<table>
<thead>
<tr>
<th>No., Subject, Presenter</th>
<th>(duration)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. How to Review a Project 1, Tim</strong></td>
<td>(60 minutes)</td>
</tr>
<tr>
<td><strong>Goal One:</strong> Learn to identify which design and performance standards must be met on site</td>
<td></td>
</tr>
<tr>
<td><strong>Goal Two:</strong> Learn how to review for compliance with the nonstructural, water quantity, water quality, and groundwater recharge standards</td>
<td></td>
</tr>
<tr>
<td><strong>Goal Three:</strong> Learn how to review BMPs for compliance with the design criteria in the BMP Manual</td>
<td></td>
</tr>
<tr>
<td><strong>Goal Four:</strong> Learn how to review for the safety requirements</td>
<td></td>
</tr>
<tr>
<td><strong>(4 minute break)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>2. How to Review a Project 2, Changi</strong></td>
<td>(60 minutes)</td>
</tr>
<tr>
<td><strong>Goal One:</strong> Learn how to review soil testing results for compliance with Chapter 12/Appendix E</td>
<td></td>
</tr>
<tr>
<td><strong>Goal Two:</strong> Calculate Detention Time</td>
<td></td>
</tr>
<tr>
<td><strong>Goal Three:</strong> MTD MTFR vs drainage area</td>
<td></td>
</tr>
<tr>
<td><strong>Goal Four:</strong> Groundwater Recharge Spreadsheet</td>
<td></td>
</tr>
<tr>
<td><strong>Goal Five:</strong> Groundwater Mounding Analysis</td>
<td></td>
</tr>
<tr>
<td><strong>(4 minute break)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>3. Groundwater Mounding Examples, Lisa</strong></td>
<td>(30 minutes)</td>
</tr>
<tr>
<td><strong>(4 minute break)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Quiz 3 – Presentations 1, 2 &amp; 3, Jim</strong></td>
<td>(15 minutes)</td>
</tr>
<tr>
<td><strong>(2 minute break)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Review Quiz 3, Jim</strong></td>
<td>(15 minutes)</td>
</tr>
</tbody>
</table>
Goals

• Learn to identify the design and performance standards that must be met onsite
• Learn how to review applications for compliance with the nonstructural, water quantity, water quality, and groundwater recharge standards
• Learn how to review BMPs for compliance with the design criteria in the BMP Manual
• Learn how to review soil testing results for compliance with Chapter 12
• Learn how to review for compliance with safety requirements
Checking Application

The applicant needs to submit, at a minimum...

- **Pre-** and **post-construction site** plans
- **Pre-** and **post-construction grading** plans
- Stormwater report with calculations
- Details of BMPs
Determining Applicable Design & Performance Standards

Where does it discharge to?

- Watershed
- Category 1
- Flooding problems
- Water quality impairments or TMDLs
- Is the site in a regulated area?
  - Flood Hazard Area
  - CAFRA
  - Freshwater Wetlands
  - Highlands
- Is the site in the Pinelands?
Is the project a major development?

- Does the project disturb one acre or more?
- Does the project increase impervious coverage by \( \frac{1}{4} \) acre or more?
- What is the SCO’s definition of major development?
“Major Development” definitions:

- Residential Site Improvement Standards:
  - 1 acre of more of disturbance (N.J.A.C. 5:21)
- Stormwater Control Ordinance:
  - 1 acre or more of disturbance or
  - More stringent standard adopted by municipality
- NJDEP Division of Land Use Regulation:
  - 1 acre or more of disturbance
  - ¼ acre or more increase in impervious coverage
Design and Performance Standards for Major Developments:

- Nonstructural strategies
- Water quantity
- Water quality
- Groundwater recharge
Are there waivers or exemptions?

Sometimes...
Waivers or variances can be granted if...

- Municipality has an adopted mitigation plan in MSWMP
- Mitigation is for same standard that cannot be met onsite
- Mitigation is in same drainage area
Specific exemptions exist for...

- Water Quantity, if in Tidal Flood Hazard Area and flooding will not be increased
- Water Quality, if site has NJPDES permit with specific effluent limit
- Groundwater Recharge, for previously developed areas in urban redevelopment area
Determining Applicable Design & Performance Standards

Urban Redevelopment Area

• “Previously developed portions” of areas:
  o Delineated on State Plan Policy Map as:
    • Planning Area 1
    • Designated Centers, Cores, or Nodes
  o CAFRA Centers, Cores, or Nodes
  o Urban Enterprise Zones
  o Urban Coordinated Council Empowerment Neighborhoods
Linear development exemptions exist for...

- Construction of underground utility line, if revegetated upon completion
- Construction of aboveground utility line, if existing conditions are maintained to MEP
- Construction of public pedestrian access, if made of permeable materials and no greater than 14 ft. wide
Determining Applicable Design & Performance Standards

Waivers from strict compliance exist for...

- Enlargement of road or railroad, construction or enlargement of public pedestrian access, if applicant demonstrates:
  - Public need for project that can’t be met another way
  - D&P Standards met to maximum extent practicable
  - Meeting the standards would require condemning existing in-use structures
  - Applicant does not have and cannot get rights to other lands for mitigation
Possible waivers/variances (summary):

- Construction of utility lines, public pedestrian access
- Enlargement of road, railroad, public pedestrian access
- Tidal Flood Hazard Area
- Urban Redevelopment Area
- NJPDES Permits w/ discharge limits
- Mitigation plan
Stormwater Management Report
Reading the Report

Report should contain:

• A site description
• Discussion of applicable design and performance standards
• Calculations


https://www.nj.gov/dep/dwq/pdf/Tier_A/Tier_A_Chapter_3-4.pdf
Site description

- Existing conditions
- Proposed conditions
- Disturbance and change in impervious cover
- Soil survey information
Design and Performance Standards

• What’s required
• Applicable exemptions
• How standards were met
  o Nonstructural strategies
  o Peak flow information
  o TSS removal rates
  o Groundwater recharge information
Reading the Report

Calculations

• Time of concentration – calculated, not assumed, for NRCS methodology (see Chapter 5 revisions)
• Storm routings
• Hydrographs
• Groundwater recharge spreadsheet
• Water quality calculations
NONSTRUCTURAL STRATEGIES
Nonstructural Strategies

Nonstructural strategies are...

• Ways of minimizing adverse effects of development

• Intended to maintain pre-development hydrology
Nonstructural Strategies

Nonstructural strategies

• Must be used to the maximum extent practicable to meet design and performance standards

• Required on all new developments and redevelopments
Nonstructural Strategies

Remember that development usually...

- Removes beneficial vegetation
- Increases impervious coverage
- Reduces time of concentration
- Causes soil compaction
Nonstructural Strategies

Nonstructural strategies include...

- Protecting beneficial vegetation
- Minimize impervious coverage
- Minimize decrease in time of concentration
- Prevent soil compaction
Nonstructural Strategies

Nine Nonstructural Strategies:

1) Protect areas that provide water quality benefits or areas particularly susceptible to erosion and sediment loss

2) Minimize impervious surfaces and break up or disconnect the flow over impervious surfaces
Nonstructural Strategies

Nine Nonstructural Strategies:

3) Maximize the protection of natural drainage features and vegetation

4) Minimize the decrease in the time of concentration
Nonstructural Strategies

Nine Nonstructural Strategies:

5) Minimize land disturbance including clearing and grading

6) Minimize soil compaction
Nonstructural Strategies

Nine Nonstructural Strategies:

7) Provide low-maintenance landscaping, native vegetation and minimize the use of lawns, fertilizers and pesticides.

8) Provide vegetated open-channel conveyance
Nonstructural Strategies

Nine Nonstructural Strategies:

9) Provide source controls to prevent or minimize the use or exposure of pollutants
Nonstructural Strategies

Nonstructural strategies

• Must be identified as being incorporated into the site design

• If a strategy can’t be met, the applicant must provide a basis

• Only acceptable reasons for not incorporating a strategy:
  o Engineering
  o Environmental
  o Safety
Nonstructural Strategies

Nonstructural strategies

• Must be protected via:
  o Dedicated to a government agency or
  o Subject to conservation restriction or
  o Other equivalent restriction
WATER QUANTITY
Water Quantity

The water quantity standard...

• Protects against flooding
• Can be met in three different ways
• Must be met for each point of analysis
OPTION 1:

Demonstrate that at no point does the post-development hydrograph exceed the pre-development hydrograph for 2, 10, and 100 year storms (N.J.A.C. 7:8-5.4)

- Applicant must submit pre- and post-development hydrographs
- Total runoff volume must be equal or lower in post-development
- **Tips:**
  - Almost never used for new development, but common in redevelopment
  - Almost always **requires** decrease in impervious coverage
  - Almost always **requires** same pre- and post-construction $T_c$
OPTION 2:

Demonstrate no increase in peak flows and no increase in flood damage due to change in volume or timing assuming full build-out under current zoning (N.J.A.C. 7:8-5.4)

- Applicant must submit pre- and post-development peak flows
- Requires extremely complicated and detailed analysis
- **Tips:**
  - Almost never successfully used
  - Beware of any attempt to use this option
OPTION 3:

Reduce the post-development peak flows to 50, 75, and 80% of pre-development peak flows for 2-, 10-, and 100-year storms (N.J.A.C. 7:8-5.4)

- Applicant must submit routing calculations
- Most commonly used standard
- **Tips:**
  - Expect this standard on nearly all new development
  - Almost always requires installation of a detention structure
Water Quantity

Water Quantity Calculations – Acceptable Methods

• Rational Method for peak flows & Modified Rational Method for hydrographs

• NRCS Method
Water Quantity

Water Quantity Calculations – Required Information

- Information required from site plans/report:
  - Topography
  - Land cover
  - Soils
  - Rainfall data
Water Quantity

Topography

- Allows reviewer to identify where stormwater flows
- Required to determine drainage areas and time of concentration
Water Quantity

Topography

• Site plans must show:
  o Existing and proposed contours
  o Point of analysis
  o $T_c$ flowpath
  o Drainage area to each point of analysis
Topography

- For sites with multiple drainage areas that don’t converge or have very different cover:
  - Each DA should be calculated separately
  - Each DA should have separate Tc calculation
  - Each DA should meet water quantity standard
Water Quantity
Topography

• Reviewer needs to verify:
  o All drainage areas are delineated correctly
  o Verify that proper time of concentration flow path is used
  o Verify that time of concentration is calculated properly
Topography

• Look for depressions on existing site

• Water ponds in natural depressions

• Ignoring depression storage will overestimate existing discharge volumes and peak flows
Water Quantity
Land Cover

- Should be clearly marked on plans
- Should be specific: forest, grass, bare soil, impervious coverage
- Include any existing BMPs
Land Cover

• Reviewer needs to verify:
  o What’s on site plan matches actual conditions
  o Land cover used in the calculations is the most pervious cover that has existed in past 5 years
Soils

• Soils on-site must be determined

• Required information: HSG and soil type

• Should be submitted with report

• Best way to find soil info is NRCS Web Soil Survey:
  o https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
  o Google “Web Soil Survey”
Water Quantity

Soils

- Sometimes cannot be found in soil survey

- If information not available, two ways to find HSG:
  - Default hydrologic soil groups
  - Soil testing

- Information on both methods in Chapter 12
Soils

Default Hydrologic Soil Groups:

- In coastal plain:
  - Pre-developed: HSG A
  - Post-developed: HSG D

- Outside coastal plain:
  - Pre-developed: HSG B
  - Post-developed: HSG D
Soils

- Ideal case – soil data overlain on site plan
- Normal case – soil survey is printed or scanned and attached to report
Soils

- Reviewer needs to verify:
  - HSGs and soil types are properly identified
  - HSGs and soil types are applied to proper areas (square footage and land cover)
  - Soil testing meets requirements of Appendix E/Chapter 12
Soils

- Poor soil testing is one of the most common review issues encountered

- Soil testing can make or break a stormwater management design

- Often the best practice to review soil testing first
Time of Concentration

- Required for both Rational/Modified Rational Methods and NRCS Method

- Should be calculated in accordance with the NEH and also Chapter 5 of the BMP Manual
Water Quantity

Time of Concentration

• Three flow conditions:
  o Sheet flow
  o Shallow concentrated flow
  o Channel flow
Water Quantity

Time of Concentration

• Sheet flow calculations
  o Flow length should not be above 100 feet
  o Sheet flow roughness coefficient must match cover
  o Slope should be measured directly from the plan
  o 2-year, 24-hour rainfall should come from NOAA or NRCS

\[ T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5}s^{0.4}} \]
Water Quantity

Time of Concentration

• Sheet flow calculations
  o Calculation is very sensitive to slope and roughness
  o Maximum roughness coefficient is 0.4
  o For two distinctly different covers in first 100 feet, use two separate sheet flow calculations
Water Quantity

Time of Concentration

• Shallow concentrated flow calculations
  o Flow velocity found using chart in National Engineering Handbook
  o Velocity based on land cover and slope

\[ T_t = \frac{L}{3600V} \]
Water Quantity
Time of Concentration

- Shallow concentrated flow calculations
  - Ensure proper land cover and slope
  - Check charts to be sure that the right velocity curve was used
Water Quantity

Time of Concentration

- Channel flow calculations
  - Only exists when a defined channel exists on-site
  - Must use Manning’s roughness coefficient for open channels

\[ T_t (hr) = \frac{L(n)}{3600 \left(1.49R^3S^{0.5}\right)} \]
Time of Concentration

- $T_c = \text{sheet flow} + \text{shallow concentrated flow} + \text{channel flow (if applicable)}$
- Rational/Modified Rational Method: minimum $T_c$ of 10 minutes
- NRCS Method: minimum $T_c$ of 6 minutes must be calculated
Time of Concentration Common Errors:

• Using minimum $T_c$ of 10 minutes instead of 6 minutes for NRCS method

• Standard $T_c$ calculations won’t work if there are significant depressions on-site

• Assuming minimum time of concentration in post-construction conditions is conservative
Time of Concentration

• Takeaways:
  o $T_c$ generally significantly decreased in post-construction
  o Runoff flows much more slowly over vegetated areas
  o SCS Unit Hydrograph calculations (flow rate) inversely related to time of concentration

\[ q_p = \frac{726AQ}{t_c} \]
Let’s say the reviewer requires applicant to use:
- Nonstructural strategy #2: Minimize impervious surface and break up or disconnect the flow over impervious surfaces
- Nonstructural strategy #8: Provide vegetated open-channel conveyance

They would also probably achieve:
- Nonstructural strategy #4: Minimize the decrease in the time of concentration
Water Quantity

Time of Concentration

- Achieving nonstructural strategy #4 will also reduce the increase in the peak flow
- Contributes to meeting water quantity control standard
- For example, increasing $T_c$ from 6 minutes to 10 minutes on 1 acre site can reduce peak flow as much as 12-12.5%
Water Quantity

In summary...

- Review sheet flow, shallow concentrated flow, and channel flow inputs
- Don’t mix up minimum $T_c$ for rational/modified rational method and NRCS method
- Pre-construction $T_c$ should always be proven by calculation
- Post-construction $T_c$ can no longer be assumed as an allowable minimum
Water Quantity

Curve Numbers/Runoff Coefficients

• Used to calculate amount of runoff caused by given precipitation

• Curve numbers – NRCS Method

• Runoff Coefficients – Rational/Modified Rational
Curve Numbers/Runoff Coefficients

- Stormwater report and plans should clearly show area for each different land cover and HSG

- Both must always be based on “good” hydrologic condition
## Curve Numbers/Runoff Coefficients

<table>
<thead>
<tr>
<th>Area (sf)</th>
<th>Land Cover</th>
<th>Soil Type</th>
<th>Hydrologic Soil Group</th>
<th>Curve Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>38,173</td>
<td>Pavement</td>
<td>Bucks silt loam</td>
<td>B</td>
<td>98</td>
</tr>
<tr>
<td>24,689</td>
<td>Lawn</td>
<td>Bucks silt loam</td>
<td>B</td>
<td>61</td>
</tr>
<tr>
<td>14,787</td>
<td>Lawn</td>
<td>Lehigh silt loam</td>
<td>C</td>
<td>74</td>
</tr>
<tr>
<td>9,950</td>
<td>Forest</td>
<td>Dunellen sandy loam</td>
<td>A</td>
<td>30</td>
</tr>
<tr>
<td>2,654</td>
<td>Pavement</td>
<td>Lehigh silt loam</td>
<td>C</td>
<td>98</td>
</tr>
</tbody>
</table>
Water Quantity

Curve Numbers/Runoff Coefficients

• Curve numbers can all be verified from Chapter 5

• Runoff coefficients are generally estimates with ranges

• Reviewer is responsible for ensuring that the designer’s chosen value is reasonable
Water Quantity

Subarea Routing

• Required to route pervious and impervious areas separately

• Never use a weighted average of pervious and impervious areas
  o Underestimates flow rates and volumes
Rainfall

• For NRCS Method:
  o 2-, 10- and 100-year, 24-hour storms (NOAA or NRCS)
  o Water Quality Design Storm (BMP Manual Chapter 5)

• For Rational/Modified Rational Method:
  o 2-, 10- and 100-year, IDF Curves (NOAA or BMP Manual Chapter 5)
  o Water Quality Design Storm Intensity-Duration Curve (BMP Manual Chapter 5)
Rainfall Distribution (NRCS Method only)

- BMP Manual mentions Type III rainfall distribution
- NRCS developed other distributions for NJ in 2012:
  - NOAA_C
  - NOAA_D
- NOAA_C and NOAA_D already built into many stormwater modeling programs
Water Quantity

Design Storm Event (Modified Rational Method)

- Applicant must show critical storage volume calculation

- Detention basin design must be based on storm event that results in critical storage volume
Unit Hydrograph (NRCS Method only)

- SCS Unit Hydrograph may be acceptable throughout the entire state, but must be used outside coastal plain area
- DelMarVa Hydrograph is acceptable in the coastal plain area only
- Must use the same hydrograph in both pre and post conditions
Water Quantity

In summary…

• Curve numbers required for each segment with different soils or cover
• Never use a weighted average of pervious and impervious areas
• DelMarVa Unit Hydrograph – only used for applicable areas of coastal plain
• Type NOAA_C or D rainfall distributions for NRCS
Detention Structures

- Excavated or natural depressions, or excavated underground chambers
- Store runoff for extended period of time (generally 24-72 hours)
- Slowly release runoff through outlet structure
Detention Structures

- Various BMPs can be designed to provide detention:
  - Extended detention basins
  - Constructed wetlands
  - Infiltration basins
  - Bioretention systems
  - Sand filters
  - Pervious paving systems
  - Blue roofs
Stormwater Quantity Control BMPs

Outlet Structure

• Contains one or more orifices or weirs

• Designed to achieve specific outflow rates

• Flow leaving basin governed by outlet size and hydraulic head
Stormwater Quantity Control BMPs

Hydrologic Routing

• Given inflow hydrographs, basin storage and outlets, determine outflow hydrograph

• Most commonly achieved using routing software

• Basin information usually put in using stage-storage data and outlet design
### Basin Design

#### Stormwater Quantity Control BMPs

**Stage / Storage Table**

<table>
<thead>
<tr>
<th>Stage (ft)</th>
<th>Elevation (ft)</th>
<th>Contour area (sqft)</th>
<th>Incr. Storage (cuft)</th>
<th>Total storage (cuft)</th>
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</thead>
<tbody>
<tr>
<td>0.00</td>
<td>121.10</td>
<td>2,143</td>
<td>0</td>
<td>0</td>
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<tr>
<td>0.40</td>
<td>121.50</td>
<td>2,997</td>
<td>1,028</td>
<td>1,028</td>
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<tr>
<td>1.00</td>
<td>122.10</td>
<td>3,374</td>
<td>1,911</td>
<td>2,939</td>
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<tr>
<td>1.15</td>
<td>122.25</td>
<td>3,755</td>
<td>535</td>
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<tr>
<td>1.20</td>
<td>122.30</td>
<td>3,775</td>
<td>188</td>
<td>3,662</td>
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<tr>
<td>1.40</td>
<td>122.50</td>
<td>3,880</td>
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<td>2.40</td>
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<td>4,490</td>
<td>2,151</td>
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<tr>
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<td>124.00</td>
<td>4,849</td>
<td>2,335</td>
<td>10,912</td>
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<tr>
<td>3.40</td>
<td>124.50</td>
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<td>125.00</td>
<td>5,677</td>
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</table>

**Culvert / Orifice Structures**

<table>
<thead>
<tr>
<th>[A]</th>
<th>[B]</th>
<th>[C]</th>
<th>[D]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise (in)</td>
<td>11.25</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Span (in)</td>
<td>11.25</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>No. Barrels</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Invert El. (ft)</td>
<td>122.30</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Length (ft)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Slope (%)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>N-Value</td>
<td>0.013</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Orif. Coeff.</td>
<td>0.60</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Multi-Stage</td>
<td>n/a</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

**Weir Structures**

<table>
<thead>
<tr>
<th>[A]</th>
<th>[B]</th>
<th>[C]</th>
<th>[D]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crest Len (ft)</td>
<td>12.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Crest El. (ft)</td>
<td>124.25</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Weir Coeff.</td>
<td>3.33</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Weir Type</td>
<td>Rect</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Multi-Stage</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Exfiltration = 0.000 in/hr (Contour) Tailwater Elev. = 0.00 ft

---
Stormwater Quantity Control BMPs

OUTLET STRUCTURE INPUT DATA

<table>
<thead>
<tr>
<th>Structure ID</th>
<th>Structure Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Weir-Rectangular</td>
</tr>
</tbody>
</table>

- # of Openings: 1
- Crest Elev.: 105.45 ft
- Weir Length: 2.00 ft
- Weir Coeff.: 3.100000
- Weir TW effects (Use adjustment equation)

<table>
<thead>
<tr>
<th>Structure ID</th>
<th>Structure Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>Orifice-Circular</td>
</tr>
</tbody>
</table>

- # of Openings: 1
- Invert Elev.: 102.70 ft
- Diameter: 0.7500 ft
- Orifice Coeff.: 0.600

<table>
<thead>
<tr>
<th>Structure ID</th>
<th>Structure Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Orifice-Circular</td>
</tr>
</tbody>
</table>

- # of Openings: 1
- Invert Elev.: 100.20 ft
- Diameter: 0.2500 ft
- Orifice Coeff.: 0.600

USER DEFINED VOLUME RATING TABLE

<table>
<thead>
<tr>
<th>Elevation (ft)</th>
<th>Volume (ac-ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.20</td>
<td>0.000</td>
</tr>
<tr>
<td>100.70</td>
<td>0.005</td>
</tr>
<tr>
<td>101.20</td>
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<td>103.20</td>
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<td>104.20</td>
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<td>104.70</td>
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<tr>
<td>105.20</td>
<td>0.089</td>
</tr>
<tr>
<td>105.70</td>
<td>0.094</td>
</tr>
</tbody>
</table>
Stormwater Quantity Control BMPs

Detention Structures Summary

• Reviewer needs to verify:
  o Basin design input matches plans and details
  o Correct subareas are routed to the basin
  o Outputs make sense
  o Infiltration was not included in the routings
Water Quantity

Dealing With Depression Storage

• Depressions and high permeability soils clearly provide stormwater management benefits

• Nonstructural strategy #3: Maximize the protection of natural drainage features and vegetation
Dealing With Depression Storage

• Not possible to accurately calculate time of concentration

• Depression storage should be modeled as an existing basin in pre-development conditions
Water Quantity

Dealing With Depression Storage
Water Quantity

Dealing With Depression Storage

- Determine time of concentration to depression area
- Calculate stage-storage data for depression area
- Model outlet from depression area as a weir
- Route contributory drainage area to depression area
Water Quantity

Dealing With Depression Storage

AREA EX-2 → Depression Storage
Dealing With Depression Storage

### Stormwater Quantity Control BMPs

| Inflow Area = | 29,359 sf, 1.01% Impervious, Inflow Depth = 1.45” for 10-Year Storm event |
| Inflow = | 0.84 cfs @ 12.19 hrs, Volume = 3,538 cf |
| Outflow = | 0.50 cfs @ 12.44 hrs, Volume = 2,685 cf, Atten = 40%, Lag = 15.2 min |
| Primary = | 0.50 cfs @ 12.44 hrs, Volume = 2,685 cf |

Routing by Stor-Ind method, Time Span = 0.00-36.00 hrs, dt = 0.01 hrs / 2
Peak Elev = 49.64’ @ 12.44 hrs  Surf.Area = 3,695 sf  Storage = 1,001 cf

Plug-Flow detention time = 151.0 min calculated for 2,685 cf (76% of inflow)
Center-of-Mass det. time = 57.6 min (930.8 - 873.2)

### Storage Description

<table>
<thead>
<tr>
<th>Volume</th>
<th>Invert</th>
<th>Avail.Storage</th>
<th>Storage Description</th>
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</thead>
<tbody>
<tr>
<td>#1</td>
<td>49.10’</td>
<td>1,228 cf</td>
<td><strong>Custom Stage Data (Prismatic)</strong> Listed below (Recalc)</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>49.10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>49.70</td>
<td>4,093</td>
<td>1,228</td>
<td>1,228</td>
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<table>
<thead>
<tr>
<th>Device</th>
<th>Routing</th>
<th>Invert</th>
<th>Outlet Devices</th>
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</thead>
<tbody>
<tr>
<td>#1</td>
<td>Primary</td>
<td>49.60’</td>
<td>22.0’ long x 1.0’ breadth Broad-Crested Rectangular Weir</td>
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</table>

<table>
<thead>
<tr>
<th>Head (feet)</th>
<th>Coef. (English)</th>
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<tr>
<td>0.20</td>
<td>2.69 2.72 2.75</td>
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<tr>
<td>0.40</td>
<td>2.85 2.98 3.08</td>
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<tr>
<td>0.60</td>
<td>3.20 3.28 3.31</td>
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<tr>
<td>0.80</td>
<td>3.30 3.31 3.32</td>
</tr>
<tr>
<td>1.00</td>
<td>3.00 3.00 3.00</td>
</tr>
<tr>
<td>1.20</td>
<td>2.90 2.90 2.90</td>
</tr>
<tr>
<td>1.40</td>
<td>2.80 2.80 2.80</td>
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<td>2.00</td>
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<tr>
<td>2.50</td>
<td>2.40 2.40 2.40</td>
</tr>
<tr>
<td>3.00</td>
<td>2.30 2.30 2.30</td>
</tr>
</tbody>
</table>

**Primary OutFlow** Max = 0.50 cfs @ 12.44 hrs  HW = 49.64’ (Free Discharge)  
1 = Broad-Crested Rectangular Weir  (Weir Controls 0.50 cfs @ 0.55 fps)
Water Quantity

Dealing With Depression Storage

• If depression area is in middle of site:
  o Model depression area
  o Calculate time of concentration from depression outlet to point of interest
  o Lag depression outflow hydrograph by calculated time of concentration
  o Calculate time of concentration for remaining area and route it separately
WATER QUALITY
Water Quality

Water Quality Criteria

• Remove TSS by 80%

• Remove nutrients to maximum extent feasible

• Applies at ¼ acre increase of impervious coverage
Water Quality

Water Quality Criteria

• Removal rates apply to each on-site drainage area, unless the runoff converges on-site

• Pursuant to FHACA Rules, runoff from WQDS discharged within a 300-foot riparian zone must reduce TSS by 95%
Water Quality

Water Quality Criteria

• New impervious surface:
  o Any net increase in impervious surface
  o Any change in an existing stormwater drainage system, where the proposed change increases the capacity of the existing stormwater system
  o Existing impervious where runoff is provided with existing water quality treatment, but which is proposed to be collected and discharged into a regulated area
• Added definition of “regulated motor vehicle surface”
• Added definition of “regulated impervious surface”
• Changed definition of major development
  • 1 acre of disturbance; or
  • $\frac{1}{4}$ acre of regulated impervious surface; or
  • $\frac{1}{4}$ acre of regulated motor vehicle surface
• Definitions of regulated motor vehicle surface and regulated impervious surface will include FAQ 10.2 (newly collected impervious surface and changes to existing drainage systems count as “new”)
Water Quality

Water Quality Criteria

• Pervious paving areas
  o Often used to replace traditional pavement – collect same pollutants as regular impervious areas
  o Considered new impervious area toward the ¼ acre increase
  o If designed properly, pervious paving systems can provide required TSS removal
Water Quality

Water Quality Criteria

• Rooftop runoff
  o Not considered significant source of TSS
  o Does not require treatment for TSS
  o Can be infiltrated using dry well
  o Can be significant source of nutrients
Water Quality Design Storm

- Design storm based on historic data
- Nonlinear rainfall distribution resulting in 1.25 inches of precipitation in 2 hours
- Relatively common and intense storm
- Designed to capture frequent storms that cause significant stormwater runoff pollution
Stormwater Runoff Quality

Water Quality Design Storm
Figure 5-3: NJDEP 1.25-Inch/2-Hour Stormwater Quality Design Storm Rainfall Intensity-Duration Curve
Water Quality

Water Quality BMPs

• Water quality criteria met through implementation of BMPs

• NJ BMP Manual contains design criteria for various BMPs
  
  o Chapter 9 – current location for all BMPs
  o New Rules – BMPs will be in Chapters 9, 10 & 11 to match rules
    
    • Chapter 9 – Table 5-1 GI BMPs
    • Chapter 10 – Table 5-2 GI BMPs with a Waiver or Variance
    • Chapter 11 – Table 5-3 BMPs with a Waiver or Variance

• Most BMPs have adopted TSS removal rates, meaning they can be used for Water Quality
Water Quality

Structural BMPs

*Chapter Nine:* provides general information on Structural Stormwater Management Measures

- Chapter 9.1 Bioretention Systems
- Chapter 9.2 Standard Constructed Wetlands
- Chapter 9.3 Dry Wells
- Chapter 9.4 Extended Detention Basins
- Chapter 9.5 Infiltration Basins
- Chapter 9.6 Manufactured Treatment Devices
- Chapter 9.7 Pervious Paving Systems
- Chapter 9.8 Blue Roofs
- Chapter 9.9 Sand Filters
- Chapter 9.10 Vegetative Filter Strips
- Chapter 9.11 Wet Ponds
- Chapter 9.12 Grass Swales
- Chapter 9.13 Subsurface Gravel Wetlands
- Chapter 9.14 Green Roofs ***NEW***
- Chapter 9.15 Cisterns ***NEW***
## Water Quality BMPs

<table>
<thead>
<tr>
<th>BMP</th>
<th>TSS Removal Rate</th>
<th>Phosphorus Removal Rate*</th>
<th>Nitrogen Removal Rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioretention Systems</td>
<td>80-90%</td>
<td>60%</td>
<td>30%</td>
</tr>
<tr>
<td>Standard Constructed Wetlands</td>
<td>90%</td>
<td>50%</td>
<td>30%</td>
</tr>
<tr>
<td>Extended Detention Basins</td>
<td>40-60%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>Infiltration Basins</td>
<td>80%</td>
<td>60%</td>
<td>50%</td>
</tr>
<tr>
<td>Manufactured Treatment Devices</td>
<td>Varies</td>
<td>Varies</td>
<td>Varies</td>
</tr>
<tr>
<td>Pervious Paving Systems</td>
<td>80%</td>
<td>60%</td>
<td>50%</td>
</tr>
<tr>
<td>Sand Filters</td>
<td>80%</td>
<td>50%</td>
<td>35%</td>
</tr>
<tr>
<td>Vegetative Filter Strips</td>
<td>60-80%</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>Wet Ponds</td>
<td>50-90%</td>
<td>50%</td>
<td>30%</td>
</tr>
<tr>
<td>Grass Swales</td>
<td>≤ 50%</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Subsurface Gravel Wetlands</td>
<td>90%</td>
<td>N/A</td>
<td>90%</td>
</tr>
</tbody>
</table>
Water Quality BMPs in Series

- Not all BMPs meet 80% TSS removal
- Can use multiple BMPs in series to achieve reduction

- For two BMPs in series: \( R = A + B - \frac{AB}{100} \)
Water Quality

Water Quality BMPs in Series

- When using BMPs in series, arrange BMPs from upstream to downstream in:
  1. Ascending order of TSS removal rate
  2. Ascending order of nutrient removal rate
  3. By relative ease of sediment and debris removal

- Should not use two of same BMPs in series

Vegetative Filter Strip (60%)
Wet Pond (70%)

\[
R = 60 + 70 - \frac{(60 \times 70)}{100} = 88\%
\]
Water Quality

Nutrient Removal

• Required on all major developments

• Some BMPs have adopted nutrient removals

• Nutrient removal often best performed through source control
Nutrient Removal

• Nonstructural Strategy #7: Provide low-maintenance landscaping that encourages retention and planting of native vegetation and minimizes the use of lawns, fertilizers, and pesticides

• Nonstructural Strategy #9: Provide source controls to prevent or minimize the use or exposure of pollutants
Water Quality

Water Quality BMPs

• Stormwater Management rules require:
  o Design BMPs in accordance with BMP Manual or
  o Alternative designs if design engineer provides documentation demonstrating capability of alternative removal rates and methods

• Any approved alternatives must be submitted to the Department
Water Quality

Water Quality Review

- Ensure water quality BMPs chosen are adequate to achieve required TSS removal rate
- Ensure runoff from all drainage areas requiring water quality treatment is being collected and treated
- Ensure BMP design meets criteria under applicable BMP Manual subchapter
Water Quality

Water Quality BMPs – General Design Criteria

• All BMPs must drain within 72 hours of storm
  o Exceptions: wet ponds, constructed wetlands, gravel wetlands

• In general, most BMPs require at least 1 ft separation from seasonal high groundwater table
  o Exception: all infiltration BMPs require at least 2 ft
Water Quality

Water Quality BMPs

• Commonly used BMPs:
  o Extended detention basins
  o Infiltration basins
  o Bioretention systems
  o Wet ponds
  o Manufactured treatment devices
9.5 Infiltration Basins

Infiltration basins are stormwater management systems constructed with highly permeable components designed to both maximize the removal of pollutants from stormwater and to promote groundwater recharge. Pollutants are treated through settling, filtration of the runoff through, and biological and chemical activity within, the components. The total suspended solids (TSS) removal rate is 80%.

<table>
<thead>
<tr>
<th>N.J.A.C. 7:8 Stormwater Management Rules - Design and Performance Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nonstructural Strategy</strong></td>
</tr>
<tr>
<td><strong>Assist with Strategy #2; See Page 3</strong></td>
</tr>
<tr>
<td><strong>Water Quantity</strong></td>
</tr>
<tr>
<td><strong>Yes, when designed as an on-line system</strong></td>
</tr>
<tr>
<td><strong>Groundwater Recharge</strong></td>
</tr>
<tr>
<td><strong>Yes</strong></td>
</tr>
<tr>
<td><strong>Water Quality</strong></td>
</tr>
<tr>
<td><strong>80% TSS Removal</strong></td>
</tr>
</tbody>
</table>
Infiltration Basins

- Designed to infiltrate runoff into subsoil
- 80% TSS removal rate
- Can also be used to meet the water quantity and groundwater recharge requirements
Infiltration Basins – Design Criteria

- Can only be designed to infiltrate water quality design storm volume
  - No exfiltration is allowed for quantity storms

- Must meet infiltration criteria and permeability testing in accordance with Chapter 12

- Maximum ponding depth from water quality design storm of 24 in.
Infiltration Basins – Design Criteria

- Must include a 6 in. sand layer

- Bottom of basin must be level and un-compacted

- Subsurface infiltration basins require 80% TSS pretreatment

- Design permeability rate 0.5 – 10 inches/hour
Infiltration Basins— you shouldn’t see...

- Designed for water quantity control but no outlet structure
  - Exfiltration for the 2-, 10-, 100- year storms

- Underdrains or liners

- Topsoil or vegetation

- No standing water 72 hours after the precipitation stops
Bioretention systems are stormwater management facilities used to address the stormwater quality and quantity impacts of land development. The system consists of a soil bed planted with vegetation; it can be underdrained, or runoff can infiltrate into the subsoil. Pollutants are treated through the processes of settling and uptake and filtration by the vegetation. Pollutants are also treated within the soil bed through infiltration. The total suspended solids (TSS) removal rate is 80 - 90%; this rate will depend on the depth of the soil bed and the type of vegetation selected.

<table>
<thead>
<tr>
<th>N.J.A.C. 7:8 Stormwater Management Rules - Design and Performance Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nonstructural Strategies</strong></td>
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<tr>
<td><strong>Water Quantity</strong></td>
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<tr>
<td><strong>Groundwater Recharge</strong></td>
</tr>
<tr>
<td><strong>Water Quality</strong></td>
</tr>
</tbody>
</table>
Bioretention Systems

- Thick soil bed and dense vegetation to enhance pollutant removal
- TSS removal rate based on types of plants and soil bed thickness

<table>
<thead>
<tr>
<th>Desired TSS Removal Rate</th>
<th>Minimum Depth of Soil Bed</th>
<th>Design Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>80%</td>
<td>18 Inches</td>
<td>Terrestrial Forested Community</td>
</tr>
<tr>
<td>80%</td>
<td>24 inches</td>
<td>Site-Tolerant Grasses</td>
</tr>
<tr>
<td>90%</td>
<td>24 inches</td>
<td>Terrestrial Forested Community</td>
</tr>
</tbody>
</table>
Bioretention Systems

- Vary in size from small rain gardens to large basins

- Can be designed to infiltrate or to be underdrained
Water Quality

Bioretention Systems – Design Criteria

• Must include a soil bed at 18-24” thick

• Bioretention mix must consist of following:
  o 85-95% sand (< 25% fine or very fine sand)
  o No more than 15% silt and clay
  o 2-5% clay
  o Amended with 3-7% organics, by weight
Water Quality

Bioretention Systems – Design Criteria

• Maximum water quality depth of 12 in. for flat-bottomed systems or 18 in. for sloped systems

• Maximum bottom slope of 10%

• Minimum density of vegetation of 85%
Water Quality

Bioretention Systems – you shouldn’t see...

• Designed for water quantity control but no outlet structure
  o No infiltrating 2-, 10-, 100- year storm

• Topsoil, sand cover, turf grass, etc.
Water Quality

Infiltration Criteria

• Applies to any BMP designed to infiltrate runoff
  o Infiltration basin
  o Dry well
  o Bioretention basin (w/o underdrain)
  o Sand filter (w/o underdrain)
Water Quality

Infiltration Criteria

• Soil permeability must be tested

• Must apply a factor of 2 to any tested permeability

\[
\text{Design Permeability} = \frac{\text{Field Permeability}}{2}
\]

• Minimum design permeability of 0.5 inches/hour, maximum of 10 inches/hour
Water Quality

Infiltration Criteria

• Must have at least 2 ft. of separation from seasonal high water table

• Depth to Seasonal High Water Table must be proven via soil testing

• Must assess groundwater mounding impacts
Infiltration BMPs – What you should see

• Calculation of water quality design storm volume

• Maximum storage depth of water quality design storm volume

• Outlet set at the storage depth of water quality design storm
Infiltration BMPs – What you should see

• Protection of infiltration area from compaction and sedimentation during construction

• Nonstructural strategy #6: Minimize soil compaction

• Post-construction soil testing to verify as-built conditions are sufficient to allow infiltration
More Information:

Bureau of Nonpoint Pollution Control
Division of Water Quality
401 East State Street
PO Box 420, Mail Code 401-2B
Trenton, NJ 08625-420
Tel: 609-633-7021
www.njstormwater.org

Timothy Ebersberger
timothy.ebersberger@dep.nj.gov