About This Guide
Stormwater retrofits are constructed in the existing urban environment to improve runoff quality and help mitigate flooding. Retrofits include new installations or upgrades to existing stormwater management measures where there is a lack of water quality treatment and/or management of flooding. These measures can target trash, sediment, nutrients, bacteria, or other concerns. Often, retrofits can be completed in tandem with other capital projects including roads, parks, and downtown revitalization efforts to achieve multiple benefits and manage cost. This document provides concise guidance on how to plan for, identify, locate, design, construct and maintain retrofit projects.

Retrofit Engineering: The Process
Retrofits are prioritized in areas of identified water quality problems or flood zones, then, multiple retrofit options can be evaluated to determine the most appropriate measures for the site, soil conditions, topography, existing infrastructure, and community goals. All retrofit sites are unique and no single solution fits all conditions. In the end, the final project should be attractive in appearance, satisfy the desired stormwater goals, and have minimal maintenance needs.

- **Retrofit Planning**: Meeting with local government staff, reviewing water quality data and local drainage problems, obtaining maps and plans, considering community master plans, performing field reviews of potential sites, identifying stakeholders, defining if within a Watershed Protection Plan or Total Maximum Daily Load watershed (TMDL), and sketching potential retrofit concepts.

- **Water Quality/Flood Mitigation Assessment**: Modeling the estimated water quality improvements and flood reduction benefits, estimating the stream/habitat benefits, evaluating potential water supply benefits, and considering other public benefits (streets, utilities, parks, etc.).

- **Retrofit Inventory & Evaluation**: Refining conceptual designs, estimating construction and life-cycle costs, identifying potential funding sources/grants, and prioritizing top performing retrofit sites.

- **Design and Permitting**: Performing field surveys, assessing potential cultural and environmental resources, defining soil conditions, obtaining local government guidance, preparing construction plans, sharing plans with stakeholders and obtaining input, finalizing funding sources, and coordinating with the regulatory agencies to obtain approvals.

- **Construction**: Defining construction access, public outreach, initiating the contractor selection process, completing contracts, installing construction phase erosion controls, building the improvements, and revegetating the site.

- **Inspection & Maintenance**: Performing periodic site inspections after major storm events, ensuring proper drainage and vegetation management, removing accumulated sediment and debris, operating a project database to track maintenance requirements, and hosting education outreach events.
Retrofit Planning

The important first step is to develop an understanding of the local water quality challenges, drainage issues, and flooding problems.

<table>
<thead>
<tr>
<th>Study Area Context</th>
<th>Conditions</th>
<th>Externalities</th>
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<tr>
<td>Stakeholders</td>
<td>Topography</td>
<td>Existing utilities</td>
</tr>
<tr>
<td>Jurisdictions (regulatory)</td>
<td>Water quality data</td>
<td>Public lands</td>
</tr>
<tr>
<td>Adjacent land uses</td>
<td>Soils</td>
<td>Private property</td>
</tr>
<tr>
<td>Available land area</td>
<td>Geotechnical (soil conditions)</td>
<td>Funding sources</td>
</tr>
<tr>
<td>Land use and ownership</td>
<td>Floodplains</td>
<td></td>
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<tr>
<td>Other project opportunities</td>
<td>Vegetation</td>
<td></td>
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<tr>
<td>Community master plans</td>
<td>Tidal influences</td>
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<tr>
<td>Watershed Protection Plan or TMDL</td>
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</tbody>
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The retrofit planning effort will target large parking lots, streets, urbanized areas and flood zones that lack stormwater management and are directly connected to rivers, creeks, and tidal waters.

Water Quality and Floodplain Mitigation Assessment

To determine the potential benefits of a stormwater retrofit project, modeling and analysis is performed to define the potential reduction in pollution and/or management of flooding. The pollutants below come from single-family, multi-family, commercial, industrial, and highway systems.

<table>
<thead>
<tr>
<th>Data Sources</th>
<th>Guiding Characteristics</th>
<th>Findings</th>
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<tr>
<td>Topographic maps</td>
<td>Minimize retrofit footprint</td>
<td>Identify pollution sources</td>
</tr>
<tr>
<td>Aerial photography</td>
<td>Maximize pollutant reduction</td>
<td>Pollution managed</td>
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<tr>
<td>GIS mapping (FEMA and others)</td>
<td>Reduce peak runoff rates</td>
<td>Reduced flooding of homes, businesses, roads</td>
</tr>
<tr>
<td>Impervious cover data</td>
<td>Avoid groundwater interaction</td>
<td>Reduced water demands</td>
</tr>
<tr>
<td>Land use plans</td>
<td>Stable discharge to waterways</td>
<td></td>
</tr>
<tr>
<td>Water quality data</td>
<td>Minimize maintenance needs</td>
<td></td>
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<tr>
<td>Pollution hotspots</td>
<td></td>
<td></td>
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<tr>
<td>Stakeholder input</td>
<td></td>
<td></td>
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<tr>
<td>Number of flooded structures</td>
<td></td>
<td></td>
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<tr>
<td>Road/bridge flooding</td>
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</tr>
</tbody>
</table>

Identify pollution sources
- Impervious cover
- Chemicals
- Nutrients
- Bacteria
- Spills
- Trash
- Animal waste

Quantity benefits
- Pollution managed
- Reduced flooding of homes, businesses, roads
- Reduced water demands
Retrofit Inventory and Evaluation

The above steps will most likely identify a number of retrofit possibilities in your community based on existing issues and available appropriately located project spaces. The concept designs will be refined based on the modeling and construction cost estimates prepared for each alternative, some sites may have several alternatives. A ranking system will be prepared to rate pollution and flood mitigation benefits in combination with cost and other benefits such as parkland, downtown redevelopment, utility, and transportation improvements.

Prioritization of Features

<table>
<thead>
<tr>
<th>High</th>
<th>Low</th>
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</thead>
<tbody>
<tr>
<td>• High pollutant management</td>
<td>• Low pollutant management</td>
</tr>
<tr>
<td>• Flood flow management</td>
<td>• Low flood flow reduction</td>
</tr>
<tr>
<td>• Manage large impervious area</td>
<td>• Limited impervious area management</td>
</tr>
<tr>
<td>• Available land</td>
<td>• Requires land acquisition</td>
</tr>
<tr>
<td>• Direct connection to waterways</td>
<td>• Requires conveyance system (pipes, channels, culverts)</td>
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<tr>
<td>• Link with other projects</td>
<td>• Stand-alone project</td>
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<tr>
<td>• Downtown revitalization</td>
<td>• Limited community benefits</td>
</tr>
<tr>
<td>• Amenity (attractive, adds community value)</td>
<td>• Structural in nature</td>
</tr>
<tr>
<td>• Low cost</td>
<td>• High cost</td>
</tr>
<tr>
<td>• Limited permitting needs</td>
<td>• High permitting requirements</td>
</tr>
<tr>
<td>• Low maintenance requirements</td>
<td>• High maintenance requirements</td>
</tr>
<tr>
<td>• Potential for grant funding</td>
<td>• Limited funding options</td>
</tr>
<tr>
<td>• Educational benefits (demonstration project)</td>
<td>• Limited educational opportunities</td>
</tr>
</tbody>
</table>

RETROFIT EVALUATION PROCESS

- Project Design
- Identity Retrofit Alternatives
- Lessons-Learned
- Select Highest Scoring Alternatives and Define Funding
- Technical
- Assess Benefits/Costs/Value
- Collaboration
- Rank Alternatives
- Evaluation

Commercial Center Rain Garden
Design and Permitting

The retrofit design is based on the collection of detailed site data to ensure that the proposed project can be properly constructed and safely function while minimizing maintenance needs.

**Key Data Requirements Include:**

- Field survey to define ground elevations, trees, existing utilities, wetlands infrastructure, unique features, floodplains and property boundaries
- Subsurface soil investigation to determine groundwater levels and infiltration capacity
- Environmental and cultural resource studies to avoid impacts and minimize permitting requirements

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**Bioretention (Rain Garden) Schematic**

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**Bioretention**

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**Design Considerations**

- Siting requirements to avoid infrastructure, trees, environmental resources, and connect with existing utilities as needed
- Positive drainage, no standing water beyond the design goals
- Slope safety accomplished through grading plans to avoid drop-offs and hazards
- Stabilize slopes so soil does not wash away during rains
- Provide construction and permanent maintenance access but use curbs and fences when necessary so that vehicles cannot enter the facility
- Maximize native vegetation, natural materials, and landscapes to improve stormwater performance and appearance
- Provide trash control features so that pipes and spillways are not clogged during floods

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**Permitting Considerations**

*While the project design will define permitting requirements, the permitting process is considered in the project design to minimize needs for needs for mitigation and is informed by the environmental and cultural resources studies.*

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**Agencies and Their Jurisdictions**

- **Local government**
- **US Army Corps of Engineers (USACE Galveston):** Potential impacts to aquatic environments of U.S. waters under Section 404 of the Clean Water Act
- **Texas Historical Commission:** Potential impacts to cultural resources under Section 106 of the National Historical Preservation Act
- **US Fish and Wildlife Service and National Marine Fisheries Service:** Potential impacts to (“take” of) federally-protected species
- **General Land Office Beach Access and Dune Protection Program**

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**Potential Requirements**

- Drainage, public safety, traffic management, aesthetics, landscape, building setbacks, zoning changes
- Avoidance and minimization
- Response planning in the event of a “take”
- Mitigation for “take”
- Various post-construction monitoring
- Within 1000 feet of the mean high tide
- Any applicable Rights of Way and easements
Construction

Once the construction plans and supporting materials are permitted, specifications and bid documents are prepared by the project sponsor. This process can include advertising and distributing bid package(s), a pre-bid meeting, response to questions/comments, reviewing bids for completeness and qualifications and contract award to the selected bidder. The selection of a qualified and experienced contractor versed in the construction of stormwater projects goes a long way towards a successful project completion.

Construction Phase Erosion Controls

A key aspect of the construction phase is the proper installation of construction phase erosion controls so that dirt, sediment, fuels, and construction chemicals are retained on site. The Texas Commission on Environmental Quality (TCEQ) requires a Stormwater Pollution Prevention Plan (SWPPP) for all projects that disturb more than one acre in area. This plan guides the installation and maintenance of construction phase erosion controls and the rapid revegetation of the site. Primary techniques include silt fence, mulch logs, rock berms, stabilized construction entrances, and storm drain inlet barriers to retain sediment on-site, however, the most effective erosion control approach is to minimize and phase ground disturbance. Final stabilization of soil disturbing activities is considered complete when perennial vegetative cover reaches 70% of the native background vegetative cover.

A successfully built and revegetated project ensures long-term water quality and flood management performance and facilitates fewer maintenance concerns and costs. Frequent communication between the contractor and project team is necessary to resolve questions, adapt to field conditions, and verify environmental compliance.
Inspection and Maintenance

To achieve desired stormwater management benefits, periodic inspection is necessary to document facility conditions and guide maintenance needs. Accumulated sediment and debris removal (especially at the inflow point) will be the primary maintenance function. Other potential tasks include replacement of dead vegetation, erosion repair at inflow points, media replenishment, unclogging drain-pipes, and repairing overflow structures. An added benefit of inspection and maintenance is that lessons learned are applied to the next retrofit design effort so a process of continuous improvement occurs throughout the retrofit implementation program. Specific maintenance requirements include:

Inspections
Stormwater measures should be inspected at least twice a year (once during or immediately following wet weather) to evaluate facility operation.

Sediment Removal
Remove sediment from the facility when the depth reaches 3 inches or when it interferes with the vegetation or ability to meet required water drawdown times.

Drain Time
When the drain time exceeds 72 hours, the filter media should be removed and replaced with more permeable material. Drainage pipes should also be cleaned.

Vegetation
All dead and diseased vegetation shall be removed and replaced during semi-annual inspections. Bare spots larger than 10 square feet should be reseeded and irrigated.

Grass areas in and around the stormwater measures must be mowed at least twice annually to limit vegetation height to 18 inches.

Use non-chemical methods for maintaining vegetation health. Pesticides, herbicides, or fertilizers should only be used as a last option, and then as minimally as possible.

Debris and Litter Removal
Debris and litter will accumulate in the facility and should be removed during regular mowing operations and inspections.

Underdrain (if a project component)
Clean underdrain piping network to remove any sediment buildup every 5 years, or as needed to maintain design drawdown time.
## Retrofit Techniques

Stormwater retrofits can improve water quality and reduce flood flow rates in existing urbanized areas. As noted above, one size does not fit all, potential retrofit sites are unique and in some situations only one type of solution will work while in other areas multiple solutions could function well.

### Stormwater Management Measures

<table>
<thead>
<tr>
<th>Stormwater Management Measures</th>
<th>Construction Cost</th>
<th>Recommended Drainage Area</th>
<th>Maintenance Requirement</th>
<th>Liability/Safety Issues</th>
<th>Other Benefits</th>
</tr>
</thead>
</table>
| Buffers                       | N/A               | creek, river and tidal water boundaries | very low to none | none | • Water quality and flood management  
|                               |                   |                           |                         |                         |   | • Water supply and resilience |
| Natural Area Preservation      | N/A               | N/A                       | low                     | none | • Water quality and flood management  
|                               |                   |                           |                         |                         |   | • Water supply and resilience |
| Roof-top Disconnection        | low               | house and business roof-top | low                     | none | • Water quality and flood management  
|                               |                   |                           |                         |                         |   | • Water supply and resilience |
| Vegetated Filter Strip        | low               | <3 acres or downstream of other measures | low | none | • Water quality  
|                               |                   |                           |                         |                         |   | • Resilient |
| Vegetated Swale               | low               | <2 acres                   | low | low | • Water quality  
|                               |                   |                           |                         |                         |   | • Resilient |
| Extended Detention Basins     | mod               | less than 128 acres       | low-med                 | low, short term standing water | • Flood and water quality management  
|                               |                   |                           |                         |                         |   | • Promote baseflow enhancement |
| Bioretention/Rain Gardens     | mod               | <10 acres                  | med-high                | low, shallow standing water depth | • Water quality  
|                               |                   |                           |                         |                         |   | • Promote baseflow enhancement |
| Infiltration                  | mod               | downstream of BMP          | med-high                | mod, standing water       | • Water quality  
|                               |                   |                           |                         |                         |   | • Water supply |
| Rainwater Harvesting          | mod               | house roof-top             | mod                     | low, rainwater stored in property owner tanks | • Water quality  
|                               |                   |                           |                         |                         |   | • Water supply |
| Wet Basins                    | mod-high          | >20 acres and less than 128 | med-high                | high, long term standing water | • Water quality and flood management  
|                               |                   |                           |                         |                         |   | • Habitat |
| Constructed Wetlands          | mod-high          | >20 acres and less than 128 | med-high                | mod, longterm standing water | • Water quality and flood management  
|                               |                   |                           |                         |                         |   | • Habitat |
| Porous Pavement               | mod-high          | no off-site area drains to pavement | mod | low, potential pavement issues | • Water quality  
|                               |                   |                           |                         |                         |   | • Peak flow reduction  
|                               |                   |                           |                         |                         |   | • Water supply |
| Water Quality Vaults on Storm Drain Systems | high | varies, typically less than 2 acres | high | limited safety issues since underground but could have moderate liability if not maintained and the storm drain system becomes clogged | • Manage water quality at hot spots such as gas stations, industrial sites |

### “Green” (Softer) Techniques

- Buffers
- Natural Area Preservation
- Roof-top Disconnection
- Vegetated Filter Strip
- Vegetated Swale
- Extended Detention Basins
- Bioretention/Rain Gardens
- Infiltration
- Rainwater Harvesting
- Wet Basins
- Constructed Wetlands
- Porous Pavement
- Water Quality Vaults on Storm Drain Systems
Buffers

Low Creek, river, and tidal water boundaries

Very low to none

None

Water quality and flood management

Water supply and resilient

Most common retrofits in the urban landscape include rain gardens/bioretention basins, permeable pavements, extended detention basins, and water quality vaults. Retrofits are a valuable tool to improve runoff water quality from existing urban areas and can demonstrate the feasibility of cost-effective stormwater management that can lead to wider adoption of these practices by residents, businesses, and local governments.

After downtown retrofit

Before downtown retrofit