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RETROFITTING STORMWATER BASINS

by Jeff MacKay, PE, CPESC

Stormwater basins have been constructed for decades to manage runoff generated by development. Early designs focused primarily on reducing peak discharge rates to minimize downstream flooding. As understanding of stormwater impacts has evolved, regulatory requirements now also address runoff volume reduction, groundwater recharge, and water quality improvement.

Trash and debris accumulation at a basin outlet structure should be removed and cleaned up. Photo: NTM Engineering, Inc.

Many existing basins were constructed prior to these expanded requirements and may no longer perform as intended due to aging infrastructure, sediment accumulation, or outdated design criteria. Retrofitting these facilities provides an opportunity to restore functionality and improve performance without the cost and land requirements associated with constructing new stormwater control measures (SCMs).

How Stormwater Basins Function

Stormwater basins are designed to temporarily store runoff and release it at a controlled rate through an outlet structure. During a storm event, runoff enters the basin and is detained, allowing peak flows to be reduced before discharging downstream. Traditional basin designs primarily controlled large storm events using a single outlet structure. Modern SCM designs expand this function by:

- Managing smaller, more frequent storm events,
- Promoting infiltration into underlying soils, and
- Removing pollutants through settling and filtration processes.

These additional functions rely on properly functioning storage volume, outlet structures, and, in many cases, infiltration or filtration surfaces.

Common Causes of Basin Underperformance

Over time, stormwater basins may fail to meet their intended performance due to a combination of physical deterioration and operational issues.

One of the most common issues is **sediment accumulation,** which reduces available storage volume and limits the basin's ability to attenuate peak flows. Sediment-laden runoff entering the basin without adequate pretreatment can accelerate this process.

Pennsylvania
Department of Transportation
Local Technical Assistance Program

400 North Street, 6th Floor
Harrisburg, PA 17120
1-800-FOR-LTAP • FAX (717) 783-9152
ltap@pa.gov
https://gis.penndot.pa.gov/ltap/

Vegetative overgrowth in a basin can lead to erosion and obstruct flow, both of which can reduce efficiency and overall environmental benefits. Photo: NTM Engineering, Inc.

Outlet structure deterioration or blockage is another frequent problem. Corrosion, debris accumulation, or structural damage can impair flow control, leading to either excessive discharge or restricted flow conditions.

In basins designed with infiltration or filtration components, **soil compaction and surface clogging** are major causes of failure. Compaction reduces the porosity of the soil, limiting the ability of water to infiltrate, while clogging from fine sediments can seal the surface and prevent infiltration altogether. These issues are often associated with improper construction practices or maintenance activities.

Vegetation can also impact performance. **Poorly managed vegetation** may lead to erosion, obstruct flow paths, or allow invasive species to dominate, reducing both hydraulic efficiency and environmental benefits.

Why Retrofit Stormwater Basins?

Retrofitting existing basins generally falls into three categories, depending on the underlying issue and desired outcome.

Restoring Original Function – As basin components age, repairs may be necessary to maintain the original design performance. This includes replacing deteriorated pipes, repairing outlet structures, and restoring embankments or vegetation. These retrofits are intended to bring the facility back into compliance with its original design criteria.

Improving Flood Control Performance – Older basins often provide limited control of smaller, more frequent storm events. Modifications to outlet structures, such as raising low-flow orifices or adding additional control elements, can improve management of these events. Increasing basin storage volume through excavation or regrading may further enhance flood control capabilities.

Enhancing Water Quality and Volume Management – Modern stormwater requirements emphasize pollutant removal and runoff volume reduction. Retrofitting can incorporate features such as forebays, infiltration areas, and amended soils to improve treatment performance. Vegetation upgrades, such as converting turf grass to meadow plantings, can also enhance water quality and reduce maintenance needs.

Amended soils in a bioretention facility can improve treatment performance. Photo: NTM Engineering, Inc.

Retrofit Approaches and Design Considerations

Retrofitting a stormwater basin requires a comprehensive evaluation of both the existing facility and the contributing drainage area. Unlike new construction, retrofit projects must work within site constraints, existing infrastructure, and current performance deficiencies. A successful retrofit design balances hydraulic performance, water quality treatment, constructability, and long-term maintenance.

Assessment of Existing Conditions

The first step in any retrofit project is to evaluate the current condition and performance of the basin. This includes reviewing original design plans (if available), inspecting structural components, and identifying

deficiencies such as sediment accumulation, outlet malfunction, or erosion.

Watershed characteristics must also be reassessed. Changes in land use, increases in impervious area, or altered drainage patterns can significantly affect basin performance. Design modifications should account for these changes to ensure the retrofit meets current stormwater management goals.

Selection of Retrofit Strategy

Stormwater retrofit approaches generally fall into three categories: hydraulic modifications, water quality enhancements, and infiltration improvements. In many cases, a combination of these strategies is used.

Hydraulic modifications focus on improving flow control and storage. This may include resizing outlet structures, adding additional control devices, or increasing basin volume through excavation. Outlet structures must be designed to prevent clogging and provide reliable discharge control across a range of storm events.

Water quality enhancements are often achieved by incorporating pretreatment features such as forebays or filter systems. A sediment forebay is a separate cell designed to capture coarse sediment and debris before runoff enters the main basin, helping preserve storage capacity and reduce maintenance needs. Forebays can also be designed with accessible geometry, stablized access, or hard-bottom surfaces to allow accumulated sediment to be periodically removed, which is a significant maintenance advantage over systems where sediment is distributed throughout the basin.

Infiltration and filtration improvements may be introduced where site conditions permit. These practices rely on soil permeability and must consider soil type, groundwater conditions, and potential for clogging. Engineered soil media or compost amendments are often used to restore or enhance infiltration capacity.

Site Constraints and Physical Feasibility

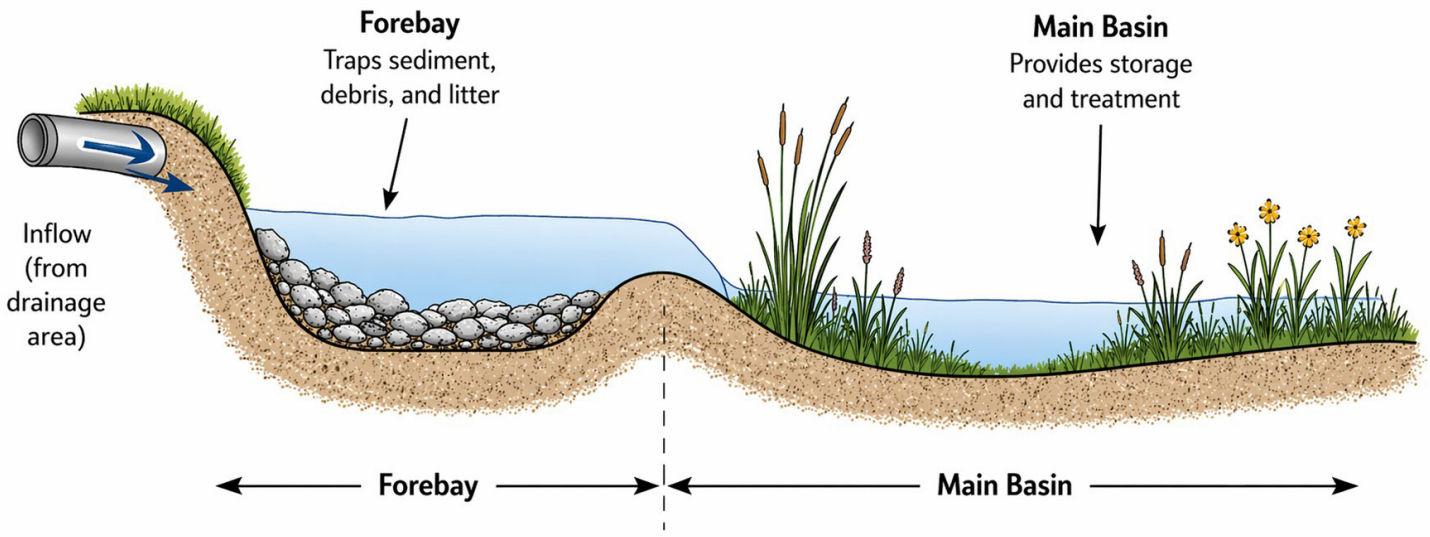
Retrofit projects are often constrained by existing site conditions, including limited available space; existing utilities or infrastructure; adjacent development or property boundaries; or soil conditions and groundwater levels. These factors influence the selection and feasibility of retrofit options. For example, infiltration practices may not be suitable in areas with low-permeability soils or high groundwater, while expanding basin storage may be limited by available footprint.

Hydrologic and Hydraulic Analysis

All retrofit designs must be supported by appropriate

Forebay Concept

Forebays capture sediment and debris before entering the main basin.



Graphic: Created with ChatGPT

hydrologic and hydraulic modeling. This includes evaluating peak flow attenuation, runoff volume management, and water quality treatment performance. Designs should consider a range of storm events, including both large design storms and smaller, more frequent events that contribute significantly to pollutant loading.

Construction and Maintenance Considerations

Proper construction and long-term maintenance are critical to the success of retrofit projects. During construction, **erosion and sediment control (E&S) measures** must be implemented to prevent sediment-laden runoff from entering the basin. Sediment barriers and other BMPs are designed to capture sediment from disturbed areas and must be properly installed to function effectively.

The photo illustrates slope regrading with sediment control measures in place during construction. Photo: NTM Engineering, Inc.

For basins with infiltration or filtration components, **protecting soil surfaces from compaction is essential.** Equipment should not operate on basin floors when soils are wet, as this can significantly reduce infiltration capacity. Low ground pressure equipment and techniques should be used where access to these areas is necessary.

Long-term maintenance is a key design consideration for retrofit projects. Design features should facilitate easy sediment removal (e.g., accessible forebays), **safe and convenient access for maintenance equipment,** and durable vegetation that requires minimal upkeep. Maintenance considerations should be incorporated into the design phase, as inadequate access or overly complex features can lead to neglect and eventual system failure.

Permitting and Compliance Considerations

Stormwater basins are constructed under specific regulatory permits, and retrofitting activities must consider these requirements. In Pennsylvania, the Pennsylvania Department of Environmental Protection (PA DEP) administers National Pollutant Discharge Elimination System (NPDES) permits for construction stormwater and Municipal Separate Storm Sewer Systems (MS4).

In addition to state-issued permits, most municipalities have adopted stormwater ordinances that establish local requirements for the design and construction of stormwater control measures. While these ordinances are not permits themselves, SCM retrofits must comply with applicable municipal standards, and coordination with the municipality is necessary to ensure consistency with current ordinance criteria.

Repairs that restore the original design function of a basin may not require permit modifications. However, changes that alter basin storage volume, drainage area, outlet structures, or overall function typically require coordination with the original permitting authority.

Summary

Retrofitting stormwater basins is a practical and cost-effective approach to improving stormwater management performance. By addressing aging infrastructure, correcting deficiencies, and incorporating modern design features, existing facilities can be upgraded to meet current regulatory requirements and environmental goals.

Successful retrofit projects require a clear understanding of basin function, careful design, and proper construction and maintenance practices to ensure long-term performance.