Stormwater Management Design: Procedures and Applications

Executive Summary

This document outlines a comprehensive framework for stormwater management design, emphasizing a structured, multi-phase approach grounded in regulatory compliance, engineering ethics, and site-specific analysis. The core of the methodology is a detailed 10-step design procedure for new developments in New Jersey, which systematically addresses requirements for groundwater recharge, water quality, and water quantity (flood control). This procedure mandates the use of specific design storms for each objective, ranging from an average precipitation year for recharge to 100-year storms adjusted for climate change for flood control. The framework strongly advocates for the integration of low-impact development principles and Green Infrastructure Best Management Practices (BMPs) to achieve compliance without the need for waivers. The practical application of these principles is demonstrated through three distinct case studies: a green roof at Rutgers University's Engineering building, a bioretention and underground detention basin system for a new Chemistry building, and a large-scale bioretention basin and manufactured treatment device for the New Jersey Turnpike Interchange 14A improvement.

----

1. Foundational Considerations in Stormwater Management

Effective stormwater management design is predicated on a wide array of considerations that extend beyond pure engineering calculations. These factors ensure that a project is viable, responsible, and compliant from conception through its entire life cycle.

The key considerations include:

- **Engineering Ethics:** Adherence to professional standards and moral principles.
- **Client Needs:** Aligning the design with the project owner's goals and requirements.
- **Professional Communications:** Clear and effective dialogue among all stakeholders.
- **Rules and Regulations:** Ensuring full compliance with all applicable local, state, and federal laws.
- **Site Assessment:** A thorough evaluation of the project site's existing conditions.
- **Site Planning:** Strategic placement of developments and infrastructure.
- **BMP Type and Placement:** Selecting and locating the most appropriate Best Management Practices.
- **Alternative Analysis:** Evaluating different design options to determine the optimal solution.
- **Feasibility Study:** Assessing the practicality and viability of the proposed design.

- **Environmental Impact Assessment:** Analyzing the potential environmental effects of the project.
- **Preliminary Design:** The initial phase of design development.
- **Final Design:** The detailed and complete set of construction documents.
- **Cost and Benefit Estimating and Life Cycle Analysis:** Evaluating the long-term economic performance of the stormwater system.

2. New Jersey Design Procedure for New Developments

For new developments in New Jersey, a specific 10-step procedure provides a systematic pathway for designing stormwater management systems that meet state requirements. The process emphasizes the use of small-scale Green Infrastructure BMPs to satisfy regulatory standards without requiring a waiver or variance.

The 10-Step Procedure:

1. **Determine Applicable Regulations:** Identify all relevant rules, regulations, goals, and objectives that govern the project.
2. **Apply Low-Impact Principles:** Follow low-impact development principles and New Jersey's non-structural strategies to site buildings, roads, and associated Stormwater BMPs.
3. **Identify Discharge Points:** Locate all points where runoff will discharge into existing storm drainage systems or receiving waters.
4. **Determine Catchment Areas:** Delineate the catchment area corresponding to each identified discharge point.
5. **Conduct Hydrologic Modeling:** Perform calculations for both pre-development (existing) and post-development (new) conditions to determine runoff volume, peak runoff rate, and groundwater recharge.
6. **Design for Groundwater Recharge:** Size BMPs to meet the post-development groundwater recharge requirements, using all storm events from an average precipitation year as the design standard.
7. **Design for Water Quality:** Size BMPs to meet post-development water quality requirements. This involves using the New Jersey Water Quality Design Storm (NJWQDS) and determining if the BMP should be sized based on runoff volume or peak flow rate.
8. **Design for Water Quantity (Flood Control):** Size BMPs to manage post-development flood control. This requires using the 2-year, 10-year, and 100-year NRCS 24-hour design storms, which must be adjusted for climate change.
9. **Design Storm Sewer Network:** Size the new development's storm sewer pipe network using the design storm specified by the local authority or landowner, whichever is larger (e.g., a 25-year storm). Ensure runoff from the catchment area enters each BMP under all design storm conditions.
10. **Model for Emergency Management:** Conduct hydraulic calculations for the entire site, including individual BMPs and drainage systems, under storm conditions that exceed the largest design storm (e.g., a 500-year storm) to plan for emergency scenarios.

Design Storms and Corresponding Objectives

The New Jersey procedure assigns specific storm events to each design objective to ensure comprehensive performance.

Design Objective	Required Design Storm
Groundwater Recharge	All storm events in an average precipitation year
Water Quality	New Jersey Water Quality Design Storm (NJWQDS)
Water Quantity (Flood Control)	2-year, 10-year, and 100-year NRCS 24-hour storms (adjusted for climate change)
Storm Sewer Pipe Network	As specified by local authority (e.g., 25-year storm)
Emergency Management	Storms exceeding the largest design storm (e.g., 500-year storm)

3. Case Studies in Stormwater Design

The following examples illustrate the application of these design principles in real-world projects.

3.1. Rutgers University - Richard Weeks Hall of Engineering (2016)

This project incorporated a **Green Roof** as its primary stormwater BMP. The plan view of the design shows an irregularly shaped roof area with a gridded surface, enclosed by a perimeter with a minimum width of 6 feet. The design includes specific dimensions and features, such as a staircase, within the green roof's footprint.

3.2. Rutgers University - New Chemistry Building (2014)

The stormwater management plan for this new facility utilized a **bioretention basin** and an **underground detention basin**. The design process involved a detailed comparison of existing and proposed drainage area plans. The plans delineate multiple sub-drainage areas and points of analysis to model the site's hydrology before and after construction, ensuring the proposed BMPs effectively manage the changes in runoff.

3.3. New Jersey Turnpike - Interchange 14A Improvement (2014)

This large-scale infrastructure project implemented a **bioretention basin** and an **underground manufactured treatment device (MTD)** to manage stormwater runoff.

- **Drainage Plan:** The proposed plan shows runoff from the toll plaza area being directed to the MTD before flowing into a ditch that ultimately discharges to Newark Bay. The large, oval-shaped bioretention basin is strategically placed within a highway ramp loop. Other areas of the interchange are shown to drain towards Upper New York Bay.

- **Verification:** Satellite imagery confirms the post-construction locations of the key BMPs. The oval bioretention basin is visible within the loop of Ramp ET, and the MTD is identifiable adjacent to the toll plaza facilities.