Why Choose Stormwater Wetlands?

The Texas Gulf Coast is a unique landscape with multiple types of wetland habitats, including salt marshes to prairie potholes. The rapid and on-going development of the Texas Gulf Coast however, threatens these valuable habitats. In the short term, it is a loss of habitat utilized by our native species for food and shelter. In the long-term, it is a loss of water quality as the continued loss of wetlands removes the buffering system which treat incoming waters (runoff or designated releases) entering our bayous and thus our bays.

Wetlands provide remarkable ecological functions within a landscape. Wetlands can remove nutrients and sediments from incoming/inflowing waters through biogeochemical processes. This natural transformation can be mimicked in a constructed system such as a Stormwater Wetland.

Stormwater wetlands are created, engineered systems and are similar in function and appearance to natural marshes (Kadlec and Wallace 2009). Stormwater wetlands are employed as a best management practice (BMP) to treat urban stormwater runoff. These constructed systems can be attractive, in addition, to their significant water quality benefit. Because a major source of nonpoint source pollution (NPS) is untreated stormwater runoff, BMPs which can slow and filter runoff, and therefore remove NPS pollutants will have an overall positive effect on the water quality of local waterways. Therefore, stormwater wetlands are a valuable tool to amend poor water quality.

Supporting Evidence for Stormwater Wetland BMPs

Urban stormwater runoff has serious water quality concerns and for many cities this means that stormwater runoff can no longer be ignored. With new regulations and needed compliance, municipalities—from large cities like Houston to smaller towns like Dickinson--must mitigate existing water quality impairments.

The presence of bacteria (enterrococci or E. coli) in our bayous is also a growing concern for urban streams within the Galveston Bay region and with the continued addition of Total Maximum Daily Load (TMDL) studies for these urban streams, the need to address bacterial loading has not been greater (Payne and Valle 2001).

Stormwater wetlands mimic a natural wetland's ability to improve the water quality of influent waters for most constituent pollutants. Multiple studies (International Stormwater BMP Database 2007, Carleton et.al 2000) have demonstrated that stormwater wetlands have high removal rates for Total Suspended Solids (TSS), Total Nitrogen (TN) and bacteria.

There are few local examples of stormwater treatment wetlands, and one of which has documented data supporting the effectiveness of this type of BMP. The Texas AgriLife Extension Service has been collecting basic water quality data from the Mason Park Stormwater

Treatment Wetland in Houston (Sipocz 2008). The created treatment system demonstrated significant bacteria removal rates for the collection period. In certain instances, outflowing samples measured orders of magnitude less than inflowing waters (see Figure 1). This is critical evidence to support the further implementation of stormwater wetland BMPs for this region.

These systems do the work of treatment facility infrastructure with less overall cost (minimal cost savings in construction to significant cost savings in maintenance), and better durability and beauty.

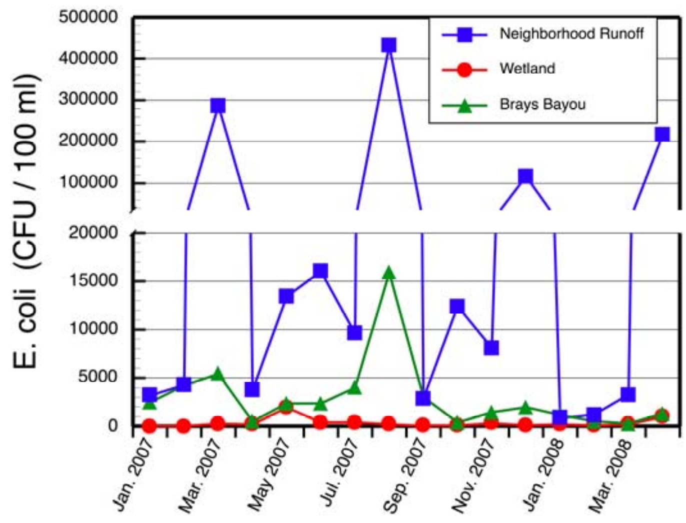


Figure 1 – Mason Park water quality data

Understanding Wetlands and their benefits

Stormwater wetlands, like constructed and natural wetlands, are "excavated basins with irregular perimeters and undulating bottom contours into which wetland vegetation is purposely placed to enhance pollutant removeral from stormwater runoff" (Constructed Wetllnd 1997).

> In 2000, the Environmental Protection Agency published "Guiding Principles for Constructed Treatment Wetlands" as a reaction to the increasing number of treatment wetland creation projects within the United States. This document in conjunction with other state generated guidance manuals provided a basis for local government to implement their own wetland BMPs where applicable.

Wetlands can act as "sources, sinks and transformers of chemicals" which vary in effectiveness based on several influencing factors including wetland type, seasonality, chemical loadings, hydrologic conditions, productivity rates, and adjacent ecosystems (Mitsch and Gosselink 2000). Slowing down the inflow waters allows for sediments to "fall" out of the water column and settle into the soils within the wetland. Additionally, wetlands within temperate regions like the Texas Gulf Coast show "a high rate of uptake of nutrients by emergent and submerged vegetation from the water and sediments" during the growing season (Mitsch and Gosselink 2000). Wetlands also change the chemistry of inflowing nutrients, converting inorganic nutrients into organic forms, transforming common pollutants like nitrogen, phosphorus, iron and manganese into other usable or storable forms within the wetland system. All of these processes exemplify the ability of wetlands to function as water quality treatment tools.

Considerations for Implementing Stormwater Wetland BMPs

Our community has many small stormwater detention areas which are eyesores and provide little additional value other than basic detention. In choosing to build a stormwater wetland, you are considering an option which will enhance the appeal of your site, provide your basic detention and additional water quality services. The emergining consensus for detention within our region is moving towards multiple uses—such as water quality and recreation.

In choosing a stormwater wetland BMP, consideration must be given to location and overall performance of the BMP within the landscape. Selection of a particular design for your wetland will depend on several factors including: contributing watershed, available land, and the desired environmental goals for your wetland BMP (Schueler 1992).

New recommendations from the Center for Watershed Protection suggest that your system should “consume approximately 3% or less of the contributing drainage area” (Cappiella et.al. 2008) and the utilization of off-line water supplying wetland cell. Additionally, these wetland systems should be incorporated as part of a series of BMPs for a given location. For example, installing rain gardens and buffers within a neighborhood to catch runoff and treat prior to entering the wetland system will increase the effectiveness and life span of the wetland.

General Steps for Site Selection and Investigation:

- Review of existing site information, including aerial photography
- Preliminary Field survey of the site
- Subsurface exploration and collection of environmental data
- Evaluation of data, potential environmaental effects and regulatory requirements

(from “Artificial Wetland Storm Water Management Systems:, Wisconsin Storm Water Manual, 2000)

Additionally, the challenge in the creation of stormwater treatment wetlands arises with multiple considerations including:

- Land cost - if land must be acquired, then your cost will be dictated by the cost per acres of purchased land
- Construction cost – maybe be influenced by considerations for cubic foot of material to be removed and associated off-site disposal costs

The manager/implementor must decide on the performance goals for the site and then give consideration to cost constraints. Cost constraints in conjunction with site specific constraints will determine the final design of the stormwater wetland BMP.

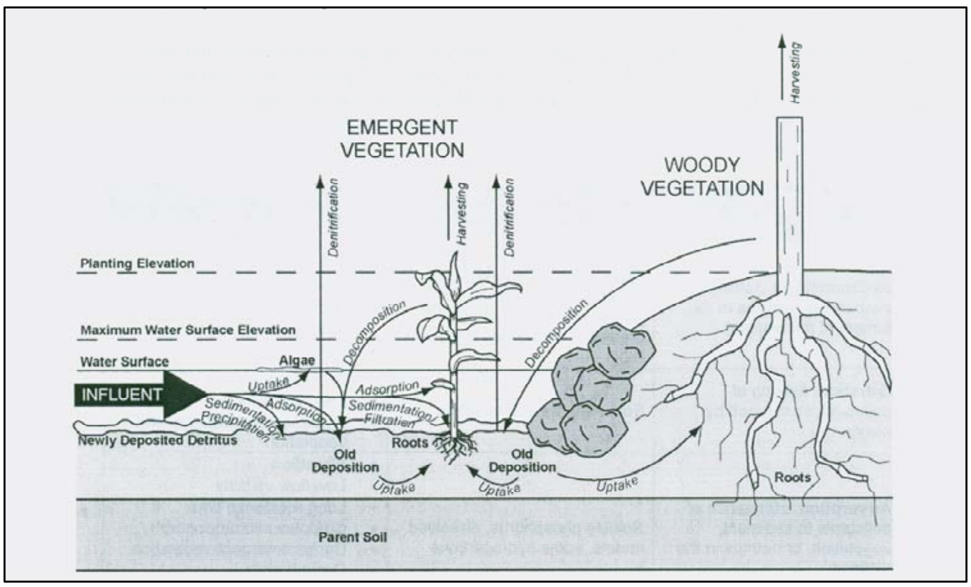
Concerns for overall effectiveness stem from the possibility of release of captured pollutant during overflow or large flow events. Knight (1993) suggests that location decisions of wetlands should be driven by overall goal; should water quality be the driving force, then multiple upstream sites should be investigated. Otherwise, if the primary driving force is the control of large flow events, then larger-scaled, downstream systems should be employed (Tilley 1998).

The capacity for stormwater wetlands to address localized problems (i.e. dissolved oxygen and bacteria) throughout the year (during the majority of rainfall events) makes this BMP appealing as a choice for water quality abatement. Effectiveness will then be dictated by: target water quality volume, the surface area to volume ratio of the wetland, the length of the internal flow path, presence of a forebay and treatment redundancy (Schuler 1992). The effectiveness of a created stormwater wetland system "should be based on its cumulative, long-term removals of pollutant mass loadings (Wu et.al. 1996, Schueler 2007).

Design Considerations for the Manager

Hydrology

With any wetland creation project, the water source is necessary for the maintenance of wetland functions and structure (i.e. plants). Water levels within the wetland must be maintained for proper treatment capacity. If proper hydrologic conditions can be established, then the appropriate chemical and biological processes within the wetland will respond in kind (Mitsch and Gosselink 1993).



Planning for stormwater treatment wetland in our region also means considerations for significantly larger rainfall events such as hurricanes, and making appropriate provisions for such events. Emergency overflow weirs which are reinforced may be necessary. The hydrologic analysis of inflow for your project site will determine whether this is necessary. On the other end of the spectrum, extended dry periods within the wetland will lead to a shift in the plant community (wetland to upland vegetation) and reduce treatment capacity while simultaneously creating a maintenance problem.

Mason Park Treatment Wetland survived significant storm surge from Hurricane Ike, a category 2 storm with category 4 storm surge (Notice the trash line in the foreground).

It is important to remember that flow should not be diverted away from existing wetlands or larger areas which may contain wetlands. This alteration will significantly impact the functions of these systems and potentially lead to federal and state violations.

Placement of the stormwater treatment wetland within the contributing watershed is an equally important consideration. Where possible, the placement of the wetland should maximize the potential reduction of pollutants. This may lead to placement of the wetland systems lower within the watershed, rather than at the headwaters, where the potential for larger pollutant loads exist. However, the lower placement within the watershed may mean these systems will experience increase flows during heavy events and lead to potential releases. Ideally, having a combined effort of larger wetland systems within the headwaters to retain and slow flows *AND* smaller treatment wetlands intermingled within the watershed would provide the best treatment for a given watershed (McBrien 2000).

Soil Requirements

As hydrology is fundamental to the success of the stormwater treatement wetlands, appropriate soil characteristics are equally critical to the wetland system. Stormwater treatement wetland soils must retain water, support wetland vegetation and provide active exchange sites for adsorption of pollutants (McBrien 2000). Highly permeable soils will not retain water and proper hydrology will not be achieved for the wetland system.

(Do we address chemical composition of soils in general? Like if the soil is missing some key component, how to amend the soil to make it better?)

The presence of micronutrients within the soils will assist in the establishment of wetland vegetation within the system. It would be prudent to stockpile the nutrient-rich top soil from the project site and replace this layer on the wetland bottom post-construction completion. However, it is important to consider the seed bank lying dormant within the top soil. This seedbank may be a potential source for invasive species introduction, which encourages the manager to locate the project site within an area not dominated or surrounded by invasive plant species, or consider placing compost or other known top soil alternatives on the bottom.

Sizing Guides and Retrofit Potential

A primary consideration for sizing the stormwater wetland BMP would be to ensure there is enough land to accommodate the runoff form the tributary drainage area during the design rain (McBrien 2000). There are multiple methods for calculating the approximate land area needed to treat the designated design rain. The following simple calculation, adapted from the Wisconsin Storm Water Manual, uses a design rain of 1.5 inches:

WE = (SA/RU)/WD

WE = the approximate surface area of the stormwater wetland needed at the stage required to store water from the design storm (acres)

SA = tributary area of the watershed which will discharge to the stormwater wetland (acres)
RU = runoff depth predicted from the 1.5 inch rain event (feet)
WD = average storage depth of the stormwater wetland (feet) at the design capacity. For an approximation, the average depth can be assumed to be 2 feet.

Per new guidance from the Center for Watershed Protection, the required footprint for the BMP “will vary depending on the hydrology of the site and ahe amount of runoff reduction that is provide upstream, but the system should consume approixmatly 3% or less of the contributing drainage area. Enhanced pollutant removal performance in stormwate wetland havs been associated with salklow water depths and minimal water lever fluctuations, which has typically been achieved by consuming more land (typically more than 3% of the continbuting drainage area as noted in Table 8).” (Cappiella et.al. 2008). For additional calculations with more specific criteria, please refer to Appendix A.

Stormwater Wetland Retrofits are an alternative for regions where existing retention areas may be modified and incorporate a wetland component. This is also an ideal alternative in areas where land is not readily available or the purchase of land is cost prohibitive. Potential modifications to convert detension/retention basin to stormwater wetland systems include:

- Removing concrete low flow channels
- Revegetate basin with native wetland plants
- Excavate basin bottom to increase storage capacity below lowest orifice in the basin’s outlet
- Construct earthen berm(s) to extend the flow path and prevent stormwater form taking the shortlest route through the basin
- Install a sediment forebay near the inlet to capture sediment, debris and provide pretreatment
- Redirect all overland swales flowing into the basin away from the outlet structure to extend flow path

Vegetation Selection

Choosing the appropriate plants for a stormwater wetland BMP will facilitate final success of the BMP. It is highly recommended to actively plan for dense and diverse plantings of the stormwater wetland system rather than allowing for natural colonization of the site. Wetlands established by colonization are usually characterized by monocultures of exotic and/or invasive species—potentially lowering the treatment capacity of the BMP. Additionally, monoculture or monotypical stands of vegetation in stormwater wetland system have been documented with increased presence/persistence of mosquitos populations. Plant species diversity encourages the establishment of predatory insects which can control mosquito populations (Hunt, 2006??). Additionally, the selection of native wetland plant species is more desirable to introduced, exotic vegetation to minimize the potential dangerous introduction of noxious plants to local natural wetland systems.

Criteria generally used to select plant species include:

- Treatment Capacity
- Native
- Availability
- Aesthetic Appeal
- Species Diversity
- Herbivore resistance
- Tolerance

There may be multiple plant species which meet a variety of the selection criteria, but are not readily available to the manager. Therefore it is important to rank selection criteria by the constraints of the overall project.

Establishing the plant community within the stormwater wetland BMP is important to control erosional processes associated with early development of the wetland. Utilizing compost or erosional control mats or other comparable measures to minimize erosion prior to planting of the site is highly recommended.

Natural Deterrents

Managers may often face a dilemma of choosing plants for critieria other than resistance to herbivory (i.e. from good or bad herbivores such as migratory or resident birds, beavers or nutria). For this region, the manager does have muliptle options, including:

- Iris
- Swamp Lily
- Spider Lily
- Giant Cutgrass
- Varieties of Bulrush
- Sawgrass

These plants contain natural defense which enable them to fend off herbivores and make them ideal plants for stormwater wetlands exposed to said conditions.

Upon establishment of the system, periodic harvesting of the vegetation may be recommended to stimulate new growth and remove accumulated nutrients and organic materials.

A local plant list is provided for appropriate planning and development of the wetland system (see Appendix B).

Construction Considerations

Construction of the stormwater treatment wetland includes multiple considerations to control cost while effecting an useful BMP. Prior to construction, it is important to consult the following entities for special permits or other needs:

- local U.S. Army Corps of Engineer office
- General Land office for lease potential,
- Texas Parks and Wildlife for plant introduction permits

For this region, the Permit assistance office, hosted by the General Land Office, can provide the appropriate forms to assist in the permitting process.

A large portion of construction cost will be rolled into one of two areas:

- Mobilitzation/Demobilization and
- Excavation/Removal

Siting your stormwater treatment wetland in a location near or as near to paved roadways will decrease your costs for equipment movement. Accessibility will also play a role in long-term maintenance of the wetland system when the site must undergo appropriate maintenance work (i.e. excavation of wet pond). It has been suggested to have a maintenance access way which is 9 feet wide with maximum slope of 15% and be stabilized for vehicles.

Compaction from the movement and workings of heavy equipment is unlikely to be of great concern. If topsoil is not applied to the wetland construction site post-excavation, there may be an extended lagtime for establishment of vegetation. Therefore, adding compost or an appropriate topsoil alternative would facilitate the immediate success of the wetland system.

Construction Sequence:

1. Separate wetland area from contributing drainage area
2. Clearing and Grubbing:
    a. Clear area to be excavated of all vegetation
    b. Remove all tree roots
    c. Fill all stump holes, crevices and similar areas with impermeable materials
3. Excavate bottom of constructed wetland to desired elevation
4. install surrounding embankments and inlet and outlet control structures
5. grade and compact subsoil
6. supply and grade planting soils
7. Apply geotextiles and other erosion-control measures
8. Seed, plant and mulch according to Planting Plan
9. Install any anti-grazing measures, if necessary
10. Follow required maintenance and monitoring guidelines.

Adapted from Pennsylvania Stormwater Best Management Practices Manual, December 30, 2006

Cost/Development

It is rare to find construction cost data for stormwater wetlands, but they typically are 25% more expensive than stormwater ponds of equivalent volume. Utilizing this guide, Brown and Schueler (1997) equation for cost estimate of Wet Ponds provides a close approximation of cost for stormwater wetlands.

$$C = 30.6V^{0.705}$$

C= Construction, Design and Permitting Cost
V = Wetland Volume needed to control the 10-year storm

This equation generates the following typical values for construction:

- $ 57, 100 for a 1-acre foot facility
- $ 289, 000 for a 10-acre foot facility
- $ 1,470,000 for a 100-acre foot facility

The biggest contributor to cost variation will be: land value, excavation totals and desired density of planting project site. Wetland consume about 3 to 5 % of the contributing watershed, which is relatively high compared with other stormwater management practices, and in areas where land values are particularly high, this may make stormwater wetlands an infeasible choice. Excavation cost will change with the amount of material to be removed and proximity of disposal sites. Depending on the manager needs, the project site may be less densely planted to reduce costs; however, allowing for the site to naturally colonize is not recommended due to the likely introductions of noxious weeds.

Routine (annual) maintenance costs have been repeatedly documented as approximately 3 to 5% of the total construction cost. This value is especially important as any minimization in maintenance directly translates to a loss of water quality function.

Appendix A – A Closer Look at Load Reductions

To examine how effective a stormwater wetland system will function within a given development (whether resisdential or commericial) , the manager must gather the following information for their region:

- Watershed Area – your contributing watershed size
- Watershed Runoff coefficient (R_v)– determined in part by contributing watershed imperviousness   (0.05 + 0.009I, where I is percent imperviousness)
- Design Storm Runoff Volume – R_v x (90th percentile storm amount) x (watershed area)
- Wetland to Watershed Area Ratio – usually 2% of the contributing watershed
- Annual Flow – R_v x (annual rainfall) x (watershed area)
- Average Annual detention time
- Average annual wetland hydraulic loading rates (HLR)

For the purpose of providing treatment with your stormwater wetland system, capturing the runoff from 3 to 5% of the contributing watershed will generate treatment capacities similar to the average emergent marsh.   A recent publication documents these removal rates as follows:

Removal Rates for Emergent Stormwater Wetlands from Schueler et. al. 2007			
Total Suspended Solids	45	70	85
Bacteria	40	60	85

Capturing this percentage of the watershed runoff, essentially means your treatment wetland will provide you with up to 85% removal rates for total suspended solids and bacteria.

Appendix B – Houston-Galveston Regional Potential Plant List (Freshwater)

Plant Name	Scientific Name	Planting Zone
White-topped Sedge	*Rhynchospora colorata*	0 to 6"
Marsh Hay Cordgrass	*Spartina patens*	0 to 6"
Sugarcane Plumegrass	*Erianthus giganteus*	0 to 6"
Swamp Rose Mallow	*Hibiscus moscheutus*	0 to 6"
Horned Beakrush	*Rhynchospora corniculata*	0 to 6"
Spiderwort	*Trandescansia ohiensis*	0 to 6"
Soft Rush	*Juncus effuses*	0 to 6"
Spikerush	*Eleocharis montana*	0 to 6"
Jointed Flatsedge	*Cyperus articulatus*	0 to 6"
Anglestem beaksedge	*Rhynchospora caduca*	0 to 6”
Jamaica Sawgrass	*Cladium jamaicense*	6 to 12"
Longlobed Arrowhead	*Sagittaria longiloba*	6 to 12"
Coastal Water Hissop	*Bacopa monerii*	6 to 12"
Southern Blue Flag	*Iris virginica*	6 to 12"
False Dragonhead	*Physostegia spp.*	6 to 12"
Rush	*Juncus nodatus*	6 to 12"
Blue Waterleaf	*Hydrolea ovata*	6 to 12"
American Bulrush	*Scirpus pungens*	6 to 12"
Thinscale Sedge	*Carex hyalinolepis*	6 to 12"
Spider Lily	*Hymenocalis liriosme*	6 to 12"
Catchfly Grass	*Leersia hexandra*	6 to 12"
Grassy Arrowhead	*Sagittaria graminea*	6 to 12"
Duck Potato	*Sagittaria platyphylla*	6 to 12"
Powdery Thalia	*Thalia dealbata*	12 to 18"
Canna	*Canna glauca*	12 to 18"
Swamp Lily	*Crinum americanum*	12 to 18"
Square-stem spikerush	*Eleocharis quadrangulata*	12 to 18"
Maidencane	*Panicum hemitomon*	12 to 18"
Floating Seedbox	*Ludwegia peploides*	18 to 24"
White Water Lily	*Nymphea odorata*	18" to 24"
Yellow Water Lily	*Nymphea Mexicana*	18” to 24”

Plant Name	Scientific Name	Planting Zone
Pickerel Weed	*Pontedaria cordata*	18 to 24"
Duck Weed	*Lemna minor*	24"

For Brackish systems, may include following additional species:

Plant Name	Scientific Name	Planting Zone
Bull tongue	*Sagittaria lancefolia*	6-12"
Big Cordgrass	*Spartina cynosuroides*	6-12"
Saltmarsh Bulrush	*Schoenoplectus robustus*	6-12"
California Bulrush	*Schoenoplectus californicus*	12 to 18"