Groundwater Recharge Standards and Implementation

Executive Summary

The New Jersey Department of Environmental Protection (NJDEP) Stormwater Management rules, specifically N.J.A.C. 7:8, mandate stringent standards for groundwater recharge on major development sites. The core objective is to mitigate the adverse impacts of land development—such as the creation of impervious surfaces—which reduce the natural replenishment of groundwater. This reduction can harm streams, wetlands, and the yield of water supply wells. To ensure compliance, design engineers must demonstrate through hydrologic and hydraulic analysis that a project meets one of two standards: either maintaining 100% of the site's average annual pre-construction recharge volume or infiltrating the full increase in stormwater runoff volume from a two-year storm.

To facilitate these complex calculations, the NJDEP provides the New Jersey Groundwater Recharge Spreadsheet (NJGRS), an Excel-based tool grounded in the 1993 Geological Survey Report GSR-32. This spreadsheet enables planners and designers to compute pre- and post-development recharge volumes, identify any deficit, and subsequently design Best Management Practices (BMPs) to offset it. A case study of the Interchange 14A Improvements project in Jersey City illustrates this process, where a post-development annual recharge deficit of 62,914 cubic feet was calculated and subsequently addressed through the design of a bioretention basin BMP.

Regulatory Framework for Groundwater Recharge

N.J.A.C. 7:8-5.4 Minimum Design and Performance Standards

The foundational regulation, effective since February 2004, establishes the minimum design and performance standards for groundwater recharge. A design engineer must satisfy one of the following two requirements using the assumptions and factors detailed in N.J.A.C. 7:8-5.7:

- **Requirement 1:** "Demonstrate through hydrologic and hydraulic analysis that the site and its stormwater management measures maintain 100 percent of the average annual pre-construction groundwater recharge volume for the site."
- **Requirement 2:** "Demonstrate through hydrologic and hydraulic analysis that the increase of stormwater runoff volume from pre-construction to post-construction for the two-year storm is infiltrated."

The site designer has the discretion to choose which of the two alternative requirements to follow.

Applicability and Purpose

These standards are applicable to any "major development" project, which is defined as a project that:

- Disturbs at least one acre of land.
- Creates at least 0.25 acres of regulated impervious surface.
- Creates a combination of regulated impervious surface and motor vehicle surface totaling 0.25 acres or more.

The regulations were established in recognition that land development activities, such as covering permeable soils with impervious surfaces or compacting soil, reduce the rate of natural groundwater recharge. This can "adversely impact streams, wetlands and other water bodies by reducing the volume and rate of base flow to them," and can also "adversely impact the yield of water supply wells."

Certain projects, including urban redevelopment and some linear developments, are exempt from these requirements. Waivers may also be obtained for enlargements to public roadways, railroads, and pedestrian walkways under specific conditions.

The Hydrologic Process and Computation Methodology

Fundamentals of Groundwater Recharge

In the context of the NJDEP Stormwater Management rules, groundwater recharge is formally defined as "precipitation that infiltrates into the soil and is not evapotranspired." This process involves several stages within the hydrologic cycle:

1. **Precipitation:** Rain, snow, hail, or sleet falls on the land surface.
2. **Infiltration:** A portion of the precipitation seeps into the soil, while the rest becomes surface runoff.
3. **Evapotranspiration:** Some infiltrated water is returned to the atmosphere through evaporation from the soil surface and transpiration by plants.
4. **Recharge:** Water that infiltrates beyond the root zone of vegetation, where it can no longer be removed by evapotranspiration, continues to move downward until it reaches the saturated zone, at which point it officially becomes groundwater.

The New Jersey Groundwater Recharge Spreadsheet (NJGRS)

To standardize and simplify the required calculations, the NJDEP, with assistance from the New Jersey Geologic Survey (NJGS) and the U.S. Geologic Survey (USGS), developed the New Jersey Groundwater Recharge Spreadsheet (NJGRS).

- **Function:** This Microsoft Excel-based tool is used by site planners, designers, and reviewers to determine average annual groundwater recharge amounts under both pre- and post-development conditions and to design the necessary recharge BMPs.
- **Theoretical Basis:** The NJGRS is founded on the data and computational procedures from the 1993 *Geological Survey Report GSR-32: A Method for Evaluating Ground Water Recharge Areas in New Jersey*. It incorporates GSR-32's databases and algorithms, utilizing precipitation, soil, land cover, and climate data to estimate recharge amounts.

Four-Step Computational Process

The analytical procedure to demonstrate compliance with Requirement 1 (maintaining 100% pre-development recharge) involves four main steps performed within the NJGRS:

1. **Compute Pre-Developed Recharge:** Calculate the average amount of annual groundwater recharge for the land development site under its existing, pre-developed conditions.
2. **Compute Post-Developed Recharge:** Calculate the average amount of annual groundwater recharge for the site under its proposed, post-developed conditions.
3. **Calculate Recharge Deficit:** Subtract the post-developed amount (Step 2) from the pre-developed amount (Step 1). The result is the average annual recharge deficit that must be compensated for using structural BMPs.
4. **Design BMP:** Determine the required storage volume and dimensions of the recharge BMP needed to satisfy the deficit from Step 3, accounting for precipitation patterns and potential losses.

Technical Basis of NJGRS Calculations

Precipitation Data and Runoff Equations

The NJGRS model relies on a robust dataset and specific formulas to accurately predict runoff and recharge.

- **Precipitation Data:** The model's developers compiled and analyzed 52 years of daily precipitation data (1948-1999) from 92 stations across New Jersey. This data was used to create a normalized average annual series of 79 distinct precipitation events. The NJGRS generates a site-specific design series by multiplying these normalized event values by the average annual precipitation for the specific municipality where the project is located.
- **Runoff Equations:** To account for initial precipitation losses, the NJGRS uses three different equations to compute runoff depth (Q) based on the precipitation depth (P) of a given design event:
    - **For $P < 0.0408$ inches:** The spreadsheet assumes all precipitation is consumed by surface storage and other losses, resulting in zero runoff.
    - **For $0.04 \le P \le 1.25$ inches:** $Q = 0.95 \times (P - 0.0408) \times 0.90$
    - **For $P > 1.25$ inches:** The NRCS Runoff Equation is used with a Runoff Curve Number (CN) of 98: $Q = (P - 0.04)^2 / (P + 0.16)$

After calculating the initial runoff, the NJGRS applies additional specialized equations to estimate further losses that occur as the runoff is stored in the BMP, accounting for factors like local climate, vegetation, and soil conditions.

Green Infrastructure and Best Management Practices (BMPs)

When a post-development recharge deficit is identified, structural green infrastructure BMPs are used to provide the necessary artificial recharge. The design process involves key decisions, such as whether to use a single BMP or multiple smaller ones, where to locate them relative to buildings and property lines, and determining their required dimensions.

Overview of Green Infrastructure BMPs

The following table summarizes various BMPs and their applicability for groundwater recharge, stormwater quality, and quantity control, as specified by the NJDEP.

Best Management Practice	Stormwater Runoff Quality TSS removal rate (percent)	Stormwater Runoff Quantity	Groundwater Recharge	Minimum separation from seasonal high-water table (feet)
Cistern	0	Yes	No	-
Dry Well(a)	0	No	Yes	2
Grass Swale	50 or less	No	No	2(e), 1(f)
Green Roof	0	Yes	No	-
Manufactured Treatment Device(a)(g)	50 or 80	No	No	Dependent upon the device
Pervious Paving System(a)	80	Yes	Yes(b) / No(c)	2(b) / 1(c)
Small-Scale Bioretention Basin(a)	80 or 90	Yes	Yes(b) / No(c)	2(b) / 1(c)
Small-Scale Infiltration Basin(a)	80	Yes	Yes	2
Small-Scale Sand Filter	80	Yes	Yes	2
Vegetative Filter Strip	60-80	No	No	-

Notes: (a) Subject to contributory drainage area limitations specified at N.J.A.C. 7:8-5.3(b). (b) Designed to infiltrate into the subsoil. (c) Designed with underdrains. (e), (f) Specific conditions for Grass Swales. (g) Dependent upon the specific device.

Case Study: Interchange 14A Improvements

Project Overview and Analysis

A project for improvements at the New Jersey Turnpike Interchange 14A in Hudson County, Jersey City, provides a practical application of the groundwater recharge regulations. An analysis was conducted on May 5, 2014, to assess the impact of land use changes, such as converting grass and trees to pavement, on the site's annual recharge.

Calculating the Recharge Deficit

Using the NJGRS (Version 2.0, Nov 2003), the project team calculated the recharge volumes for the site's pre- and post-development conditions.

- **Location:** Hudson Co., Jersey City
- **Average Annual Precipitation (P):** 42.9 inches
- **Pre-Developed Conditions:**
    - Total Area: 47.7 acres
    - Total Annual Recharge: **769,139 cubic feet**
- **Post-Developed Conditions:**
    - Total Area: 48.3 acres
    - Total Annual Recharge: **706,225 cubic feet**

Based on these figures and the requirement to preserve 100% of pre-developed recharge, the analysis identified a significant shortfall:

- **Post-Development Annual Recharge Deficit: 62,914 cubic feet**

Designing the BMP Solution

To address this deficit, a bioretention basin was designed as the project's recharge BMP. The NJGRS BMP Calculations worksheet was used to size the facility and verify its performance.

- **Post-D Deficit Recharge Volume (Vdef):** 62,914 cu.ft
- **Post-D Impervious Area (Aimp):** 135,036 sq.ft
- **Calculated Annual BMP Recharge Volume: 62,914 cu.ft**

The designed BMP successfully offset the entire deficit, with the system's performance parameters indicating an **Average BMP Recharge Efficiency of 93.3%**. All calculation checks within the spreadsheet returned an "OK" status, confirming the validity of the design.