Rain Gardens: Mitigating Runoff Pollution for Coastal Texas

GLO Contract No.: 11-009-000-4307

Final Report
May 31, 2013

Submitted by
Texas A&M AgriLife Extension Service
Christina LaChance, WaterSmart Program Coordinator

A report of the Coastal Coordination Council pursuant to National Oceanic and Atmospheric Administration
Award No. NA10NOS4190207

Introduction:

As the population of Coastal Texas and urban sprawl continue to grow and replace prairies, wetlands and forests with impervious surfaces such as parking lots, roofs, and streets; increased stormwater runoff from these surfaces carrying with it large amounts of pollutants creates a significant water quality problem. With increased flow from paved or compacted surfaces, there is less opportunity for groundwater recharge. Rain gardens are bowl shaped, planted areas that have the potential to mitigate polluted runoff and loss of infiltration by capturing water from impervious surfaces during a rain event. Rain gardens slow down runoff and allow a percentage to be absorbed in the soil. The stormwater passes through and is filtered by the soil, plant material and mulch; a process which helps remove pollutants that would otherwise flow directly into the nearest water body. With the use of native plants, rain gardens naturally become wildlife habitats and are more sustaining due to the plants' viability.

With the CMP grant funds, the WaterSmart (WS) Program successfully provided Coastal Texas residents with the tools and knowledge to implement a strategy that mitigates stormwater by using a beautiful landscape feature.

The rain garden initiative included installing four demonstration rain gardens, publishing a rain garden manual for professionals and non-professionals, conducting two hands-on rain garden workshops, and uploading rain garden information on the WaterSmart website. Countless opportunities for presentations, consultations and collaborations resulted from the rain garden initiative. As a visual aid to presentations and outreach, two watershed maps of the Galveston Bay Watershed were created. **(See Appendix for copies of maps)**

There were several challenges faced during the project. The optimum time for rain garden installation to ensure the highest plant survival rate occurs during the spring and late fall, providing a small window of opportunity to construct four rain gardens. Compounding the scheduling challenge and following the first rain garden installation, was severe drought in 2011. However, because of the relationships forged with the entities sponsoring the on the ground project components and invested volunteers, the rain gardens survived with minimal plant loss and are now thriving.

Despite the challenges faced, opportunities for community involvement, networking, and finding committed individuals manifested throughout the project. It was through the close partnerships formed with the various groups mentioned in the project descriptions below that created a template for successful project outcomes and opened avenues for relationships for future collaborations.

Volunteers, providing the bulk of installation and maintenance work, formed the backbone of the rain garden effort. More than 128 volunteers contributed 1,060 volunteer hours, with additional hours added for continued monthly routine maintenance.

Reaching out to and involving youth volunteers in the process was a very rewarding experience. By playing an active role in protecting Texas water resources, the volunteers are instilled with a strong base to become environmental stewards in their community.

<u>Girl Scouts of America Partner with the WS Program to Build Rain Gardens</u>

As a side note to the rain garden initiative, the WaterSmart Program (WS) had the opportunity to partner with the Girl Scouts of America as part of their Girl Scout Forever Green Program (GSFG). The program focuses on several environmental awareness issues one of which is a rain garden initiative. As a national organization, the Girl Scouts have the potential to reach countless people with rain garden education. The WS Program installed two rain gardens with the assistance of Girl Scouts at the Environmental Institute of Houston (EIH) at the University of Houston, Clear Lake and at Armand Bayou Nature Center (ABNC). (See below)

Because of this unique partnership, the WS Program was invited to participate in the Girl Scout (GS) National Convention held at the George R Brown Convention Center, Houston, on November 9-12, 2011, drawing both national and international participants. The WS Program created an exhibit that featured a table-top model of a rain garden as well as a science experiment demonstrating how a rain garden functions by filtering “polluted” water.

In partnership with Houston Arboretum and as part of the GS Convention activities, the WS Program spear-headed the coordination of two major rain garden installations (separate from the ones installed at ABNC and EIH) at the Arboretum. Funding was provided by the Girl Scout Organization. Girls attending the convention were bused to the Arboretum where they first listened to a rain garden presentation by the WS Program Coordinator and then planted the rain gardens.

Over the course of the three-day GS National Convention, more than four hundred Girl Scouts received rain garden information. Attendance at the convention was close to 10,000 people, the majority of whom visited the WS Rain Garden booth. Four hundred girls and three hundred adults attended the Houston Arboretum rain garden installation.

As a result of their participation in the rain garden education and installation event, many Girl Scouts and their adult leaders decided to install rain gardens in public spaces as troop projects. Others, such as a group from the island of Barbados, said the rain gardens would form an essential part of their overall water conservation and water quality protection plans for their communities.

The rain garden presentation created by the WS Program Coordinator titled, “Rain Gardens: A Green Solution to Water Pollution”, was added to the GSFG website. http://www.girlscouts.org/gsforevergreen/Rain-Gardens-Details.asp (Please refer to “How to do the Project”, then #11 under “Building a rain garden takes some planning, but the effort is well worth it!)

Rain Garden exhibit at Girl Scout Convention

Presenting rain garden talk at Houston Arboretum

Girl Scouts plant the rain gardens at Houston Arboretum

Girl Scouts paint a mural on the cistern

Completed mural on cistern and planted rain garden areas

Awards

The WS Program received two awards as a result of the rain garden initiative.

- The Girl Scout Forever Green Rain Garden Project at the Houston Arboretum received the Distinguished Service Award for the 2012 Keep Houston Beautiful Mayor's Proud Partners competition. Keep Houston Beautiful is an organization dedicated to creating a cleaner, healthier environment for the city's inhabitants. Every year, the group presents the Mayor's Proud Partner Award to an individual or group of individuals who have completed a project that improves the Houston community.

- On December 6, 2012, the *Treasures of the Bay Making A Difference Award* was presented to Christina LaChance "in recognition of her outstanding initiatives in preservation, restoration and education which have improved and enriched the quality of the environment in the Galveston Bay Area". Presenting the award was the Texas Master Naturalist, Galveston Bay Chapter.

  Many of the volunteers who participated in the rain garden installations are Master Naturalists with this chapter. They continue to support the projects by assisting with ongoing rain garden maintenance and by acting as docents to interpret the rain gardens.

Rain Garden Article is Featured in the Houston Chronicle

The WS Program writes a monthly column for the Houston Chronicle as their Homes Correspondent. A discussion of rain gardens was the subject of one of those articles in September, 2012. The link to the online version is: http://www.chron.com/default/article/Rain-gardens-help-alleviate-rainwater-runoff-3880688.php (**See Appendix for scanned copy**)

Grant Deliverables

Task 1. Installation of a minimum of three demonstration rain gardens

The WS Program was able to install four demonstration rain gardens.

Two rain garden styles were chosen for the demonstrations:

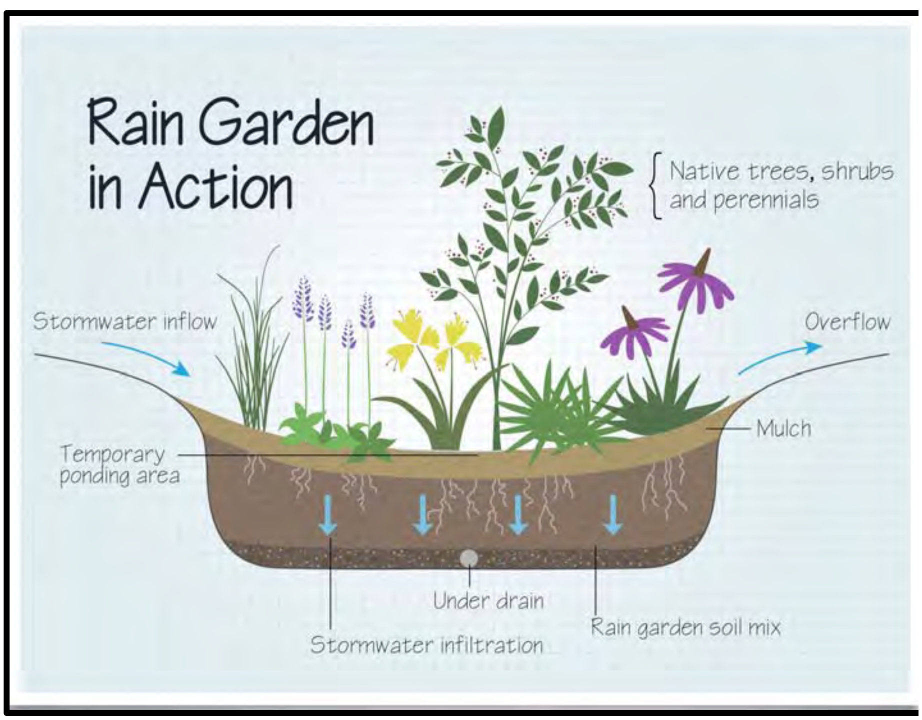
- Commercial Style: For a commercial or public application, the rain garden is excavated to three feet and four-inch perforated under-drain piping is used, making this a very robust design. The combined result allows for the maximum stormwater holding capacity and enhanced stormwater treatment. A catchment unit located near the outfall area and to which a solid four-inch pipe is attached helps to increase outflow during a large rain event. This minimizes the possibility of temporary flooding at the commercial or public site.
- Residential Style: In a residential setting, the rain garden has a shallower excavation of approximately eight to twelve inches and no under-drain is utilized. Typically, the volume of captured runoff is less and when properly designed overflow does not create an impediment.

<u>Sequence for installation</u>: For each of the four rain gardens, a similar sequence of events occurred: 1) designating a suitable site; 2) coordinating with excavation crews to prepare the site, determining the location and size of the rain garden based on calculating the stormwater runoff from the watershed area (parking lot size or roof area); 3) contracting with a landscape designer to design the rain garden; 4) ordering soil, plants and mulch; 5) soliciting volunteers to assist with the installation process; and 6) coordinating the installation event or events.

Informational signage plus plant identification tags are included in the installation.

A description highlighting each demonstration rain garden follows.

"Commercial or Public" Style Rain Gardens



Graphic shows rain garden with under drain

The following two rain gardens illustrate a rain garden design that would be suitable for public or commercial application.

A Rain Garden for Deer Park, Texas

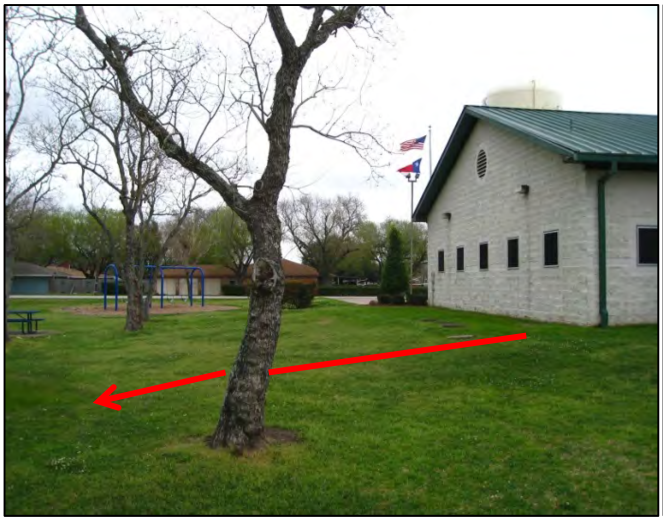
The WaterSmart (WS) Program coordinated a rain garden installation at the Burgess Community Center in Deer Park on April 15, 2011. This was also the site of one of the rain garden hands-on workshops. The project was the culmination of a collaborative effort with the City of Deer Park (Parks and Public Works/Stormwater Departments), the TX A&M Urban Solutions Center in Dallas, and the WaterSmart Program. The community center location was chosen as the site for the rain garden.

Once the site and location of the rain garden was determined, the sequence of events mentioned above began. With assistance from the Deer Park Parks Department, the site was excavated to three feet for the 424 square foot rain garden. Their in-kind services which totaled $6576, included removal of excavated soil from the site, mixing soil components (expanded shale, compost and part of the excavated soil), and moving the mixed soil into position. A hands-on workshop was held as part of the installation process. Thirty-six participants moved soil, planted 101 plants, and added mulch to complete the rain garden.

Participants represented several entities: engineers and architects representing Harris County, Galveston County, Houston, Deer Park, League City, and Pasadena; landscape architects and designers; stormwater managers; parks and recreation departments from various counties and cities; stormwater consultants; non-profit environmental groups; and staff from the University of Texas Medical Branch, Galveston, environmental office.

Burgess Community Center, Deer Park


Proposed rain garden site



Path stormwater will take to the rain garden

Excavation begins

Rain Garden Workshop led by Dr. Jaber

Workshop pariticpatns

Underdrain and gravel layer installed

Soil in place and ready for grading

Workshop participants install native plants

Completed rain garden showing underdrain and overflow catchment pipe

We did it!

Deer Park Rain Garden
April 2013

Sign for Deer Park Rain Garden
featuring under drain
(18" x 24")

Rain Garden for League City, Texas

In partnership with League City and Texas A&M AgriLife Research and Extension Service, the WS Program coordinated a rain garden installation and hands-on workshop on Wednesday, April 11, 2012 at Heritage Park in League City.

Dr. Fouad Jaber, Assistant Professor and Integrated Water Resources Management Specialist, led a workshop which was then followed by the participants installing a rain garden. Participants included TX Extension Master Gardeners and Master Naturalists, city engineers and stormwater managers, landscape architects and designers, and residents.

The event and installation received much publicity, including a front page article in the Galveston County Daily News (http://galvestondailynews.com/story/305922). Photographers from the Bay Area Citizen and Houston Chronicle were also present. Photographs can be found at the League City website http://www.leaguecity.com/gallery.aspx?PID=1746

League City Rain Garden

View of site from parking lot
Arrows indicate direction of flow

View of site from stormdrain area
Arrows indicate direction of flow

Excavation

Workshop participants preparing site for planting


Workshop participants plant native plants in the rain garden

“We did it!”--Rain Garden participants and League City Parks crew


Completed Rain Garden

League City Rain Garden in action during a 2" rain event
May 17,2013

Rain garden is captures stormwater runoff from the parking lot.

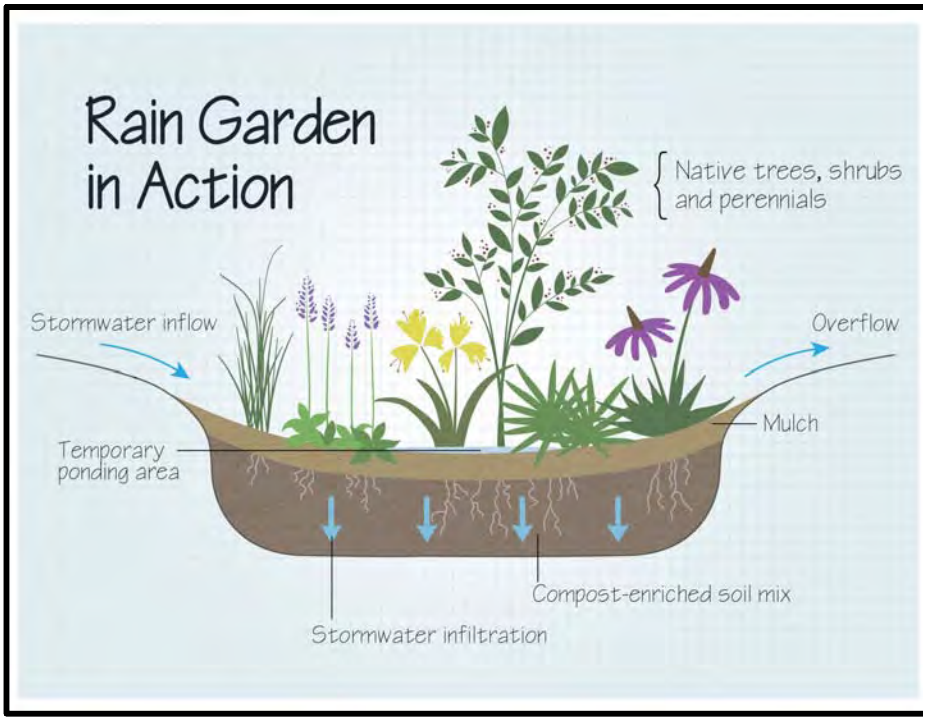
The rain garden filters the stormwater runoff. Some of the stormwater is absorbed into the soil while the remaining cleaner stormwater enters the stormdrain.

Sign for League City Rain Garden

featuring under drain

(18” x 24”)

“Residential” Style Rain Gardens



Graphic shows rain garden with no under drain

The following two rain gardens illustrate designs that would be more suitable to a residential or non-commercial application. Girl Scouts of San Jacinto Council participated in both rain garden installations as a result of the WS Program/Girl Scout partnership mentioned above.

Rain Garden at the Environmental Institute of Houston (EIH) at the University of Houston at Clear Lake

On Saturday, September 15, 2012, thirty Girl Scouts of San Jacinto Council, nine Texas A&M AgriLife Extension Service Master Gardeners and Master Naturalists, and other EIH staff and volunteers, came together to install a 555 square foot demonstration rain garden. The rain garden is incorporated into the WaterSmart Demonstration School Habitat Lab, an outdoor wildlife habitat classroom. Funding for the outdoor classroom was from a grant from the Coastal Management Program and installed in 2006-2007.

The rain garden project was a partnership with the Girl Scouts, the Environmental Institute of Houston at Clear Lake, and Texas A&M AgriLife Extension Master Gardeners and Master Naturalists. The Master Gardeners and Master Naturalists were mentors to the girls during the planting process. The girls assisted in grading the rain garden into its bowl shape, installing 165 plants and adding mulch. The site is open to the public and provides an educational platform for the community as well as for elementary, high school and university students.

A unique feature of the EIH rain garden is the addition of a 1,500 gallon cistern that captures runoff from one fourth of the roof area of the EIH building. Overflow from the cistern is directed into the rain garden allowing for stormwater capture and treatment as well as providing irrigation to the rain garden when needed.

Site for future rain garden

Cistern is added to the site

Excavation and site preparation

Rain garden ready for planting

Girl Scouts with Master Gardener and Master Naturalist mentors work together during planting


Planting the rain garden


Completed rain garden

Ongoing education: During the school year, students from the Clear Lake Independent School District (CCISD) attend advanced placement environmental classes at the EIH WaterSmart Demonstration School Habitat site with rain garden presentations by the WS Program Coordinator included in the curriculum. The EIH outdoor classroom/rain garden site regularly hosts teacher workshops. In the last year alone, sixty-four students attended one-day a week classes and three hundred eighty nine teachers attend fourteen workshops.

Sign for Environmental Institute of Houston, University of Houston at Clear Lake
Residential Style Rain Garden (no under drain)
(18" x 24")

Rain Garden at Armand Bayou Nature Center
Pasadena, Texas

The fourth and final rain garden was installed at Armand Bayou Nature Center in Pasadena on Saturday, December 1, 2012. Adult volunteers worked to excavate the site in preparation for the Girl Scouts of San Jacinto Council to participate in the rain garden installation. Twenty-four Girl Scouts of San Jacinto Council mentored by twenty Texas A&M AgriLife Extension Service Master Gardener and Master Naturalist volunteers, and Armand Bayou Nature Center volunteers came together to install a 720 square foot demonstration rain garden at the nature center's new visitors center. The Girl Scouts and the adult volunteers planted 165 plants and added mulch to the rain garden.

Included in this rain garden project is a 1,000 gallon cistern that captures runoff from one fourth of the roof area of the new visitor building. Overflow from the cistern is directed into the rain garden allowing for a twofold stormwater capture and treatment. Water from the cistern also provides irrigation to the rain garden.

Partners included Armand Bayou Nature Center, Texas A&M AgriLife Extension Master Gardeners and Master Naturalists and Rain Bird Irrigation Systems.

Video: The ABNC rain garden work day was also the subject of a video produced by the City of Pasadena for their cable access station and can be viewed on the YouTube at: http://www.youtube.com/watch?v=VpV5VSeRcZw&feature=youtu.be The video is being used to educate citizens about the importance of protecting water quality and on ways they can help.

New visitor center at ABNC under construction

Excavating site of rain garden

Rain garden site preparation

Site preparation

Site preparation

Final grading of the site

Site ready for planting

The 1000 gallon cistern arrives


Final preparations before Girl Scouts arrive

WS Program coordinator instructing the group

WS Program coordinator giving a planting demonstration

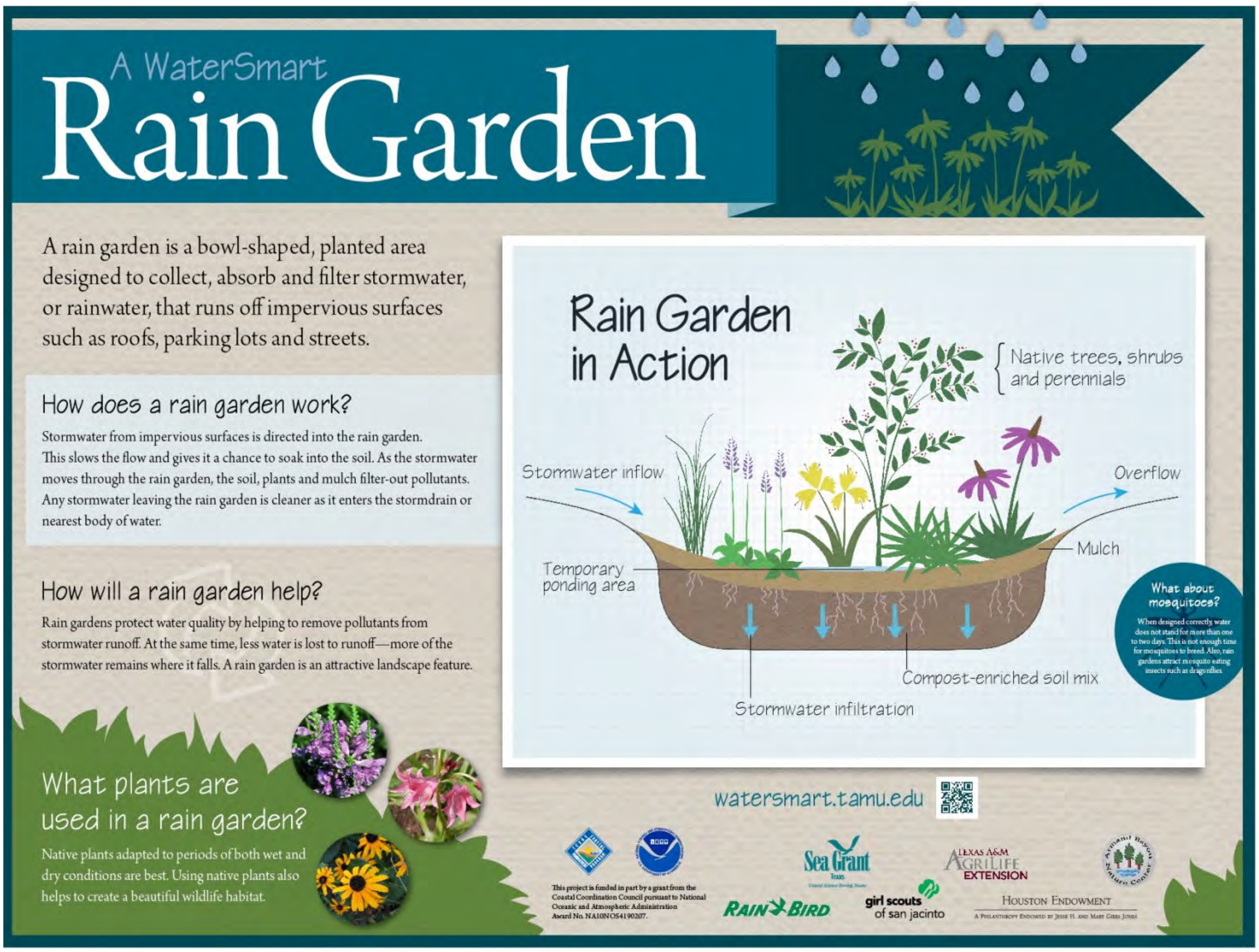

Planting fun!






Completed Armand Bayou Nature Center rain garden project

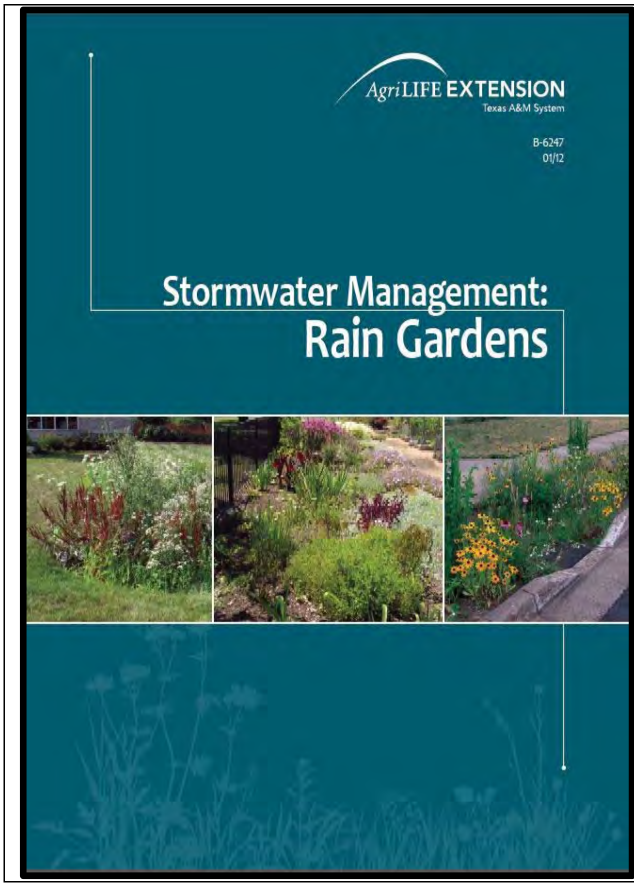
Sign for Armand Bayou Nature Center
Residential Style Rain Garden (no under drain)
(18” x 24”)

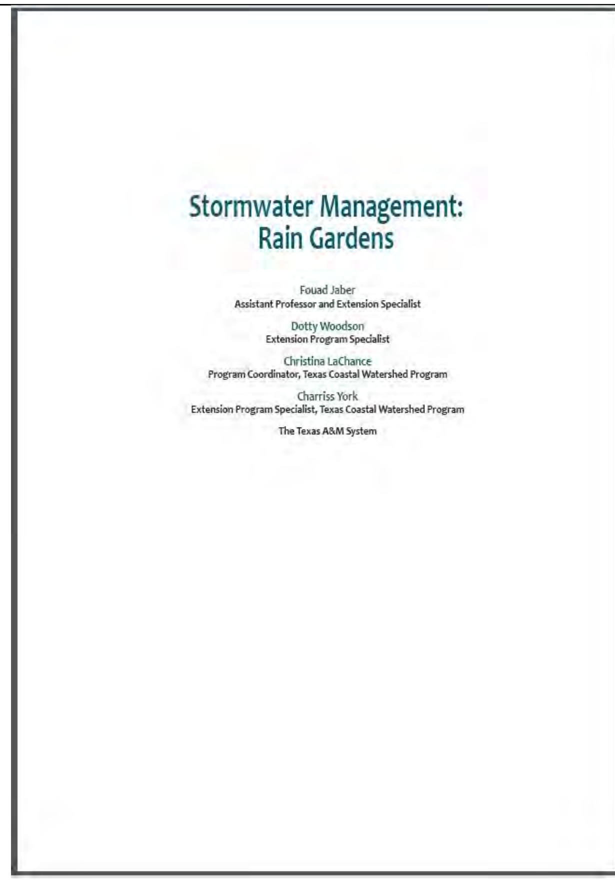


Task 2. Publication of a rain garden manual for Coastal Texas

In collaboration with Dr. Fouad Jaber, Stormwater Specialist with Texas A&M AgriLife Research and Extension Service, a rain garden how-to manual was published. “Stormwater Management: Rain Gardens” is available as a free download from the Texas A&M AgriLife Extension online bookstore. https://agrilifebookstore.org/publications_search.cfm **To date, 1,644 manuals have been distributed or downloaded.**

- **See Appendix for full version**




Stormwater Management:
Rain Gardens

Fouad Jaber
Assistant Professor and Extension Specialist

Dotty Woodson
Extension Program Specialist

Christina LaChance
Program Coordinator, Texas Coastal Watershed Program

Charriss York
Extension Program Specialist, Texas Coastal Watershed Program

The Texas A&M System

Task 3. A minimum of two hands-on rain garden workshops

The hands-on workshops coincided with the rain garden installations at two of the four sites--Deer Park and League City.

Deer Park: The WaterSmart (WS) Program coordinated a rain garden hands-on workshop at the Burgess Community Center in Deer Park on April 15, 2011. The workshop was in partnership with the WS Program, City of Deer Park, Stormwater group, the TX A&M Urban Solutions Center in Dallas, and TX A&M Master Gardeners and Master Naturalists.

The workshop, led by Dr. Fouad Jaber, Assistant Professor and Integrated Water Resources Management Specialist with TX AgriLife Extension, included a two hour presentation that gave participants background information on stormwater and the need to manage it on site, reasons to use rain gardens in a stormwater management plan, and guided them through the rain garden construction process. The 36 participants included: city and county engineers and architects representing Harris County, Galveston County, Houston, Deer Park, League City, and Pasadena; landscape architects and designers; stormwater managers; parks and recreation departments from various counties and cities; stormwater consultants; non-profit environmental groups; and staff from the University of Texas Medical Branch, Galveston, environmental office.

Pre-post knowledge assessments tests concluded that participants were completely satisfied with the information they received, all increased their knowledge of stormwater management and rain garden installation, and would “encourage their local municipalities to make use of rain gardens as viable Best Management Practices in both public and residential locations.”

Dr. Jaber leading the rain garden workshop in Deer Park

League City:
In partnership with League City and Texas A&M AgriLife Research and Extension Service, and TX A&M AgriLife Extension Master Gardeners and Master Naturalists, the WS Program coordinated a rain garden installation and hands-on workshop on Wednesday, April 11, 2012. This was the result of a partnership and collaboration with League City and the WS Program to install a demonstration rain garden to educate citizens in the Houston-Galveston area about the benefits of using this stormwater BMP (Best Management Practice) as an important stormwater management tool. League City is poised to create a WaterSmart Park that will feature several BMPs, including rain gardens.

Dr. Fouad Jaber, Assistant Professor and Integrated Water Resources Management Specialist, presented the two hour workshop which was then followed by attendees installing a rain garden. The twenty-seven participants included TX A&M AgriLIfe Extension Master Gardeners and Master Naturalists, city engineers and stormwater managers, landscape architects and designers, and residents.

Dr. Jaber leads rain garden workshop in League City

Dr. Jaber leads the hands-on portion of the rain garden workshop in League City

Follow up testimonials from participants:

Chris,

Thank you so much for the chance to participate. Learned much that I put to immediate use this past weekend at my home where I installed a rain garden to take advantage of runoff. David and I will be working the rain garden issue at MDA and we will let you know once we get one planned and ready for installation.

James (Jim) E. Power, P.E.
Chief Engineer (Civil)
Administrative Facilities and Campus Operations
UT M.D. Anderson Cancer Center

Dear Chris,

I have been working with some "semi-wild" rain garden/swales in a fruit orchard at St. Catherine's Montessori school. I started them before the workshop and learned some things I could have done better. Overall I think it did pretty well since they were planted not long before the extreme drought summer……

If I get a chance, I hope to make some additional improvements in grading, enhance plantings and maybe add another rain garden, since we still have some low areas that flood. Based on the workshop and experience I would put more than one specimen of each plant in an area.

I am hoping to add a rain garden at my home this fall. I will be able to use the principles from the workshop better there. I will be able to monitor it better and will need to keep it a bit more manicured to satisfy the HOA.

Best regards,
Lucy Randel

Task 4. Rain Garden section added to the WaterSmart website watersmart.tamu.edu

During the past year, the WS website's format and address changed at which time the website was migrated to be included under the TX A&M University umbrella (from watersmart.cc to watersmart.tamu.edu). Consequently the site had to undergo renovation and went to a WordPress format per TX A&M University requirements. Addition of content will be ongoing.

The rain garden section includes a link to download the rain garden manual. To follow their progress and growth, updated photos of the rain gardens will be regularly added. On each of the four rain garden signs located at each site, a QR code directs visitors to the website for more information.

Not yet completed is the mapping of the four rain gardens to allow visitors to take self-guided tours of the site.

The following shows visitor activity from the time rain garden information was first added to the website in late September 2011:
From October 2011—May 2013, visitors totaled 3,446 despite interruption due to the website change of address and format.

Appendix

GARDENING

IN THE GARDEN WITH URBAN HARVEST

Rain gardens help alleviate rainwater runoff problems

By Chris LaChance
HOMES CORRESPONDENT

Photos courtesy of Chris LaChance

A rain garden in League City.

There are many reasons to create landscapes in our yards — to add softness to the harsh angles of a home, to make the transition from the natural environment to the built environment appear more seamless, to abide by deed restrictions for foundation planting or simply to foster a passion for gardening. What if these same landscapes could serve important functions and go beyond aesthetics? What if they could help protect water quality, recharge groundwater and provide habitat for wildlife? If this seems like a tall order, that is exactly what rain gardens can do. And a rain garden can fit into almost any landscape.

First, a little background. In undeveloped areas, rainwater (also called storm water) soaks into the soil, provides water for plants and moves the remaining water far below the surface, also known as groundwater recharge. It is filtered by the plants and soil before it enters rivers, streams, bayous or lakes. As we develop the land, however, we create lots of impervious surfaces (places where water cannot penetrate), like parking lots, roadways, roofs and sidewalks. These cause water to run off more quickly — not allowing for much absorption — and to arrive at the nearest body of water in greater volume, contributing to flooding. The runoff often carries with it things that pollute our waterways such as synthetic fertilizers and pesticides, soil from erosion, oil and grease from cars, and pet waste. We created the problem but landscaping an area as a rain garden just might be a beautiful solution to effectively managing storm water where it falls.

Buttonbush grows in wet areas.

many sources such as a roof, sidewalks and streets, or a yard.

A rain garden is a shallow excavated area in the soil (think bowl-shaped), planted as a garden and designed to capture rainfall from impervious surfaces. The storm water pools for a period of time, slowing the flow and allowing some of it to soak into the soil. The rest of the storm water is filtered through the plant material, soil and mulch. This allows us to keep more of the rain that falls on our yards while the storm water that finally enters the storm drain is cleaner. Planted with native plants, specifically those indigenous plants that can tolerate wet and dry conditions, a rain garden also can function as a habitat for wildlife such as birds and butterflies. When designed properly, water in the rain garden should stand for no more than 24 to 48 hours, too short a period for mosquitoes to breed.

Location of a rain garden can be anywhere; however, careful evaluation is necessary to make sure it slopes gently away and is at least ten feet from the foundation of any structure and is free of utility lines. Also notice how and where rainfall moves across the property during a rain event since the rain garden can capture storm water from

For more detailed information regarding size, depth and soil mixture, refer to the Texas A&M AgriLife Extension Service publication on rain gardens, https://agrilifebookstore.org/ and search for rainwater harvesting. Click on the rain garden publication L-5482. The download is free.

Ways to direct the flow to the rain garden can be a downspout, a downspout with a corrugated pipe extension, a swale, which is a shallow ditch, or simply the slope of the yard.

Rain gardens have planting zones. Remember the bowl shape. For the center where water pools the longest, use native plants that can stand wet feet. The sides, the median zone, need those plants that like it wet for a short time. The top edges are the third zone so plants here like it dry most of the time. The plant list is quite long and varied.

Like any other planted area, a rain garden will need regular watering during the critical establishment period, usually one to two years and, thereafter, supplemental watering during extended dry periods. As with any garden, proper maintenance is necessary.

Crinum lilies like wet feet.

Above all, a rain garden is a landscape amenity, blending beauty and function — a beautiful, WaterSmart solution to water pollution.

Chris LaChance is WaterSmart Coordinator for the Texas A&M AgriLife Extension Service and Texas Sea Grant, part of the Texas A&M University System. WaterSmart is funded by a grant from Houston Endowment, Inc. Contact Chris at c-lachance@tamu.edu. This column is sponsored by Urban Harvest. To find out more about community gardens, school gardens, farmers markets and gardening classes, visit www.urbanharvest.org.

A GREENER VIEW

Follow these steps to save annual seeds for next year's garden

By Jeff Rugg
CREATORS SYNDICATE

Q: When I was a kid, my mom and the neighbor ladies would gather seeds from the marigolds and other plants. They spent the afternoon doing something to them and then in the spring, they replanted them with great success. I want to do that with my daughters. What do I need to do?

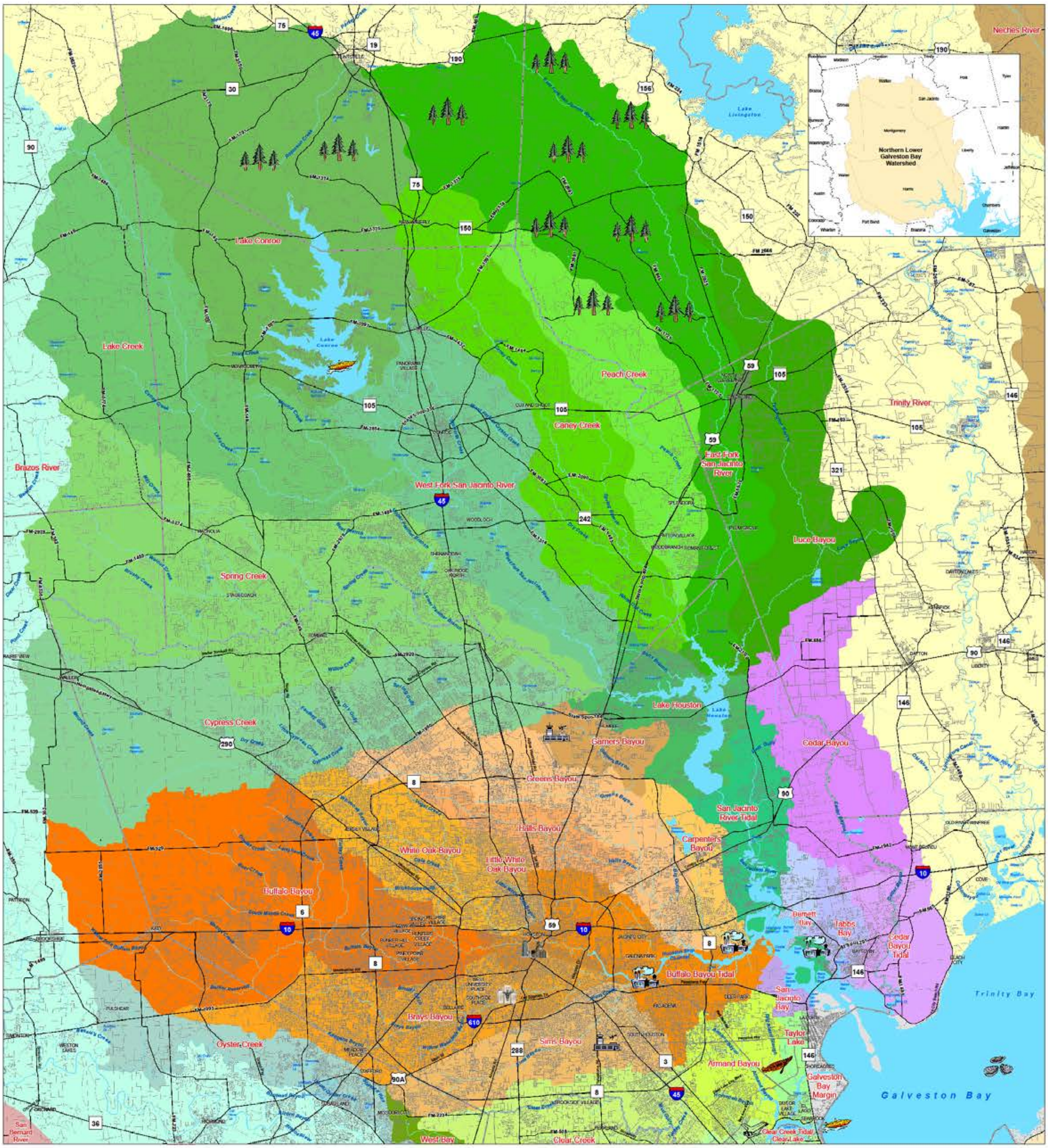
doing all afternoon. Chaff hides insects and their eggs. It may be moist, which will encourage fungal disease problems or cause the seeds to rot during storage. If you collected berries or other fruits such as tomatoes or cucumbers, you will need to get the seed out of the gooey stuff (a botanist's technical term) before letting the seeds dry out.

Save and store only clean and dried seeds. Place them in a cool dry location

Label the bags. You will forget what seed is in what bag, and other people may be inclined to throw them away if they are not labeled. The label needs to state the kind of seed with as much detail for the name, as you know. It needs to list the location and date they were gathered. Knowing how old the seeds are will be useful in the future. Seeds slowly grow while stored, and they will eventually die if not planted. Some seeds can last for many years, while others should be planted next spring.

Most seeds should be stored in a cool, dry location. The vegetable drawer of the refrigerator is a good place for most seeds. The paper bags of seeds can be stored

What is Your Watershed Address?



Northern Lower Galveston Bay Watershed

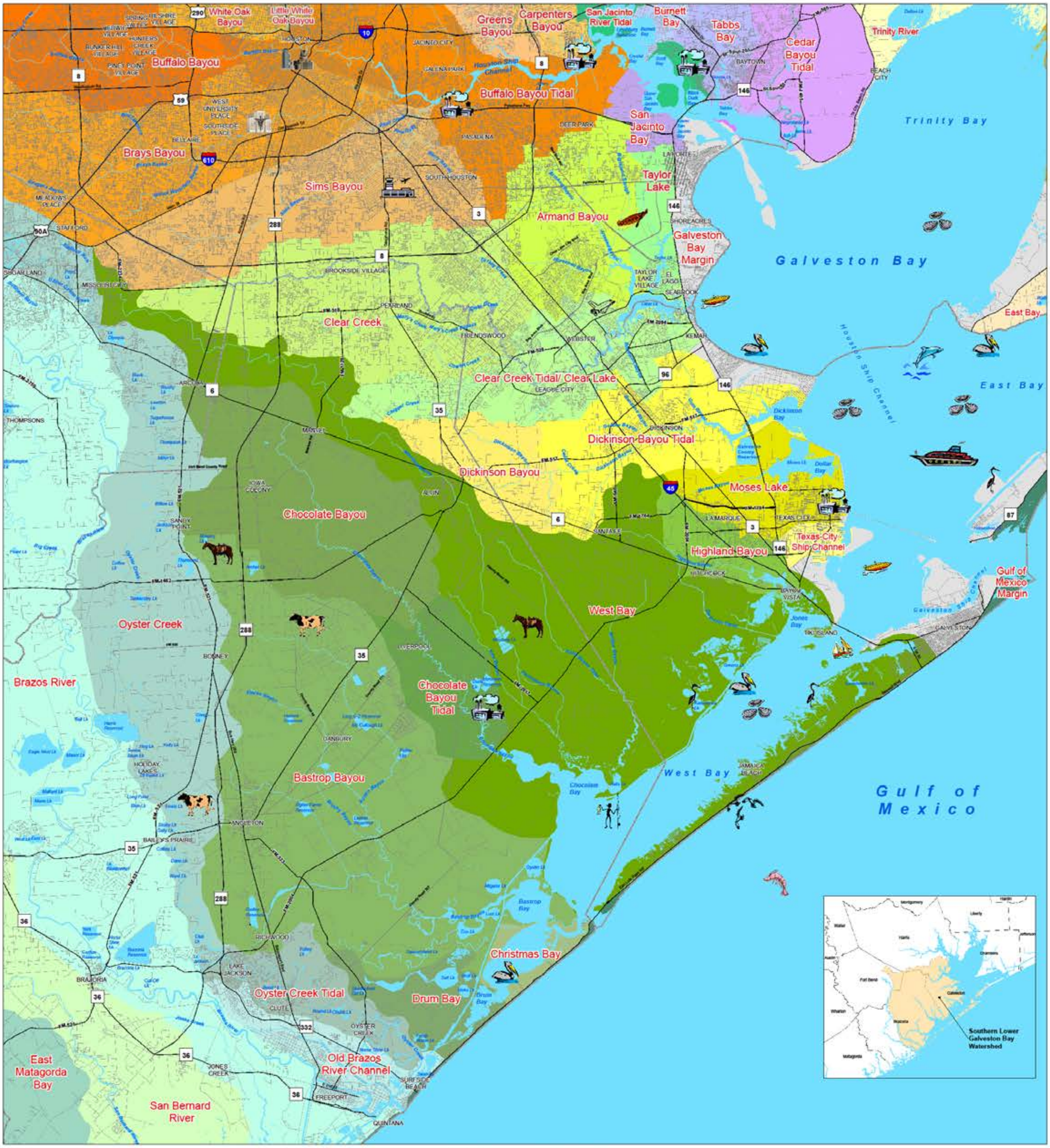
Sources:
Watersheds – Compiled and derived from Houston-Galveston Area Council CRP Watersheds, Texas Coastal Watershed Program/Texas A&M AgriLife Extension/Texas Sea Grant data, and USGS Hydrologic Unit Codes
Major Roads – Compiled and derived from Houston-Galveston Area Council [illegible] and modified by Texas A&M Sea Grant/Texas Coastal Watershed Program
Streets – Derived from 2012 TIGER/Line Shapefiles [illegible]
City Limits – Derived from Houston-Galveston Area Council [illegible]
Lakes and Rivers – Derived from US Geological Survey National Hydrography Dataset [illegible], from Texas General Land Office [illegible], and Texas Commission on Environmental Quality Stream Segments data
Counties – Derived from H-GAC [illegible]

[illegible]
Note: This map is to be used for educational purposes only.

Produced by [illegible], Texas Coastal Watershed Program/Texas A&M AgriLife Extension/Texas Sea Grant
March 2013

This poster is funded by a grant from the Coastal Coordination Council pursuant to National Oceanic and Atmospheric Administration Award No. NA10NOS4190207.

What is Your Watershed Address?



Southern Lower Galveston Bay Watershed

Texas Coastal Watershed Program | Texas A&M AgriLife Extension | Sea Grant Texas | Texas NEMO

This poster is funded by a grant from the Coastal Coordination Council pursuant to National Oceanic and Atmospheric Administration Award No. NA10NOS4190207

Sources:

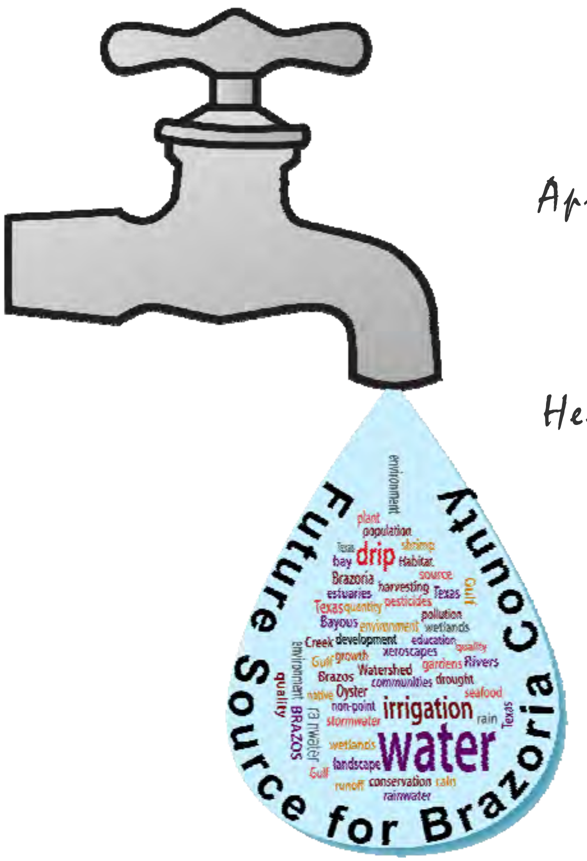
Note: This map is to be used for educational purposes only.

Legend

- Major Highways and Roads
- Open Water
- County Boundaries

1 in = 1.9 miles

2013 Lawn and Garden Water Conference



Saturday

April 13, 2013

8:00 a.m.

Henry Munson Park

2013 Lawn & Garden Water Conference

Saturday

April 13, 2013

8:00 a.m.

Henry Munson Park

Program Agenda

8:00am .... Registration/View Exhibits

9:00am .... Welcome
John P. O'Connell, CEA
Texas A&M AgriLife Extension Brazoria County

9:05am .... The State of Texas Water
Representative Dennis Bonnen,
Texas State Representative, District 25

9:45am .... Rain Water Harvesting
John Smith, Extension Specialist
Texas A&M AgriLife Extension

10:30am .... Break/View Exhibits

10:45am .... Rain Gardens
Chris LaChance
Water Smart Program Coordinator, Texas Sea Grant

11:15am .... Texas Native Plants
Mary Keilers,
Texas Native Plant Society

12:00pm .... Surveys/Q&A/ View Exhibits

Thank you Sponsors!

Program Agenda

8:00am .... Registration/View Exhibits

9:00am .... Welcome
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Texas A&M System

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01/12

Stormwater Management: Rain Gardens



Stormwater Management: Rain Gardens

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Assistant Professor and Extension Specialist

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The Texas A&M System

A rain garden is a planted shallow depression that collects rainwater runoff from roofs, parking lots, and other surfaces. While a rain garden can blend into the landscape and serve as a garden area, its main function is to retain and treat collected stormwater.

Rain gardens (also known as bioretention areas) are either bowl-shaped or surrounded by berms to retain water. They are typically planted with native or adapted vegetation that tolerates both waterlogging and drought.

Rain gardens can be constructed in a variety of soils from sand to clay. The size varies depending on the catchment area, which is the area where runoff ends up in the rain garden. Rain gardens can be incorporated into a home lawn or a parking lot (Figs. 1 and 2).

Figure 1. Rain garden built to capture rainwater from a parking lot and roof.

Figure 2. Rain garden built as an island in a parking lot. (Source: United States Department of Agriculture, Natural Resources Conservation Service)

Rain garden benefits include:

- Less stormwater runoff
- Slower runoff
- Less pollution in the runoff
- More water to replenish groundwater supplies
- Improved landscape

How Do Rain Gardens Work?

Rain gardens use the chemical, biological, and physical properties of soils, plants, and microbes to remove pollutants from stormwater through four processes:

- Settling
- Chemical reactions in the soil
- Plant uptake
- Biological degradation in root zones

Settling

When runoff enters a rain garden, the water slows down because of the physical depression of the garden and the vegetation in it. The soil and debris that are then deposited cause settling.

The vegetation also traps some of the pollutants attached to the sediment in a process known as filtration. The main pollutants trapped in rain gardens are debris, some microbes, other solids suspended in the water, and soil-particle-bound pollutants such as phosphorus. Because sediments tend to settle on top of the rain garden and clog it, the garden must be maintained regularly to help remove sediments efficiently.

Chemical Reactions in the Soil

The soil in rain gardens interacts with pollutants via two main processes: adsorption and volatilization.

- Adsorption occurs when the pollutants stick to soil particles.
- Volatilization occurs when the pollutants evaporate.

Plant Uptake

Plants take up nutrients through their roots and use the nutrients for growth and other processes. Plants can be selected for high nutrient uptake.

When the plants die, those nutrients may be released back into the rain garden. To prevent this release, remove the dead plants regularly.

Biological Degradation in Root Zones

Microbes in the soil break down organic and inorganic compounds, including oil and grease, and help eliminate disease-causing microorganisms, or pathogens. Two microbial processes that remove nitrogen from the soil are nitrification and denitrification:

In nitrification, bacteria convert nitrogen products that are not readily taken in by plants, such as ammonia and ammonium nitrates, into nitrate, which is soluble in water and easily absorbed by the root system.

Denitrification occurs when bacteria convert nitrate into gases that are released into the atmosphere. Denitrification requires specific conditions such as low oxygen (as in waterlogged conditions), high temperature, and the presence of organic matter.

Design and Construction of Rain Gardens

Two common rain garden designs are used for stormwater retention:

- A planted depression is placed downstream from a drainage area. This design is commonly used in home and retail landscapes to collect rain from roofs or in sandy soil areas with high infiltration rates. For information on designing and building a residential rain garden, see *Rainwater Harvesting: Raingardens*, Texas AgriLife Extension publication L-5482.
- Existing soil is replaced with layers of high-infiltration soils, gravel, and mulch, and a variety of vegetation is planted. This design also commonly includes a perforated drainage pipe placed at the bottom of the growing media but above the gravel layer. It is best suited for clay soil, parking lots, and highway medians.

Selecting a Site

To select the location for a rain garden, consider the existing land use, vegetation, slope, proximity to building foundations, and the aesthetic value of the site. A rain garden should be designed to collect runoff from an area of no more than 1 to 2 acres. Larger areas can produce flows that cause erosion.

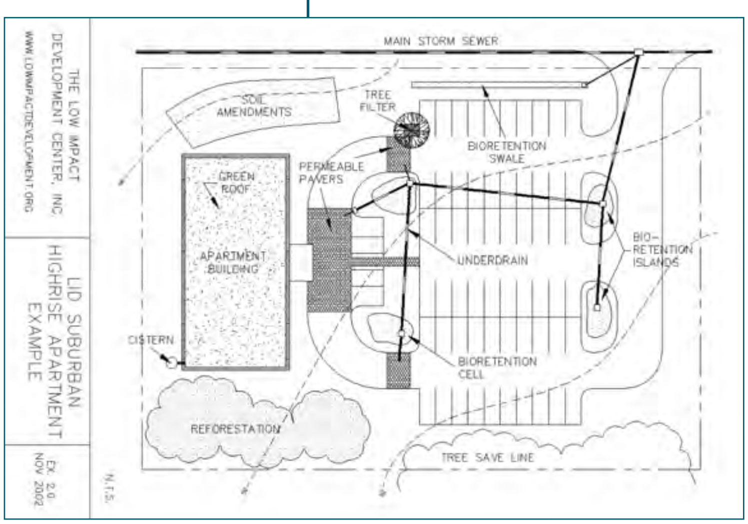

Figure 3. Parking lot design showing several rain garden cells connected with underground drains. (Source: Low Impact Development Center Inc.)

If the rain garden will collect runoff from a parking lot, replace some of the paved area instead of putting the rain garden in an existing grassed area that already filters stormwater.

Avoid placing the rain garden close to soil disturbed by construction so that the rain garden won't be clogged by sediments from the construction site runoff. If it must be close to a disturbance, use best management practices such as installing silt fences to protect the garden. In clay areas, it should be at least 10 feet (but preferably 30 feet) away from buildings to prevent any damage to foundations.

Determining the Catchment (or Contributing) Area

If the rain garden will be used to collect roof runoff, the catchment area will consist of the roof area as well as the area between the building and the rain garden.

For parking lots, determine the drainage pattern or design to estimate the catchment area. If the parking lot is not level or water flows out in more than one location, use a topographic map to delineate the catchment area. A surveyor can do this step manually or by using Geographic Information System (GIS) software.

If the area is larger than 2 acres, consider building two or more rain garden cells (Fig. 3). Rain gardens can be placed as islands in parking lots with concrete-curb cut openings (Fig. 4).

Figure 4. Curb cut opening. (Source: USDA, NRCS)

1. Runoff Volume Calculation

Not all rain becomes stormwater. Some rain is trapped in depressions; some seeps into the soil; some evaporates.

There are various ways to estimate the amount of runoff after a rain. A common method is the Natural Resources and Conservation Service (NRCS) Curve Number Method:

$$\text{Runoff depth} = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

Where:

P is precipitation (inches).

$$S = \frac{1000}{CN} - 10$$

CN is the curve number.

The curve number is a land use and soil type factor that reflects the imperviousness of the ground surface (Table 1).

Table 1. Curve numbers for various types of land and hydrologic groups.

Cover Type and Hydrologic Soil Group	A	B	C	D
Open space (lawns, parks, golf courses, cemeteries, etc.)	49	69	79	84
Paved parking lots, roofs, driveways, etc.	98	98	98	98
Streets and roads:				
Paved, curbs and storm drains	98	98	98	98
Paved, open ditches	83	89	92	93
Gravel	76	85	89	91
Dirt	72	82	87	89
Urban areas:				
Commercial and business (85% impervious)	89	92	94	95
Industrial (72% impervious)	81	88	91	93
Developing urban areas: Newly graded areas (pervious areas only, no vegetation)	77	86	91	94

(Adapted from TXDOT Hydraulic Design Manual)

Hydrologic Soil Group Descriptions

A: Well-drained sand and gravel, high permeability

B: Moderate to well-drained, moderately fine to moderately coarse texture, moderate permeability

C: Poor to moderately well-drained, moderately fine to fine texture, slow permeability

D: Poorly drained, clay soils with high swelling potential, permanent high water table, claypan, or shallow soils over nearly impervious layer(s)

Most rain gardens are designed for a 1-inch storm, allowing them to perform as a first-flush system. The first flush of runoff is usually the most polluted as it carries all the debris and pollution that accumulated since the previous rainfall. Rainfall in excess of 1 inch goes through an overflow system.

As a first-flush system, a rain garden will retain most of the rainfall during the course of a year. For example, storms with more than 1 inch per day happen only 12 times a year, on average, in Dallas, Texas.

To calculate the total volume, multiply the runoff depth by the catchment surface area using the following formula:

$$\underset{\text{(gallons)}}{\text{Runoff volume}} = \underset{\text{(inches)}}{\text{Runoff depth}} \times \text{area (ft}^2\text{)} \times 0.623$$

Example 1: Calculating Runoff Volume

Maggie wants to build a rain garden to collect stormwater flowing off the 3,000-square-foot paved parking lot of her store built on clay soils. She first calculates the runoff depth resulting from a 1-inch rain. From the curve number table, she identifies that her hydrologic soil group is D, and for paved parking lots, the curve number CN is 98. She then calculates the value of S from the curve number method equation:

$$S = \frac{1000}{CN} - 10 = \frac{1000}{98} - 10 = 0.20$$

She then calculates the runoff resulting from a 1-inch rainfall using the following equation:

$$\text{Runoff depth} = \frac{(P - 0.2S)^2}{(P + 0.8S)} = \frac{(1 - 0.2 \times 0.2)^2}{(1 + 0.8 \times 0.2)} = 0.79 \text{ inches}$$

She then determines the volume in gallons that 0.79 inches make on 3,000 square feet of parking lot:

$$\underset{\text{(gallons)}}{\text{Runoff volume}} = \underset{\text{(inches)}}{\text{Runoff depth}} \times \text{area (ft}^2\text{)} \times 0.623$$

3,000 ft^2

$$\underset{\text{(gallons)}}{\text{Runoff volume}} = 0.79 \text{ (inches)} \times 3{,}000 \text{ (ft}^2\text{)} \times 0.623 = 1{,}869 \text{ (gallons)}$$

Rain Garden Design

Figure 5. Placing a perforated pipe on top of the gravel.

Follow these steps to build a 3-foot-deep rain garden, the usual size:

1. Fill the bottom foot (the retention zone) with gravel (0.5 to 1.5 inches in diameter—sometimes called #57 stone).
2. At the top of this layer, place a perforated underdrain pipe for drainage purposes (Fig. 5).
3. Lay a filter fabric over the gravel and the drain to reduce the silting of the gravel zone (optional) (Fig. 6).
4. Place 1.5 feet of soil over the filter fabric.

Figure 6. Placing the filter fabric.

5. If the native soil is of low infiltration such as clayey soils, bring in soil from another area. The soil should consist mainly of sand or another coarse material such as crushed expanded shale, yet still contain some fine material and organics to support plant growth. For clay soil, use a mix of 50 percent compost, 25 percent native soil and 25 percent expanded shale (or similar material). For sandy soils, use a 50 to 75 percent native soil and 25 to 50 percent compost mix. Use well-aged yard waste compost.
6. Add 2 inches of mulch, preferably well-aged shredded hardwood, which will not float, on top of the soil around the plants.
7. Build the rain garden to hold 6 to 9 inches of water over the top of the soil (Fig. 7). Assuming that the gravel and soil are 30 percent pore space, calculate the depth of water the rain garden will hold at full capacity. One foot of gravel with 30 percent pore space will hold 3.6 inches of water. One and a half feet of expanded shale/clay/compost mix with a 30 percent pore space will hold 5.4 inches of water.
8. Add the 6 inches of standing water on top of the rain garden soil for a total water depth of 15 inches (Fig. 8).

Figure 7. Completed rain garden.

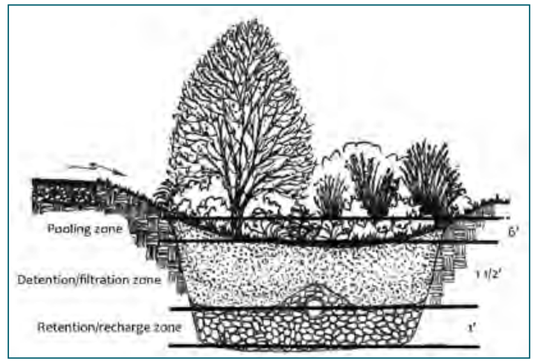

Figure 8. Typical cross section of a rain garden. (Source: George's County, Maryland)

Rain Garden Sizing

To determine the surface area of the rain garden, divide the total amount of runoff by the depth of water held at full capacity. The water volume in gallons held in a square foot of rain garden is:

$$\text{Volume per square foot (gallons)} = \text{Water depth (inches)} \times 0.623$$

$$\text{Surface area of rain garden (ft}^2\text{)} = \frac{\text{Volume of runoff (gallons)}}{\text{Volume per square foot (gallons per ft}^2\text{)}}$$

Example 2: Calculating the Size of the Rain Garden

After determining the runoff volume generated from her parking lot, Maggie needs to calculate the size of her rain garden. Knowing that her rain garden holds a water depth of 15 inches, she first calculates the volume of water held in each square foot of rain garden using the following equation:

$$\text{Volume per square foot (gallons)} = \text{Water depth (inches)} \times 0.623$$

$$\text{Volume per square foot (gallons)} = 15 \text{ (inches)} \times 0.623 = 9.35 \text{ gallons}$$

Using this number and the total runoff volume from Example 1, she calculates the surface area required to build her rain garden:

$$\text{Surface area of rain garden (ft}^2\text{)} = \frac{\text{Volume of runoff (gallons)}}{\text{Volume per square foot (gallons per ft}^2\text{)}}$$

$$\text{Surface area of rain garden (ft}^2\text{)} = \frac{1{,}869 \text{ (gallons)}}{9.35 \text{ gallons per ft}^2} = 200 \text{ ft}^2$$

Maggie needs 200 square feet to build a rain garden that will hold runoff from 1 inch of rainfall falling on her parking lot. This amounts to 6.67 percent of the total catchment area. Typically, rain gardens range from 3 to 10 percent of the total catchment area.

Table 2. Typical hydraulic conductivity (K) ranges for various soil types.

Soil Texture	Saturated Conductivity (in./hr)
Sand	8.27
Loamy sand	2.41
Sandy loam	1.02
Sandy clay loam	0.17
Loam	0.52
Silt loam	0.27
Clay loam	0.09
Silty clay loam	0.06
Silty clay	0.04
Clay	0.02
(Adapted from *Handbook of Soil Science*, Sumner ME, 2000)	

Table 3. Manning's roughness coefficient for various types of pipes.

Surface Material	Manning's Roughness Coefficient n
Brass	0.011
Brick	0.015
Cast iron, new	0.012
Copper	0.011
Corrugated metal	0.022
Galvanized iron	0.016
Plastic	0.009
Steel, coal-tar enamel	0.010
Steel, new unlined	0.011
Steel, riveted	0.019

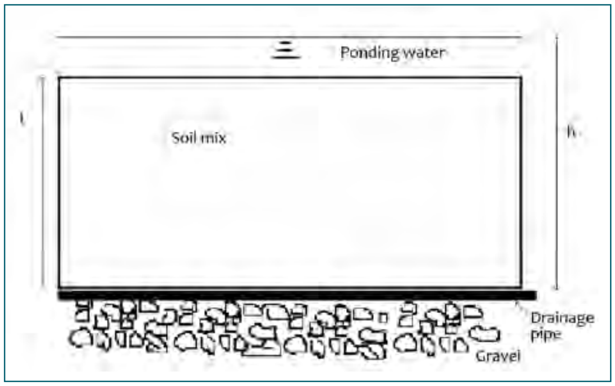

Figure 9. Cross section of a rain garden showing the height of water above the drain (h) and the depth of the soil (L) of Darcy's Law.

Drainage Pipe Sizing

The drainage pipe placed under the soil area (1.5 feet) should be designed to carry up to 10 times the minimum flow through the soil calculated using Darcy's Law:

$$Q = AK\frac{h}{L}$$

Where:
Q is the flow through the soil media (cfs).
A is the rain garden surface area.
K is the hydraulic conductivity of the soil or how fast water flows through the soil.
h is the height of water above the drain.
L is the depth of the soil (Fig. 9).

The hydraulic conductivities for various soils are in Table 2.

To determine the size of the perforated pipe, use the Manning's equation:

$$D = 16 \times \left[\frac{n \times Q}{S^{0.5}}\right]^{3/8}$$

Where:
D is the diameter of the pipes (inches).
Q is the flow to be carried (cfs).
n = Manning roughness coefficient (0.01 for smooth plastic pipe)
S = slope of the pipe (for this site, assume 0.1 percent)

A list of Manning's roughness coefficients for various pipe types is in Table 3.

Example 3: Sizing the Drainage Pipe

In Example 2, Maggie determined that her rain garden needs to be 200 square feet. To size the underdrain, she needs to calculate the flow going through the loamy sand soil at capacity. The depth of her soil L is 1.5 feet. The height of the water above the drain h is the 1.5 feet of soil plus the 6 inches of standing water, which is equal to 2 feet. From Table 2, a loamy sand will have a hydraulic conductivity of 2 inches per hour. Applying the Darcy equation:

$$q = K\frac{h}{L}$$

$$q = 2.41\ in./hr\left(\frac{2\ ft}{1.5\ ft}\right) = 3.21\ \text{in./hr per square foot of rain garden.}$$

For 200 square feet, the total flow is

$$Q = 200\ ft^2 \times 3.21\ in./hr \times \left(\frac{1}{12}\ in./ft\right) \times \left(\frac{1}{3600}\ hour/sec\right) = 0.015\ cfs$$

The pipe needs to be designed for 10 times the calculated flow, that is 0.15 cfs. To determine the pipe size, using a plastic pipe, determine the roughness coefficient from Table 3 for plastic n = 0.009. If the pipe is laid at a 0.1% (0.001) slope, you can calculate the size of the pipe using Manning's equation:

$$D = 16 \times \left[\frac{n \times Q}{S^{0.5}}\right]^{3/8}$$

$$D = 16 \times \left[\frac{0.009 \times 0.15}{0.001^{0.5}}\right]^{3/8} = 4.90\ inches$$

Rounded up to the nearest available pipe size, we find that a 6-inch pipe is needed to carry the water ten times the minimum flow rate from this site.

Overflow Design

If more rain falls than can be filtered by the rain garden, it may overflow. Design your rain garden to account for this possibility. The solution can be as simple as allowing the water overflow at the downstream end. This design requires a large enough vegetated area to absorb the overflowing water.

If the rain garden is next to an impervious area such as a road, you will need an alternative strategy such as redirecting overflow. To route overflow into an adjacent drain or ditch:

1. Install an overflow drop box (catch basin) (Fig. 10).
2. Place the top (inflow) of the drop box at least 6 inches higher than the top of the rain garden soil. This allows for holding 6 inches of water on top of the rain garden.
3. Connect the outlet of the drop box to a pipe that routes the water to the adjacent drainage system.

Figure 10. Drop box for overflow in a rain garden.

Plant Selection

Plants placed in rain gardens should be able to withstand short periods of inundation (up to 48 hours), as well as drought conditions. The vegetation you select will depend on regional weather conditions and the adaptability of the plants. Ask a county horticulture Extension agent, local horticulturist, Texas Master Gardener, or local nursery manager for a list of plants suitable for rain gardens in Texas. A partial list is shown in Table 4.

Table 4. List and characteristics of rain garden plants

Botanical Name	Common Name	Height/Width	S/SH	W/D
Perennials				
Achillea millefolium	Yarrow	1 ft/1 ft	S	D
Acorus calamus	Sweet flag	4 ft/2 ft	S	W
Alstroemeria pulchella	Peruvian	3 ft/2 ft	S/PSH	W/D
Aquilegia hinckleyana	Texas columbine	12 in./12 in.	S	W/D
Asclepias tuberosa	Butterfly weed	3 ft/6 in.	S	D
Aspidistra elatior	Cast iron plant	24 in./24 in.	SH	W/D
Amorpha fruticiosa *	False indigo	5 ft to 10 ft/8 in.	S/PSH	W
Baptisia australis	Blue false indigo	3 ft to 6 ft/24 in.	S	W
Calyptocarpus vialis	Horseherb	4 in./18 in.	SH	W/D
Canna generalis	Canna	2 ft to 6 ft/2 ft to 6 ft	S	W
Coreopsis verticillata 'Moonbeam'	Moonbean coreopsis	1 ft/1 ft	S/PSH	W/D
Dichondra argentea 'Silver Falls'	Silver falls	2 in./4 in.	S/PSH	D
Echinacea purpurea	Purple cone flower	2 ft/2 ft	S	W/D
Eupatorium coelestinum	Blue mistflower	8 in./16 in.	S	W/D
Eupatorium purpureum	Joe-Pye weed	4 in. to 4 ft/2 ft	S/SH	W
Heliopsis helianthoides	Ox-eyed sunflower	3 in. to 5 in./30 in.	S	W
Hibiscus coccineus	TX Star hibiscus-red	6 ft/4 ft	S	W/WD
Hibiscus coccineus 'Lone Star'	TX Star hibiscus-white	6 ft/4 ft	S	W/WD
Hibiscus moscheutos	Swamp rose mallow	3 ft to 4 ft	S	W/D
Hymenocallis liriosme	Spider lily	2 ft/1 ft	S	W/D
Ipomopsis rubra	Standing cypress	2 ft to 6 ft/6 in. to 12 in.	S	W
Iris spp. *bearded* and hybrids	Iris	12 in./6 in.	S	D
Iris brevicaulis Louisiana species and hybrids	Louisiana iris	Up to 40 in./6 in.	S/PSH	W
Kosteletzkya virginica	Marsh mallow	6 ft/6 ft	S	W
Liatris spicata	Gayfeather	2 in./18 in.	S	W
Lobelia cardinalis	Cardinal flower	2 ft to 4 ft/2 ft	S/PSH	W
Lythrum salicaria	Loosestrife	3 ft/3 ft	S	W/D
Monarda fistulosa	Bee balm	2 ft/2 ft	S	W/D
Rudbeckia hirta	Black-eyed Susan	1 ft to 2 ft/1 ft	S	W/D
Rudbeckia fulgida 'Goldstrum'	Black-eyed Susan	2 ft/2 ft	S	W/D
Rudbeckia maxima	Giant coneflower	4 ft to 6 ft/2 ft to 3 ft	S	W
Ruellia brittoniana 'Katie's'	Ruella Katie	6 in./12 in.	S	W/D
Salvia coccinea	Scarlet sage	3 ft to 5 ft/1 ft to 2 ft	S/SH	W/D
Setcreasea pallida	PurpleHeart	12 in./24 in.	S/PSH	W/D
Sisyrinchium angustifolium	Blue-eyed grass	6 in. to 12 in./12 in.	S	W/D
Solidago altissima	Goldenrod	2 ft to 4 ft/3 ft to 5 ft	S	W/D

continued on next page

Table 4 continued.

Botanical Name	Common Name	Height/Width	S/SH	W/D
Perennials continued				
Stachys byzantina	Lamb's ear	6 in./12 in.	S	D
Tradescantia occidentalis	Spiderwort	2 ft/1 ft	SH/PSH	W/D
Vernonia fasciculata	Ironweed	4 ft to 6 ft	S	W
Zephyranthes spp.	Rain lily	6 in. to 10 in.	S	W
Grasses				
Carex spp.	Sedge	Varies	Varies	W/D
Chasmanthium latifolium	Inland seaoats	2 ft to 4 ft	SH	W
Muhlenbergia reverchonii	Seep muhly	2 ft to 4 ft	S	W
Panicum virgatum	Switch grass	3 ft to 4 ft	S	W/D
Shrubs				
Aesculus pavia	Scarlet buckeye	10 ft to 15 ft/6 ft to 10 ft	PSH/SH	W/D
Callicarpa Americana	American beauty berry	4 ft to 6 ft/5 ft to 8 ft	S/SH	W/D
Cephalanthus occidentalis *	Buttonbush	5 ft to 15 ft/6 ft to 8 ft	S/PSH	W
Clethra alnifolia	Summersweet clethra	3 ft to 10 ft/5 ft	S/PSH	W/W/D
Ilex decidua	Possumhaw holly	20 ft/15 ft	S/SH	W/D
Ilex vomitoria	Yaupon	20 ft/20 ft	S/SH	W/D
Itea virginica	Virgina sweetspire	3 ft to 5 ft/3 ft	PSH	W/D
Leucothoe recemosa *	Leucothoe, Sweetbell	3 ft to 10 ft/6 ft	S/PSH	W/W/D
Myrica cerifera	Southern wax myrtle	15 ft/10 ft	S/SH	W/D
Sabal minor	Dwarf palmetto	4 ft/5 ft	SH	W/D
Symphoricarpos orbiculatus	Coralberry	1 ft to 6 ft/1 ft to 2 ft	PSH/SH	D
Spirea x bumalda 'Anthony Waterer'	Anthony water spirea	2 ft to 3 ft/3 ft	S	D
Trees				
Acer rubrunm var. drummondii	Southern swamp maple	70 ft/30 ft	S	W/D
Betula nigra	River birch	30 ft to 50 ft/20 ft to 30 ft	S/PSH	W/D
Cyrilla racemiflora *	Leatherwood (Titi)	15 ft/10 ft to 15 ft		W/D
Magnolia virginiana	Sweet bay magnolia	2 ft to 30 ft/20 ft	S/PSH	W/W/D
Sophora affinis	Eve's necklace	30 ft/20 ft	S	W/D
Taxodium distichum	Bald cypress	70 ft/30 ft	S	W/D

S – Sun SH – Shade PSH – Part Shade W – Wet D – Dry
* Suitable for Texas Gulf Coast

Cost

Construction activity and materials required to build a rain garden include:

- Excavation and hauling of existing soil
- Importing new soil
- Gravel
- Filter fabric
- Mulch
- Perforated pipes
- Overflow drop box
- Plants

The per-unit area (square feet) cost of building a rain garden will vary based on the size of the rain garden, the type of soil, and the design (bowl shaped vs. gravel and soil design).

An estimate of the costs for the activities and materials in the previous example are listed in Table 5. The cost of building this rain garden are also calculated and normalized per square foot.

Table 5. Cost estimate for rain garden construction.

Activity/Material	Unit	Unit cost	Cost for 200 ft^2
Excavation/hauling	Cubic yard	$6.30	$150
New soil import and installation	Cubic foot	$.5	$200
Gravel import and installation	Cubic foot	$.5	$150
Filter fabric	Square foot	$.5	$100
Mulch	Square foot	$0.5	$100
Perforated pipe	Linear foot	$2	$50
Overflow drop box	1 box	$50	$50
Plants	Square foot	$2	$400
Total			**$1,200**
Cost/ft^2			**$6**

Operation and Maintenance

Rain gardens work best when they are maintained regularly. Completing the following practices on a regular basis is essential.

- Remove or thin weeds and invasive and overly aggressive plants regularly, preferably by hand, to reduce water contamination.
- Monitor diseases and insects and remove infected plants as soon as you see them.
- Aerate and add compost regularly to reduce compaction and decreases in the infiltration rate.
- Shovel out any clay layer that forms from sedimentation on the top of the rain garden.
- Water during drought and high heat, usually if less than 0.5 inches of rain has fallen in the previous 3 weeks.

Resources

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Texas Water Resources Institute
make every drop count

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7.5M, New

Rain Garden Workshops

free

FRIDAY, APRIL 15

9:00AM—2:00PM

Claude Burgess
Community Center
4200 Kalwick Dr
Deer Park, TX 77536

Please bring a sack lunch. Drinks and snacks will be provided.

Who should attend?

- Municipal Officials
- City/County Engineers and Architects
- Landscape Architects
- Landscape Designers
- Stormwater Managers
- Community Leaders
- Residents

RSVP

Questions?

Chris LaChance

281.218.0721

c-lachance@tamu.edu

RAIN GARDENS: A HANDS-ON WORKSHOP

MANAGING STORMWATER WHERE IT FALLS

Join Dr. Fouad Jaber, Assistant Professor and Integrated Water Resources Management Specialist, Texas AgriLife Extension, as he leads an educational program on stormwater management which includes hands-on construction of a rain garden.

Participants will help to install a rain garden. Come prepared to get dirty!

RSVP REQUIRED

Sea Grant Texas

AgriLIFE EXTENSION Texas A&M System

TEXAS COASTAL WATERSHED PROGRAM

WaterSmart

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION NOAA U.S. DEPARTMENT OF COMMERCE

CITY OF DEER PARK Birthplace of Texas EST. 1892

DEER PARK Parks & Recreation QUALITY - FIRST TIME, EVERY TIME

TEXAS COASTAL MANAGEMENT PROGRAM

RAIN GARDENS: A HANDS-ON WORKSHOP

MANAGING STORMWATER WHERE IT FALLS

Learn by doing!
Participants will help to install a rain garden.

Join Dr. Fouad Jaber, Assistant Professor and Integrated Water Resources Management Specialist, Texas AgriLife Extension, as he leads an educational program on stormwater management which includes hands-on construction of a rain garden.

The workshop is free, but registration is REQUIRED.

Space is limited.
Come prepared to get dirty!

free

WEDNESDAY, APRIL 11

8:30AM—3:00PM

Lecture at:
Johnnie Arolfo
Civic Center
400 West Walker
League City, 77573

Rain Garden Installation:
Heritage Park
1220 Coryell St
League City, 77573

Who should attend?

- Municipal Officials
- City/County Engineers and Architects
- Landscape Architects
- Landscape Designers
- Stormwater Managers
- Community Leaders
- Residents

Please bring a sack lunch. Drinks and snacks will be provided.

RSVP

Questions?

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AgriLIFE EXTENSION
Texas A&M System

Rain Garden Workshop

Sea Grant
Texas

April 15, 2011

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Rain Garden Workshop

AgriLIFE EXTENSION Texas A&M System — Sea Grant Texas

April 15, 2011

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RainGarden Workshop April 11, 2012

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	Locke	Luz	LLocke@ci.pasadena.tx.us	Luz H Locke	Excellent presentation. please send it to me.
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✓	ELDER	KATHY	katelder@sbcglobal.net	Kathy Elder (PDF Please)

Letters from Students

2228 Ocotillo, St
Leauge city
77573
Wed/1-30-13

Dear Ms. La Change,

Thank you for teaching us about the water smat program. I really liked the word biorentention which means rain garden. Plus I liked to learn about the impervious sufaces. I never Knew that if the land was sloped it could help the water Flow. And how dog dropping can effect drinking water. We appreciate yout time and effert to visit our class.

Sincerely,

Samantha Wood

2202 Hethergreen
Clearlake TX
77062
Wed. 1-30-13
@Isabelle_Dance7

Dear ms. Lachance

Thank you for teaching us about the water smart. I will use this info. I learnd alot from you. I hope you can come again. I also learnd about rain gardens (bioretention) You thought me about plutions. You told me about what type of plants can hold water but not to much but like native plants. I herd my science teacher back at school was teaching use about this stuf to. We appreciate your time and effort to veset our class. You are the smart one to teach us smart things

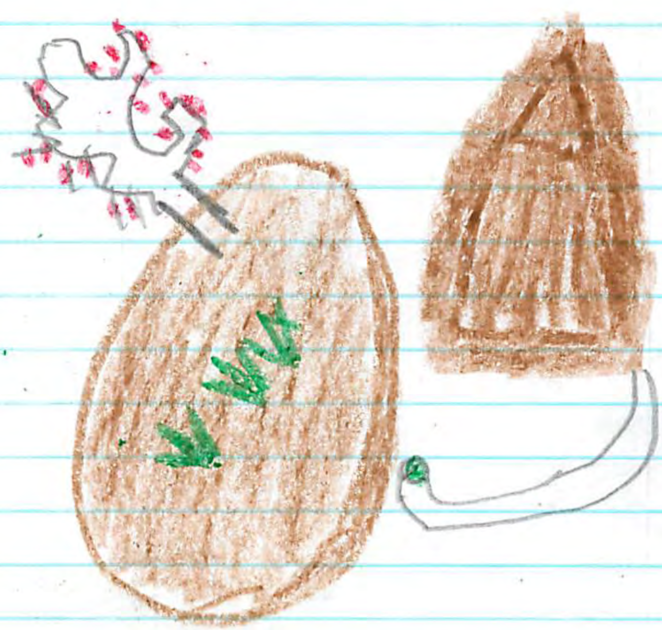
Sincereley,
Isabelle Chan
Science Trek

Ramla place Tr. Houston
Tx. 77089
Wed. 01-30-13

Dear Ms. La Chance

Thank you for teaching us about the Watersmart program. I learnd that impervious surfaces is surfaces that don't hold water. Thanks for teaching us how to care to take care of water. I learnd what types of plants and that native plant are the best for a rain garden. I learnd what can pollution our water. Thanks for teaching us about a beautiful solution for less water pollution. We appreciate your time and effert to visit our classroom.

Sincerely,
Walter Zelaya



1851 Raintree Circle
Seabrook, Tx 77586
January 30, 2013

Dear Ms LaChance,

Thank you for teaching us about the watershed! You are always so helpful and sincere to each and every child. I appreciate your extra effort in bringing the large watershed map so each of them could learn which watershed they live in. It is always interesting to learn how much they do not know about Galveston Bay. I love the slide show with impervious surface diagrams and details about stormwater management! I am glad they could walk around the rain garden to see the different plants. We appreciate your time and effort to visit the Science Trek class.

Sincerely,
Sheila Brown
Teacher