do this for each hole then find the average of all the test holes. This will determine the infiltration rate for the proposed rain garden site. For a rain garden the infiltration rate range should be between .5” and 1” per hour. If your infiltration rates are outside of the optimal range, adding compost will help slow infiltration in sandy soils while adding compost will increase the infiltration rate in clay soils. In sandy soils, you may find that all the water has drained out of your hole prior to 24 hours, so adjusting the amount of time that has lapsed before all your water has infiltrated may be necessary to acquire the proper infiltration rate.

## Determine the Type of Soil You Have

To determine the type of soil you have, dig about 4-6 inches from the surface and grab a small handful of soil. Add a few drops of water until it’s nearly like putty and is moldable. Try to shape the soil into a ball. If the ball of soil does not hold its shape, you likely have sandy soil. If your soil maintains a ball shape, add more water until you can slickly rub the muddy soil over your fingers using your thumb. If the soil feels sticky (like clay) when wet, you more than likely have a clay soil. If the soil feels smooth and silky like talcum powder, you more than likely have a silty soil. If you feel none of these, then your soil is likely a good mix of sand, silt, and clay. Once you determine your soil particle size and you know the infiltration rate, you can determine the measurements of your rain garden.

Conversely, you can identify your soil type by knowing your infiltration rate:

- Sandy Soil Infiltration Rate = > 1” per hour
- Silty Soil Infiltration Rate = 0.41 - 1” per hour
- Clay Soil Infiltration Rate = 0.15 - 0.4” per hour.

## Determining the Size of Your Rain Garden

When thinking about the size of your rain garden, consider the volume of water that can be held before it overflows. Ponding depth and square feet of surface area are the most important considerations when planning your rain garden. If you are treating impervious areas such as a roof, sidewalk, or driveway, your rain garden will need to be even bigger, or you can simply build multiple rain gardens.

**Aesthetically pleasing and functional rain garden**

## Determine the Ponding Depth and the Area of the Rain Garden Based on Soil Type/Infiltration Rates and Impervious Area Measurements

Once you know your soil infiltration rate, soil type, and the impervious area measurements your rain garden will treat, you can easily figure out your ponding depth and the area of your rain garden. Ponding depth is how deep water can pond at the top of your rain garden before it overflows. The following are simple rules to follow when calculating your rain garden dimensions.

- The optimal soil infiltration rate is about 1 inch per hour. Adding compost can help get to an infiltration rate of 1"/hour with sandy and clay soils. You can and should amend your soils with compost once you have excavated your rain garden area and are ready to fill it, especially if your infiltration rate is outside of the optimum 1" per hour.
- Choosing your ponding depth considerations:
  - o Sandy soils cause water to infiltrate fast which can limit the rain gardens ability to filter contaminants out before it reaches the water table. If your soils are sandy with greater than 1 inch per hour infiltration rates, you will need a ponding depth between 3-6 inches.
  - o Clay soils drain much slower so you will need at least 3 inches of ponding depth with infiltration rates of less than 1 inch per hour.
- Once you know your ponding depth, calculate your rain garden area using your impervious area measurements.
  - o For a 3-inch ponding depth, the rain garden size equals the impervious area to be treated divided by 10.
  - o For a 6-inch ponding depth, the rain garden size equals the impervious area to be treated divided by 20.

### How to determine the ponding depth and area:

As an example, let's say our rain garden will capture water from two downspouts that include half our roof.

- Our half- roof measurement is 80 x 40 feet (length x width).
- Our roof is 3,200 square feet.
- Now we want a 6-inch ponding depth because we have sandy soil. Recall above that if you need a 6 inch ponding depth, you simply divide your impervious area by 20.

$$\frac{80 \times 40 = 3{,}200}{20} = 160 \text{ ft}^2 \text{ rain garden}$$

Using the above result, calculate the square root to get the dimensions of your rain garden

$$\sqrt{160} =$$

**12.6 foot x 12.6 foot rain garden with a 6 inch ponding depth**

## Determine the Depth of Your Rain Garden Using Slope Measurements

Determining how deep your rain garden should be is simple. You'll need two stakes, string, and a measuring tape. Simply follow these step-by-step directions.

**01** Lay a rope or string in the desired shape and in the desired location of your rain garden according to the size you determined is best to treat all impervious surfaces.

**02** Determine the slope of your rain garden; this will help ensure you dig deep enough. Pound in a stake at the uphill end of your rain garden, and then pound a stake at the downhill end of your rain garden.

**03** Tie a string at the bottom of the uphill stake. Pulling the string tight and ensuring the string is level by using a carpenter's level, tie the other end to the downhill stake.

**04** Measure the width between the stakes.

**05** Measure the height from the ground of the string on the downhill stake but make certain the string is level.

**06** Divide the height by the width and multiply by 100 to get the slope of the rain garden.

**07** Once you know the slope of your rain garden, consider the following when deciding how deep you want it:

- Less than 4% slope - 3-5 inches deep + ponding depth
- 5-7% slope - 6-7 inches deep + ponding depth
- 8-12% - 8-9 inches deep + ponding depth
- Greater than 12% - it's best to find another location for your rain garden that has less of a slope.

**08** Add your ponding depth to the total depth of your rain garden.

## Determine the Area of Your Rain Garden Based on Your Desired Ponding Depth and Infiltration Rate

**01** Determine your drainage area in square feet (length x width). This will include any impervious surfaces such as a roof or driveway as is mentioned above. If your rain garden is on a slope, also include in the drainage area where water will flow downhill to your rain garden.

**If your rain garden will be treating water from a roof, determine if the downspout is either within 30 feet of the rain garden or if the rain garden is more than 30 feet from the rain garden.**

- When your downspout is within 30 feet of your rain garden
    - Measure the roof by multiplying length x width. Next, take a look at the number of downspouts that will eventually drain into your rain garden and estimate what percentage of water from your roof will actually make it to your rain garden. Let's say your roof is approximately 50 x 80 feet, then you have an area of 4,000 square feet. If your roof has four total downspouts, but the rain garden will only treat water from one downspout, then you can estimate the rain garden will be receiving water from only 25% of your roof. Multiply the square feet of your roof by the percentage of roof water that will make it to your rain garden. So our roof area is 4,000 square feet and our rain garden will be receiving 25% of the roof water therefore, 4,000 x 0.25 = roof drainage area of 1,000 square feet.
- When your downspout is greater than 30 feet from your rain garden
    - First measure how far the downspout is from your rain garden. As an example, let's say our downspout is 40 feet from our rain garden. From the steps above in the first bullet, we know the roof drainage area is 1000 square feet. Next measure the lawn area that will drain into the rain garden. Let's say we have about 20 feet of lawn area draining into the rain garden. Our next step is to calculate the total drainage area. Multiply the distance of the rain garden to the downspout (40') by the area of lawn that will drain into the rain garden (20'). So, 40' x 20' = 800 $ft^2$ of lawn drainage area. Once we have the lawn drainage area, we then need to add our roof drainage area, so 800 $ft^2$ + 1,000 $ft^2$ = 1,800 $ft^2$ total drainage area. Be sure to add any additional drainage areas (impervious) you have identified such as slopes, driveways, sidewalks, etc.

**02** Looking at the table on the following page, find your soil type or infiltration rate and the rain garden depth you determined in previous steps, or the rain garden depth you prefer, then note the pertinent size factor. Multiply your drainage area by the size factor. In our example from above, we have a total drainage area of 1,800 ft². Our soil particle size is mostly sandy and we want a depth of 6-7”. The size factor that meets these criteria is 0.13. So here we multiply our drainage area by the size factor; 1,800 ft² x 0.13 = 234 ft² recommended area for our rain garden.

**03** Square root the recommended area for your rain garden to get square dimensions. The square root of 234 is equal to a rain garden with dimensions of about 15 x 15 feet.

- It is recommended that if your rain garden is not square, you place the longest edge perpendicular to downspouts.
- If the slope is greater, the soil you excavate should be placed on the downslope edge as a berm to keep water within the rain garden
- Divide the total size of your rain garden by either your preferred width or length to find your dimensions of length and width.

**04** A recommended rain garden area that is greater than 300 ft² should be divided into multiple smaller rain gardens.

| GARDEN DEPTH | SOIL INFILTRATION RATE AND SIZE FACTOR | | |
|---|---|---|---|
| | SANDY SOIL > 1”/hour | SILTY SOIL 0.41-1”/hour | CLAY SOIL 0.15-0.4”/hour |
| 3-5 “ depth | 0.17 | 0.35 | 0.44 |
| 6-7” depth | 0.13 | 0.3 | 0.35 |
| 8-9” depth | 0.11 | 0.23 | 0.25 |
| >30’ from downspout | 0.03 | 0.08 | 0.1 |

## Construction of Your Rain Garden

Now that you have your shape, ponding depth, and overall dimensions of your rain garden, it's time to dig. Be sure to add ponding depth to the overall depth of your rain garden. Start digging the rain garden to your desired depth ensuring the bottom is level using a carpenter's level. Build up the downslope edge to form a berm to keep water from breaching the rain garden if there is a slope.

A simple way to ensure the bottom of your rain garden is level is to put a stake in both the upslope and downslope edges. Tie a string from the bottom of the stake (on the soil surface) at the downslope edge straight across to the upslope stake making certain with a carpenter's level that the sting is level. Start digging at the upslope edge, measuring down from the sting to your desired depth. If you want your rain garden to be 6 inches deep, then dig down 6 inches from the string making sure you dig deep enough to also accommodate your ponding depth. While digging, put the excavated soil around the interior edge of the rain garden to form a gently sloping interior berm. The sides of the rain garden should not be vertical or steep but gently sloping and angled. The berm should be especially robust on the downslope edge and then compacted to keep water within the rain garden. Laying a flat board at the bottom of your excavated rain garden with a carpenter's level on top of the board can help you identify areas that need more fill. It's recommended to have a rain garden with gently sloping interior sides (berm) surrounding a flat and level bottom; paying special attention to berm construction on the downslope side.

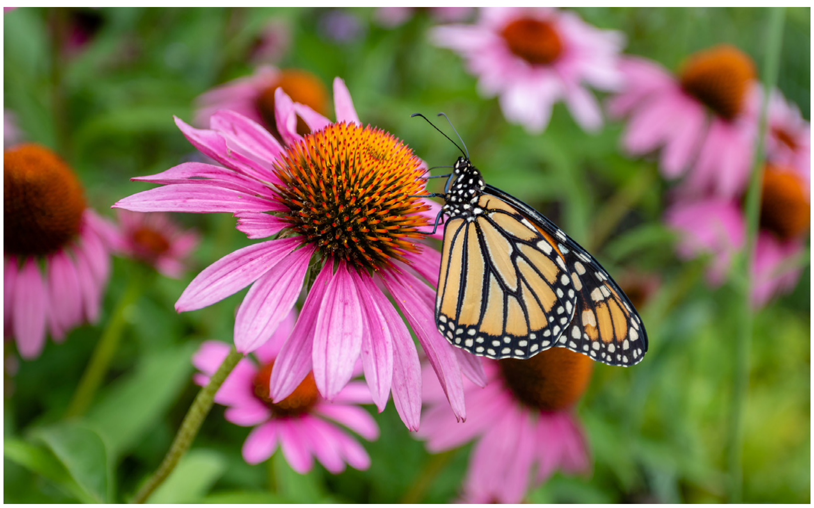
The substrate level of your rain garden can be filled with a thin layer of sand or gravel to increase infiltration, but this is optional. Create an amended soil mix of 50-60% sand, 20-30% topsoil, and 20-30% compost to promote optimal infiltration and fill your rain garden with this mixture. Ensure you also consider these percentages if you already have a sandy soil by adding less sand. Adding compost to the soil will allow the right amount of airspace between the soil particles to allow water to drain at the proper speed. This eliminates standing water and adjusts the infiltration rate to allow for the filtration of contaminants. It is not recommended to use masonry sand as an amendment because all the particles are the same size. It is always better if the particles are all different sizes and irregular shapes to allow for air space in the soil. Air space also means water can move through the soil freely. Washed concrete sand works great in a soil amendment mix.

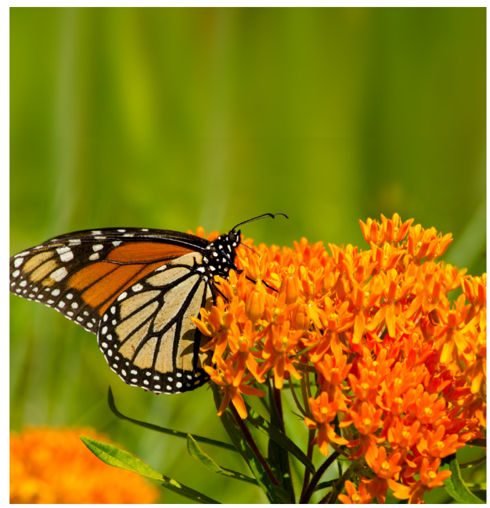
A good rule of thumb is to fill the rain garden with 3-4 inches of amended soil, and top with 2-3 inches of mulch adjusting these measurements according to the depth of your rain garden. Ensure you have your ponding depth clear from materials from the top layer of material (mulch) to the edge of the rain garden. The ponding depth will initially look like empty space between the edge of the rain garden to your mulch layer. You can also mix the mulch in with your amended soil if you prefer. You can top off your rain garden with larger rocks for aesthetic purposes and to prevent erosion of the berm at the downslope edge and to increase infiltration. Your ponding area will be at the top of your rain garden extending from the top of the mulch layer to your plants. Confirm that your rain garden ponding depth does not exceed the top of your downslope berm.

# Plants for Your Rain Garden

Native plants that don't mind excess water are the best for rain gardens while it's also important to take into consideration hardiness zones, soil requirements, sun requirements, and tolerance to moisture. The types of plants you select will depend on your region's native species as well as the characteristics of your location. Taking into account an aesthetic preference of plants is also an important consideration as rain gardens add appeal to any property when done correctly.

Rain garden plants that are ideal in the Midwest for both short-term flooding and drought include Nodding Pink Onion, Common Bluestar, Big Bluestem, Goat's Beard, Red Milkweed, Heart Leaved Aster, Purple Coneflower, Shootingstar, Palm Sedge, Copper Shouldered Oval Sedge, Beak Grass, and Canada Wild Rye. These are just a few examples of the many plants that can provide great benefits to your rain garden and the aesthetics of your space.





**Upper left is Purple Coneflower, Upper Right is Butterfly Milkweed, and Below is a rain garden with native species.**

# Bioremediation

**Most Effective For:**
Contaminated soils including those with diesel, some heavy metals and explosives, total petroleum hydrocarbons (TPH), chlorinated and nonchlorinated hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), diethylhexyl phthalate (DEHP), wood preservatives, and some agricultural chemicals

**Not Suitable For:**
Non-degradable substances, lackadaisical controls, low microbial density/diversity, and a lack of heat generation during the process of composting

Bioremediation is the process of using a compost system to degrade and/or sequester toxic and hazardous materials in soil and sediment. This can be accomplished either on-site or off-site. Bioremediation can occur by adding mature and cured compost to degraded soils on-site or through the actual process of composting, which requires excavating degraded soils, adding various feedstocks and then initiating the process of composting either on-site or off-site.

**Contaminated brownfield site.**
Photo Credit: US EPA

Compost is rich in fungi and microorganisms that biologically degrade or bind-to (prevents plant uptake) hazardous substances in the soil including hydrocarbons, wood preservatives, numerous organic pollutants, and some heavy metals such as arsenic, cadmium, and zinc. Bioremediation of contaminated soils can be effective by incorporating mature and cured compost into the soil on-site, or the process of composting various feedstocks including the excavated contaminated soil, but this is all dependent upon the contaminants in the soil as well as the availability of various feedstocks in your region that can aid in cleaning-up soils laden with pollutants.

Compost is often used to remediate soils affected by mining operations, excessive herbicide use, accidental chemical spills, leaky petroleum storage tanks, explosive contamination from military ammunition plants, among others. As an example, to remediate soils contaminated with explosives, Umatilla Army Depot developed a compost recipe while taking into account the carbon to nitrogen ratio, pH, degradability of feedstocks, organic matter content, and moisture content. The recipe to remediate explosives found in soils included various feedstocks: 30% contaminated soils, 21% cattle manure, 18% sawdust, 18% alfalfa, 10% potato waste, and 3% chicken manure. Placed in windrows and turned three times per day, the treatment time for a 2,700 cubic yard operation was about 10-12 days.

It's important to note that the recipe developed to remediate contaminated soils will vary depending on the type of soil in need of remediation, the type of contaminant affecting the soil, and available feedstocks. Clay soils have the smallest soil particle size so you may need more compost and manure with less soil to allow for more air and microorganisms to access the contamination. Another example of a feedstock recipe used to remediate contaminated soils via composting includes contaminated sediment mixed with horse manure, saturated horse bedding, old horse feed, alfalfa, sawdust, and wood chips. Many different materials can be utilized depending on local/regional availability, and compostability.

Composting contaminated soils requires tight controls and monitoring to promote degradation of contaminants. Treatment time and temperature are crucial to create the optimal environment for microbial activity and therefore, to maintain optimal temperature and moisture levels. It is imperative to prevent runoff of contaminated soil from entering local stormwater or surface water sites. Frequent monitoring and testing is necessary to determine the levels of contamination and when the compost is considered safe to land apply. Remediation rates from herbicide contamination have been reported from 3,000 parts per million to undetectable levels in just 50 days.

**Contaminated brownfield site.**
Photo Credit: US EPA

Compost and composting are both ideal for mitigating contaminated soils, however bioremediation is not the answer for every contaminant and research is ongoing as to the degradation and sequestration of particular chemicals, contaminants, and pollutants. In some instances, bioremediation results in volatile organic compounds found within the soil to off-gas emissions, which would then require off-gas collection and control. Bioremediation requires extremely close monitoring, laboratory testing and depends on many factors including availability and types of feedstocks, the type of contaminant affecting the soil, turning time, moisture content, carbon to nitrogen ratios, bulk density, free air space, odor control, VOC emission control, temperature, etc.

With over 160 types of contaminants that can be remediated using the composting process or incorporating compost into soils, there exists an extensive array of methods and recipes in which to achieve mitigation and remediation of contaminated soils. Contact the Iowa Waste Reduction Center if you are interested in current literature and research about particular contaminants and the success or failure of bioremediation efforts using compost or composting.

# Conclusion

Compost is extremely effective at filtering-out various pollutants, reducing soil erosion, retaining moisture, and blocking or slowing pollutant-laden stormwater that can enter and contaminate water resources such as rivers, lakes, or groundwater. Compost use and composting sequesters or "binds" some types of hazardous and toxic substances within the soil, which means that these substances are prevented from migrating to water resources or being absorbed by plants. In addition, compost can actually degrade some pollutants into less harmful and even harmless substances. This makes compost a low cost alternative to traditional means of storm water treatment, and an efficient solution to erosion control.

The methods and strategies outlined in this training guide provides a general overview but one of the most important considerations is ensuring you use a certified quality compost in your applications. The US Composting Council's STA Certified Compost Program will allow you to see the compost product's laboratory test results upon request, so you can confirm the compost you are using meets the qualities you are seeking. To find local or regional STA Certified Compost, visit the following webpage: https://www.compostingcouncil.org/page/participants

IWRC

Iowa Waste Reduction Center

UNI

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