Briefing

Large-Scale Green and Non-Green Infrastructure for Stormwater Management

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Executive Summary

This briefing summarizes **large-scale Green Infrastructure (GI)** and **non-GI (traditional engineered) Best Management Practices (BMPs)** for stormwater management under **New Jersey's regulatory framework**. The organizing idea is **BMP selection and design to meet three core standards**:

1. **Groundwater recharge**
2. **Stormwater runoff quality** (primarily **TSS removal**)
3. **Stormwater runoff quantity** (peak and volume controls)

A clear distinction is maintained:

- **GI BMPs**: mimic natural hydrology (infiltration, filtration through soil/vegetation, evapotranspiration, storage)
- **Non-GI BMPs**: engineered conveyance/storage/treatment systems that do not primarily function through soil/vegetation infiltration/filtration pathways

Key Takeaways

- **Regulatory hierarchy matters:** NJ rules prioritize **GI BMPs** for meeting **recharge and water quality**; **non-GI BMPs** are generally allowable only with a **waiver/variance**.
- **A small set of BMP families dominates practice:** bioretention systems, constructed wetlands, (extended) detention basins, and **Manufactured Treatment Devices (MTDs)**.
- **Bioretention is a cornerstone GI practice:** configured **with underdrains** (filtration) or **without underdrains** (infiltration), with defined media, ponding, and groundwater separation requirements.
- **MTDs are essential when space is limited:** NJ certification distinguishes **GI vs. non-GI MTDs** based on treatment mechanism; performance is tracked via certified TSS removal.
- **Performance-based selection:** TSS removal rates drive compliance (GI MTDs commonly certified at **80% TSS**; non-GI devices vary).
- **Sizing is engineering-driven:** design is based on hydrologic calculations tied to the **NJ Water Quality Design Storm (1.25 inches over 2 hours)**.

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1) Regulatory Framework for Stormwater BMPs in New Jersey

New Jersey stormwater rules create a **compliance pathway** that starts with GI.

1.1 Core Requirements (How Engineers Must Comply)

A) Groundwater Recharge + Runoff Quality

- Must use **GI BMPs (Table 5-1)** or an **approved alternative measure** to satisfy recharge and water quality standards.

B) Stormwater Runoff Quantity

- May use BMPs from **Table 5-1**, **Table 5-2**, and/or an approved alternative.

C) Waivers / Variances

- If a project receives a waiver/variance, BMPs from **Tables 5-1, 5-2, or 5-3** may be used to meet **all three standards** (recharge, quality, quantity).

1.2 Maximum Contributory Drainage Area Limits (Selected GI BMPs)

Some GI BMPs are restricted by drainage area served:

BMP	Maximum Contributory Drainage Area
Dry Well	1 acre
Manufactured Treatment Device (MTD)	2.5 acres
Pervious Paving Systems	Additional inflow area ≤ 3× BMP area
Small-scale Bioretention Systems	2.5 acres
Small-scale Infiltration Basin	2.5 acres
Small-scale Sand Filter	2.5 acres

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2) Classification and Performance of Stormwater BMPs

NJ regulations organize BMPs into three “tables” that reflect **priority and permissibility**. Performance is evaluated primarily by:

- **TSS removal (%)**
- Ability to address **quantity control**
- Ability to provide **groundwater recharge**
- **Minimum separation** from seasonal high water table (where applicable)

2.1 Table 5-1: GI BMPs for Standard Compliance (Recharge + Quality Priority)

These are the primary options for meeting **groundwater recharge** and **runoff quality** without a waiver.

Representative entries (as provided):

- Cistern, dry well, grass swale, green roof, GI MTDs, pervious paving, small-scale bioretention, small-scale infiltration basin, small-scale sand filter, vegetative filter strip
- Typical TSS removal ranges from **0% (storage-only practices)** to **80–90%** for filtration/infiltration practices.

2.2 Table 5-2: GI BMPs Approved for Runoff Quantity Control

These practices are approved for **quantity**, and can also support recharge/quality **if a waiver/variance is granted**.

Representative entries (as provided):

- Bioretention system, infiltration basin, sand filter, constructed wetland, wet pond
- TSS removal can reach **90%** for wetlands; ponds vary depending on configuration.

2.3 Table 5-3: BMPs Permissible Only with a Waiver or Variance (Mostly Non-GI)

These BMPs may be used to meet recharge/quality/quantity only when GI requirements are waived.

Representative entries (as provided):

- Blue roof, extended detention basin, non-GI MTDs, sand filter (non-GI configuration), subsurface gravel wetland, wet pond
- TSS removal varies widely (e.g., detention basins often **40–60%**, depending on detention time).

2.4 Key Design Notes (As Used in the Tables)

- (a) Subject to contributory drainage area limitations
- (b) Designed to infiltrate into subsoil
- (c) Designed with underdrains
- (d) Vegetated shoreline + reuse component for wet ponds (as specified)
- (e)/(f) Swale slope criteria
- (g) GI MTDs meet NJ GI definition
- (h) Non-GI MTDs do not meet the GI definition

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3) In-Depth BMP Categories

3.1 Bioretention Systems

Bioretention systems are shallow landscaped practices that manage runoff through **filtration and/or infiltration**, often providing a strong "3-for-3" option (quality + quantity + recharge) when feasible.

Two Primary Configurations

A) Infiltration Bioretention (No Underdrain)

- Goal: maximize recharge
- Requires **≥ 2 ft** separation from seasonal high water table (SHWT)
- Filter fabric placement: typically **sides only** to allow infiltration into undisturbed subsoil

B) Filtration Bioretention (With Underdrain)

- Used when infiltration is limited
- Requires **≥ 1 ft** separation from SHWT
- Underdrain network in gravel layer; fabric often wraps sides/bottom of gravel layer to manage fines

Typical Design Components (As Provided)

- **Soil planting bed:** 18–24 in minimum depth
    - 85–95% sand; ≤15% silt/clay; 3–7% organics
- **Ponding depth:** up to 12 in (18 in for linear systems)
- **Layering:** optional mulch → soil bed → ~6 in sand → gravel with underdrains (if used)
- **Outlet control:** structure with trash rack and staged release as needed

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Example Sizing Workflow (Case Study Format)

Design basis: NJ Water Quality Design Storm = **1.25 in over 2 hours**

Given

- Regulated motor vehicle surface: 1.2 acres
- Runoff coefficient: 1.0
- Max ponding depth: 6 in
- Media permeability: 4 in/hr
- Safety factor: 2

1) Runoff volume

- Depth = 1.25 in
- Area = 1.2 acres
- Volume ≈ **5,450 ft³**

2) Required bottom area

- Ponding depth = 6 in = 0.5 ft
- Bottom area = 5,450 / 0.5 ≈ **10,900 ft²** (~0.25 acre)

3) Ponding time check

- Effective infiltration rate = 4 / 2 = 2 in/hr
- Time = 6 / 2 = **3 hr**
- Below maximum allowable (72 hr), so sizing is acceptable

3.2 Constructed Wetlands

Constructed wetlands use wetland plants, soils, and microbial processes for treatment.

Typical Elements

- Forebay for pretreatment/sedimentation
- Marsh/pool zones (depth-based)
- Outlet riser + emergency spillway
- Minimum length-to-width ratio (e.g., ≥ 1:1 as noted)

Example Criteria (As Provided)

- Pond/marsh wetlands: minimum drainage area ~25 acres
- Extended detention wetland: minimum drainage area ~10 acres
- Depth zoning: high marsh (shallow), low marsh (moderate), pools (deeper)

3.3 Extended Detention Basins (Primarily Quantity Control)

Extended detention basins temporarily store runoff and release it through a staged outlet.

- Quantity control: primary purpose
- Water quality: moderate benefit
- TSS removal increases with detention time:
  - ~40% at ~12-hour detention
  - ~60% at ~24-hour detention (as noted)

3.4 Subsurface Gravel Wetlands (Enhanced Nitrogen Removal)

A specialized wetland practice designed to improve nitrogen removal via:

- Anaerobic zones in gravel media
- Microbial denitrification
- Multi-cell configurations + pretreatment zone commonly used

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4) Manufactured Treatment Devices (MTDs)

MTDs are proprietary engineered units—often underground—used where space is limited (dense redevelopment corridors, constrained rights-of-way, etc.). NJ certification typically includes laboratory and field testing.

4.1 Major MTD Families (As Provided)

1. **Hydrodynamic separators** (vortex + gravity separation)
2. **Media filters** (filtration through sand/sorbents, etc.)
3. **Retention/detention/recharge chambers** (storage and/or infiltration)

4.2 Regulatory Guidance Highlights

GI vs. Non-GI MTD Classification

To be **GI**, an MTD must:

- Infiltrate into subsoil **and/or**
- Treat via filtration by **vegetation or soil** (e.g., tree boxes, planter boxes, vaults infiltrating below)

Sizing Methodology Update (As Provided)

- As of July 2023: **NRCS methodology** required for MTD sizing (Rational Method no longer used for sizing MTDs).

Certified TSS Removal

- Certified **GI MTDs**: typically **80% TSS**
- Non-GI MTDs: certified at **50% or 80%**, depending on device/test outcomes

4.3 Physical Principle Note (Hydrodynamic Separation)

Many hydrodynamic separators rely on vortex/secondary-flow behavior that concentrates sediment for removal—analogous to secondary currents in curved channels (conceptually similar to sediment sorting in meanders).

4.4 Maintenance Reality

MTD performance is maintenance-dependent:

- periodic removal of accumulated sediment/trash/debris
- vacuum truck cleanout is common for underground units

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5) Advanced / Emerging Treatment Enhancements

Enhancing Nitrogen Removal (Research Direction)

One emerging approach is to amend bioretention media with materials like **biochar** and promote microbial pathways (e.g., nitrate-reducing communities). Reported experimental outcomes (as provided) suggest nitrate reduction to near-zero within ~48–72 hours under favorable biotic conditions.

Practical Design Summary

When selecting large-scale stormwater BMPs in NJ, the workflow is typically:

1. **Start with GI BMPs** (recharge + quality compliance priority)
2. Apply **drainage-area limits** and site constraints (space, SHWT, soils, utilities)
3. Choose practices based on **certified/assumed performance** (especially TSS removal)
4. Size using the **NJ Water Quality Design Storm (1.25 in / 2 hr)** and required hydrologic method
5. Confirm feasibility via **drawdown time**, groundwater separation, and maintenance access
6. Use **non-GI BMPs** only when permitted through waiver/variance and justified by constraints