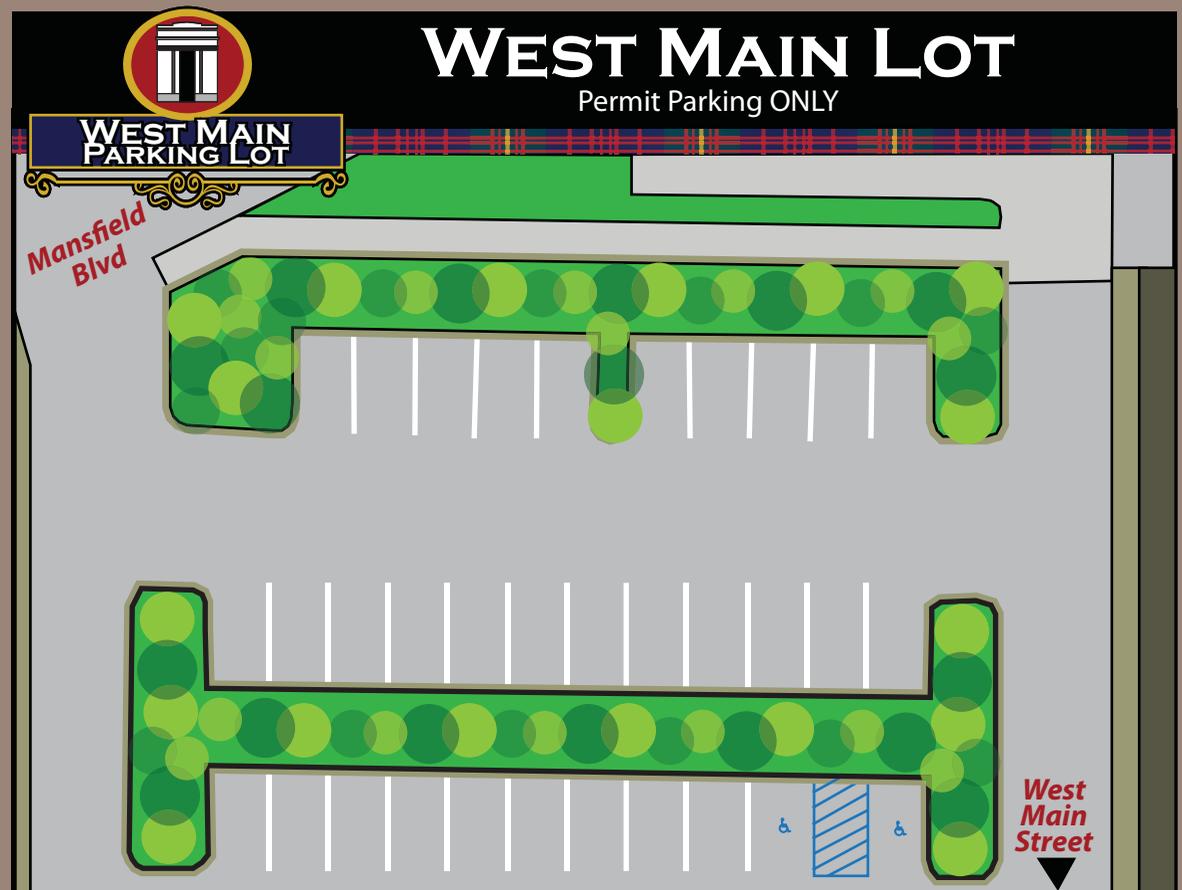
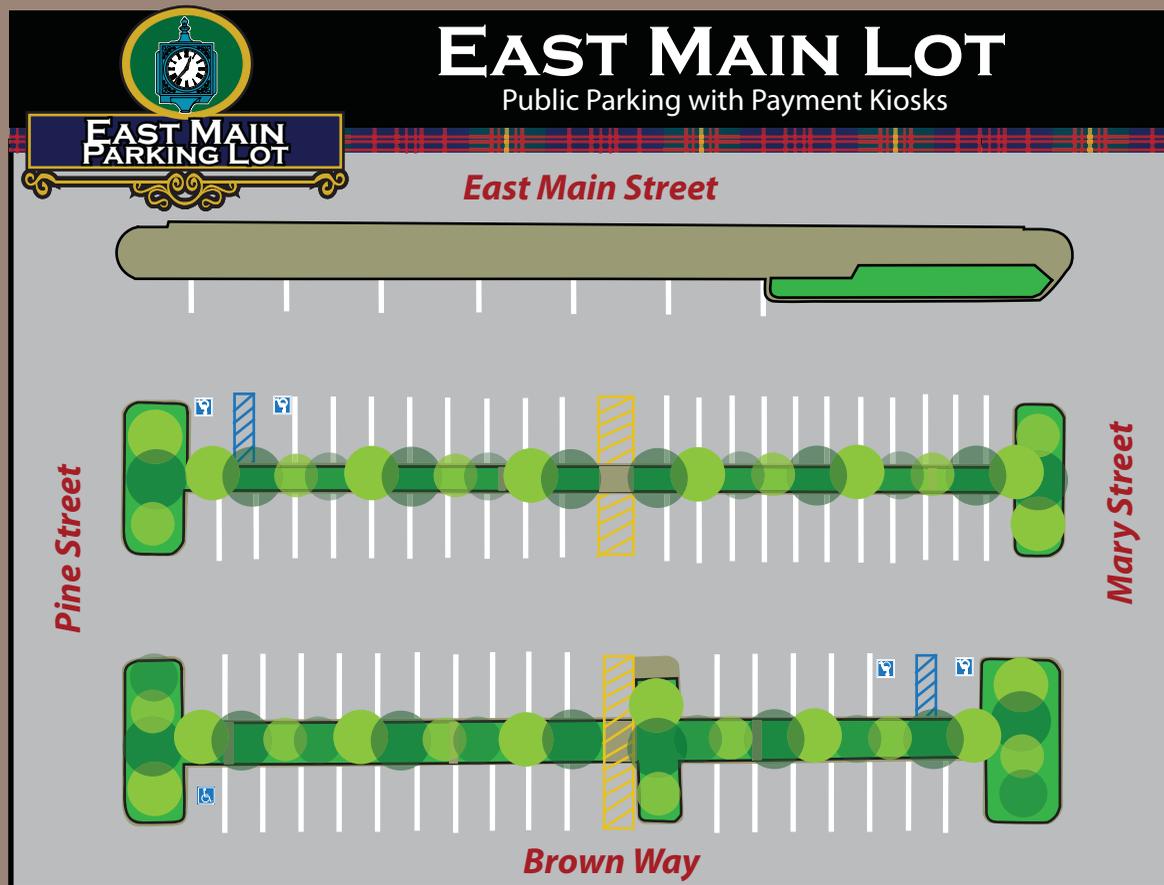


# Stormwater Management & Bioretention Carnegie East and West Main St. Parking Lots

## RAIN GARDENS



# A Rain Garden is a Bio-Retention Cell



# RAINFALL STATISTICS

Climate Report  
National Weather Service  
Pittsburgh, PA

	Observed Value	Normal Value	Depart from Norm	Last Year
Month to Date	4.83	2.53	+2.30	1.71
Since June 1	12.12	10.91	+1.21	7.11
Since Jan 1	26.85	26.79	+0.06	25.71
2020	39.33	38.19	+1.14	
2019	52.46	38.19	+14.27	
2018	57.83	38.19	+19.64	
2017	42.15	38.19	+3.96	
2016	35.01	38.19	-3.18	

Rain Gardens in the East & West Main Street Parking Lots absorb more than 800,000 gallons of stormwater each year.

## PLANTING CONSIDERATIONS for PARKING LOT RAIN GARDENS

- Native shrubs are recommended over perennials due to increased evapotranspiration and water quality enhancement. Refer to PaDEP's 2006 Stormwater BMP Manual, Ch. 6.4.5
- Conditions: full sun; hot; exposed windy.
- Water sources: rain, runoff, and snow melt; dryish soil much of the time. Constructed soils well drained with infrequent ponding up to 48 hrs.
- Plant List Criteria: low-maintenance; no groundcover due to need for mulch replacement; no tall trees due to limited soil depth and gravel envelope at bottom; commercially available; no tap roots, thorns; no invasive species.

## WATER QUANTITY MANAGEMENT

- Properly designed bioretention cells capture, retain, and exfiltrate water from 1/8" to 1" rain events.
- Runoff from a 1" rain within 24 hours should drain within 1 to 2 days maximum.
- In a large 10- or 25-year storm, an integrated system of bioretention cells can help mitigate peak flows and reduce nuisance flooding.
- Rain gardens manage water quantity effectively for large areas when integrated with other stormwater BMPs, referred to as a "treatment train".

## EVALUATION MATRIX

Benefits - Bioretention cells or "rain gardens" can effectively:

1. Clean runoff water by removing or reducing pollutants and sediments
2. Manage runoff quantity from 1" or less rain events
3. Mitigate peak flow from larger storm events and reduce nuisance flooding
4. Become landscape assets in urban and built environments
5. Prevent de-watering of small watersheds

Water Quality Management - Runoff contains a spectrum of potential pollutants. Pennsylvania's focus on sediment/nutrient reduction is the following 3 aspects.

Percentages express reduction in infiltration systems, from 2 sources:

Total Suspended Solids	53.91%	85%
Total Phosphorous	63%	85%
Nitrate	(-16)-16%	30%

Source: PaDEP's 2006 SWM BMP Manual, Ch. 8/6.1, Analysis of Water Quality Impacts from Developed Land

## BMP Integration

Underdrains are essential in bioretention systems to facilitate timely drainage of excessive runoff in southwest PA's clay-based soils and compact urban fill. Rain gardens by themselves, are effective in small drainage areas up to six acres. On large sites, or as part of a larger stormwater management plan, they integrate well with other types of stormwater BMPs, such as:

- Inputs from rooftops, rain barrels, or cisterns;
- Outputs to level spreaders, stormwater wetlands, infiltration basins, sub-surface storage, on-site storm sewers, and detention basins.

## Construction Considerations

A bioretention cell should be installed after a site has been stabilized and its drainage area developed or fully vegetated. If installed during construction, rigorous E&S controls must be deployed on site so that silt and sediments in the drainage area do not infiltrate the gravel envelope, underdrain, connector pipe, or inlet. This is critical for long-term rain garden function.

## Liabilities

A bioretention cell is a sensitive, living, engineering system.

1. Winter salt may damage plants. Alternative methods of managing snow and ice should be used (i.e. plowing).
2. Rain gardens may need soil and/or plant replacement every 10-15 years, or sooner if there is heavy pollutant loading, or a malfunction in the cell.
3. Bioretention cells are susceptible to clogging from upslope erosion sources. They should be constructed in stable watersheds.

## Cost Effectiveness

Relative to progressive stormwater BMPs in clay soils, "bioretention is the most economical option up to about 6 acres, followed by wet ponds for mid-sized watersheds, and stormwater wetland for watersheds over 10 acres" based on both construction costs and annual operation, including inspection and maintenance. Source: The Economics of Structural Stormwater BMPs in North Carolina [http://www2.ncsu.edu/unity/lockers/users/g/gawossin/Structural\\_Stormwater\\_BMPs.pdf](http://www2.ncsu.edu/unity/lockers/users/g/gawossin/Structural_Stormwater_BMPs.pdf)

## Seasonal Influences

Plants transpire very little in the winter. However, their root systems continue to interact with soil bacteria, air, and water, and provide moderate cleaning benefits to runoff and snow melt.



## ENGINEERING

Careful consideration is necessary to the design of these living engineering systems. Calculations must accurately determine the amount of water to be treated, the bioretention size and the underdrain which is necessary in southwest PA. Construction and maintenance are equally important since these units are sensitive to clogging over time. As an integrated stormwater BMP, bioretention systems can mitigate peak flows and clean runoff waters. Refer to Pennsylvania DEP's 2006 Stormwater Management BMP Manual for more information.

## ENGINEERING FUNCTIONS

Plants used in bioretention cells are subject to highly variable moisture and climatic conditions, especially in parking lot retrofits, where they must thrive in demanding microclimates.

## OVERFLOW DRAIN

The role of the overflow drain is to alleviate high levels of runoff water during short, intensive rain events. Stable, well-anchored inlets, such as concrete are best.  
3" MULCH - Coarsely shredded hardwood bark has proven to be the most durable mulch and exhibits the best staying power. It is less likely to blow or wash away. An outage edge material, such as a grass strip or coarse gravel, dissipates flow and filters out objects – good for system stabilization, longevity, and aesthetics.

Constructed Soil Mix is the most critical element for long-term success. It must be moderately fast draining (2-4 inches / hour) and contain some clay for metals adsorption – but not too much. Mixes should contain less than 10% clay to prevent clogging. Excessive sand dries out cells too quickly. Designers can assume the uncompacted soil mix has a 30% void space. Arbitrary fill materials shouldn't be used and soil mixes should not be compacted during construction. This mix provides both mechanical and chemical qualities that encourage soil biota and microflora that help clean runoff water.

## IDEAL SOIL MIXTURE:

20% organic material (such as compost)  
30% sand, pea gravel, or crushed slag  
50% topsoil (all rocks and foreign matter must be removed).

## GRAVEL ENVELOPE

A geotextile fabric (Class 1 non-woven geotextile as specified in PennDOT's Design Manual, Section 735) envelope is the underdrain area that allows water to pass through, while keeping soil out. Designers can assume the gravel envelope has a 40% void space.

## UNDERDRAIN

An underdrain is necessary in clay soils and compacted urban fill. Size the underdrain pipe according to the expected inflow (minimum six inches). The underdrain connects to the overflow drain which can connect to existing storm sewers, stormwater wetlands or infiltration basins. See PennDOT design manual, Section 610.2(a) 1c for perforated plastic underdrain. Note: an underdrain control valve may be needed to minimize the rate and volume of dewatering the bioretention cell.

# ECOLOGY

Bioretention cells are designed to emulate the functioning of the upper layer of forest soils, where water, plants, soils, bacteria, and other microflora interact to clean and infiltrate water, sustain plant communities, and recharge ground waters. Forest soils also have the documented ability to cycle and assimilate pollutants and metals through interactions among plants, soil, and the organic layer.

## ECOLOGICAL FUNCTIONS

**Evapotranspiration** - Large amounts of water are pulled up into trees, shrubs, and plants from the surrounding soil in a process called transpiration. Water is drawn up into leaves during photosynthesis, and once utilized, is returned to the air as water vapor. This process creates a pump-like effect, in which a constant flow of moisture from the roots is drawn upward to replace what has escaped into the air. A growing plant transpires 5-10 times as much water as it can hold. During this plant uptake, dissolved pollutants are carried up into the plant tissue and rendered harmless.

**Mulch Layer** - After runoff hits the dissipator strip, the mulch layer acts like the leaf litter on a forest floor by slowing the rate of water entering bioretention areas. Sediments and colloids fall out of suspension, and dissolved pollutants and toxic chemicals in the runoff are carried into the bioretention cell for treatment. The mulch layer plays a critical role in heavy metal uptake with nearly all the metal removal occurring in the top few inches of the bioretention area. Heavy metals affiliate strongly with organic matter and humus in this layer. Microorganisms are also credited for degrading petroleum-based solvents (hydrocarbons) and other pollutants.

**Soil Biota & Pollutant Reduction** - Soils provide water and nutrients to plants, as well as a physical, chemical, and biological setting for living organisms. Soil biota existing within the soil layer is critical to the filtering of nutrients and pollutants and assist in maintaining soil fertility. Soil particles play a role. Clay, due to its molecular properties provides adsorption sites for hydrocarbons, heavy metals, nutrients, and other pollutants (EPA Office of Water, 1999)

**Water Cooling** - In warm months, heated runoff from impervious surfaces is cooled through the bioretention facility.

**Additional Water Cleaning** - Some water will remain under the drain at the base creating anaerobic conditions. Though this condition is undesirable in the plant root zone, specific pollution removal occurs here, namely, some transformation and reduction of nitrates.



# MAINTENANCE REQUIREMENTS

**OVERFLOW DRAINS** need to be free of clogging. All debris such as mulch must be removed before it moves further down into the system. MULCH provides essential microflora and bacteria that work to clean water. These active “cultures” depend on fresh nutrient supplies to flourish, so mulch must be renewed 1x/year, and completely replaced every 3rd year.

The **UNDERDRAIN CONNECTION** must be checked and cleared of debris; ponded runoff needs access to the overflow drain.

**Maintenance of the GRAVEL ENVELOPE** can be best avoided through careful construction. If ponding times are excessive in small rain events, the **UNDERDRAIN** may be clogged or compromised and will need to be flushed out via overflow drain or dug up and reconstructed.

**CONSTRUCTED SOILS** will need to be replaced when they become exhausted or over-concentrated with contaminants, possibly every 5 to 10 years. Plant health will be a major indicator for when it’s time to replace soil.

**BIORETENTION PLANTS** will eventually become exhausted from their work in absorbing and transforming contaminants that occur in stormwater runoff. They will need to be replaced over time before the woody plants reach maturity. Current research shows that in a properly functioning rain garden, plants can thrive from 5-10 years. Annual mulch replacement, and after three years, old mulch needs to be removed and new mulch laid down. New mulch carries bacteria and microflora that work to clean runoff waters. All intentional landscapes, industrial, commercial, and residential, need to be weeded, bioretention cells are no exception.

## A STABLE DRAINAGE AREA

Construct bioretention cells after the site has been fully stabilized. Bioretention cells work best in drainage areas that are either permanently vegetated, or fully built out. The reason: upstream development is likely to create erosion and sediment transport that will make its way into the rain garden. Sediments can raise depressed areas, clog, and impair long-term infiltration capacity. Sources of potential erosion need to be anticipated during construction.

## DESIGN AND SIZING

Rule of Thumb – In general, 2,0—square feet of bio-infiltration, 3.5-feet deep, can treat a 1-inch rain event from one acre of impervious area.

# Maintenance Guidelines

for the Carnegie East and West Main St. Parking Lots

## **R A I N   G A R D E N S**



## Introduction

This guide is to assist those maintaining the rain gardens in the East and West Main Parking Lots. It is organized by appropriate maintenance tasks per season. However, it is advised to visually monitor the gardens performance on a regular basis, particularly during rain events. **Please note that the appearance of water in the basin of the garden is normal for approximately 24-72 hours after a rain event.**



These photos show the same rain garden during both wet and dry weather. (Photos: NMRWA)

*\*It is advised not to work in the garden after watering or after a rain event as walking on wet soils can cause compaction, which will lessen the garden's infiltration abilities.*



### Tools for Rain Garden Maintenance:

- Round shovels
- Flat shovels
- Pitchforks
- Hard rakes
- Leaf rakes
- Hand shovels
- Push broom
- Hose and water supply
- Weed puller
- Pruners
- Buckets
- Tarps, to collect discarded plant material
- Mulch, if needed
- Supplemental plants, if needed
- Wheelbarrow
- Trash bags

## Winter/Spring

- Flushing the Rain Garden

Deicing salts have a negative effect on plant material. Although many of the plants have been selected for their salt tolerance, it is still recommended to flush the garden out as soon as the snow season ends. This consists of literally watering the vegetation and soils to flush out accumulated salts, before the plant emerges in the spring.

- Cutting back

In early spring use pruners or a string trimmer to cut dormant perennials and grasses down to about an inch from the ground. This can be done in late fall, but is recommended by many gardeners to do so in the early spring as dried grasses and perennials provide winter interest. **Use caution not to cut back woody plants like trees and shrubs.**



Perennials and ornamental grasses in winter, making a compelling case to wait until spring to cut back. (Photo: groundeddesign.com)



Ornamental grasses cut properly cut back in the spring. (Photo: psu.edu)

## Summer/Fall

- Watering

Water all vegetation approximately 2-3 times weekly for the first two years of establishment during the growing season (May-October). After year two, watering biweekly in the summer months should provide adequate moisture.

- Weeding

Remove unwanted weeds, roots and all, by hand pulling throughout beds. Properly dispose of weeds to ensure they will not re-establish in the garden. For images and a list of common weeds see page 5.

- Re-Mulching

To help inhibit weed growth, conserve soil moisture, and enhance soil nutrients, it is recommended to reapply a 2" layer of double shredded hardwood mulch to all of the planting areas every year in early summer.

- Replanting

Plants can be added to your rain garden to fill gaps or to replace some of the original plants if damage or loss has occurred. Rain gardens perform best when densely vegetated.

Plant selection should consider nativity, mature size of the plant, sun exposure, and the changing conditions of the rain garden. If you have questions about what to plant, consider a plant that is already thriving in the garden or consult a landscape architect or designer.



Water around the base of rain garden plants to keep foliage dry, which helps prevent disease. (Photo: NMRWA)



Mulching a rain garden with buckets of mulch. (Photo: earthfix.opb.org)

## As Needed

- **Debris/Sediment Removal**

Sediment or debris that has accumulated in the rain garden, near the inlets, or in the channel drain should be cleared out annually or as needed based on monthly visual inspections. Sediment buildup can prevent runoff from entering the garden or increase the amount of time it takes the water to soak into the soil.

Remove sediment from the base of a rain garden when it accumulates to a depth of two to three inches (or sooner). This will allow for water to flow through the garden as it was designed. Place removed sediment in trash bags and dispose of it with other solid waste/trash. Do not attempt to compost sediment.

**The Carnegie East and West Main parking lots were designed and installed with stone at the inlets, so removing sediment from those stone-lined areas consists of the following:**

- Remove the stone with a shovel or pitch fork and place it in a wheelbarrow, using caution to not to remove the sediment
- Shovel out the sediment that remains in the rain garden and dispose of properly
- Rinse the stone in the wheelbarrow with a garden hose, allowing any sediment to settle to the bottom of the wheelbarrow.
- Return the washed stones to the rain garden
- Properly dispose of any sediment that may have accumulated in the bottom of the wheelbarrow



Sediment accumulation in a rain garden. (Photo ces.org)



Sediment accumulation at the inlet of a rain garden (Photo: vwrrc.vt.edu)



- **Loosening Soil and Mulch**

On a regular basis, or as needed, it may be necessary to loosen the top layer of soil or mulch that may have become compacted due to foot traffic and other environmental conditions. Doing so will ensure that the rain garden is absorbing runoff as designed.

To loosen the top layer of mulch or soil, work a long tined pitchfork back and fourth in three foot sections throughout the garden. Smooth out any areas disturbed by this process with a hard rake.

### Trees and Shrubs



Serviceberry



Black Chokeberry



Inkberry Holly



Black Gum



St. John's  
Wort



Winterberry



Sweetbay Magnolia

### Grasses



Switchgrass



Pink Muhly Grass

### Perennials



Blue Flag Iris



Threadleaf  
Tickseed



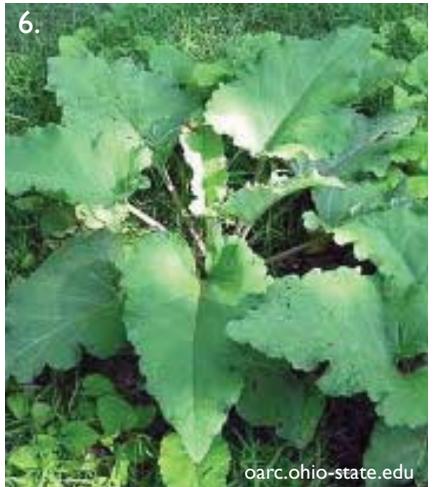
Sneezeweed



Blazing Star



Oct. Skies Aster



Common name	Botanical name
1. Canada Thistle	<i>Cirsium arvense</i>
2. Crownvetch	<i>Securigera varia</i>
3. Dandelion	<i>Taraxacum officinale</i>
4. Garlic Mustard (spring)	<i>Alliaria petiolata</i>
5. Garlic Mustard (flowering)	
6. Burdock	<i>Arctium minus</i>
7. Goutweed	<i>Aegopodium podagraria</i>
8. Mugwort	<i>Artemisia vulgaris</i>
9. English Ivy	<i>Hedra helix</i>
10. Princess Tree	<i>Paulownia tomentosa</i>
11. Japanese Knotweed	<i>Polygonum cuspidatum</i>
12. Japanese Knotweed (spring)	

