

WATER RICH

Water Recycling, Infiltration, and Conservation for the Home



What is WaterRICH?

WaterRICH is a RiverLink initiative to assist homeowners in managing rainwater. Through the program, RiverLink provides an online handbook with additional resources designed specifically for smaller sites and private individuals. Special workshops, trainings, and presentations will be provided as well.

What is in this handbook?

- Why we manage water
- The hydrologic cycle
- How to conduct a site analysis
- How to measure runoff
- Selecting, designing, and installing stormwater control measures
- Additional Resources

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WaterRICH—An Overview



WaterRICH is a RiverLink initiative to assist homeowners in understanding rainwater management. Through the program, RiverLink provides an online resource designed specifically for smaller sites and private individuals. The WaterRICH Program is designed for homeowners and residents of Western North Carolina and was funded through a grant from the Community Foundation of Western North Carolina and the Pigeon River Fund to help improve the water quality in the French Broad River. The Program is designed to assist homeowners and residents in the management of stormwater on their property with a focus to [reuse](#), [infiltrate](#) and [conserve](#) water.

Benefits

- Reduce water usage
- Save money
- Solve drainage issues
- Certification!

Counties Served

- Avery
- Mitchell
- Yancey
- Madison
- Buncombe
- Haywood
- Henderson
- Transylvania



Table of Contents

The Program

This handbook is designed to walk a homeowner through a step-by-step process to learn how to manage the stormwater on their property, in turn maximizing reuse, infiltration, and conservation. Along with this handbook, RiverLink offers a series of workshops to assist homeowners in this process, including how to conduct a site analysis, how to calculate stormwater runoff, and how to select and construct stormwater control measures (SCMs).

Chapters

1. Introduction to Stormwater Management for Residential Sites
 - a. Hydrologic Principles
 - b. Hydrology as the Integrating Framework for the Site
2. Site Inventory and Analysis
 - a. How to Perform a Site Inventory and Analysis
3. Calculating Your Stormwater Runoff
4. Measuring Slope
5. Stormwater Control Measure Selection
6. Designing and Implementing Your Stormwater Control Measure
 - a. Berm and Swale Complex
 - b. Enhanced Swales
 - i. Dry Swales
 - ii. Wet Swales
 - c. Check Dams
 - d. French Drains
 - e. Rain Barrels
 - f. Rain Gardens
7. Professionally-Installed Options
 - a. Bioretention
 - b. Pervious Pavers
 - c. Stormwater Wetlands
8. Appendices
 - a. Appendix A: Terminology
 - b. Appendix B: Plant Selection
 - c. Appendix C: Local Professionals
 - d. Appendix D: A-Frame Level



Chapter 1: Introduction to Stormwater Management for Residential Sites



This chapter introduces concepts of stormwater management and the reasons for implementing stormwater control measures on a residential scale.

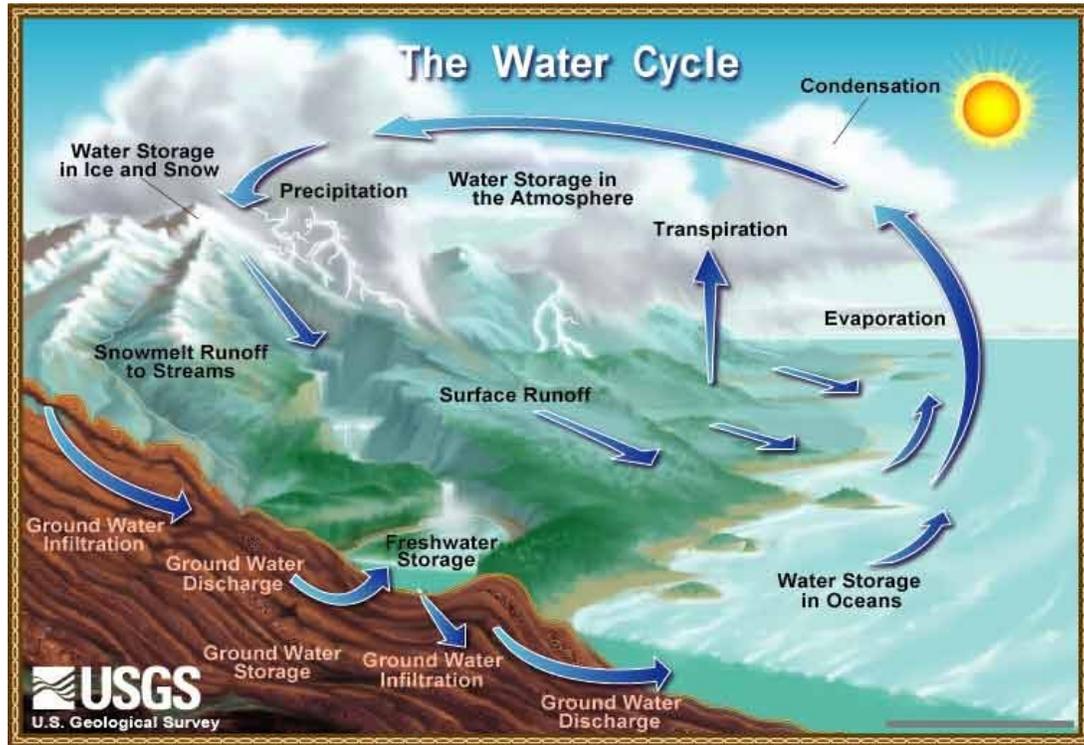
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Hydrologic Principles



Hydrological Cycle. Source: USGS. John M Evans USGS, Colorado District

The Hydrological Cycle

In the hydrological cycle, rain, ice, or snow falls to the ground as precipitation. This precipitation then takes one of two routes. The water can infiltrate or seep into the ground through percolation. This water is then either taken up by vegetation and trees, returning it to the atmosphere through evapotranspiration, or the water seeps into the ground and moves under the ground until it reaches the groundwater table or surface water such as a stream or lake. Precipitation can also stay on the ground surface as overland flow where it is called runoff. This water can re-enter the atmosphere through direct evaporation. It flows directly to our surface waters either through an engineered municipal stormwater system or by overland flow, usually in rivers and streams.

When we talk about stormwater management, we are focusing on how to mimic the natural hydrological cycle prior to development. This means we are looking at how to infiltrate or harvest the rainwater from a typical storm event on the site, minimizing the runoff from said site. This is counterintuitive to the traditional practices of the past that favored moving water off-site as quickly as possible. In our urban watersheds, we have begun to see the catastrophic changes this “out of sight, out of mind” concept of design has caused. In response, the current trend is to approach development and stormwater management with a comprehensive approach that includes both preventative and quality control methods.



Hydrology is the study of water and how it moves through natural and built environments. The **Hydrological Cycle** is critical in the understanding and management of stormwater.

Hydrologic Principles

The Urban Hydrological Cycle

Rainwater reacts differently within the urban environment than in the natural environment. Much of this is due to the imperviousness of the built environment. Understanding the principles of runoff volume, flow, and rate, along with drainage areas and storm size, is key to managing stormwater in an increasingly natural way.

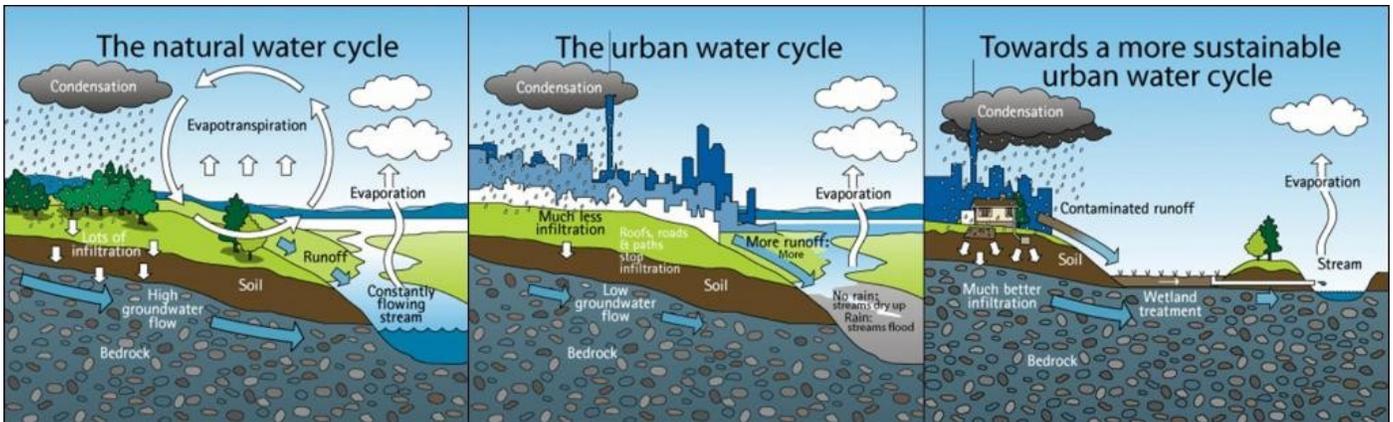


Figure 2: Hydrological Cycle Natural, Urban, Intermediary, source: Sustainable Sanitation and Water Management, www.sswm.info/category/concept/water-cycle

Stormwater Runoff Factors

Stormwater runoff is determined by drainage area, storm size, and land cover. In natural areas, the rain is intercepted by trees, shrubs, and other vegetation, allowing for infiltration, evapotranspiration, transpiration, and overland runoff. When we increase the amount of land cover that is impervious, meaning any surface that does not allow water to infiltrate (such as patios, driveways, roofs, and roads), this causes drastic changes in runoff rate and volume.

The **runoff rate** refers to how quickly water begins to concentrate and move from its point of origin. Prior to development, vegetation intercepted rainfall, slowing runoff naturally due to changes in terrain, soil composition, and cover from trees and shrubs. Impervious surfaces are graded to direct sheet flow and increase the velocity at which water moves across a site. They also disallow infiltration, therefore increasing the runoff rate. **Runoff volume** is the quantity of runoff for a given site. The more dense the development and the higher the percentage of impervious surface in a drainage area, the higher the runoff volume.

Therefore, as impervious surface increases, the rate and volume of runoff also increases. This creates what we call “flashy” runoff events, where water moves more quickly and in greater volume from a site. Our streams catch the brunt of these massive peak flows. As a result of this, we find increased erosion, reduced infiltration and groundwater recharge, and degradation of ecological health in surface waters.



Hydrologic Principles



Storm drain collecting stormwater from impervious surfaces near West Asheville Park. Stormwater flows straight to our waterways and does not undergo any treatment.



Rhododendron Creek—a typical urban stream—rises and falls rapidly during and after high rainfall events greater than or equal to one inch.

Urban streams receive stormwater through the storm drainage system, which is a series of pipes that direct water to streams, usually without any water quality treatment. This is the case for all of North Carolina. The runoff velocity increases as the rainwater flows through the stormwater system. This water then rushes from the pipe into an urban stream, increasing erosion and degradation.

As stewards of our water resources, RiverLink hopes to improve residents' understanding of stormwater and how it affects our environment. The WaterRICH program will assist homeowners to design features that help increase infiltration and improve water quality, thus moving stormwater management toward a more sustainable system.



Hydrology as the Integrating Framework for the Site

How Do I Start?

We begin with observation. Many of us overlook the importance of understanding how water flows on or through our property. Knowing this will give us clues to help determine how to solve issues and make improvements.

Start with observations:

When it rains, observe:

- Where water goes
- Where it collects
- What your gutters are doing (if you have them)
- Where it drains from
- What is working
- Where there are problem areas
- Where you have wet areas in your basement and/or along your foundation
- Where the storm drains are around your property
- If you have under drains and, if so, where they are and if they function properly

When it's dry, observe:

- Which areas dry more rapidly than others
- Sun patterns
- If your gutters are clean
- Note significant vegetation, i.e. trees, etc.
- Note slope (the lay of the land) — do you have steep areas? Flat areas?
- Soils (we will discuss this in more depth in [Chapter 2: Site Inventory and Analysis](#))
- Where the storm drains are around your property

There are numerous resources to assist in evaluating your property. These systems are meant to be accessible to everyone but they can still be overwhelming because of the large amount of information they contain. If you have trouble using these resources, look for classes held by RiverLink, local community colleges such as AB-Tech, and NC State Cooperative Extension that offer help with site evaluation techniques.

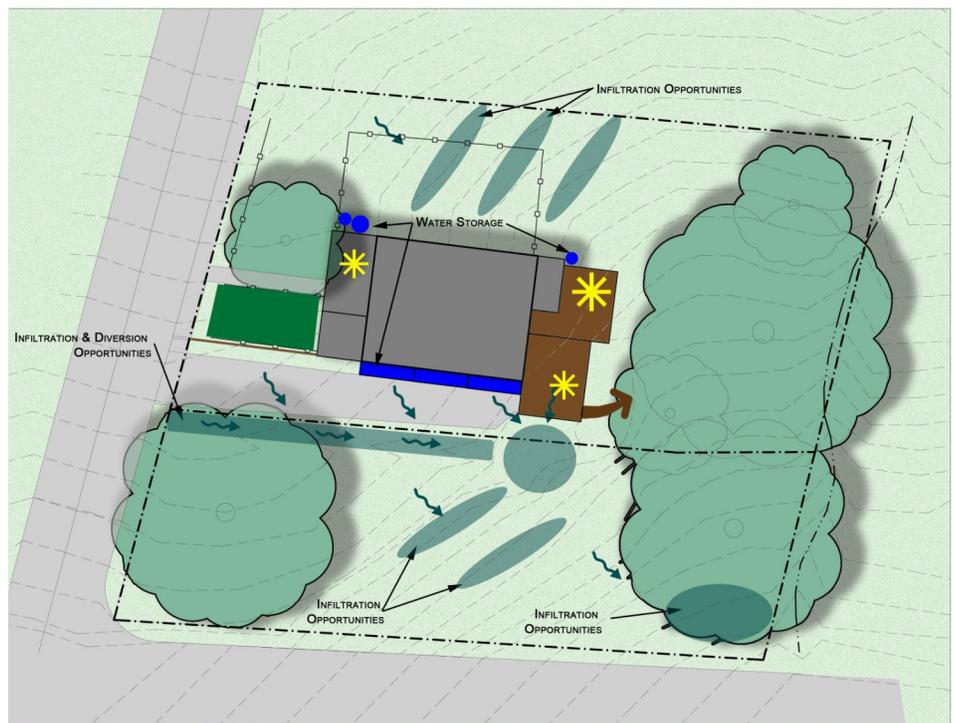


Chapter 2: Site Inventory and Analysis

Site Inventory is taking stock of the existing conditions on your property. These include social, environmental, and constructed features. An inventory can identify problems such as erosion, drainage issues, unsightly elements, along with positive attributes such as specimen plants or a good view. Social elements identify how people use and move through the site, such as typical paths of travel or gathering spaces. Environmental elements include aspect, wind and sun patterns, plant communities, and noise issues. The constructed components include utility lines, buildings, sidewalks, driveways and decks or patios. It is also important to note the patterns of water movement during rain events, noting the severity of the storm to help identify opportunities to use what's working and mitigate what's not.

Materials

- Scaled map of site
- Computer with Internet
- Colored pens or pencils
- Slope measuring tool
- Calculator
- Measuring tape
- Ruler
- Trace paper



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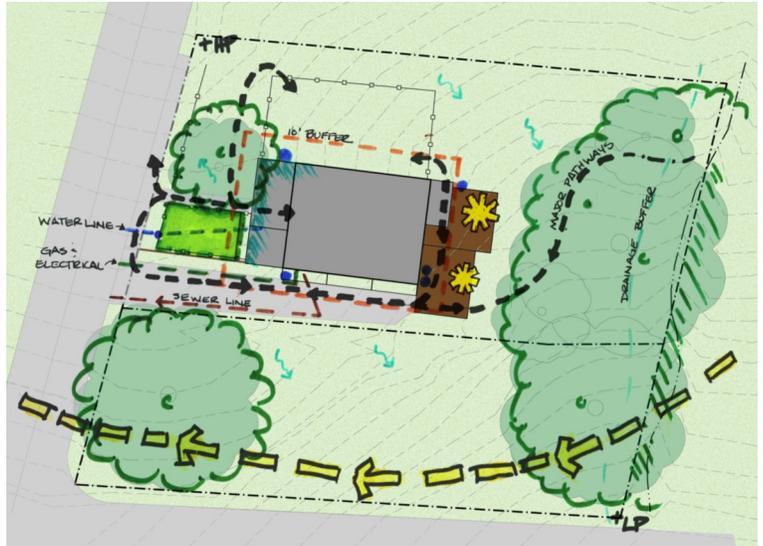
How to Perform a Site Inventory and Analysis

Step 1: Obtaining a Scaled Map of Your Property

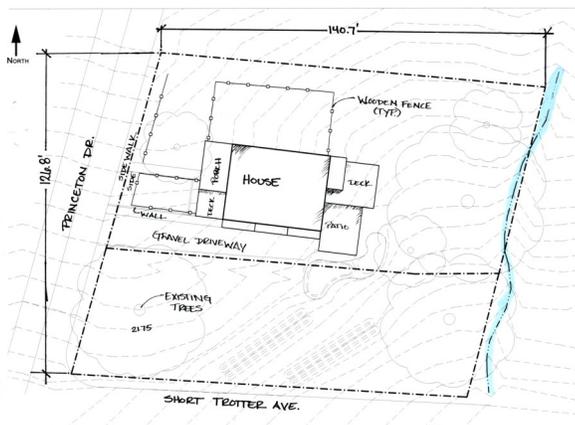
You can obtain a scaled map of your property in one of two ways:

1. You may have received a Plat or survey map of your property in the closing of the property. Either of these documents is the best to use. **Note: if you only have one copy, either scan it to an electronic file or overlay it with trace paper to make comments and denote features.**
2. You may be able to obtain a Plat or survey map through your county's online GIS system, or even your city hall. Check the links in [Step 2: Gathering Information](#) to see what data are available in your area online.

Scaled maps can usually be found by locating your property parcel and selecting the link next to "Plat Book and Page."



Example site inventory



Property Plat map

Step 2: Gathering Information

There are numerous resources to assist in evaluating your property. These systems are meant to be accessible to everyone but they can still be overwhelming because of the large amount of information they contain. **To get a sense of the data you will need, review [Step 3: Recording Site Data](#).**

The websites listed below contain publicly accessible information and use a service called Geographic Information Systems (GIS). This allows users to easily access geospatial data pertinent to their property.



How to Perform a Site Inventory and Analysis

BUNCOMBE COUNTY

Visit <https://www.buncombecounty.org/governing/depts/gis/default.aspx> and click “Full Access GIS.” You can then zoom to your property on the map or use the search bar to enter your address or PIN (Property Index Number). Use the panel on the left side of the screen to click on additional information.

MADISON COUNTY

[VISIT MADISON COUNTY, NC GIS](#) You can then zoom to your property on the map or use the search bar to enter your address or PIN (Property Index Number). At the top right, you can select which layers to view. There is also a measuring tool below the search bar.

HENDERSON COUNTY

Visit <https://henderson.roktech.net/gomaps4/> and either zoom to your property or use the search bar to enter your address or PIN. At the top of the screen, you can select which layers to view.

TRANSYLVANIA COUNTY

Visit <https://www.webgis.net/nc/transylvania/> and either zoom to your property or use the search bar to enter your address or PIN. Toggle the panel on the left side of the screen to select which layers to view.

HAYWOOD COUNTY

Visit <http://maps.haywoodnc.net/gisweb/default.htm> and either zoom to your property or use the search bar to enter your address or PIN. Toggle the panel on the left side of the screen to select which layers to view.

YANCEY COUNTY

Visit <https://yancey.connectgis.com/Disclaimer.aspx> and click “I accept this disclaimer.” You can then zoom to your property or use the search bar to enter your address or PIN. Toggle the panel on the right side of the screen to select which layers to view.

EVERY COUNTY

Visit <https://www.webgis.net/nc/avery/> and either zoom to your property or use the search bar to enter your address or PIN. Toggle the panel on the left side of the screen to select which layers to view.

MITCHELL COUNTY

Visit <http://mapping.mitchellcounty.org/> and either zoom to your property or use the search bar to enter your address or PIN. On the left side of the screen, click the Layers tab to view more information.



How to Perform a Site Inventory and Analysis

Step 3: Recording Site Data

Record the following data on your scaled map. Be sure to include elements you favor as well as those you don't.

Environmental

- Slope aspect (which direction the slope faces)
- Soil types
- Sun/shade locations
- Slope (note the steepness and extend of grade changes, including where the grade changes)
- High and low spots
- Erosion (include location, area, severity, and depth)
- Water issues
- Ponding water
- Vegetation (existing, invasive, misplaced, unhealthy)

Social

- How people and animals move through the site
- Proximity to other elements
- Privacy

Constructed

- House and outlying buildings such as sheds, garages, and animal shelters
- Decks, patios, and porches
- Sidewalks
- Driveways
- Fences
- Play equipment, fire pits/rings, and social gathering spaces
- Existing rain barrels or cisterns
- Propane or oil tanks
- Belowground pipes or utilities (if known)
- Septic fields



Example site inventory

How to Perform a Site Inventory and Analysis

Step 4: Analyzing the Information

After all inventory has been taken, it is important to process the information gathered, as well as think about future developments or uses. Begin thinking about how you use the space and the elements that are important to you. Ask yourself how you want to use the site. See [Questions to Consider](#) below.

Return to your inventory map with your design elements in mind. Begin examining the inventory and thinking about how all the elements could fit together. Draw on the map areas for future or changing uses, design elements, issues, and opportunities.

QUESTIONS TO CONSIDER

- Are there special areas you love to be in for one reason or another (i.e., shade, privacy ,etc)?
- Are you looking to expand your home, outdoor living space, or driveway in the future?
- Are you looking to add specific elements to your outdoor area, such as a playground, fences, fires pits or water features?
- Are any trees or vegetation going to be removed?
- Where are the best places for infiltration?
- Where do I have impervious surfaces and how do I re-route the runoff to infiltrate?

REASONS TO CONSULT THE EXPERTS

- You will be disturbing one or more acres of land.
- Any portion of your property falls within the floodplain.
- Your property is governed by steep slope ordinances. The specifics of these change frequently, so check with your local municipality for up-to-date information.
- Residents of the city of Asheville should consult the [Tree Preservation in Steep Slope Zones](#) document before altering their landscape.
- Residents of Henderson County should consult the [Water Resources \(Development\)](#) website prior to construction.



Chapter 3: Calculating Your Stormwater Runoff

Materials

- Scaled map of site
- Ruler
- Calculator

Knowing how much water runs off or through your property is critical to the correct design and implementation of any stormwater feature. In order to calculate this volume, you will need a scaled map of your property with all impervious surfaces visible.



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Calculating Your Stormwater Runoff



How much water can you expect to harvest? How much water will you have to control? In a given storm event, the amount of runoff depends on many factors, making precise calculations complicated, but a rough estimate is easily obtained by using runoff coefficients. In this method, runoff is calculated by multiplying the surface area by a coefficient (see the table “[Runoff Coefficients](#)” on the next page) that estimates the conditions of your site. This is then multiplied by the depth of rainfall to obtain a volume of runoff. To make the calculation easier, you can assume that rainfall depth comes in units of 1 (1in or 1cm, etc.). That way, you’ll know how much runoff you’ll have per inch of rainfall. We recommend accounting for 1” rain storms because most rain events in North Carolina are 1” or less. Therefore, your stormwater control measure will be suitable for most rain events.

The next page provides an example of how to calculate stormwater runoff from your site.

Calculating Your Stormwater Runoff

The Equation

Volume of Runoff = Surface Area x Runoff Coefficient x Rainfall Depth

RUNOFF COEFFICIENTS

Find the Hydrologic Soil Group(s) of your site's soil(s) (see Chapter 2: How to Perform a Site Inventory and Analysis). Soil Groups A and B are sandier and Soil Groups C and D are more clayey.

Land Use/Cover	Soil Group A	Soil Group B	Soil Group C	Soil Group D
100% impervious (parking lots, rooftops, paved sidewalks or patios)	0.98	0.98	0.98	0.98
Open space with grass cover <50%	0.68	0.79	0.86	0.89
Open space with grass cover 50% to 75%	0.49	0.69	0.79	0.84
Open space with grass cover >75%	0.39	0.61	0.74	0.80
Woods in fair hydrologic condition	0.36	0.60	0.73	0.79
Residential lot (1/4 acre)	0.61	0.75	0.83	0.87
Residential lot (1/2 acre)	0.54	0.70	0.80	0.85
Residential lot (1 acre)	0.51	0.68	0.79	0.84

Adapted from USDA NRCS Curve Numbers, 1986

Example

Step 1: Assess Site Conditions

In this example we will use a 200 ft² patio.

Step 2: Obtain Runoff Coefficient

Using the Runoff Coefficients table on the left, look up the runoff coefficient that most closely resembles your site. In this case it is 0.98 because the patio is 100% impervious.

Step 3: Do the Math

Refer to the equation above:
 Volume of Runoff = 200ft² x 0.98 x 0.083ft* = **16.3ft³**

*Make sure that "Surface Area" and "Rainfall Depth" are the same units. Here, we converted inches of rain to feet. **1 inch ÷ 12 inches/ft = 0.083 ft.** It doesn't matter what you use, just stay consistent -- measurements in feet or meters are generally easiest.



Chapter 4: Measuring Slope



Infiltration swale

Materials

- Measuring tape or yardstick
- String
- Line level (see photo in Step 2 on [next page](#); costs about \$2)
- Any screwdriver
- Hammer
- Tall stake or something similar (in this example, we used the broken handle of a rake)

Controlling storm water runoff depends largely upon how much, and in what direction, the ground slopes. Direction can be measured using a compass, but if you just want to know which way your runoff is going (for instance, toward or away from your house), turn on the hose and sprinkle the area until you can see where the water runs, or put a tennis ball on the ground and see where it rolls.

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Measuring Slope

STEP 1: SETUP

Using the hammer, pound the stake firmly into the base of the slope. Make sure the stake is straight up and down. Tie the string to the shaft of the screwdriver and then push into the ground at the top of slope as pictured to the right.



STEP 2: LEVELING

Now that the string is anchored to the ground, pull the string tight between the screwdriver and the stake. Use the level to measure how level the string is. When the string is level, tie it to the stake.



STEP 3: MEASURING

Measure the height of the string at the stake by using a measuring tape or yardstick. Next, measure the length of the string from the stake to the screwdriver.

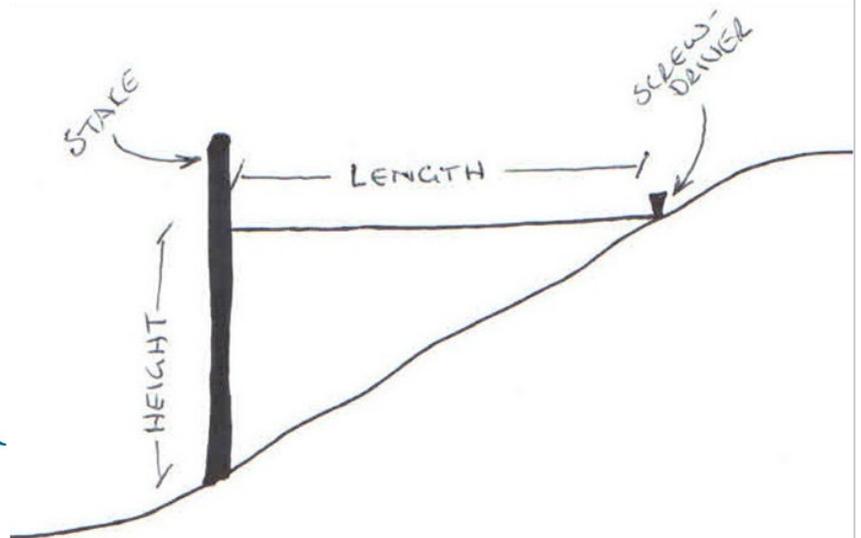


STEP 4: CALCULATING SLOPE

To calculate percent slope, divide the height of the string at the stake by the length of the string and multiply by 100.

Ex: Height of string at stake = 35"
Length of string = 105"

$$(35'' / 105'') \times 100 = \mathbf{33\% \text{ slope}}$$



Chapter 5: Stormwater Control Measure Selection

Materials

- Site inventory and analysis

Once the site inventory and analysis have been completed, you may begin scouting the location for your stormwater control measure and, finally, selecting the right one for your needs! SCMs are divided into five categories based on their abilities to recreate the natural hydrologic cycle: 1) infiltration, 2) filtration, 3) detention, 4) retention, and 5) wetland features. The major factors in selecting the best SCM for your site are pollutant treatment needs, the physical characteristics of the site, and environmental and social (neighborhood) factors.



WaterRICH Rain Garden

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Factors in Locating the SCM

The location of your water feature is important for determining both its shape and type. Your site inventory will be key for determining ideal locations. Strong considerations must be given to the topography and drainage of your property, the location of your downspouts, and any ponding that occurs. You must also be aware of constraints such as utilities, soil type and water table depth.

Topography and Drainage

- The SCM should be located at a low lying area of your property. This allows it to intercept the majority of the water runoff that flows through the property.
- The SCM should be along a slope to allow for a natural flow of water.
- The SCM must be downhill from all building foundations.

Downspouts

- The important question to consider with your downspouts is, can they drain to the water feature? If so, the water feature needs to be placed downhill from the downspouts. If not, a cistern or rain barrel can be used to collect the water.

Ponding

- Ponding can be a serious problem for both the aesthetics and functionality of your landscape, although it does provide a great opportunity for a rain garden! View the [Rain Gardens](#) section of [Chapter 6](#).

Constraints

- UTILITIES! Avoiding your utilities is top priority. To learn the location of all your utilities, **call 8-1-1**.
- Your water feature **MUST** be downhill from any house crawl space or basement, wellhead, and septic system drain field. It is suggested that all water features remain at least 10 ft from the house crawl space or basement and wellhead and 25 ft downhill or lateral from a septic system drain field. Other state and local regulations might apply.
- Soil type can also be a limiting factor in your SCM location and type choices. Some considerations are:
 - The seasonal high water table (SHWT) should be at least two feet below the bottom of your SCM.
 - If you have poorly drained soils, it would be best to consult a professional.
 - Consult [Chapter 2: Step 4](#) for more reasons to call a professional.



Factors in Selecting the SCM

Environmental Factors

The first step in selecting your stormwater control measure is to review the stormwater runoff volume for the specific site. In residential developments there are no requirements for reducing rate or volume of runoff from a site even though this is one of the largest known sources of water pollution. As WaterRICH citizens, we are looking to return the hydrology of the site towards its undeveloped natural state and will use this information in the siting and selection of an appropriate SCM.

Stormwater management practices for residences are designed to be both aesthetic improvements as well as pollutant-removal devices. Typically, the lower you are in the watershed, the more water runoff and pollutants you will receive. Slowing runoff and allowing it to be absorbed by a cast of native plants will filter the runoff returning the stormwater to the cycle cleansed and healthy. Examine the table below to get a better idea of what improvements you will be making to your watershed by taking responsibility for the runoff from your property.

Stormwater Pollutant	Sources	Related Impacts
Nutrients: Nitrogen, Phosphorus, various others	Animal waste, fertilizers, failing septic systems	Algal growth, reduced clarity
Total Suspended Solids (TSS): Sediment deposited and suspended in the water	Construction sites, bare soil, road sanding, eroding banks	Increased turbidity, reduced clarity, deposition of sediment, lower dissolved oxygen
Organic Materials	Leaves, grass clippings, compost, brush	Oxygen deficit to receiving waters
Pathogens: Bacteria and Viruses	Animal waste, livestock, failing septic systems	Human health risks
Hydrocarbons: Oil and Grease, Polycyclic aromatic hydrocarbons	Automobile wear, waste oil, emissions and fuel leaks	Water toxicity, sediment, and bioaccumulation through the food chain
Metals: Lead, Copper, Cadmium, Zinc, Mercury, Chromium, Aluminum	Wear of automobile brake linings and tires, emissions and fuel leaks, and metal roofs	Water toxicity, sediment, and bioaccumulation in the food chain
Pesticides: PCBs, Synthetic Chemicals	Herbicides, insecticides, fungicides, etc.	Water toxicity, sediment, and bioaccumulation in the food chain
Chlorides	Road salt, uncovered salt storage	Toxicity of water columns and sediment
Trash and Debris	Litter washed through storm drain networks	Degradation of the beauty of surface waters, threat to wildlife

Adapted from Minnesota Urban Small Sites BMP Manual



Factors in Locating the SCM



Community members installing a rain garden at a City of Asheville fire station

Physical Factors

The physical factors that determine the selection of stormwater control measures include soils, depth to the water table, drainage area, areas of concentrated pollutants, slope of site, and the area required. These are all elements you should review in the site inventory and analysis section in [Chapter 2](#).

Social Factors

In any design or modification, the social factors need to be assessed to assist in selecting an appropriate feature. These factors include existing and future elements such as playground areas, patios or pathways. Many of these you examined in the site Inventory and analysis process. In addition (if you didn't already), weighing the maintenance requirements and community acceptance of a given practice will help in the selection process. In Western North Carolina, we have a mix of acceptance levels of any given feature based on physical appearance and nuisance problems.

Chapter 6: Designing and Implementing Your Stormwater Control Measure



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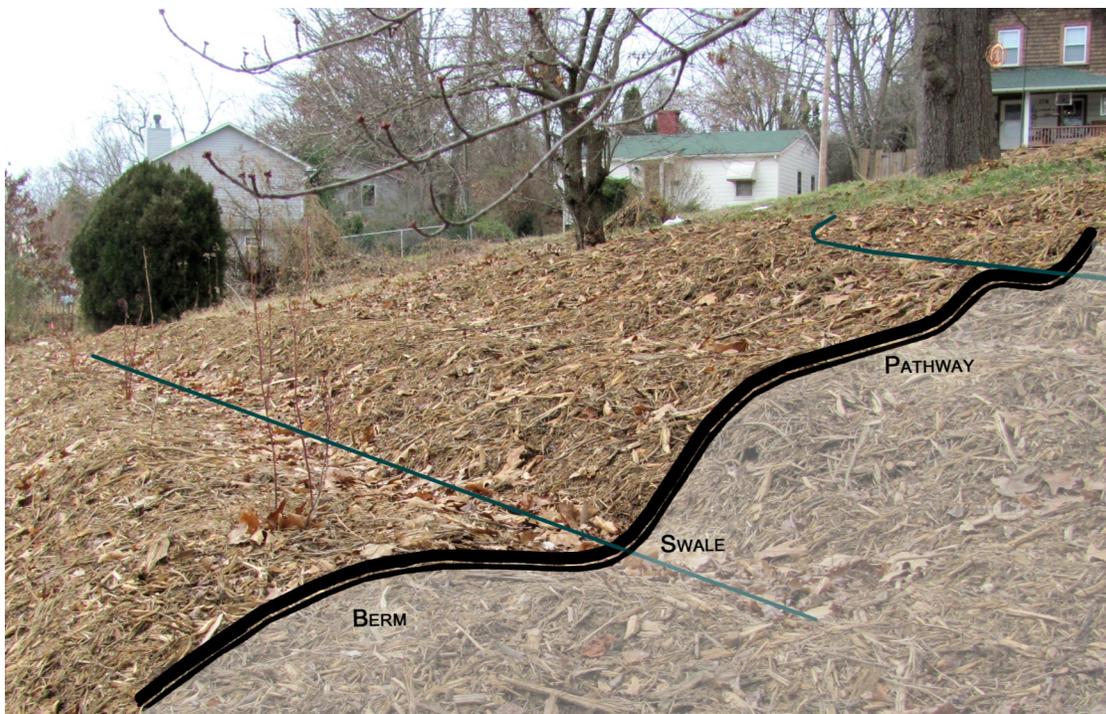
Berm and Swale Complex

Berm and swale systems are utilized in the landscape to capture, direct and infiltrate rainwater into the soil where it is needed. This complex allows a homeowner to develop a natural watering system focusing on maintaining vegetation needs. There are numerous variations on the basic berm and swale design, some of which are explained in the [Enhanced Swales](#) and [Check Dams](#) sections of this chapter. As the series becomes more complex, specifically when working in areas with steep slopes, you may want to consult one of the designers listed in [Appendix C: Local Professionals](#).

The following pages will assist you in designing, sizing and constructing a berm and swale complex.

Things to Consider

- Do not dig within 10 feet of foundation
- Do not back water up against buildings or foundations
- Berms can double as paths and trails
- Berms and swales are great places for vegetation
- Swales can occur around existing vegetation if you excavate around the tree or shrub carefully
- Review the [Enhanced Swales](#) and [Check Dams](#) sections of this chapter prior to designing
- Be creative and have fun!



Berm and Swale Complex Designed by Zev Friedman of Living Systems Design.

Berm and Swale Complex

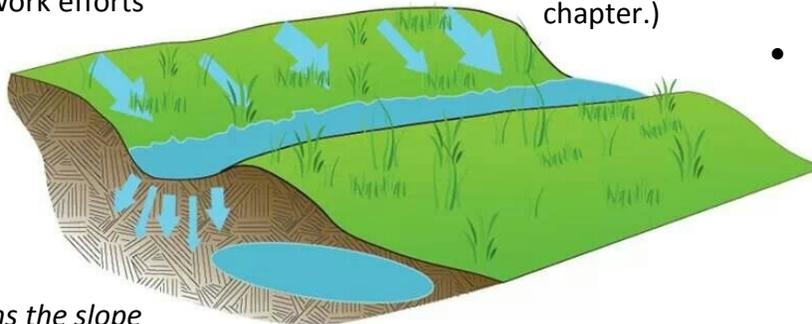
Berm and swale complexes work in two parts. 1) The swale is an excavated depression running parallel to the slope with little to no horizontal slope. It slows and collects water, allowing it to infiltrate underground and seep into the berm. 2) The berm is a mound of soil taken from either the excavated swale or from additional earth, brush, or rock. It is located downslope of the swale and is situated parallel to the slope. Berm and swale complexes can be vegetated or mulched.

Advantages

- Can be used on slopes from 50:1* to 4:1 (2% to 25%)
- Berms and swales can be designed to work with the existing landscape, lessening your work efforts
- They are fairly easy to construct
- They require minimal maintenance

Disadvantages

- Can only be installed on sloped areas
- Swales with gradients greater than 10% may need additional components. (See the [Check Dams](#) section in this chapter.)
- Design errors easily lead to concentrated flow, gullies, and berm breaching



* A 50:1 slope means the slope consists of 50 feet of run per 1 foot of rise. This is equivalent to a 2% slope.

Photo courtesy of Earth Repair Corps

Design Considerations

- Must be utilized only on slopes between 2% and 25%.
- Make berms bigger rather than smaller to reduce the risk of the berm failing during a large storm event. If water breaches a berm during such an event, it can create a gully.
- Berms should always have 3:1 slope (3 feet of run per 1 foot of rise).
- If doubling the berms as walking paths or trails, make sure to flatten the trail portion of the berm while maintaining the 3:1 slope ratio on the sides.
- Leave a 1-foot-wide undisturbed area between each berm-and-swale series.

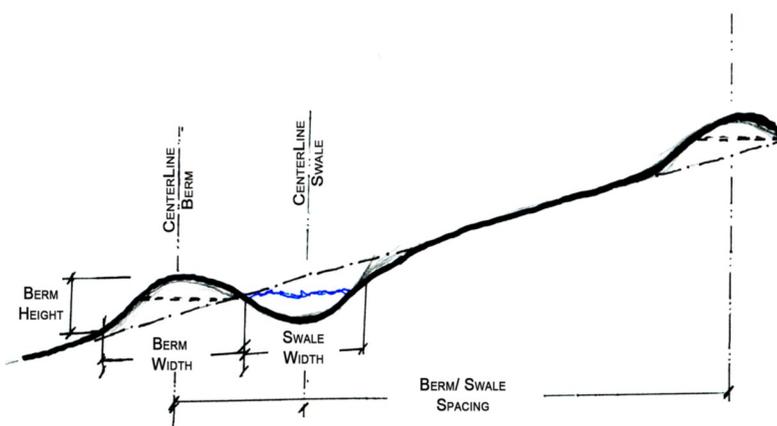
Berm and Swale Complex

Implementation

1. Begin by reviewing your overall site analysis based on the design considerations, advantages, and disadvantages to determine locations for berms and swales
2. Once your location is determined, use the runoff volume calculation to determine the water storage capacity needed for a 1-inch storm minimum. Base the size and spacing on your site goals as well. [See next page to determine swale size.](#)
3. Use an A-frame level to lay out the centerline of the berm and swale with flags or other means of marking. See [Appendix D](#) to learn how to make and use your own A-level.
4. Lay out all berms and swales, then determine if there is opportunity to connect them or if they are independent of each other.
5. Start at the top and dig a basin just up-slope of the berm, using the excavated soil to build the berm below. You can leave established shrubs and trees within the swale; simply dig around them.
6. If needed, bring in additional soil to create the necessary berm size.
7. Level and tamp the berm under human weight and power only.
8. Locate appropriate spillways for the overflow, zig-zagging to spread and infiltrate the runoff, minimizing concentrated flows. Always design the spillway flow path.
9. Revegetate (see [Appendix B: Plant Selection](#) for a list of appropriate plants for berms and swales) or mulch any exposed soil as soon as possible after construction.

Materials

- Site analysis
- Scaled map of site
- Calculator
- A-Frame level (see [Appendix D: A-Frame Levels](#) to learn how to make and use your own)
- Flagging or other marking materials
- Hand tamper
- Shovel
- Hard rake
- Mattock
- Mulch
- Plants
- Stone (optional)



Maintenance

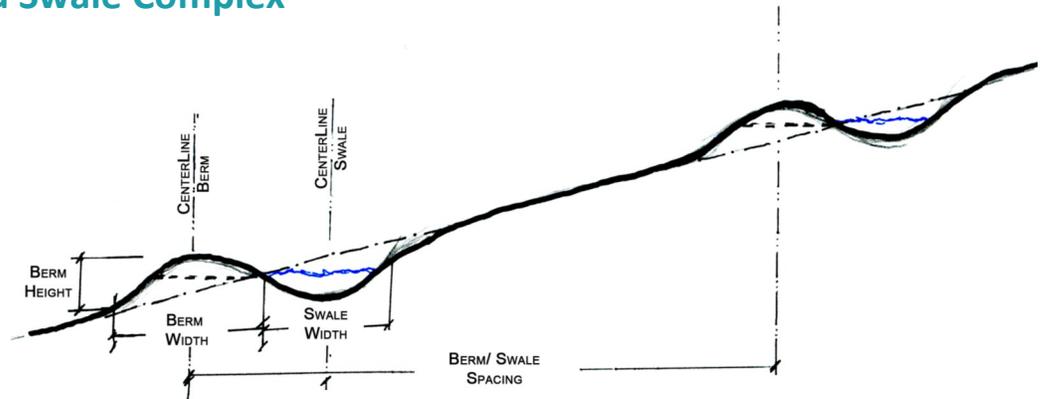
- Check berms OFTEN for stability and possible areas of breaching, especially after storms with greater than 1" of precipitation.
- Weed as needed.
- Maintain recommended 3" mulch layer.
- Maintain level slope of swales to minimize the possibility of erosive runoff.



Berm and Swale Complex

Sizing the Berm and Swale Complex

The size of your SCM will be limited by the area and soils of your site. First, follow the steps below to determine the amount of stormwater runoff your berm and swale complex can hold given the depth, width, and length of your site. Once you're familiar with the equations, continue to the next page for an example with different limiting factors.



1. Water Holding Capacity

$$\begin{aligned}\text{Volume of H}_2\text{O Capacity} &= \text{Area} \times \text{Length} \\ \text{Area} &= 1/2 \text{ Width} \times \text{Berm Height} \\ \text{Volume} &= (1/2 \text{ Width} \times \text{Berm Height}) \times \text{Length}\end{aligned}$$

Width = 10ft, Length = 25ft, Depth of Swale = 2ft, Height of Berm = 2ft

Volume = 1/2 x 10ft x 2ft x 25ft

Volume = 250ft³

2. Water Capacity per Foot of Length

$$\text{Capacity} = (1/2 \text{ Width} \times \text{Berm Height}) \times 1\text{ft}$$

Width = 10ft, Length = 25ft, Depth of Swale = 2ft, Height of Berm = 2ft

Capacity = 1/2 x 10ft x 2ft x 1ft

Capacity = 10ft³

3. Spacing Distance

$$\text{Distance} = \text{Capacity (per ft.)} / (\text{Runoff Coefficient} \times \text{Rainfall Depth})$$

Width = 10ft, Length = 25ft, Depth of Swale = 2ft, Height of Berm = 2ft, Capacity per ft. = 10ft³, Runoff Coefficient (See [Chapter 3: Calculating Your Stormwater Runoff](#)) = 0.79, Rainfall Depth = 0.083ft

Distance = 10ft³ / (0.79 x 0.083ft)

Berm and Swale Complex

Sizing the Berm and Swale Complex

Below is an example that uses the same equations as the previous page, but with different limiting factors. In this instance, the width of the berm and swale complex is unlimited, so we solve for that width using the maximum volume of stormwater runoff that we want to control (this can be calculated visiting [Chapter 3: Calculating Your Stormwater Runoff](#)). Note that sometimes you will even want to solve for width AND length, if your site has enough available space. Play around with different scenarios. There is more than one possible design for each site.

1. Water Holding Capacity

$$\begin{aligned}\text{Volume of H}_2\text{O Capacity} &= \text{Area} \times \text{Length} \\ \text{Area} &= 1/2 \text{ Width} \times \text{Berm Height} \\ \text{Volume} &= (1/2 \text{ Width} \times \text{Berm Height}) \times \text{Length}\end{aligned}$$

$$\begin{aligned}\text{Volume} &= 250\text{ft}^3, \text{Length} = 25\text{ft}, \text{Depth of Swale} = 2\text{ft}, \text{Height of Berm} = 2\text{ft} \\ 250\text{ft}^3 &= 1/2 \text{ Width} \times 2\text{ft} \times 25\text{ft} \\ \text{Width} &= 10\text{ft}\end{aligned}$$

2. Water Capacity per Foot of Length

$$\text{Capacity} = (1/2 \text{ Width} \times \text{Berm Height}) \times 1\text{ft}$$

$$\begin{aligned}\text{Width} &= 10\text{ft}, \text{Length} = 25\text{ft}, \text{Depth of Swale} = 2\text{ft}, \text{Height of Berm} = 2\text{ft} \\ \text{Capacity} &= 1/2 \times 10\text{ft} \times 2\text{ft} \times 1\text{ft} \\ \text{Capacity} &= 10\text{ft}^3\end{aligned}$$

3. Spacing Distance

$$\text{Distance} = \text{Capacity (per ft.)} / (\text{Runoff Coefficient} \times \text{Rainfall Depth})$$

$$\begin{aligned}\text{Width} &= 10\text{ft}, \text{Length} = 25\text{ft}, \text{Depth of Swale} = 2\text{ft}, \text{Height of Berm} = 2\text{ft}, \text{Capacity per ft.} = 10\text{ft}^3, \text{Runoff} \\ \text{Coefficient (See } &\text{Chapter 3: Calculating Your Stormwater Runoff)} = 0.79, \text{Rainfall Depth} = 0.083\text{ft} \\ \text{Distance} &= 10\text{ft}^3 / (0.79 \times 0.083\text{ft})\end{aligned}$$



Enhanced Swales

Swales are slight depressions, usually trapezoidal in shape, which are used to convey runoff from surrounding impervious areas. They can either run along the contour of the land or perpendicular, as long as the longitudinal slope does not exceed 5%. In the past these runoff-transporting mechanisms have simply been grassed. Today, we can design these features with various vegetation and interest, including mimicking a dry streambed. All swales fall into two typical design groups, the dry swale and the wet swale.

The following pages will assist you in designing, sizing and constructing enhanced swales.

Things to Consider

- Do not design within 10 feet of foundation
- Do not back water up against buildings or foundations
- Have fun and be creative!



Enhanced swale at Evergreen Charter School

Enhanced Swales: Dry Swales

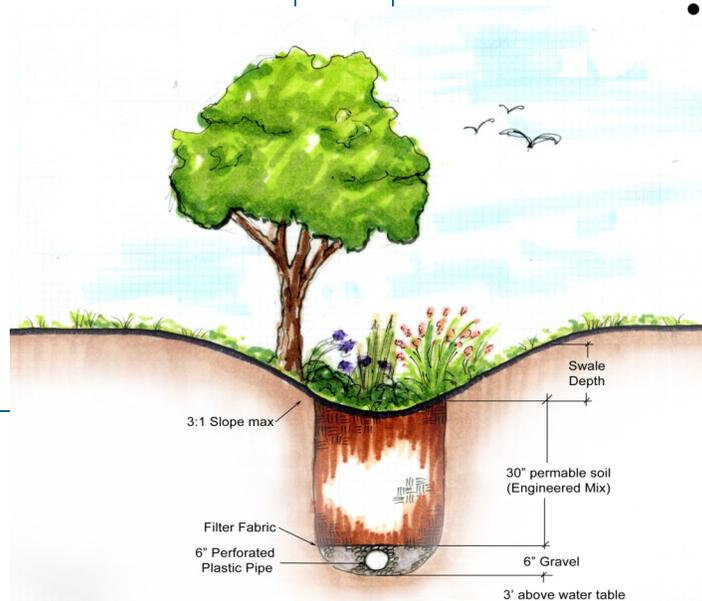
A dry swale, also known as a grassed, vegetated, or enhanced swale, is an open vegetated channel used to both treat the water quality and volume of excess stormwater to the selected destination. In Western North Carolina, an under-drain system is installed under an engineered soil mix placed under the base of the swale, similar to that of a bio-retention or rain garden, to improve and promote infiltration and water quality.

Advantages

- Swales can be designed to work with existing landscape and in small areas
- Minimal maintenance
- Works in small drainage areas
- Discourages long standing water
- Traps sediment and other pollutants
- Controls peak discharge, promoting infiltration

Disadvantages

- Maximum slope of swale is 4%
- Drainage area is not to exceed 3 acres
- Impractical for flat or steep areas
- May erode when flow volumes and/or velocities are high during certain storm events



Design Considerations

- Channel shape is trapezoidal or parabolic.
- Bottom width should be 2 ft. min. – 6 ft. max.
- Side slope should be 3:1 or flatter, so 1 foot of rise every 3 feet.
- Channel longitudinal slope should be 1% min. – 6% max. If it is over 3% slope, check dams will need to be installed to reduce erosion within the channel (see next section [Check Dams](#)).
- Bottom of swale should be 3 feet above groundwater levels.
- Do not place within 10 feet of a structure.
- Ponding in the swale can be up to 18" depth maximum.

Enhanced Swales: Dry Swales

Materials

- Site Analysis
- Site Map
- Site plan schematic
- Calculator
- A-frame Level
- Flagging or marking materials
- Gravel (size #57)
- 6" Perforated pipe
- Permeable soil mix
- Filter fabric
- Shovel
- Hard rake
- Mattock
- Mulch
- Plants



Implementation

1. Begin by reviewing your overall site analysis, and based on advantages and disadvantages of various designs, determine locations of swales.
2. Once your location is determined, use the runoff volume calculation to determine the water storage capacity needed for a 1 inch storm minimum. Base the size and spacing on your site goals as well. Refer to the [Sizing the Berm and Swale Complex](#) section of this chapter.
3. Lay out the centerline of the swale with flags or other means of marking, using the slope tools to check slope of swale.
4. Bring in additional soil to create the necessary berm size if needed.
5. Remove all existing vegetation.
6. Dig swale, maintaining a parabolic base and maximum 3:1 side slopes (1 foot of run per 3 feet of rise).
7. Excavate 36" and lay the 6" perforated pipe along the centerline of the excavated site sloping downhill.
8. Surround the pipe with 6" of gravel (#57).
9. Cover gravel with filter fabric.
10. Fill 30" of the excavated site with permeable soil mix and re-vegetate using plants outlined in [Appendix B: Plant Selection](#).

Maintenance

- Remove weeds as needed.
- Inspect frequently for signs of scouring.
- Maintain plantings by mowing and/or pruning.

For additional resources, view the [NCSU Urban Waterways Factsheet: Designing Dry Swales for the Water Quality Event](#).

Enhanced Swales: Wet Swales

Wet swales are similar to dry swales in shape and purpose. The major difference is that a wet swale does not have an underdrain and permeable soil mixture under the swale base. Wet swales will have a tendency to retain water for longer periods of time than dry swales, specifically in Western North Carolina with our high clay content in the soil.

Advantages

- Swales can be designed to work with existing landscape and in small areas
- Easy to construct
- Minimal maintenance
- Works in small drainage areas
- Traps sediment and other pollutants
- Controls peak discharge, promoting infiltration

Disadvantages

- Maximum slope of swale is 4%
- Drainage area is not to exceed 3 acres
- Impractical for flat or steep areas
- May erode when flow volumes and/or velocities are high during certain storm events

Design Considerations

- Channel Shape: Trapezoidal or parabolic
- Bottom width: 2 ft. min. – 6 ft. max.
- Side Slope: 3:1 or flatter, so 1 foot of rise every 3 feet
- Channel Longitudinal Slope: 1% min. – 6% max. if over 3% slope check dams will need to be installed to reduce erosion within the channel
- Bottom of swale should be 3 feet above groundwater levels
- Do not place within 10 feet of a structure
- Ponding in the swale can be up to 18" depth maximum



Wet swale from nrhc.org

Enhanced Swales: Wet Swales

Materials

- Site analysis
- Site map
- Calculator
- A-frame level
- Flagging or other marking materials
- Shovel
- Hard rake
- Mattock
- Mulch
- Plants

Maintenance

- Remove weeds as needed.
- Inspect frequently for signs of scouring.
- Maintain plantings by mowing and/or pruning.

Implementation

1. Begin by reviewing your overall site analysis. Look at your design options and compare advantages and disadvantages to determine locations of swales.
2. Once your location is determined, use the runoff volume calculation to determine the water storage capacity needed for a 1 inch storm minimum. Base the size and spacing on your site goals as well. See the [Sizing the Berm and Swale Complex](#) section of this chapter to determine swale size and spacing.
3. Lay out the centerline of the swale with flags or other means of marking, using the slope tools to check slope of swale.
4. If needed, bring in additional soil to create the necessary berm size.
5. Remove all existing vegetation.
6. Dig swale, maintaining a parabolic base and max. 3:1 side slopes.
7. Replant with selected plants (see [Appendix B: Plant Selection](#) for appropriate plants for wet swales).
8. In addition to being vegetated, these swales can be formed into Dry Stream Beds and/or you can add rocks for interest and check dams (see next section, [Check Dams](#)) to slow runoff velocities (if needed).

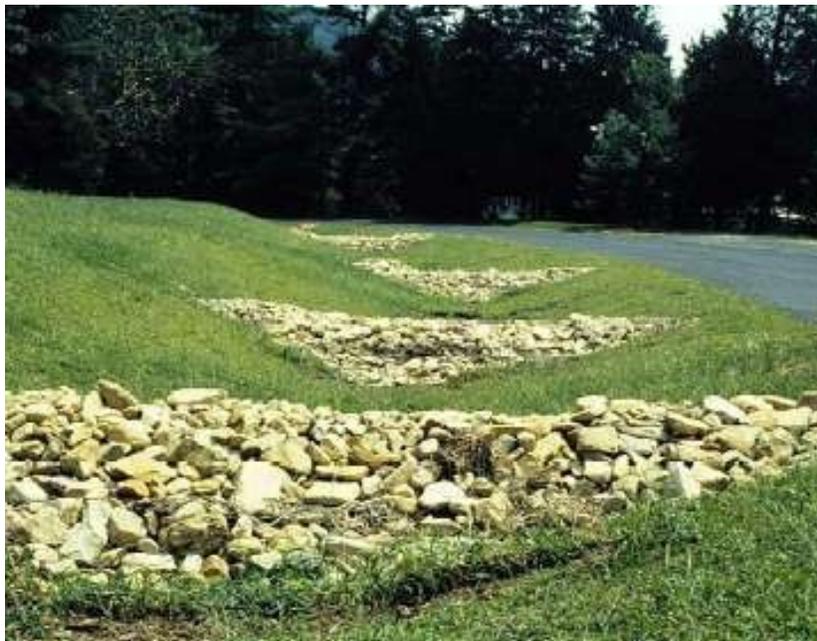


Check Dams

Check dams are low barriers within a drainage ditch, enhanced swale, or berm and swale complex. These dams sit perpendicular to the flow of water, with the intention of backing water up to allow for infiltration and sediment removal. Check dams retain some porosity, allowing for water to leak through the stones and vegetation.

Typically, check dams are constructed of rock with mixed vegetation to enhance stabilization and filtration. They are designed primarily to provide erosion control, sediment control, and suspended solids removal from runoff. In addition, they can provide a small amount of pollution removal.

Check Dams can be used to extend the use of swales to areas with greater than a 4% slope, but **should not be used without professional consulting in areas with slopes greater than 8%.**



Advantages

- Extends use of swales past 4% slope
- Relatively inexpensive and easy to construct
- Reduces sedimentation
- Can be more easily used higher in the watershed

Disadvantages

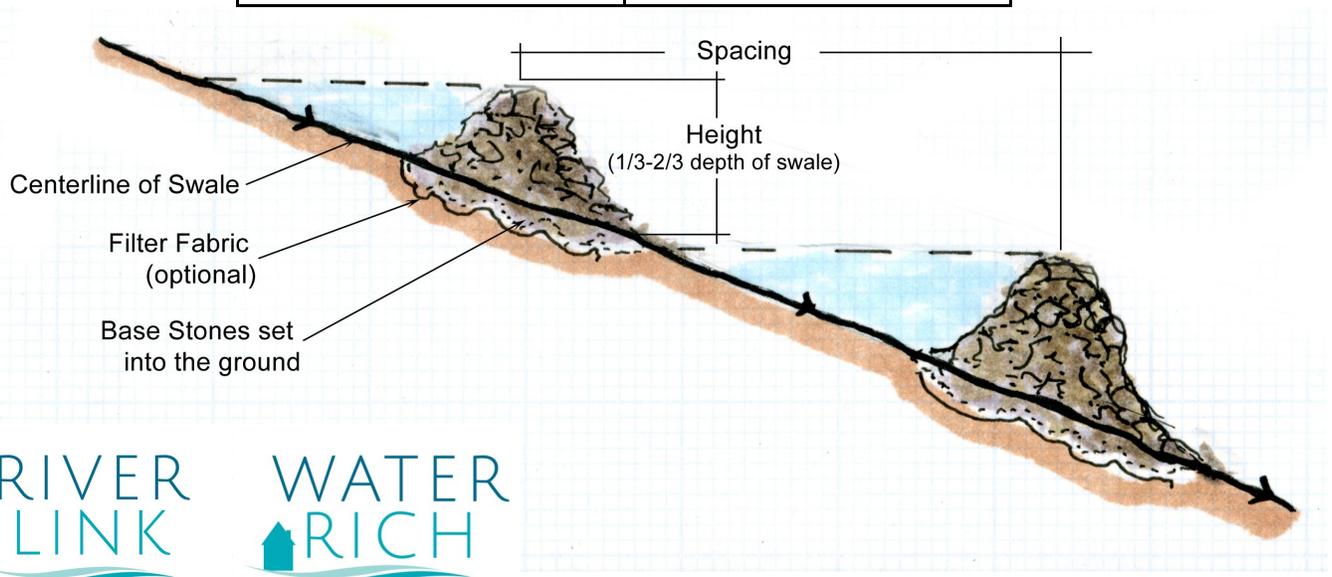
- **Maximum slope of swale with a check dam is 8% without professional assistance**
- Moderate maintenance needed
- Can be breached when flow volumes and/or velocities are high during certain storm events

Check Dams

Design Considerations

- Using an erosion control blanket will help stabilize a new check dam. This material will eventually biodegrade.
- When working in a swale on a slope greater than 6%, you will need to flatten the slope above the check dam to provide enough ponding space during rain events.
- Rocks are the typical material for permanent check dams, although there is a multitude of materials, such as coir fiber logs, available from companies specializing in erosion and sediment control management. A list of local suppliers can be found in [Appendix C: Local Professionals](#).
- A mixture of rock sizes is preferable. Size of rock will depend on the slope of the drainage and drainage area.
- Locate check dams in generally straight areas of the drainage. Space as suggested [below](#) based on slope of drainage.
- Check dams should occur within the limits of the drainage, but can be used as secondary spillway if necessary, although additional drainage might be needed.
- Planting around the edges assists in the long term stabilization.

% Slope of Drainage	Spacing Between Check Dams (in feet)
1	200
2	100
4	50
6	33
8	25



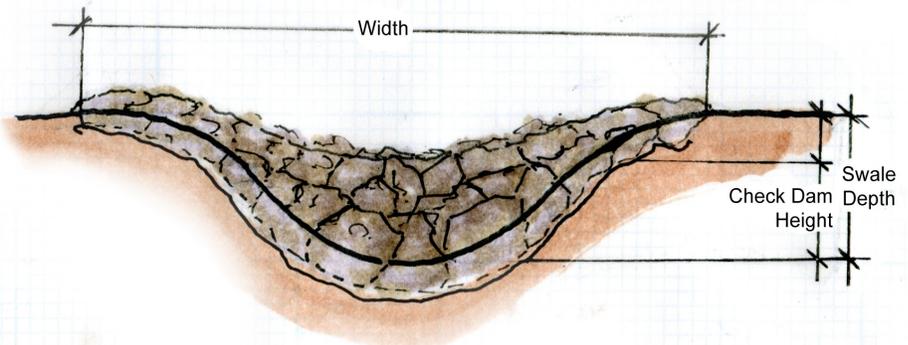
Check Dams

Materials

- Site analysis
- Site map
- Calculator
- A-frame Level
- Flagging or other marking materials
- Stone
- Wheelbarrow
- Shovel
- Hard rake
- Mattock
- Plants
- Filter fabric (optional)
- Coir fiber matting (optional)

Maintenance

- Keep free of weeds
- Inspect for damage after storm events, specifically moderate to large storm events
- Remove sediment collected within the pools on the upstream side of the check dam as needed.
- Add or remove rock as needed to maintain stability.
- Maintain plantings



Implementation

1. Begin by reviewing your overall site analysis to determine locations of the check dams based on the design considerations, advantages, and disadvantages.
2. Determine spacing between check dams by referencing the table on the [previous page](#).
3. The size of the stones will need to increase as the volume of water and slope increase and soil stability decreases. The largest stones should be used as the base rocks.
4. Excavate a trench into the banks and bed of the swale in order to anchor the base rocks. The trench should be dug both in the bed of the drainage and in the stabilized side slopes of the swale. Optional: Place geotextile fabric in the trench to help stabilize the check dam against large storm events.
5. Place heavier stones in the base and on the downstream side of the check dam.
6. Secure the base stones firmly in position.
7. Place smaller stones around the larger stones as their weight and placement help make these as stable and secure as possible. The slope of the upstream and downstream faces of the check dam are determined by the angle of repose. This is the ability for the stones to stay securely in place based on their size, shape and weight. The upstream face should be more gradual (approximately 66% or 1.5-2:1) than the downstream face.
8. The top of the check dam should be concave, as the height should be no more than 1/2-1/3 of the swale depth.

French Drains

French Drains are simple subsurface drainage trenches that collect and move subsurface drainage to a desired location, preferably to another stormwater control measure such as a rain garden or berm and swale complex. These drains are an option for removing excess water in unwanted areas. They are commonly used in Western North Carolina to reduce water from around the foundation of a building and its basement (if applicable). In simplicity, a French drain is a trench filled with gravel and a perforated pipe at the bottom.

Advantages

- Removes moisture from unwanted locations to desired locations
- Subsurface (unseen)

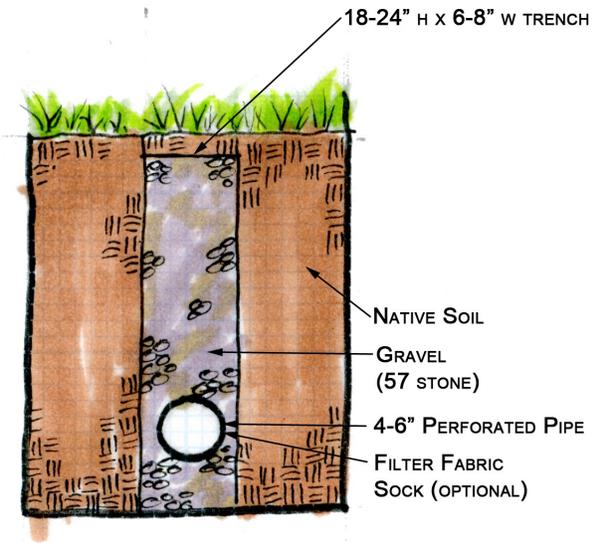
Disadvantages

- Can unnoticeably clog over time
- Typically linear
- Dependant on slope of drainage area



French drain daylighting onto a pile of gravel. Source: HGTV.

French Drains



Materials

- Shovel
- Mattock
- 6" or 4" Perforated pipe; length will vary based on site
- Standard gravel (#57 stone)
- Filter fabric pipe sock or wrap (recommended)
- Landscaping cover
- Stones for outfall (optional)

Design Considerations

- The location of the excess moisture and the location the pipe will daylight (reach the surface). At this point, the water is concentrated and needs to be dispersed appropriately.
- Linking the French drain to a stormwater feature can mitigate the concentrated flow.
- The shape of the land around the area of excess moisture. Is the property sloping towards the foundation of a building? Is there a natural depression?
- Drains located adjacent to the foundation should be placed at a minimum of 2 feet out from the foundation.

French Drains

Locating the French Drain

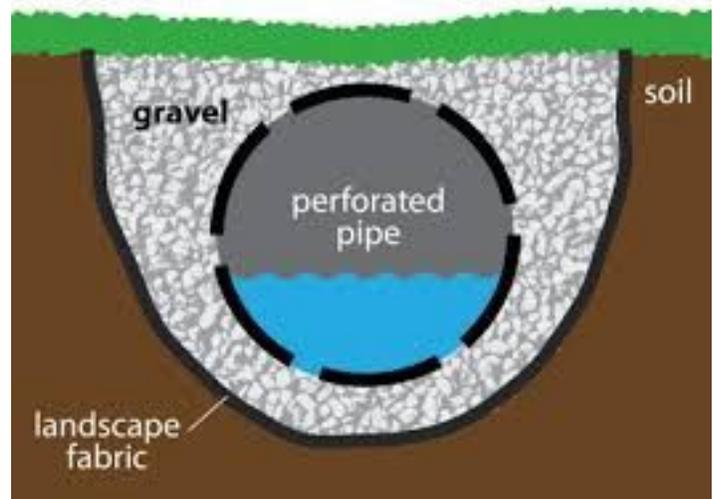
Your site analysis will help in locating the French drain. Make sure to **CALL 8-1-1** to locate all utility lines so you can route your drain to avoid these elements if possible. If a utility line must be crossed contact the service provider for assistance in placing the perforated pipe below the utility and add a PVC or other buffering sheath to protect the utility line. In some cases, like with gas lines, the utility company will need to be hired to do this. Avoiding them is the best option.

If your basement or foundation is wet after rain events, then a French drain would be necessary along the foundation where the moisture is apparent. These locations are usually higher in elevation than the basement floor or foundation. It would be useful to extend the drain past current areas of wetness to cover any additional drainage during larger storm events. Drains located adjacent to the foundation should be placed approximately 2' out from the foundation.

Locate the place you would like the 6" perforated pipe to daylight (reach the surface), preferably into a stormwater control measure. Route the drain from the location of excessive moisture to the daylight point. The daylight point must be lower in elevation than the drain itself. The pipe should slope down consistently at a slope between 2% and 10%. The steeper the slope the higher velocity of the water coming from the drain pipe, therefore the outfall may need additional armoring with stones.

Implementation

1. Excavate a trench 6 to 8 inches wide and a minimum of 18" deep along the routing line, sloping the trench consistently to the outfall location.
2. Place 2" of gravel in the trench.
3. Wrap 4" or 6" perforated pipe with filter fabric (recommended). The filter fabric will minimize clogging of individual perforations in the pipe.
4. Lay pipe in the trench and back fill with gravel up to 2-3" below ground surface.
5. Cover with soil and either seed with grass or mulch over the drain.



Cross-section of a French Drain. Source: The Plumbing Source.

Rain Barrels

Rain barrels are water storage units designed to collect water from impermeable surfaces like roofs. The most common type of rain barrel collects runoff from roofs by connecting to gutter downspouts. The catchment is typically a 55-gallon barrel fitted with a spigot and overflow drain. The system is gravity-fed so no pumps are necessary. This simple and effective design is a relatively inexpensive and easy to install way to conserve and repurpose rainwater!

RiverLink often holds rain barrel workshops where participants receive more information on stormwater management and outfit their own rain barrel to take home. Depending on the size of the barrel, classes run between \$30 and \$50. Check out our website at riverlink.org for the most up-to-date information.

If you wish to buy and install your own rain barrel, read on.

Did You Know?

For everyone 1,000 square feet of collection area, you can collect up to 620 gallons of rainwater for every 1 inch storm. In Asheville, the average home has a 1,200 square foot roof. That means, with the average rainfall of 47 inches per year, one homeowner can collect and repurpose over **35,000 gallons** of rainwater every year!



Rain barrel provided and installed by RiverLink at the Martha Jane Garden in Asheville. It was painted by kids at the Burton Street Agricultural Fair.



Rain Barrels

If you wish to buy and install your own rain barrel, there are multiple resources available to you. One option is to look out for workshops where you receive your own rain barrel held by RiverLink, NC State University Cooperative Extension, or your county's Soil and Water Conservation District.

You can also get supplies from a local hardware store or an online retailer. Look for a rain barrel size that fits your needs (55-gallon drums are popular for home gardening). Installation kits with downspout converters and spigots are easy to come by as well. Most installation kits require a pencil or marker and a hand drill. If you wish to make this a complete DIY project, follow the steps on the next few pages. **Note:** Please read through all of the steps before beginning working on a rain barrel as several variations are provided.



A 55-gallon rain barrel with mural. Source: hometalk.com

Design Considerations

- Since rain barrel systems are gravity-fed, place as high on the landscape as possible to increase pressure. You can use concrete cylinder blocks to mimic this.
- Prime or paint the rain barrel with dark colors to prevent mold.
- Kits and barrels that have a closed top are best because they prevent algae growth, mosquitoes, and clogging.
- Place barrels on a sturdy, level surface. When full, one 55-gallon barrel can weigh over **480 pounds!** You do NOT want this falling over.
- Connect multiple barrels to hold more water for your garden! See the photo at the [end of this section](#) for an example of a two barrel system.
- If you have more water than you can use, open the spigot until there is a trickle of water running from it. This reduces the stormwater runoff rate and more closely resembles the natural hydrologic cycle.

Rain Barrels

Barrel Materials

- ❑ Plastic 55-gallon drum
- ❑ Power drill
- ❑ PVC drill bit sized to fit your gutter adapter (usually between 4 1/2" and 6")
- ❑ 1 7/8" drill bit
- ❑ 1 1/8" drill bit
- ❑ Cut-to-fit screen
- ❑ Silicone caulking

STEP ONE: PREPARE THE BARREL

1. Thoroughly rinse the barrel to remove any potential contaminants.
2. Using the power drill and the PVC drill bit, drill a hole through the middle of the top of the barrel.



3. Next, drill a 1 7/8" hole in the left side of the barrel one inch from the top. Then, drill a 1 1/8" hole at the base of the front of the barrel for the spigot.



4. Remove any plastic shavings that may have fallen into the barrel.
5. Cut the screen to overlap the hole by about an inch and glue down tightly using silicone caulking or other appropriate glue. Allow glue to dry before first rain event.



Rain Barrels

Flexible Overflow Materials

- 1 1/2" nylon adapter
- 2" flexible tubing (length of your choosing)
- PVC primer
- PVC cement
- Pipe tape
- Silicone caulking
- Adjustable #16 clamp or zip-tie

STEP TWO: INSTALL THE OVERFLOW

Before installing the overflow you need to choose whether you would like a flexible drain spout that you can use to direct overflow away from the barrel (**Option 1 below**) or a rigid spout (**Option 2** on the [next page](#)) that drains overflow at the barrel.

Overflow Option 1: Flexible Spout

1. Tightly wrap the threaded end of the 1 1/2" nylon adapter with pipe tape and screw into the 1 7/8" hole at the top left hand side of the barrel. Seal the joint with silicone caulking.



2. Firmly push the flexible tubing onto the adapter to attach. Slide the adjustable clamp or zip-tie into place and tighten.



Rain Barrels

Rigid Overflow Materials

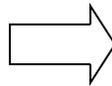
- 1 1/2" PVC adapter
- 1 1/2" PVC elbow
- PVC primer
- PVC cement
- Pipe tape
- Silicone caulking

Overflow Option 2: Rigid Spout

1. Prime the inside of the female (unthreaded) end of the 1 1/2" adapter and the outside of the male (thinner) end of the elbow with the PVC primer.



2. Glue the adapter and elbow together using PVC cement to create the overflow spout.



3. Tightly wrap the threaded end of the adapter with pipe tape and screw the overflow spout into the 1 7/8" hole near the top of the barrel. Point the spout downwards (and away from your foundation) and seal the joint with silicone caulking.



Rain Barrels

Spigot

- 3/4" spigot
- Pipe tape
- Silicone caulking

STEP THREE: INSTALL THE SPIGOT

1. Tightly wrap the threaded end of the spigot with pipe tape and screw into the 1 1/8" hole towards the bottom of the barrel.



2. Point the spout downwards and seal the joint with silicone caulking.



Rain Barrels

Installation Materials

- ❑ Downspout adaptor sized to fit your gutter downspout
- ❑ Elbow corrugated plastic pipe, sized to fit downspout adapter
- ❑ Cinder blocks
- ❑ Metal cutters

STEP FOUR: INSTALL THE RAIN BARREL!

The rain barrel should be below the gutter downspout of your building and elevated off the ground enough to easily access the spigot. Note that the higher the barrel is off the ground, the greater your water pressure will be.

1. Clear your gutter of debris to avoid clogging your new rain barrel.
2. Elevate the barrel on the cinder blocks. Using the metal cutters, cut the gutter downspout 1-2 ft. above the top of the barrel. Make sure the barrel is level so it won't slip off its foundation when it is full.



3. Fit the downspout adapter securely onto the gutter downspout.



4. Insert the corrugated pipe into the hole at the top of the barrel.
5. Fit the downspout adapter securely together with the corrugated pipe. Your rain barrel is ready to start collection!



Rain Barrels

Rain Barrel Checklist

DO

- Clear your gutters
- Periodically clean the barrel and piping
- Check for leaks
- Keep filters securely attached
- Drain each winter

DON'T

- Drink or give your pets water from your rain barrel
- Allow children to climb on the rain barrel



Source: Utah State University Extension

General Maintenance

With the proper care rain barrels can last many years. Here are some tips to keep your rain barrel functioning properly: (1) Keep your gutters clean to ensure unobstructed flow to your rain barrel. (2) Mosquitoes are generally not a concern as long as your filter and caps are secure, but as a precautionary measure, use the water from your barrel often as mosquitoes favor stagnant water (once every three days should be sufficient). (3) Scrub your barrel periodically to remove particulate buildup. (4) Inspect your rain barrel often for leaks, cracks and clogs and repair them as needed. (5) Drain the rain barrel during winter if freezing is a concern (see winterizing below).

Winterizing Your Rain Barrel

In winter, when freezing temperatures are a concern, you will need to discontinue use of your rain barrel to avoid cracking the barrel. Drain, clean, then plug the barrel or store upside down to keep dry. This is also a good time to unscrew and clean your spigot. Depending on the type of installation kit you used, taking your rain barrel offline will require you to add additional piping to your gutter downspout to direct water away from your building.



Rain Gardens



Rain garden installed at Evergreen Charter School.

Rain gardens are small vegetated depressions used to promote infiltration of rainfall runoff from roofs, driveways, and sidewalks. Rain gardens combine grasses, shrubs, and perennials with mulch and soil to filter pollutants in the water runoff. Vegetation is critical to the proper function of a rain garden and proper plant selection is important.

The following pages will assist you in designing, sizing and constructing a rain garden.

Considerations

- Do not design within 10 feet of foundation
- Do not back water up against buildings or foundations
- Rain gardens are an amenity
- Make sure to do a percolation test to determine the permeability of your location
- Be creative and have fun!

Rain Gardens

Rain gardens are best suited for well-drained sandy soils, but can be installed in areas with less permeable soils, such as clay. In Western North Carolina you can design the rain garden more as a constructed wetland. Let the following steps guide you in designing, sizing, installing, and maintaining your rain garden. These steps are modified from the [North Carolina Cooperative Extension Backyard Rain Garden Manual](#). If you would like more information, this is a free publication and a great resource!



Advantages

- Can be integrated into existing site easily
- Can be large or small, dependent on drainage area (max drainage area is 1 acre)
- Provide an aesthetically pleasing amenity
- Used at sites where storm sewers are not available
- Can provide groundwater recharge

Disadvantages

- Ponding water may take 24 to 48 hours to drain
- Some maintenance required (e.g. maintain plants, keep the basin clean, and clean out the overflow)
- Should not be used on lots with high sediment loading, especially clay deposits

Design Considerations

- **Call 8-1-1 BEFORE you dig to locate any utilities!**
- Dig to account for a 10" ponding depth.
- Locate your rain garden in natural depressions so water can move naturally.
- Rain garden should not be within 10 feet of a building foundation.
- Locate at least 25 feet from septic tank or well head.
- Locate where the water table is at least 3 feet below the surface at the lowest point in the depression.



Rain Gardens

Materials

- Post hole digger or shovel
- Water
- Ruler or yardstick



STEP ONE: DETERMINE DRAINAGE OF SOILS

Rain gardens work best when constructed in well-drained soils, but they can also be installed on sites with less permeable soils with more clay content. Determining how the soil drains will help determine the type of plants most likely to succeed in the rain garden.

Pick a few places and dig a one-ft-deep hole for the preliminary infiltration test, then fill with water a few times. Time how long it takes for the test pit to drain. If satisfied with drainage time, dig 2-3 more one-ft-deep holes in that area to get an average drain time. It is good practice to conduct this test at each hole at least **twice**. Finally, refer to the table below to determine which type of rain garden is best for your site.



Drainage Time	Appropriate Type of Rain Garden
< 12 hours	Quick Draining Rain Garden
12—72 hours	Standard Rain Garden
> 3 days	Wetland Garden

Rain Gardens

Materials

- ❑ Site plan and analysis
- ❑ Scaled map of property
- ❑ Writing utensil

STEP TWO: LOCATE AND SIZE THE RAIN GARDEN

Using your site plan and analysis, determine where the rain garden will be located and the area from which it will receive stormwater runoff.

The size of the rain garden should be at least 10% of the impervious surface draining to the rain garden. Rain gardens should be designed to pond 10 inches of rainwater on top of the mulch. Use the equation below to determine the size of your rain garden.

Equation: **Area of Rain Garden = Area of Impermeable Surface Treated x 0.1**

Example: A portion of a 60' by 60' house (with 4 downspouts) and 500 ft² of driveway runs off to the rain garden location. What size should the rain garden be to adequately capture the runoff from a 1" storm?

Determine area of roof that will drain to rain garden: (60 ft x 60 ft) / 4 = 900 ft²

Determine runoff area: 900 ft² + 500 ft² = 1400 ft²

Use the equation above: 1400 ft² x 0.1 = 140 ft²

An 11'X12' or 14'X10' garden design would be sufficient.

The size of your rain garden can also depend on the space available and your budget. If you don't have enough space, you can build multiple rain gardens or build a smaller one and plan for it to overflow more often.



Rain garden installed by RiverLink and Green Opportunities at West Asheville Park.

Rain Gardens

Materials

- Tape Measure
- Stakes and string
- Shovels and/or small backhoe
- Rakes
- Pitchforks (optional)
- Trowels (optional)
- Tamper
- Wheelbarrow (very useful)
- Line level and/or straight edge
- Tarp
- Extra hands are handy!

STEP THREE: CONSTRUCT THE RAIN GARDEN

Once you have located where you will dig, mark off the boundaries using stakes and string, landscaping flags, spray paint, or any other method of your choice. Remember, before you dig **CALL 8-1-1**.

When digging, remove sod (if present) and save to use later for the berm and weir. Then, remove the topsoil and set aside in a separate pile. Continue digging to account for 10" ponding depth and 3" mulch (13" deep total). Finally, till the bottom 4-6" of soil and mix in the topsoil you saved earlier. This provides nutrients for the plants and improves drainage (which is what we want!).



After digging the pool, it's time to form the berm and overflow weir. A berm is a mound of soil, mulch, or rock at the back end of the garden that allows water to pool during storms greater than 1". Yours should be between 3" and 6" tall, compacted slightly just by the weight of your body and the tamper, and covered with mulch, plants, rocks, or the sod you saved earlier.

Rain Gardens

An overflow weir is a depression in the berm that allows water to flow out of the garden during extreme rain events, preventing the berm from collapsing. To determine an appropriate length for the weir, use the area of the impervious surface(s) from which your rain garden receives stormwater runoff (see the table on the right). Weirs should be level, lower than the berm, and covered with sod or rocks. Alternatively, they can also be created with wood.

Impervious Surface Area (ft ²)	Overflow Weir Length (ft)
2000 or less	1.0
3000	1.5
4000	2.0
5000	2.5



Weir in a rain garden at Guilford County Cooperative Extension. Photo courtesy of NC Cooperative Extension Backyard Rain Garden Manual.



Source: bluegrassraingardenalliance.com

Rain Gardens



PLANT SELECTION

A complete list of plants native to Western North Carolina and suitable for rain gardens and wetlands can be found in [Appendix B: Plant Selection](#). This is your chance to make your rain garden or wetland your own. Here are some tips for selecting and placing plants:

- Place plants that are most water resistant toward the center of the rain garden.
- Place plants that are most drought resistant around the edges of the rain garden.
- After planting, cover everything with 3" of mulch.
- There should be no need to fertilize as excess nutrients will enter the rain garden from the stormwater. However, use your best judgment in this.

Maintenance

- During the first year, water once every 7-10 days without adequate rainfall (1") until plants are established.
- Weed as needed until plants become established, usually within the first year or two.
- Refresh mulch as needed, maintaining a 3" even layer.
- Prune plants annually. Allow shrubs, grasses, and forbs to become full. Trim trees so that they do not shade out garden.

Chapter 7: Professionally-Installed Options

Often given the terrain of our landscapes and our clay-dominant soils, you will find the need to reach out to an expert familiar with designing stormwater management features in this area of North Carolina. What type of professional you should reach out to depends on the scale and scope of the project or issue.

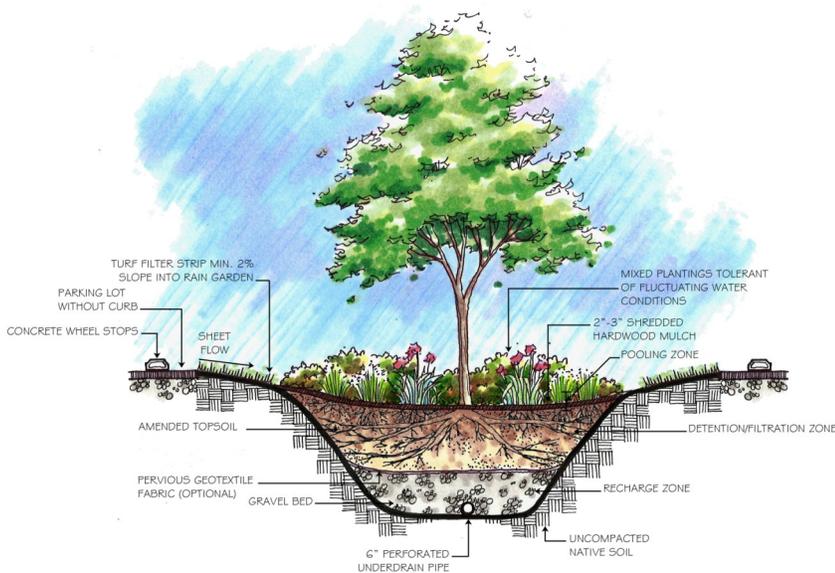
There are numerous types and levels of professionals who can provide assistance in managing stormwater on your property. These include landscape contractors, design-build landscapers, engineers, landscape architects, environmental engineers and geotechs.

Under different circumstances you will want to contact different levels of professionals. Landscape architects, engineers and geotechs are all licensed professionals able to certify drawings. This is necessary for any situation where you need to permit the project at any level. Landscapers, landscape designers, and design-build firms can be licensed contractors, but are not typically professionally licensed.

In [Appendix C: Local Professionals](#) we have listed a number of contacts who have experience in this work.

Inside This Chapter

- Bioretention
- Permeable pavers
- Stormwater wetland



Bioretention pond schematic. Source: Clemson University.

Contact RiverLink's Watershed
Resources Manager at:

170 Lyman St.
Asheville, NC 28801

waterresources@riverlink.org
828-252-8474 x14



Professionally-Installed Options

Bioretention

Bioretention areas are vegetated depressions intended to catch and filter stormwater runoff. They are constructed with plants, an underdrain system, and engineered soil to improve filtration and absorption.

Design Considerations

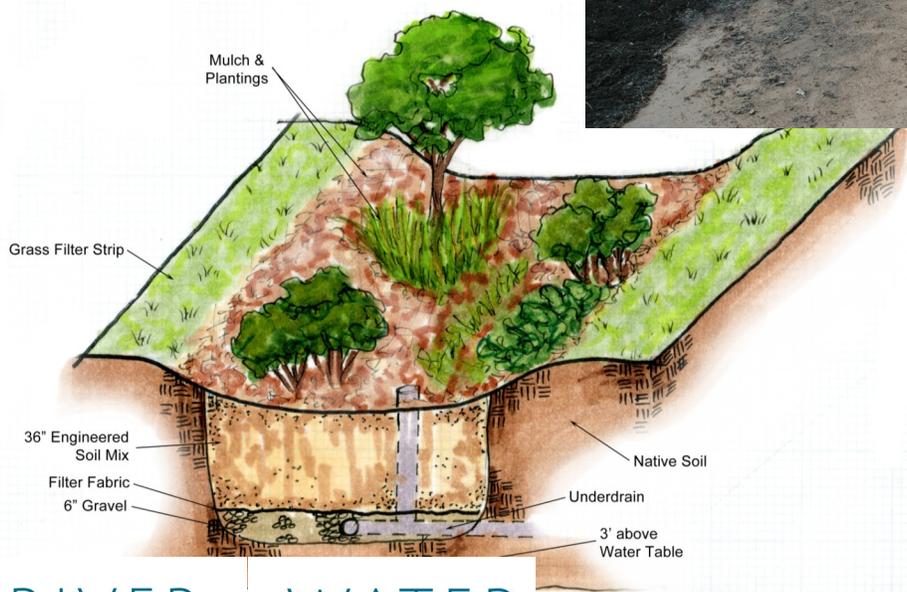
- Optional pretreatment area (filter strip or forebay)
- Inlet and outlet controls
- Underdrain cleanouts and maintenance
- Ponding depth 6-12", usually 6"
- Sensitive to high sedimentation rates, which can clog the system
- Small drainage areas, under 3 acres
- Effective at removing heavy metals, nitrogen, phosphorous, and pathogens.
- Call a landscape architect or engineer for assistance.



Bioretention area in the rain.



Bioretention area under construction. The white pipe is the overflow device. An engineered soil mix has been placed over the underdrain system.



Bioretention design.

Professionally-Installed Options

Pervious Pavers

Pervious pavers and porous pavement are hard or reinforced surfaces which allow for infiltration through the material. There are numerous types of pervious pavers and porous paving. Porous pavement, such as porous concrete or porous asphalt, consists of a uniform material resembling its impervious counterpart. The pavements are not typically recommended for use in this area, due to the high clay content in our soil, which limits porosity and ability for water to infiltrate.

Pervious pavers are suited better for this area and come in a surprising variety of materials, forms, and colors. These include: interlocking pavers, turf reinforcing, and grid pavers.

Design Considerations

- Soil permeability
- Small drainage area
- Sensitive to high sedimentation rates, can clog the system
- Reduces overall runoff volume
- Variety of selection
- Contact landscapers, design build firms, landscape designers or landscape architects for assistance. Due to the potential small scale of these paving projects, landscape architects or engineers may steer you towards a designer.

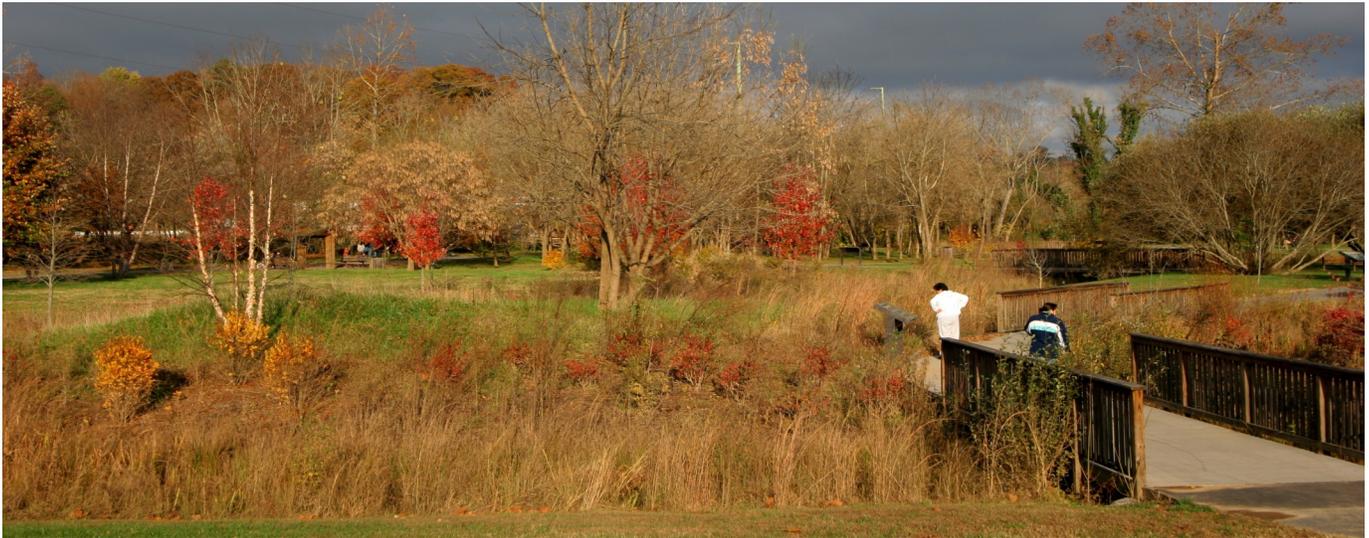


*Grass plastic grid reinforcement.
Source: invisiblestructures.com*



*Left: Grid pavers.
Right: Porous asphalt and pervious pavers.*

Professionally-Installed Options



Stormwater wetland in Carrier Park, Asheville.

Stormwater Wetlands

Stormwater wetlands are constructed wetlands that are intended to trap and filter pollutants, as well as retain run-off volume. They are planted depressions which remain wet during a majority of the year. There are no drainage systems associated with the wetland, only an outfall directing water to the appropriate location if the wetland was to fill completely.



Stormwater wetland in West Asheville Park.

Design Considerations

- Optional pretreatment area (filter strip or forebay)
- Inlet and outlet controls
- Water table location
- Ponding depth 6-18"
- Often used due to poor soil permeability
- Effective at removing heavy metals, nitrogen, phosphorous, and pathogens.
- Contact landscapers, design build firms, landscape designers, engineers or landscape architects for assistance

Appendix A: Terminology

Basin:	The watershed of a major river system. There are 17 major river basins in North Carolina of which the French Broad is one. From “French Broad River Basinwide Water Quality Plan”; May 2000; NC Department of Environment and Natural Resources.
Buffer Zone:	Strips of natural areas such as forest or grasses between a body of water and a land disturbing activity such as agriculture, construction, or forestry
Drainage Area:	The total surface area, upstream of a point on a stream, where the water from rain, snowmelt, or irrigation which is not absorbed into the ground, flows over the ground surface, back into streams, to finally reach a certain point
Erosion:	The process of detaching, transporting and depositing soil and rock material by water, wind or gravity (sometimes called geologic erosion)
Evaporation:	The process by which liquid water becomes vapor
Evapotranspiration:	The summation of both evaporation and transpiration from a site
Flood (hydrologic):	Any level of a natural water body that exceeds its “normal” banks
French Broad River Basin:	Another way to say French Broad River watershed
French Broad River Watershed:	All the land whose runoff flows, eventually, to the French Broad River
GIS:	Geographic Information System, a system for digitally storing and manipulating geographical information
Hydrograph:	A graph of the stage (height of water) over time
Hydrologic Cycle:	The cycling of water from the earth to the atmosphere and back again
Infiltration:	The process by which water passes through the soil



Appendix A: Terminology

Non-Point Source Pollution:	Pollution that is washed into rivers, lakes, and streams from runoff during rainfall events. Sediment is the largest non-point source pollutant in North Carolina
Overland Flow:	Runoff flowing over the ground surface. Strictly, the water flowing over the ground surface that has not ever infiltrated the soil
Percolation:	The advance of water through the soil
Permeability:	The rate at which water moves through the soil
Point Source Pollution:	Water pollution that is introduced into rivers, lakes, or streams directly from a single source, such as a pipe
Pollutant:	Any substance that reduces the quality of biological habitats
Pollution:	Any physical, chemical, or biological change that adversely affects the health, survival, or activities of living organisms or alters the environment in undesirable ways
Precipitation:	Any form of water flowing from the atmosphere to the earth
Retention:	Water that is held on the land surface and does not runoff
Runoff:	Water leaving the land (this may occur at the surface, subsurface or both)
SCM:	Stormwater Control Measures; practices or measures that allow us to protect water quality from pollutants such as sediment while still continuing activities such as construction, forestry, and agriculture. Practices help control run off and erosion from running into streams; SCMs may include constructed wetland, rain barrels, rain gardens, and other measures.
Sediment:	Solid particulate matter, mineral or organic, that has been or is being moved by water, air, gravity, or ice from its origin. Sediment typically consists of clay, silt or sand-sized particles



Appendix A: Terminology

Sedimentation:	Deposition of soil or rock material that has been transported by water, wind or gravity
Topsoil:	The upper layer of soil. This layer holds most of a soil's nutrients and is the most productive layer of soil. Topsoil is the layer of soil that is usually lost due to accelerated erosion. It takes 500 years to replace one inch of topsoil
Transpiration:	The process by which liquid water in a plant becomes vapor and leaves the plant through its leaves or stems
Turbidity:	The "cloudiness" or discoloration of a body of water. Turbidity is caused by the suspension of solid particles such as clays in rivers, lakes, and streams
Vegetation:	The plants that cover the land surface
Watershed:	All the land that sheds water passing through a defined point



Appendix B

Plant List for Stormwater SCM's in Western North Carolina

Scientific Name	Common Name	Sun	Part Sun/Shade	Shade	Berms	Swales	Dry Swale	Wet Swale	Rain Garden- Quick Draining	Rain Garden- Standard	Wetland	Bioretention
Large Trees												
<i>Acer negundo</i>	Box Elder											
<i>Acer rubrum</i>	Red Maple											
<i>Aesculus flava</i>	Yellow Buckeye											
<i>Betula lenta</i>	Sweet Birch											
<i>Betula nigra</i>	River Birch											
<i>Carya cordiformis</i>	Bitternut Hickory											
<i>Carya ovata</i>	Shagbark Hickory											
<i>Diospyros virginiana</i>	Persimmon											
<i>Halesia tetraptera</i>	Common Silverbell											
<i>Nyssa sylvatica</i>	Black Gum											
<i>Platanus occidentalis</i>	Sycamore											
<i>Salix nigra</i>	Black Willow											
<i>Taxodium distichum</i>	Bald-cypress											
<i>Tilia americana var. heterophylla</i>	Mountain Basswood											
Evergreen Trees												
<i>Ilex opaca</i>	American Holly											
<i>Magnolia virginiana</i>	Sweetbay Magnolia											

Plant List for Stormwater SCM's in Western North Carolina												
		Sun	Part Sun/Shade	Shade	Berms	Swales	Dry Swale	Wet Swale	Rain Garden- Quick Draining	Rain Garden - Standard	Wetland	Bioretention
Scientific Name	Common Name											
Perennials												
<i>Aruncus dioicus</i>	Eastern Goat's-beard											
<i>Asclepias incarnata</i>	Swamp Milkweed											
<i>Asclepias tuberosa</i>	Butterfly-weed											
<i>Baptisia australis</i>	Blue Wild Indigo											
<i>Chelone glabra</i>	White Turtlehead											
<i>Chrysogonum virginianum</i>	Virginia Green-and-gold											
<i>Eutrochium fistulosum</i>	Hollow-stem Joe-pye-weed											
<i>Eupatorium perfoliatum</i>	Boneset											
<i>Iris virginica</i>	Southern Blue Flag											
<i>Liatris spicata</i>	Blazing-star											
<i>Lobelia cardinalis</i>	Cardinal Flower											
<i>Lobelia siphilitica</i>	Great Blue Lobelia											
<i>Osmundastrum cinnamomeum</i>	Cinnamon Fern											
<i>Rudbeckia fulgida</i>	Black-eyed Susan											
<i>Sagittaria latifolia</i>	Duck Potato											
<i>Solidago rugosa</i>	Wrinkle-leaf Goldenrod											
<i>Stokesia laevis</i>	Stokes Aster											
<i>Vernonia noveboracensis</i>	Ironweed											
<i>Xanthorrhiza simplicissima</i>	Yellowroot											

Plant List for Stormwater SCM's in Western North Carolina

		Sun	Part Sun/Shade	Shade	Berms	Swales	Dry Swale	Wet Swale	Rain Garden- Quick Draining	Rain Garden- Standard	Wetland	Bioretention
Scientific Name	Common Name											
Shrubs												
<i>Aronia arbutifolia</i>	Red Chokeberry											
<i>Calycanthus floridus</i>	Sweet-shrub											
<i>Callicarpa americana</i>	American Beautyberry											
<i>Ceanothus americanus</i>	New Jersey Tea											
<i>Cephalanthus occidentalis</i>	Buttonbush											
<i>Corylus americana</i>	American Hazelnut											
<i>Ilex verticillata</i>	Winterberry											
<i>Itea virginica</i>	Virginia Sweetspire											
<i>Lindera benzoin</i>	Spicebush											
<i>Physocarpus opulifolius</i>	Eastern Ninebark											
<i>Rhododendron periclymenoides</i>	Pinxterbloom Azalea											
<i>Rhododendron viscosum</i>	Swamp Azalea											
<i>Rosa palustris</i>	Swamp Rose											
<i>Sambucus canadensis</i>	Elderberry											
<i>Spiraea tomentosa</i>	Steeplebush											
<i>Vaccinium corymbosum</i>	Highbush Blueberry											
<i>Viburnum cassinoides</i>	Withe-rod											
<i>Viburnum nudum</i>	Possumhaw											
<i>Viburnum dentatum</i>	Arrow-wood											

Appendix C: Local Professionals

Engineering

Advantage Civil Engineering, PA –A.C.E

Asheville, NC

(828)-545-5393

www.aceasheville.com

Provides full service Rainwater Harvesting and Rain Garden design and Construction in and around Asheville. Committed to finding efficient, cost effective designs that can be retro-fitted in the field to provide you with any needs big or small.

Anchor QEA

Asheville, NC

(828) 281-3350

www.altamontenvironmental.com

Services include wastewater treatment design, water recycling & reuse, stormwater management, stormwater BMP design, rainwater harvesting, flood damage mitigation, low impact development, and water supply & distribution.

Baker Engineering

Asheville, NC

(828) 350-1408

www.mbakertntl.com

Assist clients in meeting and implementing their sustainability requirements and goals, including policy development, site restoration and reuse, pollution prevention, GHG evaluations, permeable surfaces, environmental management systems, NEPA, and site cleanup services ranging from initial investigations through restoration and site closure.

High Country Engineering

Asheville, NC

(828) 231-9380

(828) 255-5105



Appendix C: Local Professionals

HydroCycle Engineering

Asheville, NC

(828) 989-8075

www.hydrocycle-eng.com

Environmental engineering services including water resources planning and engineering, stormwater management, BMP design, low impact development (LID), NPDES requirements, hydrology and hydraulics, erosion and sedimentation control, floodplain and flood risk management, FEMA floodplain analysis, rainwater harvesting and reuse, watershed and stream restoration, water quality assessment, land use impact assessment, geographic information systems and mapping, infrastructure inventories, and data management.

Russell Davis and Associates

Asheville, NC

(828) 423-0720

www.russdavispe.com

Environmentally conscious building construction including due diligence, rezoning, construction plans, approvals, permitting, and construction administration.

Wildlands Engineering

Asheville, NC

(828) 774-5547

www.wildlandseng.com

Landscape Architects, Designers and Design-Build:

Akers Acres Design

Asheville, NC

(828) 772-1321

www.akersacres.com

Ambrose Landscapes

Asheville, NC

(828) 768-1861

Avant Garden

Weaverville, NC

(828) 645-1650



Appendix C: Local Professionals

Carolina Native Landscapes

Asheville, NC

(828) 665-7234

www.carolinanativelandscapes.com

Landscape design and installation of stonework, brickwork, patios, water gardens, native landscaping and plants.

Cloos Landscape Architecture

Horse Shoe, NC

(828) 243-1070

www.cloos-la.com

Landscape architecture and design.

Equinox Environmental

Asheville, NC

(828) 253-6856

www.equinoxenvironmental.com

Environmental consulting and design including land planning, sustainable landscape design, ecological restoration, storm water planning and design, greenway and park planning.

K2 Irrigation Services, Inc.

Enka, NC

(828) 633-0536

www.k2irrigation.com

Life's a Garden

Asheville, NC

(828) 275-3032

Living Roofs

Asheville, NC

(828) 252-4449

www.livingroofsinc.com

Green roof consultation, design, installation and maintenance.



Appendix C: Local Professionals

Living Systems Design

Black Mountain, NC

(828) 279-2970

www.livingsystemsdesign.net

Any scale from home-sites to green developments, including education and training, edible and medicinal landscapes, orchards and vineyards, energy and water conservation, rain-gardens, cisterns and ponds, forest gardening mushroom cultivation and myco-restoration, siting roads and home-sites, income generation strategies, village and community development, land restoration, greening schoolyards and play-scapes, restoring local economies, site development supervision

LSA, Luther E. Smith and Associates

Hendersonville, NC

(828) 697-2307

www.lsadesign.biz

Landscape design and consultation including residential landscapes, erosion control design, low-impact stormwater design, conservation easement design and consulting.

Mary Weber Landscape Architecture

Asheville, NC

(828) 281-3153

www.maryweberdesign.com

Full service landscape design specializing in public projects such as park and trails planning, plazas, and memorial gardens, children's play and learning environments, environmental restoration: natural stormwater management, native plants, slope stabilization, rain water harvesting, low impact development, infill development, commercial site planning and design, single- and multi-family residential, and edible gardens and wildlife-attracting gardens.

Morgan Landscape Installation

Asheville, NC

www.morganlandscapeinstallation.com



Appendix C: Local Professionals

Mountains to Sea Landscapes, Inc

Mars Hill, NC

(828) 337-3325

(828) 689-5214

www.mountaintosealandscapes.com

Provides high quality, low-maintenance landscapes along with superior customer service to individuals all over western North Carolina. As the industry leans toward a greener tomorrow, we stay up with the latest eco-friendly materials and sustainable practices. With such an emphasis on quality and reliability you will be confident that you made the right choice.

Otter and Arrow Land Planning

Asheville, NC

(888) 688-3720

www.otterandarrow.com

Services include stormwater management, native plantings, habitat and wetland restoration, green roofs, and 3D modeling.

Reems Creek Nursery

Weaverville, NC

(828) 645-3937

www.reemscreek.com

Landscape design, installation and maintenance. Services include patios, rock walls, walkways, steps, and native planting.

The Potting Shed

Mills River, NC

(828) 684-8050

www.tpslandscaping.com

Landscape design, installation and maintenance. Services include paver driveways and patios, drystack and boulder walls, natural stone patios, walkways, steps, recreational landscapes, outdoor kitchens, irrigation, and lighting.

Snow Creek Landscaping

Arden, NC

(828) 687-1677

www.snowcreekinc.com

Full service landscaping including invasive plant management and native plantings.



Appendix C: Local Professionals

Stollenmaier Hardscape & Pond

Asheville, NC
(828) 275-7937

WaterLinks

Candler, NC
(828) 779-1895

www.waterlinkspllc.com

Environmental consultation for point-source removal and water availability issues offering training in simple water harvesting methods, site-specific water availability assessments, water retention planning and implementation, and data collection.

Rain Water Harvesting

A2Z Plumbing

Asheville, NC
(828) 472-4858

We deliver environmentally sustainable plumbing systems and solutions to the Asheville area and specialize in rain water harvesting systems.

Cistern Sister

Asheville, NC
(828) 298-0885

Green Werks

Asheville, NC
(828)-423-5299
(828) 242-8903

www.sites.google.com/site/greenwerksllc/home

Supplies

Jesse Israel & Sons Nursery

Asheville, NC
(828) 254-2671
www.jesseisraelandsonsnursery.com



Appendix C: Local Professionals

Carolina Native Nursery

Burnsville, NC

(828) 682-1471

www.carolinanativenursery.com

Pisgah Plants

Candler, NC

(828) 670-8733

www.pisgahplants.com

Native, edible and ornamental plants.

Southeastern Native Plant Nursery

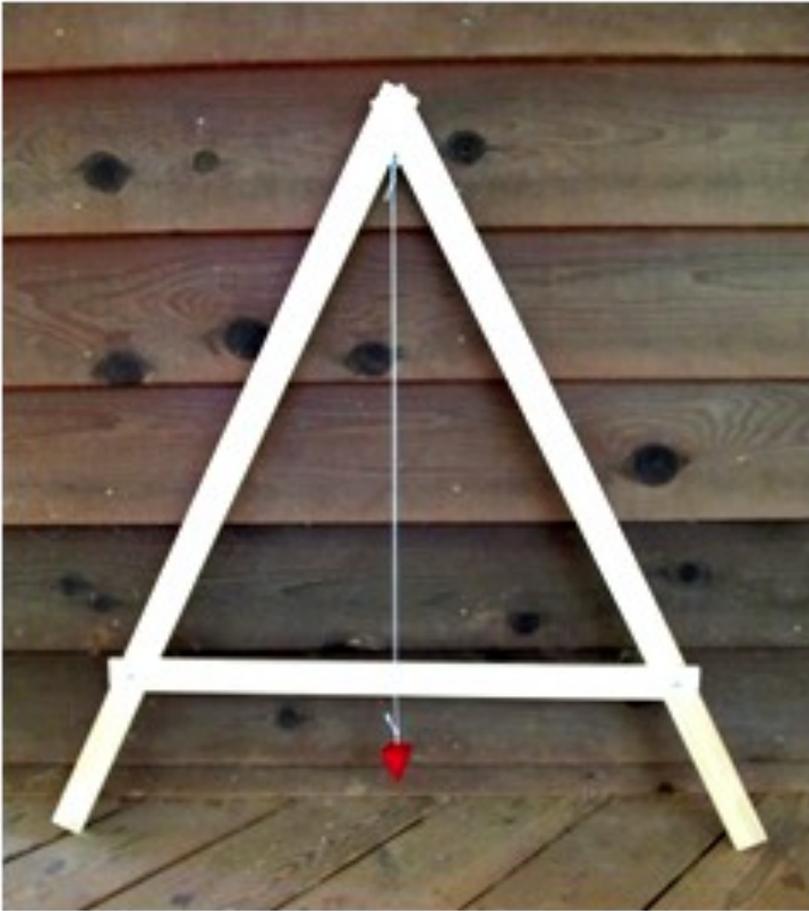
Candler, NC

(828) 670-8330

www.southeasternnatives.com



Appendix D: A-Frame Level



Materials

- 3/8"x2"x36" pine craft board (2)
- 3/8"x2"x26" pine craft board
- Power drill
- 3/16" drill bit
- 5/64" drill bit
- 10-24x1 1/4 machine screws (4)
- 10-24 wing nuts (3)
- 10-24 regular nut
- #212x15/16" eye screw
- 3ft string
- Plumb bob (or other weight such as a fishing sinker).

Sometimes you will decide that you need to stop or slow water running down a slope. Whether you want to build a retaining wall or an earthen berm, you'll need to make it level so that water doesn't build up in some places and not others. This means that you will need to mark a level line across your slope — this line is called a contour. The job can be made a lot easier by using an A-frame level, and it's easy to build. Follow the instructions on the next few pages to learn how to make and use your own A-frame level.

Appendix D: A-Frame Level

STEP 1: DRILL HOLES

- A. Using the $\frac{3}{16}$ " drill bit, drill a hole 1" in from each end of the smaller $\frac{3}{8}$ " x 2" x 26" pine craft board.
- B. Next, drill a hole 9" in from *one* end of both of the longer $\frac{3}{8}$ " x 2" x 36" pine craft boards. Using the machine screws and wing nuts, loosely bolt the $\frac{3}{8}$ " x 2" x 36" pine craft boards to the $\frac{3}{8}$ " x 2" x 26" pine craft board, then overlap the undrilled ends of the $\frac{3}{8}$ " x 2" x 36" pine craft boards (Figure 1).
- C. Carefully drill two holes through both overlapped boards at the same time (Figure 2). It isn't important exactly where the two holes are so long as they go through both boards and are far enough from the edges not to break through.

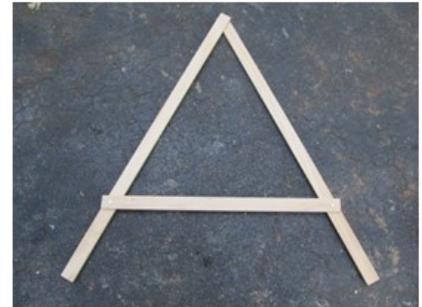


Figure 1.

STEP 2: TEMPORARILY ASSEMBLE FRAME

- A. Use two machine screws to fasten the overlapping boards together. Use one wing nut and one regular nut (Figure 3). The wing nut allows you to take it apart enough to



Figure 3.



Figure 2.

STEP 3: PLACING EYE SCREW

- A. In this step you will attach an eye screw to the top of the A-frame for the plumb bob to hang from. Mark a spot $\frac{1}{2}$ " down from the point where the boards overlap.
- B. Unscrew the overlapped boards and drill a small hole at the place you just marked, about $\frac{1}{2}$ " deep. This is called a pilot hole.
- C. Now screw the eye screw into the pilot hole. You can use a drill bit to make turning easier (Figure 4).
- D. Sink the eye screw fully into the board so that only the loop is showing.
- E. Now you can screw the overlapped boards back together (Figure 5). Tighten all screws.



Figure 4.



Figure 5.

Appendix D: A-Frame Level

STEP 4: ATTACH PLUMB BOB

- Tie one end of the three foot string to the eye screw.
- Tie the other end to the plumb bob; you want the plumb bob to hang past the bottom rung but not touching the ground (Figure 6). **Note:** You can use anything as a plumb bob as long as you can firmly attach it and it is heavy enough to pull the string tight.
- Cut away any excess string. Your A-frame should now look like Figure 7.



Figure 6.



Figure 7.

STEP 5: CALIBRATION

- Before you can use your level you need to calibrate it by finding the center point. Set the frame on a non-level surface. The first leg is in position "A" and the second leg is in position "B" (Figure 14).
- Mark where the plumb line comes to rest with a dotted line. Now flip the A-frame around so that the first leg is where the second leg was (position "B") and the second leg is where the first leg was (position "A").
- Again, mark where the plumb line comes to rest with a dotted line. You should now have two dotted lines.
- Measure halfway between these lines and mark with a heavy solid line; this is your center line. Now any time the plumb bob hangs over the center line, you know you're level!

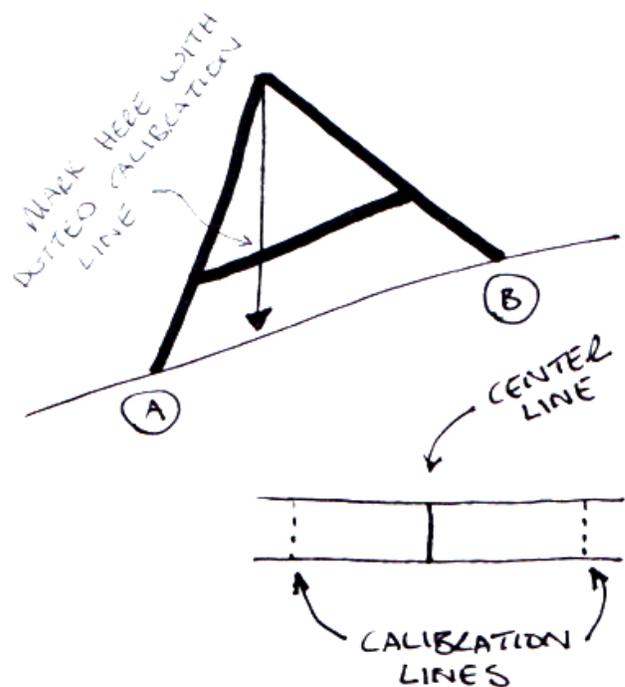


Figure 8.

Appendix D: A-Frame Level

STEP 6: HOW TO USE YOUR A-FRAME TO FIND CONTOURS

- A. You can use your new A-frame level to mark a contour across a slope. Begin by placing the A-frame where you want to start the contour line. Adjust the second leg of the A-frame until the plumb bob rests over the center line and then mark where the two legs for the A-frame rest (positions "A" and "B" in Figure 15).
- B. Now move the A-frame so that the first leg is where the second leg was. Adjust the second leg of the A-frame until the plumb bob rests over the centerline, just as you did before, and mark where the second leg rests (position "C" in Figure 16). Move along the slope in the same pattern until you've marked a contour as long as you need (Figure 17).

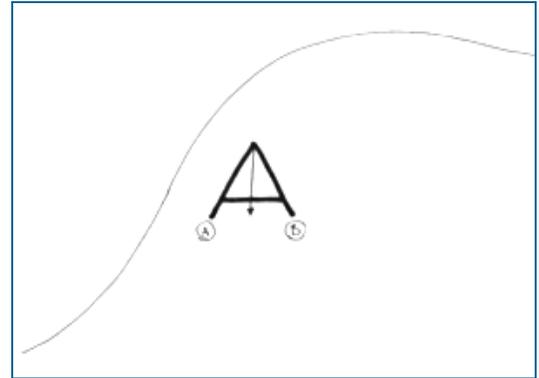


Figure 15.

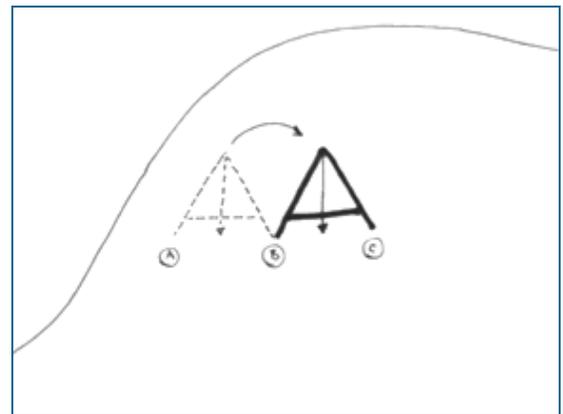


Figure 16.

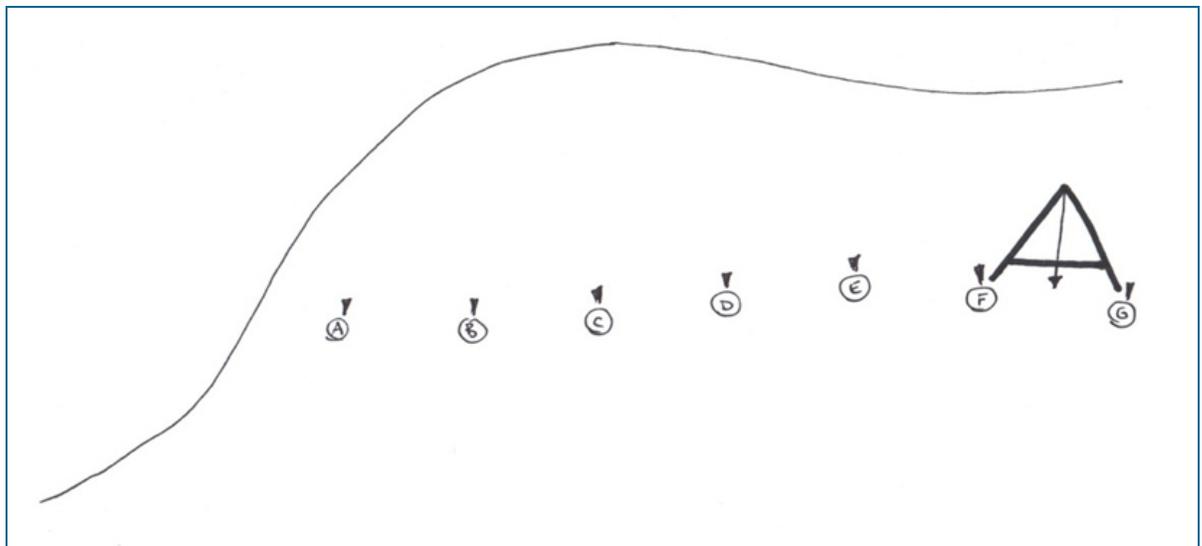


Figure 17.