

THE Green Neighbor GUIDE

Metropolitan Water Reclamation District of Greater Chicago


RESIDENT
PARKING
ONLY
STOP

TABLE OF CONTENTS

Introduction 1

What Is The Green Neighbor Guide?
How to Select Your Stormwater Management Projects
Stormwater Management Explained

1 **Downspout Disconnections** 7

2 **Rain Barrels** 11

3 **Rain Gardens and Bioswales** 17

Planting Plans
Plant List for Part to Full Shade
Plant List for Full Sun
Common Species of Concern in Illinois

4 **Permeable Pavement** 27

5 **Dry Wells** 33

Green Guide Glossary 36

Internet Resources 37

Credits 38


CLARK STREET
Voyageur

Introduction

Water is one of the most valuable resources on our planet. We require clean and fresh water for drinking, cleaning, recreation and other activities. However, too much of it can become a nuisance when it causes flooding in waterways and urban areas, impacting our travel when roads are flooded and even damaging our homes and businesses.

The Metropolitan Water Reclamation District of Greater Chicago (MWRD) has a vision for "Recovering Resources, Transforming Water." At the MWRD, we value the importance of water as a critical resource. We strive not only to protect the quality of water in our rivers and streams, but also to find ways to "transform" water—reducing its potential damaging force and turning it into a benefit for our communities. To achieve this vision, we work with local municipalities, agencies and partners to implement flood control and green infrastructure projects.

Everyone, including you as a homeowner, can be a "Green Neighbor" and play an active role in transforming water. This guide provides you with step-by-step instructions on how to improve stormwater management on your property. In doing so, you can help protect our water environment, green up your neighborhood and reduce flooding in your community.

WHAT IS THE GREEN NEIGHBOR GUIDE?

While there are myriad ways to be a Green Neighbor—some actions can be as simple as not over-fertilizing your lawn and garden, washing and maintaining your vehicles properly, or planting a native tree—this guide focuses on stormwater management projects that you can build or install on your property.

In this guide, you will learn how to stop sending stormwater directly into the sewer by disconnecting the downspouts; how to install rain barrels or cisterns to capture stormwater for reuse; how to install dry wells and rain gardens to allow stormwater to filter into the ground; and how to replace asphalt and concrete surfaces with permeable paving to reduce stormwater runoff. These projects are sometimes referred to as Best Management Practices or Green Infrastructure. They are designed to manage stormwater by slowing it down, storing it and soaking it into the ground, rather than sending the stormwater straight into the sewer.




Rain Barrel
Dry Well



An illustration of how various stormwater management projects can be implemented at a typical single-family residence.

HOW TO SELECT YOUR STORMWATER MANAGEMENT PROJECTS

The stormwater management projects in this guide are specially selected for their relative ease of installation and lower level of maintenance. Depending on the size of your lot and available yard space, not all of these projects will be appropriate for installation on your property. Use the following table to help guide your project selection. These projects are not mutually exclusive; you can incorporate more than one element if sufficient space is available.

LOT SIZE

	Downspout Disconnection	Rain Barrels	Rain Gardens and Bioswales	Permeable Pavement	Dry Wells
Small Urban (1/8 acre or less)	●	●	●	●	●
Medium (1/8–1/2 acre)	●	●	●	●	●
Large (1/2 acre or larger)	●	●	●	●	●

LEGEND: ● Suitable ● Suitable if there is adequate non-paved area

In general, downspout disconnection is the easiest stormwater management project you can implement at your home. You may need to consider including additional elements to your stormwater project to manage the stormwater released by the disconnected downspouts. If your lawn has a low spot and the stormwater pools at that location, consider installing a rain garden and/or a bioswale (see Chapter 3). If stormwater must flow over a paved surface, consider replacing the pavement with permeable pavers (see Chapter 4). If you do not have enough space on your property, consider installing a drywell (see Chapter 5) which can collect stormwater and allow it to slowly drain into the soil. You can also capture water in a rain barrel see Chapter 2) to water your landscape, returning the water to the ground and saving money on your water bill.

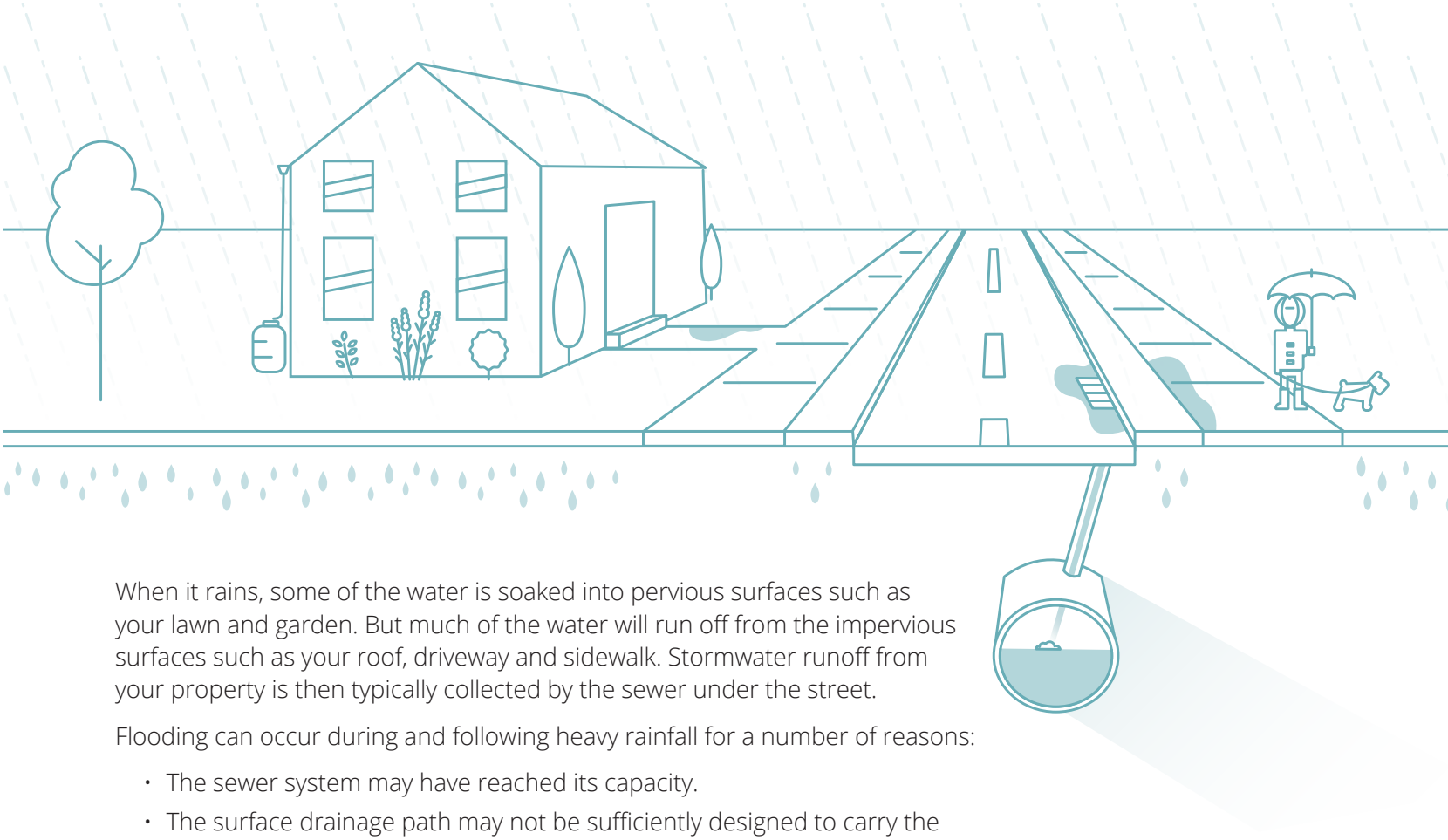
Difficulty of construction, cost, and maintenance requirements may also influence your project selection. In the following table, the quantity of a symbol is used as a measure of level of effort, cost, or time. The wheelbarrow symbol signifies the level of construction difficulty; the dollar sign indicates cost; and the clock symbol represents the amount of time required for long-term maintenance.

PROJECT COMPLEXITY

	Downspout Disconnection	Rain Barrels	Rain Gardens and Bioswales	Permeable Pavement	Dry Wells
Construction Difficulty	1	1	2	3	2
Cost	1	1	2	3	2
Maintenance Required	1	1	3	2	1

While many of these projects can be installed easily by an average homeowner, some projects involve more effort in design and construction. Hiring a professional for installation should be considered.

STORMWATER MANAGEMENT EXPLAINED



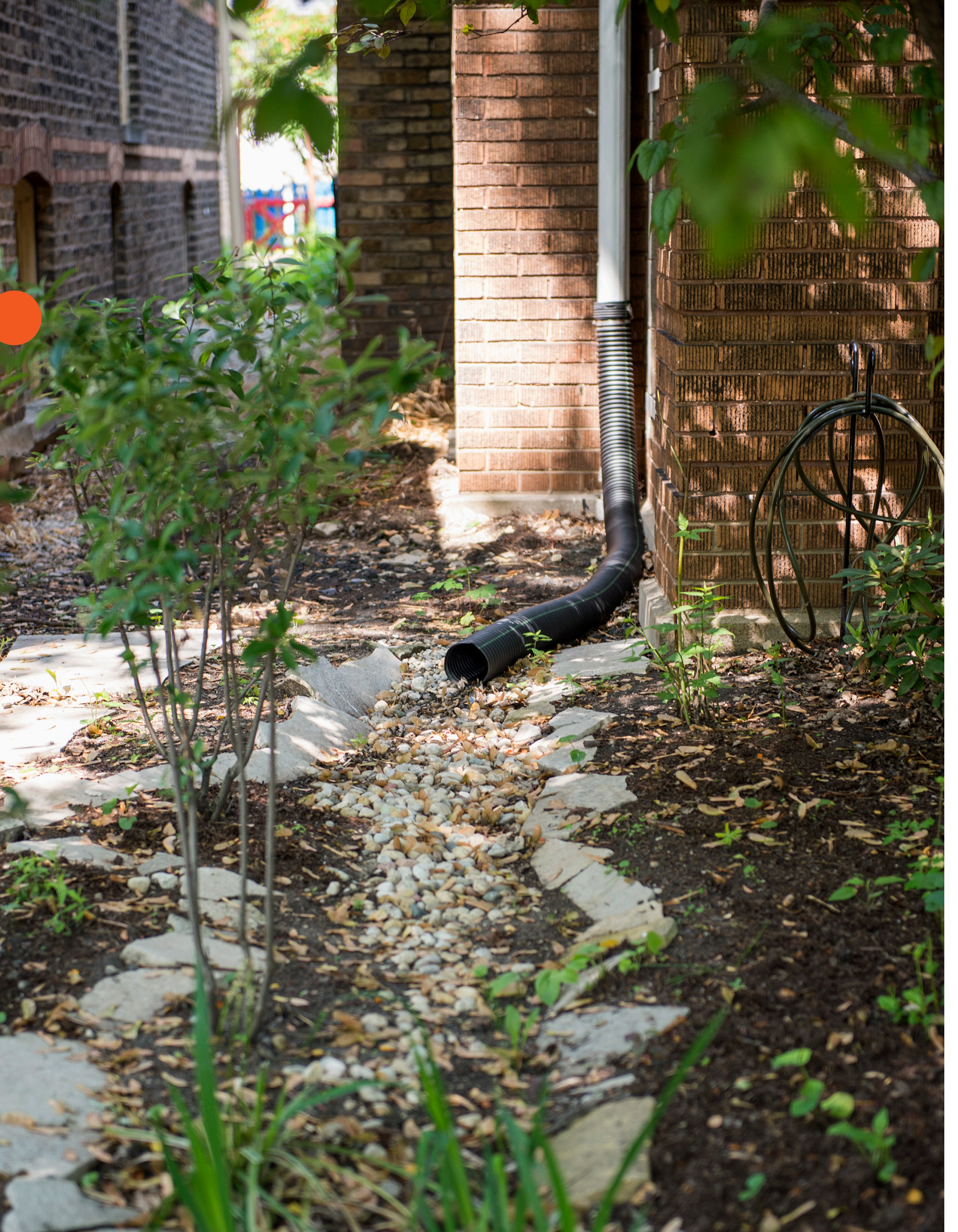
When it rains, some of the water is soaked into pervious surfaces such as your lawn and garden. But much of the water will run off from the impervious surfaces such as your roof, driveway and sidewalk. Stormwater runoff from your property is then typically collected by the sewer under the street.

Flooding can occur during and following heavy rainfall for a number of reasons:

- The sewer system may have reached its capacity.
- The surface drainage path may not be sufficiently designed to carry the stormwater flow.
- Lack of maintenance to the sewer and surface drainage system.

These all can be contributing factors to flooding. But the main culprit oftentimes is the lack of storage volume for stormwater—the excess rain simply has nowhere else to go. For many communities that were built prior to the 1980s, stormwater storage typically provided by detention ponds was often not part of the existing stormwater management system. Low-lying spots in your backyard and on the streets therefore become the effective storage areas.

Compounding the problem of insufficient storage is the fact that in some older neighborhoods, there are no separate sewers for stormwater. In this case, both stormwater and sewage are collected by the same sewer. These combined sewers were generally not designed to carry a large amount of stormwater. When the capacity of the combined system is reached, you might experience basement backups and flooding. The sewage combined with stormwater could also overflow into local streams and rivers, polluting our water environment. To prevent flooding, improve water quality and protect our ecosystems, the MWRD, municipalities and residents need to work together to responsibly manage stormwater in our communities.





CHAPTER 1

Downspout Disconnection

If your downspouts are connected to underground pipes that lead to the municipal sewer system, you can slow down the stormwater by disconnecting them and collecting the water in a rain barrel or cistern or simply letting it soak into the ground. This is especially important in older neighborhoods with combined sewers where sanitary sewage and stormwater drain into the same pipes. When it rains, stormwater from your roofs and gutters can overwhelm the sewer system and may lead to basement backups, flooding in your community and combined sewage overflowing into nearby rivers and lakes. Disconnecting the downspouts is one of the cheapest and easiest stormwater management projects you can implement at your home.



INSTALLATION INSTRUCTIONS

TOOLS & MATERIALS

You will need the following tools and materials:

- ☐ Hacksaw
- ☐ Drill
- ☐ Screwdriver
- ☐ Pliers
- ☐ Tape Measure
- ☐ Sheet Metal Screws
- ☐ Downspout Elbow
- ☐ Downspout Extension
- ☐ Standpipe Cap
- ☐ Splash Block



STEP 1

Select downspouts and locations to release stormwater

Picking the right location to redirect downspout water is important to protect the foundation of your house and prevent water from finding its way to your basement. You will want to make sure that:

- Water flows away from your house and all structures.
- A downspout can be extended at least 6 feet from your home to prevent foundation damage.
- Water will not flow into an area with a steep slope. Fast flowing water will cause erosion to a steep slope.
- A downspout does not release water directly onto sidewalks and pavement. Provide at least 6 feet of lawn or garden space for water to soak into the ground.
- Water is not released directly to your neighbor's property.

STEP 2

Measure the downspout

Measure your downspout 9 inches from the standpipe, the pipe that goes underground. Make a mark on your downspout.



STEP 3

Cut the downspout

Using the hacksaw, cut the downspout where you made your mark. Be careful to protect any siding while cutting the downspout.



STEP 4

Cap the standpipe

Place a cap on the standpipe so water cannot continue to enter the sewer from this point.



STEP 5

Attach the downspout elbow

Using pliers to ensure a tight fit, attach the downspout elbow to the downspout section still attached to your house.



STEP 6

Secure the downspout elbow

Using sheet metal screws and a drill, secure the elbow to the downspout.

STEP 7

Attach the downspout extension

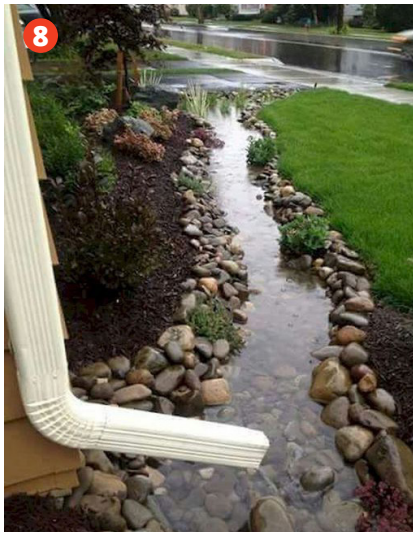
Using sheet metal screws and a drill, secure the downspout extension to the elbow.

STEP 8

Prevent erosion

Place a splash block at the end of the extension to help prevent erosion and direct water. You may also choose to place decorative rock at this location as part of a rain garden or bioswale installation.







CHAPTER 2

Rain Barrels



Rain barrels typically consist of a water-tight container, a spigot and an overflow pipe to allow excess water to drain. They are usually placed beneath downspouts which are modified to direct stormwater into them. Water captured by a rain barrel is highly oxygenated and generally lacks chemicals found in treated tap water. It is ideal for gardens and ornamental plants, contributing to healthier root structures. By installing rain barrels, you can save thousands of gallons of water annually while reducing your utility bill and helping to decrease the amount of stormwater being sent to the sewer. The MWRD sells rain barrels and shares a video of a rain barrel installation on its website at **mwrd.org/rain-barrels**. If you would like to collect and store more water than a typical rain barrel allows, you can consider installing a cistern with larger capacity instead.

Water collected by a rain barrel should not be consumed but can be used to water plants and wash cars, bikes and tools. You can paint your rain barrel if you first gently buff the surface with sand paper and apply a primer formulated for plastics.

INSTALLATION INSTRUCTIONS

TOOLS & MATERIALS

In addition to the items included with your rain barrel, you will need the following tools and materials:

- ☐ Hacksaw
- ☐ Marker
- ☐ Straight-edge ruler or T-square
- ☐ Safety glasses and safety gloves
- ☐ Sheet metal screws
- ☐ Drill
- ☐ Tin snips
- ☐ Flat-head and Phillips screwdrivers
- ☐ Level
- ☐ Hammer
- ☐ Concrete blocks or rain barrel stand*
- ☐ Pavers or pea gravel*
- ☐ Standpipe Cap
- ☐ Splash Block

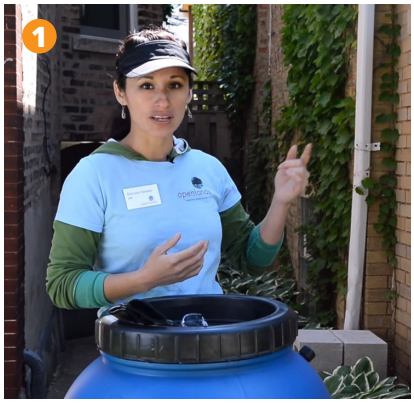
*Optional, but recommended

STEP 1

Pick a location for your rain barrel

Determine which downspout is best suited for your rain barrel. When selecting a site, consider the following:

- Pick a site closest to the area(s) you want to water.
- Select a location where the rain barrel can be elevated so that you can fit a watering container underneath the spigot or attach a hose.
- Choose a site that is mostly flat to help in leveling the rain barrel (see Step 2).
- Do not choose a site that will impede doors, driveways, paths, or equipment such as air conditioning units.
- Make sure your site slopes away from the house so water will not seep into the house foundation.
- Avoid locations near ground-level basement windows or window wells.



STEP 2

Level the base

Create a flat, level surface on which to place the rain barrel. This can be done by installing a 3-inch thick layer of pea gravel or by placing a 3-foot-by-3-foot paving stone on a level surface.

Use a level to ensure the surface is fairly flat.

If using concrete blocks, a pea gravel base surface is recommended; if using a rain barrel stand, a paver base surface is recommended.

Place your rain barrel on the stand to elevate it enough so a watering can may be placed underneath, or a hose can be attached to the spigot.















STEP 3

Measure and mark the downspout

Assemble, if required, the rain barrel according to manufacturer's instructions.

Rainwater can be diverted from the downspout to the rain barrel using a flexible, extendable plastic elbow. (You can also reuse the existing rigid elbow at the bottom of the downspout.) To measure where the downspout needs to be cut, first place the barrel beside the downspout (and on the stand if you are using one). Using a straight edge or T-square, draw a line on the downspout at the same height as the top of the barrel. Draw another line at least 8 inches above the first line. The section of downspout between these two lines will be cut out in the next step.

Extend the flexible elbow and place one end at the upper line on the downspout and the other end at the top of the barrel. Check to make sure that there is adequate height for the installation of the elbow and for the water to flow from the downspout to the barrel. Redraw the higher cut line if necessary.

Alternatively, you can choose to install a variety of downspout diverters available on the market. Some diverters allow you to reuse the existing lower portion of the downspout as an overflow; some have added screen to filter out debris; and some have a damper to turn on/off flow diversion. For the installation of a diverter, follow manufacturer's instructions specific to the diverter you purchased.

STEP 4

Cut the downspout

Using a hacksaw, cut and discard the section of downspout between the two marked lines. Place cardboard behind the downspout while cutting to protect the exterior wall of your house.

STEP 5

Attach the flexible elbow to the downspout

Attach and secure the flexible elbow to the top portion of the remaining downspout with sheet metal screws and a drill. You may need to add an additional aluminum strap to secure the downspout to the exterior wall.

You can remove and discard the lower portion of the downspout. Alternatively, if the downspout is already disconnected from the sewer and you are not too concerned about the aesthetics, you can leave it in place. When you put the rain barrel away for the winter, you can reconnect the top and bottom portions of the downspout with the flexible elbow (See Step 8).

STEP 6

Attach the lid and place rain barrel

Place the mosquito-proof screen-lid on the rain barrel and tighten using the provided hardware. Place the stand or concrete blocks (if used) and place the rain barrel on top of the stand.

Adjust the flexible elbow so that its end is pointing toward the screened inlet at the top of the barrel. Place the end of the overflow hose away from the foundation of your house.

STEP 7
Finished!

Congratulations! You have now installed your rain barrel. You will be collecting a lot of water from your roof. A common wet weather event will likely fill or overfill an empty rain barrel. Therefore, it is critical to empty your rain barrel to restore its capacity prior to a rain event. This alleviates any potential basement seepage issues or foundation damage caused by the overflow of excess water.

You may also consider connecting your rain barrel to a series of rain barrels or installing a larger cistern, so you can capture more rain water for reuse.

STEP 8
Maintenance

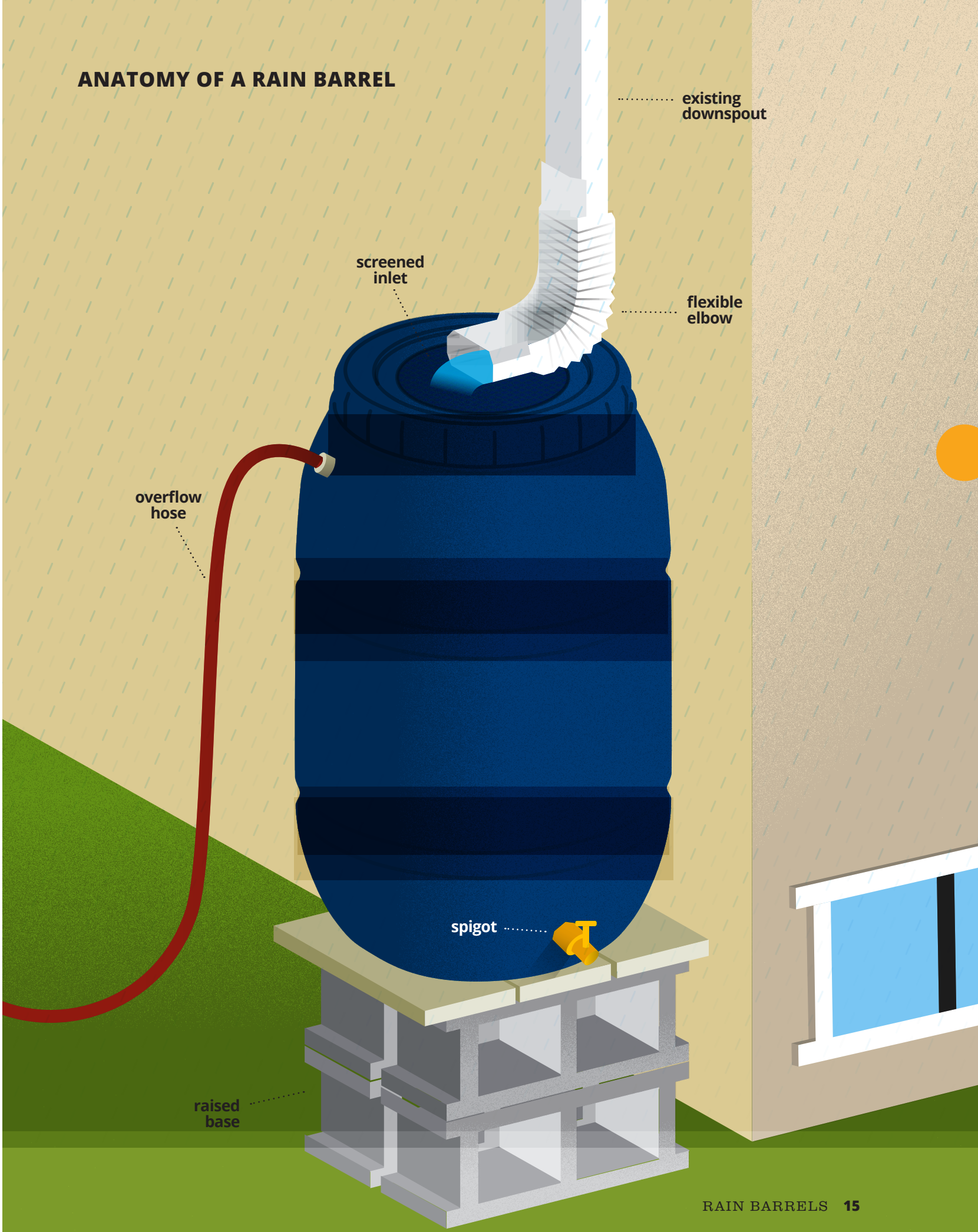
Leaves and debris collected by the gutter and downspout will clog the screened inlet over time. If the inlet is clogged, water will overflow and may cause basement seepage or lead to foundation damage. Erosion (washout) of soil around the barrel is often indicative of an overflowed barrel. Check the screened inlet monthly and keep it free of debris.

You will need to store the rain barrel over the winter. Freezing water will expand and damage the barrel. Follow these steps for the winterization of your rain barrel system:

- Drain the water from your rain barrel by opening the spigot. A full barrel is much too heavy to move – do not attempt! Allow the water to drain from the barrel; you may need to tip the barrel some to allow more water out of the spigot before moving it.
- Connect a temporary extension to the downspout that feeds the rain barrel. Position the extension to direct rainwater away from the house. If you have left the lower portion of the downspout intact during installation, reconnect to it with the flexible elbow.
- Flip the barrel over to drain any remaining stagnant water and decaying material, e.g. leaves, dirt, etc.
- Rinse out the inside of the barrel and remove any sediment by rinsing with a hose or light pressure washer.
- Clean the inside of the barrel with a hard-bristled brush and a mixture of water and a few drops of mild dishwashing detergent.
- Let the rain barrel dry.
- Inspect the rain barrel for any cracks or holes. Patch any damage using an adhesive drywall patch and waterproofing sealant.
- Store the rain barrel in a dry location while temperatures are at or below freezing.






ANATOMY OF A RAIN BARREL
existing downspout
screened inlet
flexible elbow
overflow hose
spigot
raised base



CHAPTER 3

Rain Gardens and Bioswales



Rain gardens are vegetated depressions (small basins) that capture stormwater, allowing it to soak into the ground. They can typically be placed at a low point in your yard. Stormwater can be conveyed to a rain garden from downspouts or paved areas via pipes or vegetated swales (bioswales). Bioswales are trenches lined with vegetation that direct water to a different location, treating the water along the way. Rain gardens are typically designed to drain ponding water within 24 hours and are often planted with native vegetation that can survive inundation for that length of time.

Rain gardens remove pollutants as water filters through the soil to replenish the groundwater. The native plants in them attract beneficial insects and pollinators and provide beautiful flower displays throughout the growing season.

INSTALLATION INSTRUCTIONS

TOOLS & MATERIALS

You'll need the following tools and materials:

- ☐ String level and stakes
- ☐ Shovel
- ☐ Hard rake
- ☐ Rototiller (*optional*)
- ☐ Wheelbarrow for moving soil and mulch
- ☐ Garden trowel for planting
- ☐ Pitchfork for mulching
- ☐ Scoop shovel for mulching

STEP 1

Pick a location for your rain garden

When selecting a site for your rain garden or bioswale, use the following considerations:

- Choose a site at least 10 feet away from your house, garage, and outbuildings, and at least 5 feet from your property line.
- Choose a full or partly sunny site on a relatively level area that is downhill from the water source.
- Avoid septic fields, wells, buried utility lines or areas under large trees.
- Make sure water can get to a storm drain if the rain garden overflows.

STEP 2

Test the soil

A rain garden needs to absorb stormwater within 48 hours or plants will not survive and mosquitoes may breed. A simple way to test the infiltration rate of your soil is to dig an 18-inch deep hole and fill it with water.

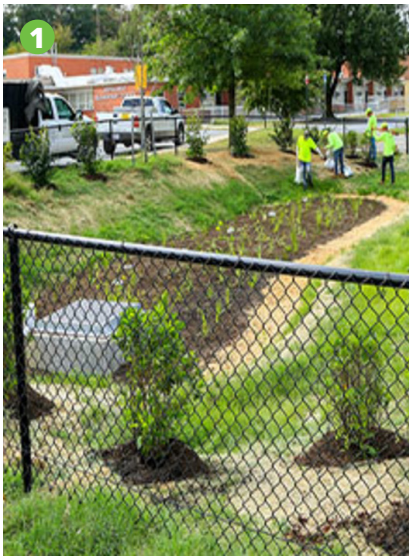
The soil is good for a rain garden if the water disappears within 48 hours. If the soil is dry and water disappears rapidly, fill the hole with water 3 times in succession and use the third fill as the test.

STEP 3

Size your rain garden

Consider the following when determining how large your rain garden will be:

- Generally, a rain garden should be about one-third the size of a contributing impervious surface such as a roof. Calculate how much roof area drains to each downspout feeding your rain garden and divide this area by 3 to determine the area of your rain garden.
- A rain garden that is between 100 and 300 square feet will be large enough to allow for plant variety, but small enough to be affordable and easy to build. A smaller rain





garden will work if you have limited space because the overflow will lead to a storm drain (see Step 1). Larger sizes will work too.

- Depths between 4 and 8 inches can hold enough water without being impractically deep.
- Rain gardens on poorly drained soils will have to be shallower and occupy larger areas. On well-drained sandy soil your rain garden can be deeper and cover less area.
- The shape of your rain garden is up to you. Have fun and be creative!

STEP 4
Excavate your rain garden

The bottom of your rain garden should be level and the downhill edge should be at your desired depth when excavation is complete. On sloping sites this means the uphill edge will be deeper than your desired depth. Follow these steps:

- Start excavating at the uphill edge and dig to the desired depth, placing excavated soil around the downhill perimeter of the rain garden.
- When the entire rain garden surface is level, the downhill mound should be 25 percent higher than the desired depth. This will allow for soil settling.
- If the downhill mound is lower, excavate more of the rain garden bottom until the mound is the desired height. Remember to excavate a little soil from the entire bottom to keep it level.
- If the downhill mound is higher, spread some of it evenly over the bottom of the rain garden until the mound is at the desired height.
- Gently slope the edges of your rain garden to blend in with the surrounding surface.

STEP 5
Plant your rain garden

It is easy to find a list of rain garden plants on the internet. The Illinois Department of Natural Resources maintains a list at **www.dnr.illinois.gov/education/Pages/PlantListRainGarden.aspx**.

Many of these lists include native plants that are well adapted to local conditions and support pollinators. This guide also provides native plant lists that are tailored to Cook County and the surrounding areas. The native plants on these lists do not grow very tall and should perform well in rain gardens.

Buying native plants for your rain garden can be more challenging than simply going to a nursery or home improvement store. Many native plants must be purchased at specialty nurseries or annual sales hosted by conservation groups and government agencies such





as the Illinois Department of Natural Resources or local Soil and Water Conservation Districts. The University of Illinois maintains a list of native plant vendors at **guides.library.illinois.edu/c.php?g=347854&p=2345331**. The US Environmental Protection Agency lists native plant vendors at **archive.epa.gov/greenacres/web/pdf/il-resor.pdf**. A simple internet search using terms like "rain garden plant vendor" and "native plant vendor Chicago" can yield additional sources.



STEP 6
Mulching your rain garden

Apply a 2-inch layer of mulch around your plants. Undyed shredded hardwood mulch, bark and leaf compost or MWRD's EQ Compost are good choices. These types of mulch break down and help soil structure over time.

Decorative stone mulch is another option although it does not help soil structure. Pine bark chips are not as good because they float. Do not fertilize your new rain garden. Native plants do not need fertilizer and it will promote weed growth.

STEP 7
Maintain your rain garden

New plants need about an inch of water each week. Water your new rain garden plants through the first two growing seasons during weeks when rainfall is less than one inch. The easiest way to do this is by placing a container in the garden and watering with a sprinkler. Water level in the container will tell you how much you have watered.

Weeds can be pulled easily when the ground is moist and the weeds are small. A trowel or dandelion tool are helpful when weeds are larger. Be sure to replace mulch once a year when you are done weeding. Use the "Common Species of Concern in Illinois" table on page 24 to identify common weeds in your rain garden. For more information, review the Illinois Invasive Species of Concern: **www.invasive.org/illinois/SpeciesofConcern.html**.

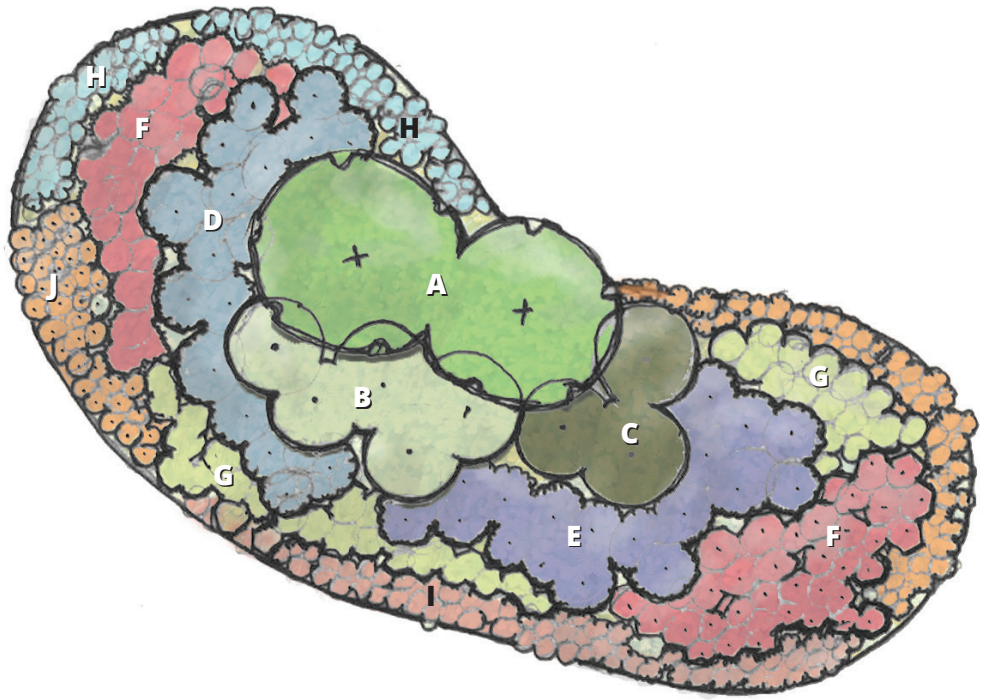
PLANTING PLANS

The sample planting plans demonstrate two possible rain garden planting approaches based on the plant lists and tips above. While they may not be the exact size and shape of your rain garden, they should give you an idea of how these plants can be arranged.

Keep these tips in mind when planning and planting your rain garden:

- Plant plants (plugs), not seed, in a rain garden.
- Place taller plants such as Joe Pye Weed, Ironweed, and Hydrangea in the center or at the back of the rain garden. Space large perennials two to three feet apart and shrubs at least half their mature diameter apart.
- Place the shortest plants such as Amsonia, Wild Ginger, and Ice Dance Sedge at the front or around the perimeter of the rain garden. Space these about one foot apart.
- Arrange your rain garden plants in large masses. It is more efficient for pollinators to gather nectar and it will make it easier for you to identify weeds within a large mass of identical plants. Try using three species in small rain gardens under 200 square feet and four to six species in medium rain gardens up to 600 square feet. Larger rain gardens can have more species, just plant them in large masses.
- If you do not have a lot of experience with native plants, using a limited number of species you can recognize will make it easier to identify weeds. Do not be afraid to use one species such as Blue Flag Iris in a small rain garden. The blade-like leaves are unique and will make weed identification very easy.
- Some native plants will behave in unexpected ways if their growing conditions are not ideal. The plants listed in this guide should be more tolerant to varying conditions.

The example planting plans below show arrangements for a large rain garden site in a sunny location and a small rain garden site in a shady location. Plants should be laid out so taller plants are placed in the center of the rain garden, with shorter plants descending in height toward the edges of the rain garden. This "layering" effect provides maximum visual appeal when all the plants mature.



LARGE SITE

A *Eutrochium dubium*
'Little Joe' Joe Pye Weed

B *Vernonia fasciculata*
Common Ironweed

C *Baptisia sphaerocarpa*
Yellow Wild Indigo

D *Liatris spicata*
Blazing Star 'Kobold'

E *Iris versicolor*
Blue Flag Iris

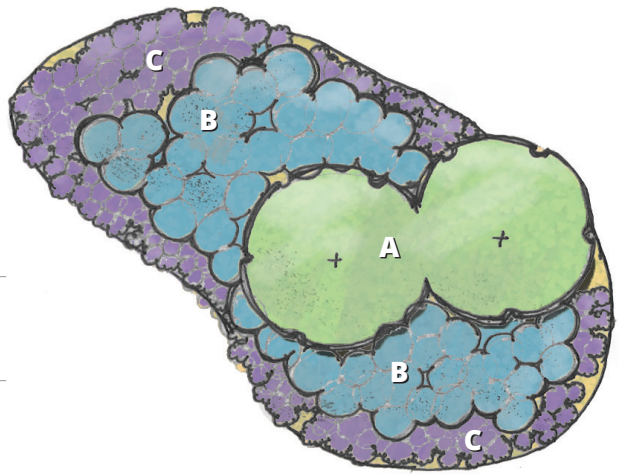
F *Packera aurea*
Golden Ragwort

G *Zizia aurea*
Golden Alexander

H *Tradescantia*
Snowcap Spiderwort

I *Amsonia 'Blue Ice'*
Blue Ice

J *Monarda bradburiana*
Eastern Beebalm



SMALL SITE

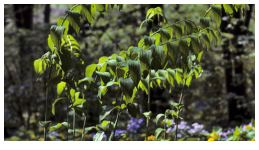
A *Hydrangea arborescens*
'NCHA1' Invincibelle spirit

B *Polygonatum biflorum*
Solomon's Seal

C *Asarum canadense*
Wild Ginger

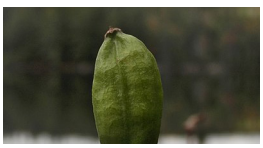
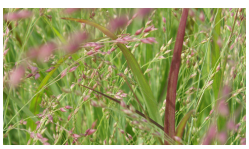
The following tables list native plants that stay relatively low and should perform well in rain gardens in this area.

PLANT LIST FOR PART TO FULL SHADE

	Spring	In Bloom	Fall
Asarum canadense Wild Ginger Bloom Time: April-May Height: 0.5'-1.0'			
Chrysogonum virginianum var. australe Golden Star Bloom Time: May-October Height: 0.5'-1.0'			
Carex 'Ice Dance' Ice Dance Sedge Bloom Time: April-July Height: .8'-1.0'			
Carex flacca 'Blue Zinger' Blue Sedge Bloom Time: July-August Height: 1.0'-1.5'			
Iodanthus pinnatifidus Purple Rocket Bloom Time: May-June Height: 1.0'-3.0'			
Chelone glabra White Turtlehead Bloom Time: August-October Height: 2.0'-3.0'			
Osmunda regalis Royal Fern Bloom Time: n/a Height: 2.0'-3.0'			
Polygonatum biflorum Solomon's Seal Bloom Time: May-June Height: 3.0'-4.0'			
Hydrangea arborescens 'NCHA1' Invincibelle Spirit Hydrangea Bloom Time: June-September Height: 3.0'-4.0'			

The MWRD offers EQ compost. Learn more by visiting **www.mwrd.org.**

PLANT LIST FOR FULL SUN

	Spring	In Bloom	Fall
Packera aurea Golden Ragwort Bloom Time: April Height: 0.5′-2.5′			
Amsonia ‘Blue Ice’ Blue Ice Bloom Time: May Height: 1.0′-2.0′			PHOTO NOT AVAILABLE
Monarda bradburiana Eastern Beebalm Bloom Time: May Height: 1.0′-2.0′			
Tradescantia Snowcap Spiderwort Bloom Time: May-July Height: 1.0′-2.0′			
Liatris spicata Blazing Star ‘Kobold’ Bloom Time: July-August Height: 1.5′-2.5′			
Zizia aurea Golden Alexander Bloom Time: May-July Height: 1.5′-2.5′			PHOTO NOT AVAILABLE
Iris versicolor Blue Flag Iris Bloom Time: May-June Height: 2.0′-2.5′			
Baptisia sphaerocarpa Yellow Wild Indigo Bloom Time: May-June Height: 2.0′-3.0′			
Panicum virgatum Cheyenne Sky Switch Grass Bloom Time: July-February Height: 2.0′-3.0′			
Vernonia fasciculata Common Ironweed Bloom Time: July-September Height: 2.0′-4.0′			PHOTO NOT AVAILABLE
Eutrochium dubium Joe Pye Weed Bloom Time: July-September Height: 3.0′-4.0′			

COMMON SPECIES OF CONCERN IN ILLINOIS


Tree of Heaven


Mimosa


Autumn Olive


Japanese Barberry

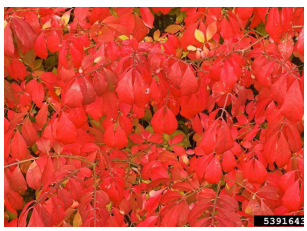

Honeysuckle


Callery Pear


European Buckthorn


Black Locust


Multiflora Rose


Burning Bush


Garlic Mustard


Canada Thistle


Common Teasel


Japanese Knotweed


Crownvetch


Phragmites


Johnsongrass


Japanese Hop


Kudzu


Winter Creeper

FOR MORE INFORMATION, REVIEW THE ILLINOIS INVASIVE SPECIES OF CONCERN:
www.invasive.org/illinois/SpeciesofConcern.html


RAIN STORAGE
IMAGINE THE JOURNEY OF A RAIN DROP!
WHEN IT RAINS HERE,
WATER SINKS INTO THE EARTH
AND COLLECTS IN A STORAGE AREA
BENEATH YOUR FEET, WHICH FILLS
UP WITH WATER LIKE A BATHTUB.



CHAPTER 4

Permeable Pavement



Permeable paving consists of a porous surface over an open-graded aggregate base or a stone reservoir (see Types of Permeable Pavements). Pervious concrete, porous asphalt and permeable unit pavers are all forms of permeable paving. They are excellent options for residential and public paving, from patios and plazas to driveways and light-use traffic zones.

Unlike traditional paving that sheds stormwater and often directs it into sewers, permeable paving allows stormwater to drain through and absorb into the ground. Ice is less likely to build up on this paving in winter as puddles will not form unless the pavers are clogged due to lack of maintenance.

Design and construction of permeable pavement can be more involved depending on the size and complexity of the installation. Hiring a professional for design and installation is recommended.

INSTALLATION INSTRUCTIONS

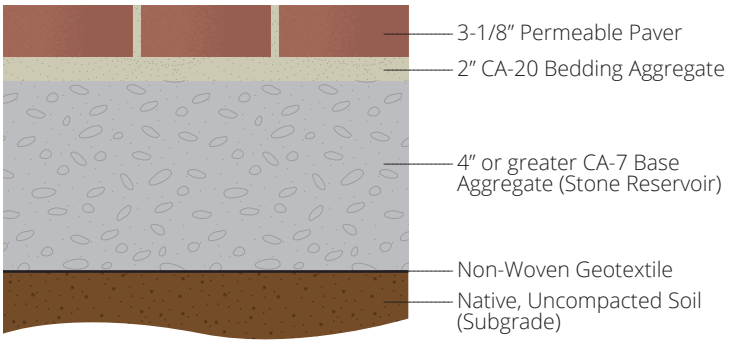
TOOLS & MATERIALS

You will need the following tools and materials at a minimum:

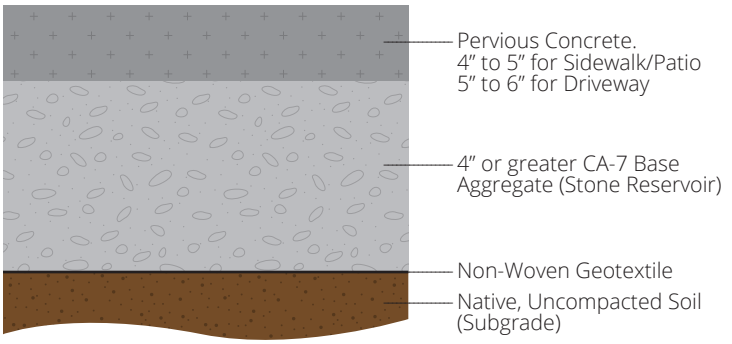
- ☐ Shovels
- ☐ Metal rakes
- ☐ Brooms
- ☐ Leveling markers (wooden stakes, string, and level)
- ☐ Straight edge and t-square
- ☐ Tape measure
- ☐ Vibratory plate compactor
- ☐ Vibratory screed
- ☐ Roller screed
- ☐ Concrete groover
- ☐ Asphalt roller
- ☐ Silt fence
- ☐ 8 oz. non-woven geotextile fabric
- ☐ Material mobilization equipment (skid-steer and wheelbarrow)
- ☐ Pavement base aggregate (CA-7)
- ☐ Pavement bedding aggregate (CA-20) for porous asphalt and permeable pavers only
- ☐ Pavement material (pervious concrete, porous asphalt, or permeable pavers)
- ☐ Edging material (metal, plastic, or timber per design)
- ☐ Grass seed and/or sod
- ☐ Garden hose

TYPES OF PERMEABLE PAVEMENTS

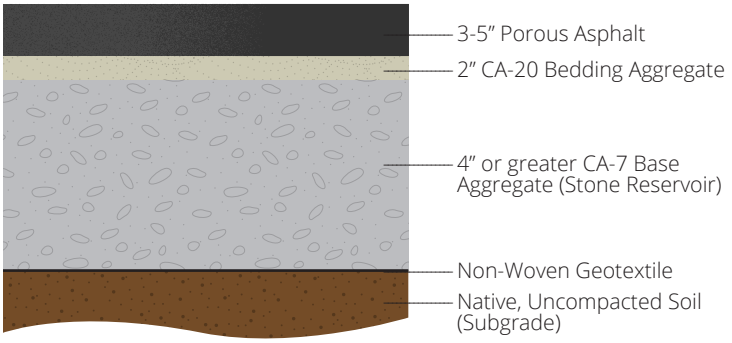
PERMEABLE PAVERS



PERVIOUS CONCRETE



POROUS ASPHALT



STEP 1

Before you begin

Test for the infiltration rate of your soil by digging an 18-inch deep hole and filling it with water. The site is appropriate for permeable pavement installation if the water disappears within 48 hours. If the soil is dry and water disappears rapidly, fill the hole with water 3 times in succession and use the third fill as the test.

Before finalizing your project design, contact JULIE (**illinois1call.com** or call 811) to have utilities marked on your property. Ensure these utility lines will not interfere with your proposed project. You also need to contact your local municipality and determine if a permit is required for your pavement project.

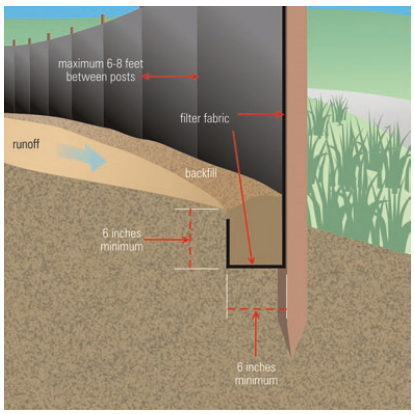


STEP 2
Stabilize your project area

Identify your project area by marking the extents of the permeable pavement to be installed. Allow for additional working space beyond pavement area as the construction zone.



Prevention of sediment from washing into the construction zone is vital to the success of the final system. Install silt fence (or straw wattles) around this area, ensuring the bottom of the fence is tucked under adjacent soils, facing outward.



Stabilize adjacent slopes with silt fence, vegetation, and/or erosion control blankets. Do not begin construction until the entire project site is protected from adjacent sites.

STEP 3
Planning for construction

Never install permeable pavements in rain or snow, or when the ground is frozen. Plan to start and complete your project between rain events.

Coordinate the delivery of necessary materials as close to construction time as possible. Washed stone material contaminated with sediments or debris cannot be used.

Coordinate where and how these materials will be stored as they are installed. Lastly, coordinate where excavated material will be stored and how it will be disposed.

Ensure this material will not wash back into the construction zone.

STEP 4
Preventing soil compaction

Limit or minimize the use of heavy equipment in the area planned for permeable pavement. Soil compaction will limit or prevent stormwater absorption. If heavy machinery is necessary for excavation or installation, machinery should be positioned outside the construction zone.

STEP 5
Excavation

The depth of excavation is determined by the total thickness of the permeable pavement. Depending on the type of paving, soil type and application, the required thickness of the permeable paving and the underlying aggregate layers can vary (see Types of Permeable Pavements). It is important to consult with a professional for the design of your permeable pavement. Generally, permeable pavement has a thickness of at least 8 inches. It is important to consult with a professional for the design of your permeable pavement.

STEP 6
Assessing subgrade

The subgrade (native, uncompacted soil present after excavation) should be sturdy enough to support the intended use of the permeable pavement. Never compact the subgrade unless a certified professional has verified it should be and to what extent.



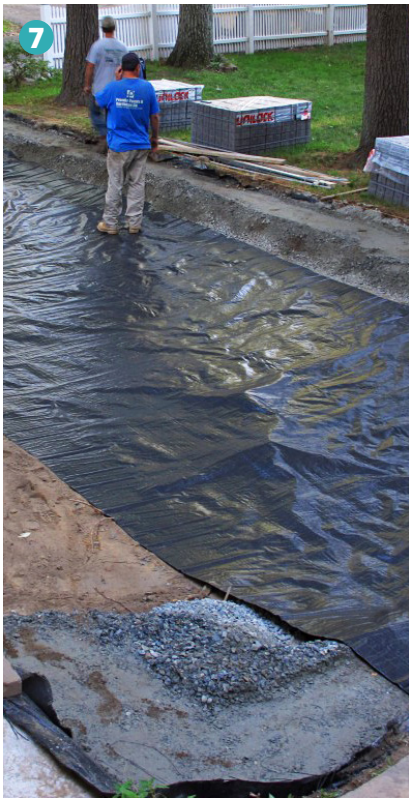




STEP 7

Material installation: Filter fabric

Begin installation by laying 8-ounce non-woven geotextile filter fabric over the subgrade. The fabric should extend beyond the excavated zone in each direction by roughly 4 feet. It can be trimmed later. Overlap fabric edges a minimum of 2 feet to cover the entire excavated zone. Be sure a filter fabric is used, and not an impermeable membrane.



STEP 8

Material installation: Base course material

Base course material for permeable pavements consists of washed stone aggregate. This stone reservoir serves as a temporary storage for rainwater. For pervious concrete, porous asphalt and permeable pavers, washed CA 7 or ASTM #57 stone should be used. The stone should also be open graded, meaning it has limited variety in particle size.

Take care in the placement of the stone not to dump heavy loads in concentrated or consistent locations, which may create depressions in the subgrade or alter geotextile filter fabric placement.

Spread the stone to a uniform depth called for by your design (see Types of Permeable Pavements) but no more than a maximum depth of 6 inches. Use a vibratory plate compactor to compact the stone. If the base thickness, per design, is more than 6 inches, add another layer of stone until the desired depth and compact. Each additional layer should not be more than 6 inches deep. If at any time throughout construction sediment or debris is introduced into the washed stone, it should be removed immediately and entirely.

STEP 9

Material installation: Bedding course material

Pervious concrete does not necessitate a bedding course material layer; however, porous asphalt and permeable pavers do. This layer consists of open-graded washed CA 20 or ASTM #8 stone applied 2 inches thick.

Do not dump this material onto the base course, instead spread it carefully with shovels and rakes to achieve a uniform layer with a level surface.

Any bedding course material contaminated with sediment must be removed and replaced with clean material. For permeable pavers, install edge restraints where the pavers should terminate.

STEP 10

Material installation: Surface material

Manufacturer and national standards should be consulted in the installation of pervious pavement surface materials.

American Concrete Institute specifications should be reviewed for *pervious concrete.* In general, the steps are as follows:

1. Lightly water the washed stone base with a garden hose.









2. Pour the pervious concrete mix 4 inches thick using wooden forms to contain the material.
3. Use a vibratory screed to smooth the top surface of the concrete in a uniform layer.
4. A roller screed may be necessary for compaction and for a uniform surface.
5. Cut in control joints with roughly 20 feet spacing using a concrete groover.
6. Cover the concrete with a plastic tarp for one week and do not allow any traffic over the surface.

National Asphalt Pavement Association standards should be reviewed for *porous asphalt*. In general, the steps are as follows:

1. Ensure asphalt is heated to manufacturers' specified temperature prior to pour.
2. Pour and spread the porous asphalt for a 4-inch thick surface.
3. Compact the asphalt using a roller.

Interlocking Concrete Pavement Institute specifications should be reviewed for *permeable pavers*. In general, the steps are as follows:

1. Carefully wet the bedding course with a garden hose ensuring the layer surface remains even and level.
2. Place pavers by hand or with mechanical equipment. Cut pavers at edges to fit if necessary.
3. Fill the paver joints with washed CA 20 or ASTM #8 aggregate or per manufacturers specifications. Use a broom to sweep the material into the voids.
4. Run a plate compactor over the paver surface to set the pavers.
5. Sweep off any remaining aggregate material.
6. Inspect entire surface for uniformity. Should dips be present, take up stones, lightly fill with aggregate, replace paver and joint aggregate, and re-compact.

STEP 11
Cleanup

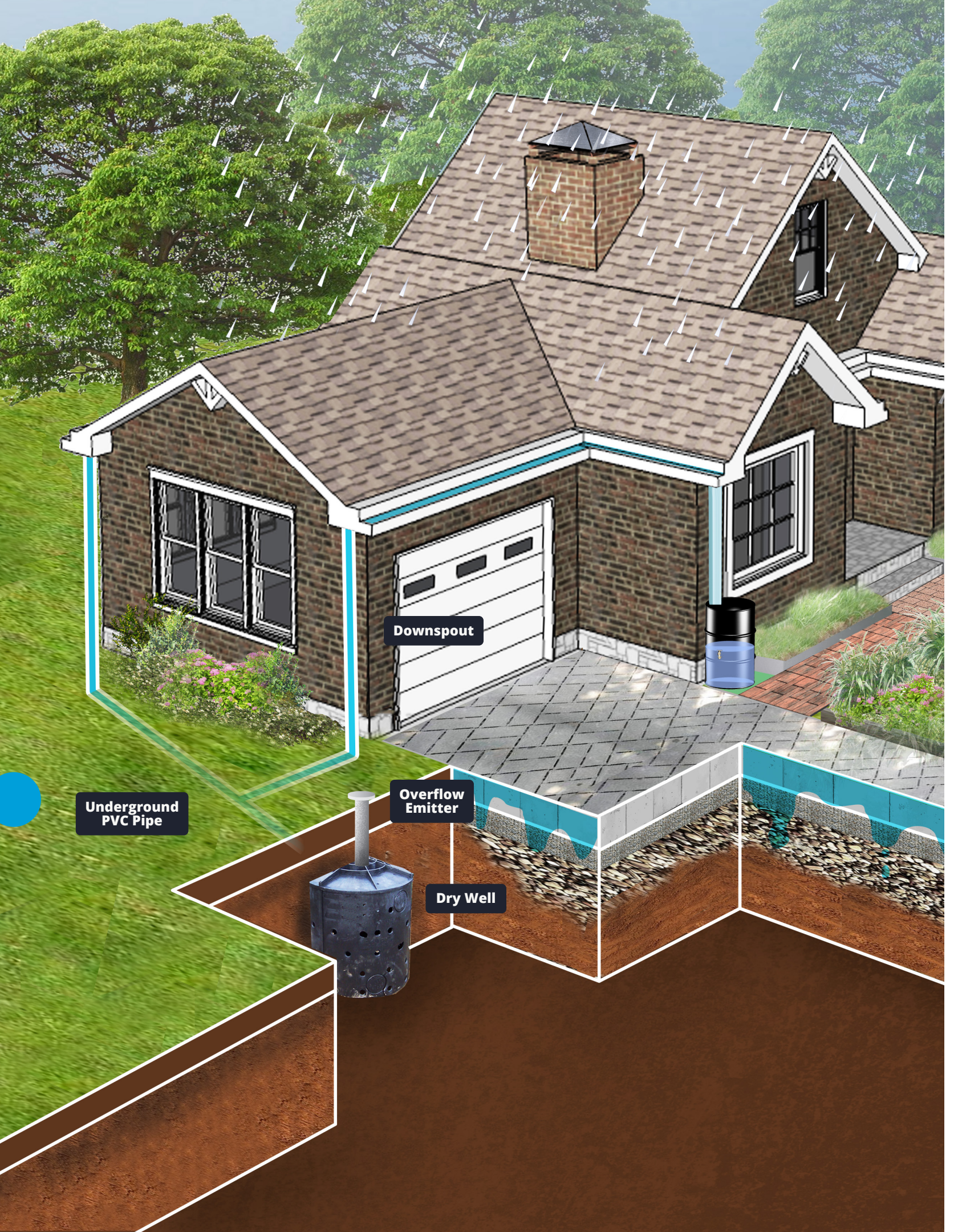
Remove and discard all of the excavated and excess material. Re-seed or re-sod turf areas that may have been damaged by construction equipment or materials.

STEP 12
Maintenance

Permeable pavement requires minimal maintenance if installed properly. For pervious concrete and porous asphalt, vacuum sweeping may be necessary if water puddles are observed following a rainstorm, indicating that infiltration has slowed down.

Never blow or sweep grass clippings or soil over pervious concrete or porous asphalt as they may clog the pores. For permeable pavers, should infiltration decrease, remove pavers in clogged areas, remove sediment or debris and replace paver and joint material.

Weed suppression may also be necessary within permeable paver joints. Hand removal of weeds is preferred over spraying with herbicide.


Downspout
Underground PVC Pipe
Overflow Emitter
Dry Well

CHAPTER 5

Dry Wells

A dry well is a buried container with small holes or openings on the sides and bottom. It can be installed on a low spot on your property. It collects the stormwater, provides for some underground storage and allows stormwater to slowly absorb into the soil. It can also receive water directed to it from a bioswale or a pipe connected from your downspouts. Dry wells are often used where limited space is available and where water must not pond on the surface. Hiring a professional for design and installation is recommended.



INSTALLATION INSTRUCTIONS

TOOLS & MATERIALS

- ☐ Long-handled shovel
- ☐ Tarp
- ☐ Landscape fabric
- ☐ 4-inch diameter schedule 40 PVC pipe*
- ☐ PVC elbow*
- ☐ Downspout adapter*
- ☐ PVC cement*
- ☐ Dry well with cap
- ☐ Pop up drainage emitter
- ☐ Spray paint
- ☐ Clean, crushed 0.75 inch stone
- ☐ Wheelbarrow
- ☐ Level
- ☐ Measuring tape
- ☐ Hammer
- ☐ Reciprocating saw or drill with non-arbored hole saw

* Not needed if not hooking up to a downspout

STEP 1
Pick the location and test the soil

A dry well should be located at least 10 feet from your home's foundation and 3 feet from any property line. Test for the infiltration rate of the soil by digging an 18-inch deep hole and filling it with water.

The soil is appropriate for dry well installation if the water disappears within 48 hours. If the soil is dry and water disappears rapidly, fill the hole with water 3 times in succession and use the third fill as the test.

STEP 2
Dig the hole and trench

Using the spray paint, paint a line coming from your downspout to the location of the dry well and around the dry well at least 4 feet in diameter. With a long-handled shovel, dig a hole for the dry well 4 feet deep and 4 feet in diameter. Then, dig a trench 1 foot deep and 6 inches wide that slopes gradually toward the hole. Shovel the soil from digging onto a tarp for easier cleanup. Save the sod to patch over the hole.

STEP 3
Line the hole

Line the hole with landscape fabric cut from a 6-foot wide roll. The fabric prevents soil from clogging the stones around the dry well. Leave enough fabric outside the hole so you can cover the stones once the dry well is installed.

STEP 4
Set up the pipe

Measure the length of pipe needed to reach from the end of the downspout, if connecting a downspout, to about 14 to 16 inches into the dry well hole. Remove the existing elbow from the bottom of your downspout. Then dry-fit the PVC elbow and downspout adaptor to the 4-inch diameter pipe. Once you have a good fit, glue the pieces together with PVC cement.



STEP 5
Check the pitch

The pipe in the trench should slope toward the dry well 0.25-inch per foot of run. A 2-foot level will show a 0.5-inch gap under one end when held level. Adjust the pitch of the pipe by adding or removing soil underneath the pipe.



STEP 6

Attach the downspout

Attach the adaptor to the downspout using stainless steel sheet metal screws and backfill around the pipe with dirt. Trim the opposite end of the pipe if it's too long.



STEP 7

Install the dry well

Assemble the dry well and use the hammer to knock out all the 1.5-inch diameter drainage holes and one of the 4.5-inch ports. Shovel a 6-inch layer of crushed stone into the hole. Set the dry well on top of the stone. Slide the 4.5-inch port over the PVC pipe. Center the dry well and fill with stone around the well until you reach its top edge.



STEP 8

Fit the Overflow Emitter

Using the reciprocating saw or drill with 4-inch non-arbored hole saw, cut a 4-inch hole in the dry well's lid. Put the lid on the well. Take a length of 4-inch pipe and glue the overflow emitter to one end. This will allow excess stormwater to escape out of the dry well. Trim the other end of the pipe so the top of the emitter is at ground level when the pipe is glued to the dry well lid. Cover the dry well with landscape fabric and place soil and sod back on top of the fabric.



STEP 9

Maintenance

If dry wells are installed properly within sites appropriate for their use, they require minimal maintenance throughout their lifespan. Clogging within the system is one of the most common causes of failure.

Continual preventative maintenance will help to ensure that the dry well operates at peak performance. Gutters connected to the dry well should be cleaned regularly or gutter guards should be installed to prevent debris and sediment from entering the system.



GLOSSARY

Aggregate: Coarse to medium grained material used in construction, including sand, gravel, crushed stone, slag and recycled concrete. "Open-graded" describes an aggregate mixture that is designed to be water permeable.

Concrete Groover: A tool, usually made of bronze or stainless steel plate, that has a V-shaped bit underneath that cuts the groove.

Cistern: A tank for storing water, usually underground.

Depression: A sunken or hollow place in the soil.

Excavate: To extract material from the ground by digging.

Inundation: Flooding.

Outbuilding: A building, such as a shed, barn, or garage, on the same property but separate from a more important one, such as a house.

Pervious Concrete: A special type of porous concrete used for concrete flat work applications that allows water to pass directly through, thereby reducing runoff.

Plugs: Seedlings which have been germinated and grown in trays of small cells, to be transplanted into larger pots or outside in the ground.

Pollinators: Animals that cause plants to make fruit or seeds by moving pollen, which fertilizes plants and allows them to reproduce. Pollinators that can be found in Illinois include hummingbirds, butterflies, moths, bees, flies and beetles.

Porous: Having small spaces or holes through which liquid or air may pass.

Reciprocating Saw: A type of machine-powered saw in which the cutting action is achieved through a push-and-pull motion of the blade.

Roller Screed: A large roller that will flatten and smooth poured concrete or angled slabs.

Rototiller: A machine that uses rotary motion of disks or teeth to turn up the ground and cultivate the land.

Sediment: Matter, such as soil, that is carried by water or wind and settled on the surface of land or the bottom of a body of water.

Septic Field: Area where wastewater is discharged from a septic tank for further treatment and dispersal in the soil via underground piping.

Silt Fence: A temporary sediment control device used on construction sites to protect water quality in nearby streams, rivers and lakes from sediment and stormwater runoff. Also known as a "filter fence."

Stormwater Best Management Practice (BMP)/Green Infrastructure: Technique, measure or structural control that is used for a given set of conditions to manage the quantity and improve the quality of stormwater runoff in the most cost-effective manner.

Sump Box: A container installed in the ground that receives stormwater via piping or a grated cover; also known as a catch basin.

Trowel: A small handheld tool with a curved scoop for lifting plants or earth.

Vibratory Plate Compactor: An engine-powered, walk-behind machine that compacts loose materials and asphalt via a bottom-mounted steel plate.

Vibratory Screed: A tool used to help smooth out and compact poured concrete.

Water Table: Underground level at which the soil is completely saturated with water.

INTERNET RESOURCES

In addition to this guide, many supplementary resources are available on the MWRD's and other websites that may be helpful as you plan and design stormwater management improvements for your property.

MWRD INITIATIVES AND PUBLICATIONS

Stormwater Management Homepage:
mwrd.org/stormwater-management

Rain Barrel Program: mwrd.org/rain-barrels

Free Trees: mwrd.org/restore-canopy

Free Compost: mwrd.org/eq-compost

Resources and Videos for Residents and Business:
mwrd.org/residents-and-businesses

Green Infrastructure Partnership Opportunity Program for public agencies: mwrd.org/green-infrastructure

Unwanted Medicine Disposal: mwrd.org/medication-disposal

Understanding Your Sewer:
mwrd.org/understanding-your-sewer-0

RESOURCES BY OTHERS

What are BMPs? www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#edu

Regional Pollinators:
www.dnr.illinois.gov/education/Pages/PollinatorMain.aspx

Pollinator Protection: www.epa.gov/pollinator-protection/what-you-can-do-protect-honey-bees-and-other-pollinators

Mosquito Control: www.epa.gov/mosquitocontrol

Your Septic System:
www.epa.gov/septic/how-your-septic-system-works

Groundwater:
www.epa.gov/sites/production/files/documents/groundwater.pdf

Illinois EPA Homepage: www2.illinois.gov/epa

ADDITIONAL TOPICS

City of Chicago Green Permit Incentives and Checklists: www.chicago.gov/city/en/depts/bldgs/provdrs/permits/svcs/green-permits.html

Green Roofs and the Heat Island Effect: www.epa.gov/heat-islands/using-green-roofs-reduce-heat-islands#types

Green Roofs: greenroofs.org/about-green-roofs

Green Walls: greenroofs.org/about-green-walls

IMAGE CREDITS

6 NJE Tree and Landscaping Service LLC, courtesy of the Chesapeake Stormwater Network

8 Milwaukee Metropolitan Sewerage District

9 Milwaukee Metropolitan Sewerage District

12 Step 2: ®Rain Water Solutions, all rights reserved

13 Step 5 middle: Construction Pro Tips, Copyright © 2019, reprinted with permission of Trusted Media Brands, Inc.

Step 5 right: Milwaukee Metropolitan Sewerage District

14 Step 7: ®Rain Water Solutions, all rights reserved

18 Step 1: United States Army

Step 2: Today's Homeowner

19 Step 4: Water Smart Gardening by Diana Maranhao - published by Cool Springs Press, a division of Quarto Publishing Group

20 Water Smart Gardening by Diana Maranhao - published by Cool Springs Press, a division of Quarto Publishing Group

22 Wild Ginger left and middle: Missouri Botanical Garden PlantFinder

Wild Ginger right: brewbooks from near Seattle, USA (commons.wikimedia.org/wiki/File:Asarum_caudatum_(wild_ginger)_-_Flickr_-_brewbooks.jpg), „Asarum caudatum (wild ginger) - Flickr - brewbooks", creativecommons.org/licenses/by-sa/2.0/legalcode

Golden Star left: Jean Everett

Golden Star middle: North Creek Nurseries

Golden Star right: Andy king50 (commons.wikimedia.org/wiki/File:Chrysogonum_virginianum_1.JPG), „Chrysogonum virginianum 1", creativecommons.org/licenses/by-sa/3.0/legalcode

Ice Dance Sedge left: Wilson Nurseries, Inc.

Ice Dance Sedge middle and right: Hoffman Nursery, Inc.

Blue Sedge left: North Creek Nurseries

Blue Sedge middle: North Creek Nurseries

Blue Sedge right: NetPS Plant Finder Tool (www.netpsplantfinder.com)

Purple Rocket left: Peter M. Dziuk, Minnesota Wildflowers (www.minnesotawildflowers.info/)

Purple Rocket middle: Missouri Botanical Garden PlantFinder

Purple Rocket right: Peter M. Dziuk, Minnesota Wildflowers (www.minnesotawildflowers.info/)

White Turtlehead left: H. Zell (commons.wikimedia.org/wiki/File:Chelone_glabra_0001.JPG), „Chelone glabra 0001", creativecommons.org/licenses/by-sa/3.0/legalcode

White Turtlehead middle: Missouri Botanical Garden PlantFinder

White Turtlehead right: North Creek Nurseries

Royal Fern left and middle: Missouri Botanical Garden PlantFinder

Royal Fern right: Stephanie Brundage, Lady Bird Johnson Wildflower Center

Solomon's Seal left: Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center

Solomon's Seal middle: © Prairie Nursery, inc.

Solomon's Seal right: Missouri Botanical Garden PlantFinder

Invincibelle Spirit Hydrangea left: peganum from Small Dole, England (commons.wikimedia.org/wiki/File:Hydrangea_arborescens_radiata_(21390940225).jpg), „Hydrangea arborescens radiata (21390940225)", creativecommons.org/licenses/by-sa/2.0/legalcode

Invincibelle Spirit Hydrangea middle: Proven Winners® ColorChoice®

Invincibelle Spirit Hydrangea right: Missouri Botanical Garden PlantFinder

23 Golden Ragwort left: © 2010-2017 by Angelyn Whitmeyer, with all rights reserved

Golden Ragwort middle: H. Zell (commons.wikimedia.org/wiki/File:Packera_aurea_001.JPG), „Packera aurea 001", creativecommons.org/licenses/by-sa/3.0/legalcode

Golden Ragwort right: Emőke Dénes (commons.wikimedia.org/wiki/File:Packera_aurea_-_wetland_1.jpg), creativecommons.org/licenses/by-sa/4.0/legalcode

Blue Ice left: Krzysztof Ziarnek, Kenraiz (commons.wikimedia.org/wiki/File:Amsonia_tabernaemontana_Blue_Ice_kz1.jpg), creativecommons.org/licenses/by-sa/4.0/legalcode

Blue Ice middle: Walters Gardens, Inc

Eastern Beebalm left: Krischan Photography. All Rights Reserved.

Eastern Beebalm middle: Missouri Botanical Garden PlantFinder

Eastern Beebalm right: United States Environmental Protection Agency

Snowcap Spiderwort left: Rasbak (commons.wikimedia.org/wiki/File:Eendagsbloem_planten_(Tradescantia_virginiana).jpg),

Snowcap Spiderwort middle and right: Walters Gardens, Inc.

Blazing Star 'Kobold' left: James L. Reveal, Lady Bird Johnson Wildflower Center

Blazing Star 'Kobold' middle: Walters Gardens, Inc

Blazing Star 'Kobold' right: Julie Makin, Lady Bird Johnson Wildflower Center

Golden Alexander left: Thomas L. Muller, Lady Bird Johnson Wildflower Center

Golden Alexander middle: John Hixson, Lady Bird Johnson Wildflower Center

Blue Flag Iris left: Jennifer Anderson, hosted by the USDA-NRCS PLANTS Database

Blue Flag Iris middle: Sally and Andy Wasowski, Lady Bird Johnson Wildflower Center

Blue Flag Iris right: Ryan Hodnett (commons.wikimedia.org/wiki/File:Northern_Blue_Flag_(Iris_versicolor)_-_Algonquin_Provincial_Park,_Ontario.jpg), creativecommons.org/licenses/by-sa/4.0/legalcode

Yellow Wild Indigo left: Photo by David J. Stang (commons.wikimedia.org/wiki/File:Baptisia_sphaerocarpa_1zz.jpg), „Baptisia sphaerocarpa 1zz", creativecommons.org/licenses/by-sa/4.0/legalcode

Yellow Wild Indigo middle: Walters Gardens, Inc.

Yellow Wild Indigo right: Jeff McMillian, hosted by the USDA-NRCS PLANTS Database

Cheyenne Sky Switch Grass left: NetPS Finder Tool (www.netpsplantfinder.com)

Cheyenne Sky Switch Grass middle: Julie Makin, Lady Bird Johnson Wildflower Center

Cheyenne Sky Switch Grass right: Jan Riggenbach, Midwest Gardening

Common Ironweed left: Missouri Botanical Garden PlantFinder

Common Ironweed middle: Walters Gardens, Inc

Joe Pye Weed left: Photo by and (c)2008 Derek Ramsey

Joe Pye Weed middle: A. Barra (commons.wikimedia.org/wiki/File:Eupatorium_purpureum.jpg), creativecommons.org/licenses/by-sa/4.0/legalcode

Joe Pye Weed right: David J. Stang (plants.ces.ncsu.edu/plants/eutrochium-dubium/), „ Eutrochium dubium 'Little Joe' spent flowers.", creativecommons.org/licenses/by/2.0/legalcode

24 Tree of heaven: Paul Wray, Iowa State University, Bugwood.org

Mimosa: Charles T. Bryson, USDA Agricultural Research Service, Bugwood.org

Autumn Olive: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Japanese Barberry: Britt Slattery, US Fish and Wildlife Service, Bugwood.org

Honeysuckle: Chuck Bargeron, University of Georgia, Bugwood.org

Callery Pear: Chuck Bargeron, University of Georgia, Bugwood.com

European Buckthorn: John M. Randall, The Nature Conservancy, Bugwood.com

Black Locust: Paul Wray, Iowa State University, Bugwood.org

Multiflora Rose: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Burning Bush: Barry Rice, sarracenia.com, Bugwood.org

Garlic Mustard: David Cappaert, Bugwood.org

Canada Thistle: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Common Teasel: Steve Dewey, Utah State University, Bugwood.org

Japanese Knotweed: David J. Moorhead, University of Georgia, Bugwood.org

Crownvetch: Dan Tenaglia, Missouriplans.com, Bugwood.org

Phragmites: Theodore Webster, USDA Agricultural Research Service, Bugwood.org

Johnsongrass: Chris Evans, University of Illinois, Bugwood.org

Japanese Hop: Chris Evans, University of Illinois, Bugwood.org

Kudzu: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Winter Creeper: James H. Miller, USDA Forest Service, Bugwood.org

28 Step 1: United States Fish & Wildlife Service

Step 2 top: Thomson200 (commons.wikimedia.org/wiki/File:Station_number_on_a_silt_fence,_Floyd_County,_GA.jpg), "Station number on a silt fence, Floyd County, GA," creativecommons.org/publicdomain/zero/1.0/legalcode

Step 2 bottom: United States Environmental Protection Agency

Step 3: Hobbit (http://techno-fandom.org/~hobbit/)

29 Hobbit (http://techno-fandom.org/~hobbit/)

30 Step 9 and 10: Hobbit (http://techno-fandom.org/~hobbit/)

31 Step 11: BMF Masonry

Step 12: Hobbit (http://techno-fandom.org/~hobbit/)

34 Misadventures in Remodeling (misadventuresinremodeling.wordpress.com)

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