Ecological Revitalization on the Bayou

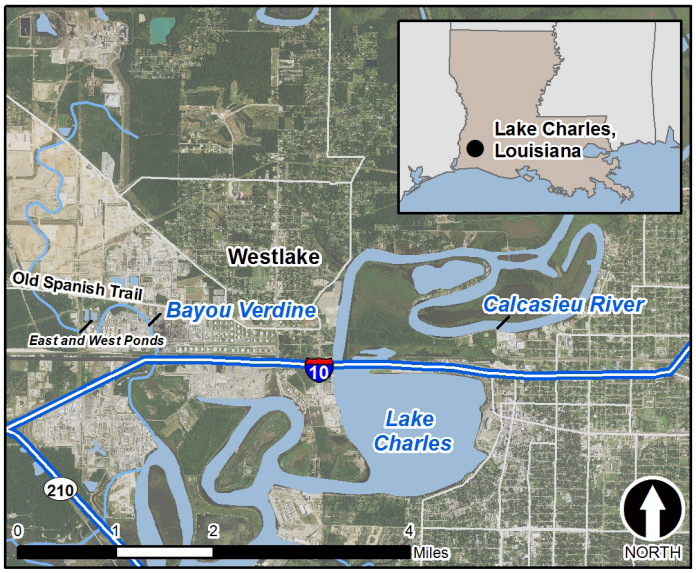
BAYOU VERDINE IN CALCASIEU PARISH, LOUISIANA

Introduction

Bayou Verdine is a shallow, tidal channel in a heavily industrialized area of southwestern Louisiana. The bayou flows into the Calcasieu Estuary, an important nursery area for many fish and wildlife species. To remove industrial contamination, about 1.5 miles of the bayou were dredged, and the contaminated sediments were placed in a containment cell. This case study tells how the containment cell area was designed not only to contain the contaminated sediments, but also to allow an innovative ecological revitalization that benefits an array of species.

The Bayou Verdine cleanup demonstrates how out-of-the-box thinking about reuse, coupled with cleanup parties committed to environmental stewardship, can turn a standard cleanup into an environmental asset that will provide benefits for years to come.

The case study provides useful information and lessons learned to companies, local governments, communities and regulators interested in exploring ecological revitalization at other cleanup sites across the United States.



Bayou Verdine is located near Lake Charles in southwest Louisiana, about 130 miles west of Baton Rouge.

Great egret in the bioswale constructed at the Bayou Verdine site (left); a damselfly rests on the site's vegetated cap (top right); native flora planted along the bioswale (bottom right).

Site History, Contamination and Remediation

Bayou Verdine is located in a heavily industrialized area; over 30 major companies are active nearby. The two companies responsible for cleaning up the bayou, Phillips 66 and Sasol North America (the cleanup parties), operate a petroleum refinery and a petrochemical complex. Both of these facilities have operated for decades, during which time their operations contaminated bayou sediments with polycyclic aromatic hydrocarbons (PAHs) and heavy metals. In 2003, the U.S. Environmental Protection Agency completed a remedial investigation for the Calcasieu Estuary. EPA's investigation found that contamination in Bayou Verdine did not pose a threat to people but was harmful to plants and animals.

In 2010, Phillips 66 and Sasol signed a consent decree agreeing to clean up the bayou. EPA approved the removal action work plan in December 2011. Cleanup work began in September 2012.

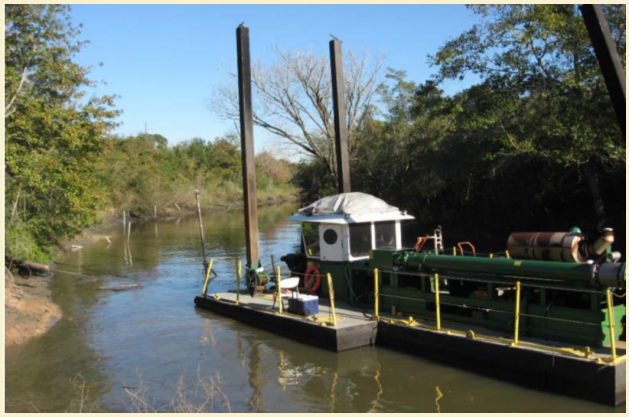
The cleanup parties first prepared a settling basin to receive sediments to be dredged from the bayou. Two pre-existing ponds on the refinery property had been created decades ago to provide fill for construction of nearby Interstate 10. One of these ponds (the east pond) was converted into the settling basin. It was emptied by pumping the water into the bayou. The bottom sediments were solidified by mixing in fly ash and a drainage system was placed at the bottom of the basin. Finally, the cleanup parties installed a flexible membrane liner on the bottom of the settling basin as an extra precaution.

Bayou dredging followed. The cleanup parties used hydraulic dredging and mechanical excavation techniques to remove the top 1 to 2 feet of sediments from about 7,000 feet of the bayou on the Phillips 66 refinery property and downstream. The dredged sediment and water mixture (slurry) was then pumped through a pipeline to the settling basin, where the sediment was allowed to separate from the water by gravity settling. The water was tested and then released into the bayou in accordance with a discharge permit from the state. About 30,000 cubic yards of bayou sediments were placed in the containment cell. Dredging was completed in February 2014.

During the cleanup process, EPA provided updates to the Calcasieu Estuary Task Force (a group of local leaders). EPA and the cleanup parties also provided fact sheets to the task force and others to keep the community informed during the cleanup.

PAHs

A group of chemicals formed during the incomplete burning of fossil fuels or other organic materials.



Floating dredge at work on Bayou Verdine.

Solidification of sediments in the settling basin in October 2014.

Installation of the containment cell's top liner in December 2014.

Project History

2011 – 2014
Putting Green Remediation Principles into Practice

When cleanup work began in 2012, the cleanup parties did not have a specific reuse plan in mind. However, throughout the cleanup, and in keeping with the cleanup parties' commitment to sustainability and good corporate citizenship, many green remediation principles were put into practice. For example, before emptying the east pond to convert it into the settling basin, the cleanup parties collected more than 1,000 fish and other aquatic organisms and released them into the bayou.

Green Remediation

The practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup actions.

Many other green remediation principles also helped reduce the project's environmental impacts:

- Recycled old tires recovered during site preparation and paper and plastic bottles. Reused the guard shack as the treatment plant office.
- Used recycled and refurbished equipment such as survey stakes and board mats.
- Minimized the need for electric pumps by using gravity settling and gravity discharge.
- Used electric motors on boats rather than gas-powered motors.
- Minimized the area of land to be cleared for staging areas.
- Pruned trees instead of removing them when possible.
- Provided wildlife habitat by stockpiling trees removed during site preparation, rather than mulching them. These salvaged trees were later reused in the bioswale.
- Adjusted access road construction to preserve several large trees.
- Preserved riparian habitat along the bayou by minimizing work along the shore.
- Carpooled to the job site.
- Used low-sulfur diesel in motorized equipment.
- Used biodegradable lubricants in the dredge.

2014 – 2015
Incorporating Ecological Revitalization

As cleanup work was ending, EPA and the cleanup parties discussed options for the site's containment cell. EPA project manager Casey Luckett Snyder focused on opportunities for the cell area to provide environmental benefits. After discussing reuse ideas with various parties, including the Pollinator Partnership, EPA's pollinator program and reuse experts at EPA, Snyder suggested that the cleanup parties focus on ecological revitalization. Phillips 66 was receptive – according to Chris McGowan, Phillips 66 remediation management program manager, "Phillips 66 decided that ecological reuse was good environmental stewardship. It made sense to avoid a sterile landfill." Rather than creating a conventional closed landfill, the containment cell area would provide ecological benefits and fulfill the company's commitment to environmental sustainability.

Local Involvement

During the early stages of the site investigation, local government and business leaders came together to form the Calcasieu Estuary Task Force to foster coordination and communication between EPA, private industry and the public.

The task force brought together site stakeholders – local and state government representatives, companies tied to the estuary, local businesspeople, environmental regulators – to help move the cleanup process along.

According to Calcasieu Parish Administrator Bryan Beam, "the task force helped to demonstrate that the community was determined to address the site's cleanup challenges."

The Pollinator Partnership

The Pollinator Partnership is a non-profit organization dedicated to the protection and promotion of pollinators and their ecosystems. The Pollinator Partnership's mission is to promote the health of pollinators, critical to food and ecosystems, through conservation, education and research.

EPA and Reuse

Since the inception of the Superfund program, EPA has been building on its expertise in conducting site characterization and remediation to ensure that contamination is not a barrier to the reuse of property. Today, consideration of future use is an integral part of EPA's cleanup programs, from initial site investigations and remedy selection through to the design, implementation, and operation and maintenance of a site's remedy.

EPA's Green Remediation Strategy fosters the use of best management practices for green remediation at contaminated sites. There are opportunities to decrease the footprint and maximize the environmental outcome of a cleanup throughout the life of a project, from site investigations through development of cleanup alternatives and remedy design, construction, operation and monitoring.

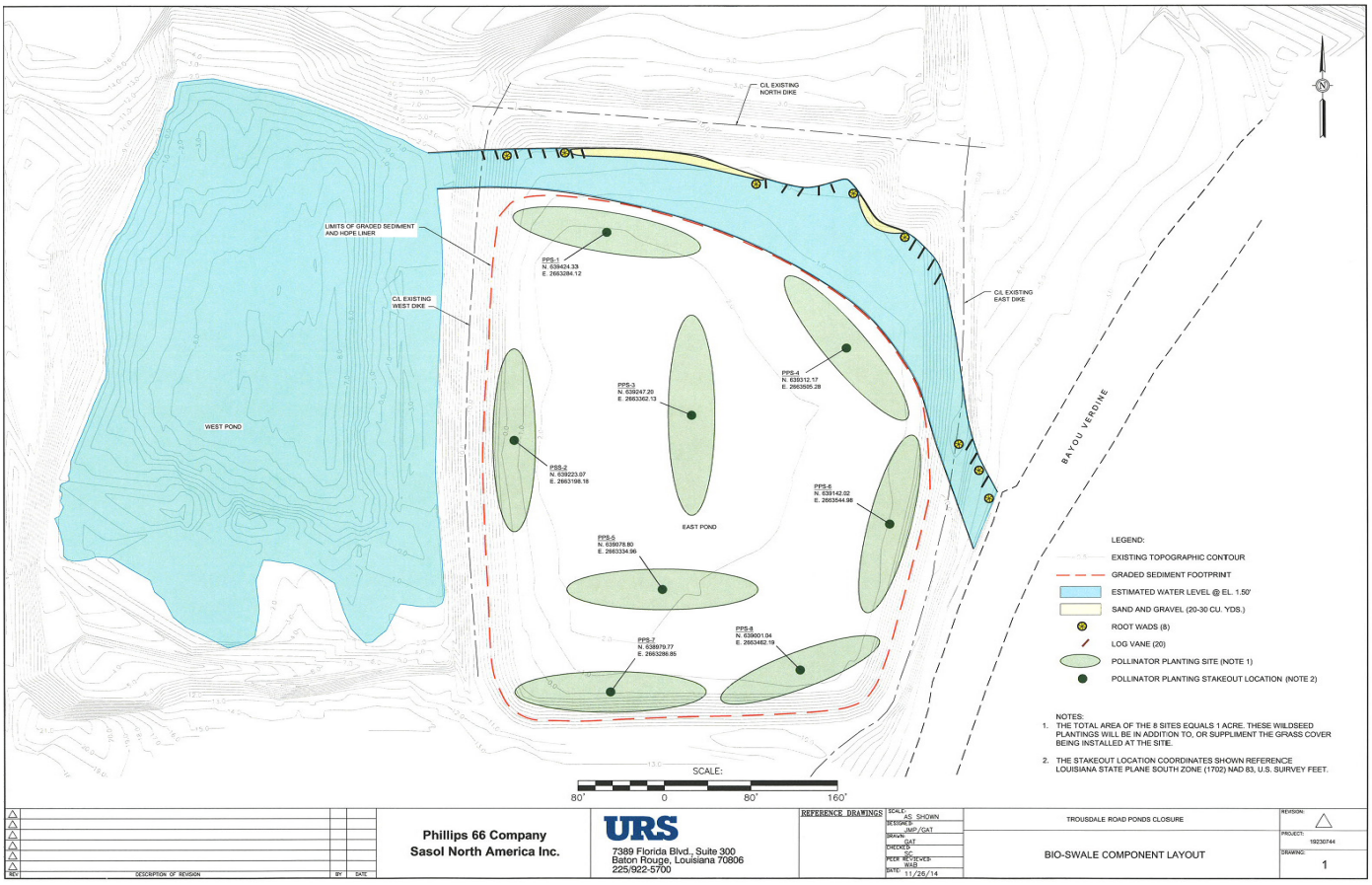
Aerial view of the revitalized west pond connected to Bayou Verdine by the bioswale constructed along the northern edge of the site's containment cell.

"During the closure planning process, we decided that we could do better than creating another closed landfill."

– Casey Luckett Snyder, EPA project manager

Timeline of Events

1942	Lake Charles petroleum refinery operations begin (now operated by Phillips 66)
1984	Vista Chemical Company (now Sasol North America Inc.) purchases the Lake Charles Chemical Complex from Conoco Inc. (now Phillips 66)
February 2002	Phillips 66 and Sasol enter into an administrative order on consent with EPA to conduct an engineering evaluation and cost analysis for Bayou Verdine
2002 – 2004	Phillips 66 and Sasol conduct a time-critical removal action to remove contaminated sediments from the West Ditch Area of Bayou Verdine on the refinery property
August 2003	EPA issues an action memorandum stating that a non-time-critical removal action was needed for the rest of Bayou Verdine
October 2010	Phillips 66 and Sasol enter into a consent decree with EPA and the state of Louisiana to clean up Bayou Verdine
December 2011	EPA approves the site's removal action work plan
September 2012	Cleanup work begins
February 2014	Dredging completed
July 2014	EPA approves the site's post-removal work plan
April 2015	Cleanup work was completed
August 2015	Phillips 66 and Sasol submit the site's Construction Completion Report
October 2015	EPA presents the Greenovations Award to Phillips 66, Sasol and other stakeholders



Design drawing showing the west pond, bioswale and wildflower plots on the containment cell.

EPA and Pollinator Protection

A pollinator is an animal that moves pollen within or to another flower, fertilizing the plant. There are about 200,000 species of pollinators, including bees, butterflies, wasps, beetles, birds and bats.

Many types of plants, including native plants and crops, require pollination to bear fruit. Recent declines in pollinator populations – and bees in particular – have raised concerns about the future of food supplies worldwide.

To help address this problem, EPA has launched the Pollinator Protection Initiative. Planting wildflower plots, as was done at the Bayou Verdine site, is one of the best ways to help revive pollinator populations.

Honeybee foraging at the site.

Although the consent decree did not require it, Phillips 66 and Sasol agreed that improving the ecological function of the containment cell area would be a valuable addition to the project. The east and west ponds had been created decades earlier to provide fill for the construction of nearby Interstate 10. However, their ecological function was limited because they were not connected to the bayou. The cleanup parties developed an ecological revitalization plan that would make the west pond a functioning part of the bayou's wetland ecology by creating a channel (called a bioswale) to connect the west pond and the bayou. The plan also called for planting native wildflowers on the containment cell's cover to create habitat for pollinators.

Ecological Enhancements in the Bioswale

The key ecological concept at the site was to hydraulically connect the west pond to the bayou, allowing the pond to function as part of the bayou and estuary ecosystem. To achieve this goal, a channel was built along the northern edge of the containment cell to connect the west pond and Bayou Verdine. Rather than creating a sterile ditch, the cleanup parties designed a bioswale with multiple ecological components to provide habitat and control erosion:

- An engineered swale would have had a 4:1 slope, straight lines, fabric, riprap and a rock ditch. The bioswale used a longer slope and logs, and less riprap. The logs provide aquatic habitat. The north side of the swale has a very gradual 10:1 slope to allow water to spread out during periods of high water.
- Logs and root wads set aside during site preparations were installed in the bioswale as weirs to create spawning habitats for fish and other aquatic wildlife.
- Native plants salvaged during the site preparation phase were later planted along the banks of the swale.
- To promote the growth of native plant species, willow trees and cattails were transported from adjacent areas and planted along the banks of the bioswale.
- A small sand and gravel area was created along the northern bank of the bioswale to serve as an area for aquatic nesting beds.

The site's ecological enhancements are working well: the site now provides habitat for waterfowl, fish, blue crabs, alligators and honeybees. Deer, raccoons and opossums have also been spotted.

Bioswale with logs repurposed as weirs to provide aquatic habitat and control erosion. Gradual slope on left side of the bioswale allows water to spread out and slow down during periods of high water.

Log Weirs

Logs placed horizontally, with part of the log in the bioswale and the rest buried in the bank. Log weirs create shallow pools along the banks and slow water velocity during periods of high water. By creating a variety of depths and water temperatures in the swale, the weirs produce complex, attractive habitat for diverse aquatic species.

Root Wads

The excavated rootball section of a tree with a section of the trunk attached. These were installed in the channel upside-down, with the trunk buried underground and the roots sticking up into the water. The root wads help to diffuse water force in the stream, protect against erosion and provide habitat for aquatic species.

To enable the area's ecological revitalization, the west pond was deepened; sediments were removed and placed on top of the dredged bayou sediments already in the east pond settling basin. In total, about 15,000 cubic yards of west pond sediments were placed in the east pond. Fly ash was mixed in to solidify the sediments. Although the consent decree required only 1 foot of soil cover on the containment cell, the cleanup parties chose to increase the protectiveness of the cover by including a synthetic liner, a drainage system and 2 feet of soil. The upper liner was then welded to the lower liner. The cleanup was completed in April 2015.

To provide habitat for bees, butterflies and other pollinator species, eight areas of the containment cell's capped surface were seeded with six species of native wildflowers – dense blazing star, clasping cone flower, black-eyed susan, red plains coreopsis, showy primrose and butterfly weed. Each of these native species attracts pollinators and thrives in hot, humid conditions. Remaining areas were hydroseeded with conventional grasses such as bermudagrass, clover and rye. Over time, the planting of the pollinator habitat will expand to include much of the containment cell's cover.

The cleanup parties will monitor the remedy for 30 years. Groundwater monitoring will take place every three years. The cover system on the containment cell will be inspected monthly. Because wildflowers require less mowing than conventional grasses, the remedy may result in cost savings over the long term.

Ecological Revitalization

Returning land from a contaminated state to one that supports a functioning and sustainable habitat.

"It means a lot when companies responsible for the contamination step up to not only meet the requirements but go beyond them. It shows you can have a cleanup done in a way where companies recognize they have a responsibility in the community to serve not only the company's interests but also the community at large. From our perspective, it shows that they have the community's goodwill at heart."

– Bryan Beam, Calcasieu Parish Administrator

Lessons Learned

For Casey Luckett Snyder, EPA's project manager at the Bayou Verdine site, the most important lesson learned during the site's redevelopment was to **approach your project with out-of-the-box thinking**. Project managers should ask themselves, "How are we going to make this site a benefit? How are we going to make the best end result?" Although an unconventional reuse may not work at every site, the extra effort will pan out at some sites. **Take the initiative to incorporate reuse considerations during cleanup design** – don't leave the site's future use solely in the hands of the engineers.

Bringing together all stakeholders to collaborate on the cleanup was key to the success of the project, according to Calcasieu Parish Administrator Bryan Beam. Rather than managing the cleanup using a top-down approach, "EPA and the parish brought the various parties together to work through the issues." This collegial approach made sure that the project benefited from broad community support.

Creating a functioning ecosystem is more challenging than placing riprap. Nevertheless, ecological redevelopment at the Bayou Verdine site has worked well. The site's project engineers encourage other site managers to **consider constructing bioswales**. "Don't be afraid of bioswales," noted project engineer William Beal. "Put a little extra thought into it and it will be just as functional as an engineered swale."

Wildflowers on the capped containment cell (bioswale in the background).

Bigger Picture

While these lessons were learned during the successful reuse at the Bayou Verdine site, there are also a range of broader lessons learned that can help guide similar projects at contaminated lands across the country.

EPA works with cleanup parties and other stakeholders to support green remediation and ecological revitalization projects that are compatible with site cleanups.

The Agency places a high priority on green remediation and ecological revitalization of cleaned-up sites. At the Bayou Verdine site, EPA collaborated with the cleanup parties to incorporate green remediation principles and tailor the site's cleanup for ecological benefit.

Communicate, collaborate and build relationships.

Before the site's cleanup began, a group of local government and business leaders came together to form the Calcasieu Estuary Task Force to foster coordination and communication between EPA, private industry and the public. By bringing together site stakeholders – local and state government representatives, companies tied to the estuary, local businesspeople, and environmental regulators – the task force helped to demonstrate the community's determination to solve the site's cleanup challenge.

Establish and sustain open lines of communication at all levels.

The site's ecological revitalization was sparked by an informal suggestion at a meeting between EPA and the cleanup parties. Rather than relying solely on formal reports and evaluations, use informal discussions to brainstorm ideas and help motivate innovative reuse.

Responsible parties and site owners are important stakeholders who can contribute to restoration and reuse planning activities as well as cleanup discussions.

Phillips 66 supported the idea of incorporating ecological revitalization at the west pond. The cost of adding a few extra weeks to the project timeline was worth it to demonstrate the

company's commitment to sustainability and good corporate citizenship. In addition, the cleanup parties followed green remediation principles throughout the project.

> ***"The bayou cleanup was a successful project that met the needs of the environment. Performing the ecological restoration and reuse was the cherry on top."***
>
> – Chris McGowan, Phillips 66 remediation management program manager

Conclusion

Out-of-the-box thinking plus corporate environmental stewardship plus constructive working relationships led to a successful ecological revitalization at the Bayou Verdine site. After constructing a containment cell for dredged bayou sediments, the capped surface was seeded with native wildflowers to provide habitat for pollinators. In addition, the cleanup parties created a bioswale along the edge of the containment cell to connect the west pond to Bayou Verdine, greatly improving the area's ecological resources. The project has earned kudos from local leaders, with Calcasieu Parish Administrator Bryan Beam noting that "the site's cleanup and reuse was a very positive outcome after many years of work by public and private parties to solve a complex problem."

Blue crab in the site's bioswale.

Recognizing Excellence

Bill Beck (Phillips 66 remediation management eastern region manager), Casey Luckett Snyder (EPA project manager) and Chris McGowan (Phillips 66 remediation management program manager) (left to right) at the 2015 Greenovations Award ceremony.

In October 2015, EPA Region 6 presented the Greenovations Award to Phillips 66, Sasol and other stakeholders. The award recognizes their above-and-beyond efforts to achieve sustainable and ecological revitalization with the construction of ecological enhancements at the cap closure area. EPA Region 6 Superfund Division Director Carl Edlund presented the award, stating that the recipients have "gone beyond just complying with the law. What they've done is restore this bayou to ecological standards. And they did so in a way that was sensitive to the environment."

In addition, EPA project manager Casey Luckett Snyder won a 2016 EPA National Notable Achievement Award for the innovation and sustainability of the Bayou Verdine cleanup and reuse.

Within the Phillips 66 company, the reuse project was nominated for a Phillips 66 Golden Shield award for its outstanding support of the company's strategy, vision and values.

The Bayou Verdine cleanup included various ecological revitalization aspects, including a bioswale (above), which improves the west pond ecosystem by connecting it to Bayou Verdine.

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Sources and Resources

Sources

Images and maps for this case study are from EPA, Phillips 66 and Sasol. This case study contains Adobe Stock images not for use elsewhere without license.

Map Sources

Maps for this case study were created with data from Esri, DeLorme, AND, Tele Atlas, First American, UNEP-WCMC, USGS, USDA (2016 National Ag. Imagery Program Mosaic), USGS, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/ Airbus DS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo and the GIS User Community.

Resources

Bayou Verdine Reuse Snapshot:
www.epa.gov/superfund-redevelopment-initiative/sites-reuse-louisiana#verdine

EPA Superfund Redevelopment Initiative – Ecological Revitalization:
www.epa.gov/superfund-redevelopment-initiative/ecological-revitalization-restoring-lands
www.epa.gov/remedytech/ecological-revitalization-turning-contaminated-properties-community-assets

EPA Green Remediation:
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www.epa.gov/greenercleanups
clu-in.org/greenremediation

EPA Region 6 Greenovations Award:
www.epa.gov/superfund-redevelopment-initiative/epa-region-6-greenovations
www.phillips66.com/EN/newsroom/feature-stories/Pages/Phillips-66-receives-EPA-award.aspx
www.youtube.com/watch?v=h7PJA3OzOqg

Protecting Pollinators:
www.epa.gov/greeningepa/pollinator-protection-epa
www.pollinator.org

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