Stormwater BMP Manual: Accounting for Infiltration

Workgroup Update

New Jersey Department of Environmental Protection

Division of Water Quality

January 10, 2018

June 2017 Stakeholdering

EXCERPT FROM MEETING INVITE

The Department has received feedback from some stormwater designers and practitioners asserting this provision results in stormwater basins that are designed and constructed larger than necessary to adequately account for stormwater quantity control. Conversely, other practitioners have expressed that not accounting for potential infiltration provides a necessary margin of safety to protect life and property from flooding and ensures the water quantity design and performance standard to reduce the post construction flow set forth in the rule is met.

June 2017 Stakeholdering

- **Soil Permeability Testing** – reliance on a limited number of soil test pits and/or improper implementation of testing protocols may not provide accurate soil permeability information
- **Construction Methods** - soil compaction during construction may decrease soil permeability and infiltration rates
- **Maintenance** – improper maintenance that decreases soil permeability, such as insufficient removal of accumulated sediment and overgrown vegetation may decrease actual infiltration rates
- **Groundwater Mounding** – a reduction in permeability rate may occur when groundwater mounding is present
- **Soil Temperature**–soil permeability may decrease when the ground is partially or fully frozen and impact the infiltration rate.

June 2017 Stakeholdering

Factors affecting infiltration

A

- Groundwater mounding
- Maximum volume that can be infiltrated
- Infiltration rates change with seasons
- Infiltration rates may vary depending on [chemical] makeup of runoff
- Factors work together
- Acceptable level of risk

B

- Poor designs receiving approval
- Poor construction techniques
- Inadequate soil testing
- System not built as designed
- System not maintained

Workgroup

- DEP held 2 large stakeholder meetings in June 2017; workgroup was formed at conclusion of June meeting.

- Workgroup met 5 times since June, and participants include:

  - Clay Emerson, Princeton Hydro
  - Glen Carleton, USGS
  - Jeromie Lange, Maser Consulting
  - Jim Serpico, Maser Consulting
  - Ed Wengrowski, Pinelands Commission
  - Derron LaBrake, Wetlands and Ecology
  - Michel Boufadel, NJIT
  - Keith Stampfel, DEP Land Use
  - Peter DeMeo, DEP Land Use
  - Gabriel Mahon, DEP Water Quality
  - Julie Krause, DEP Water Quality

Agenda

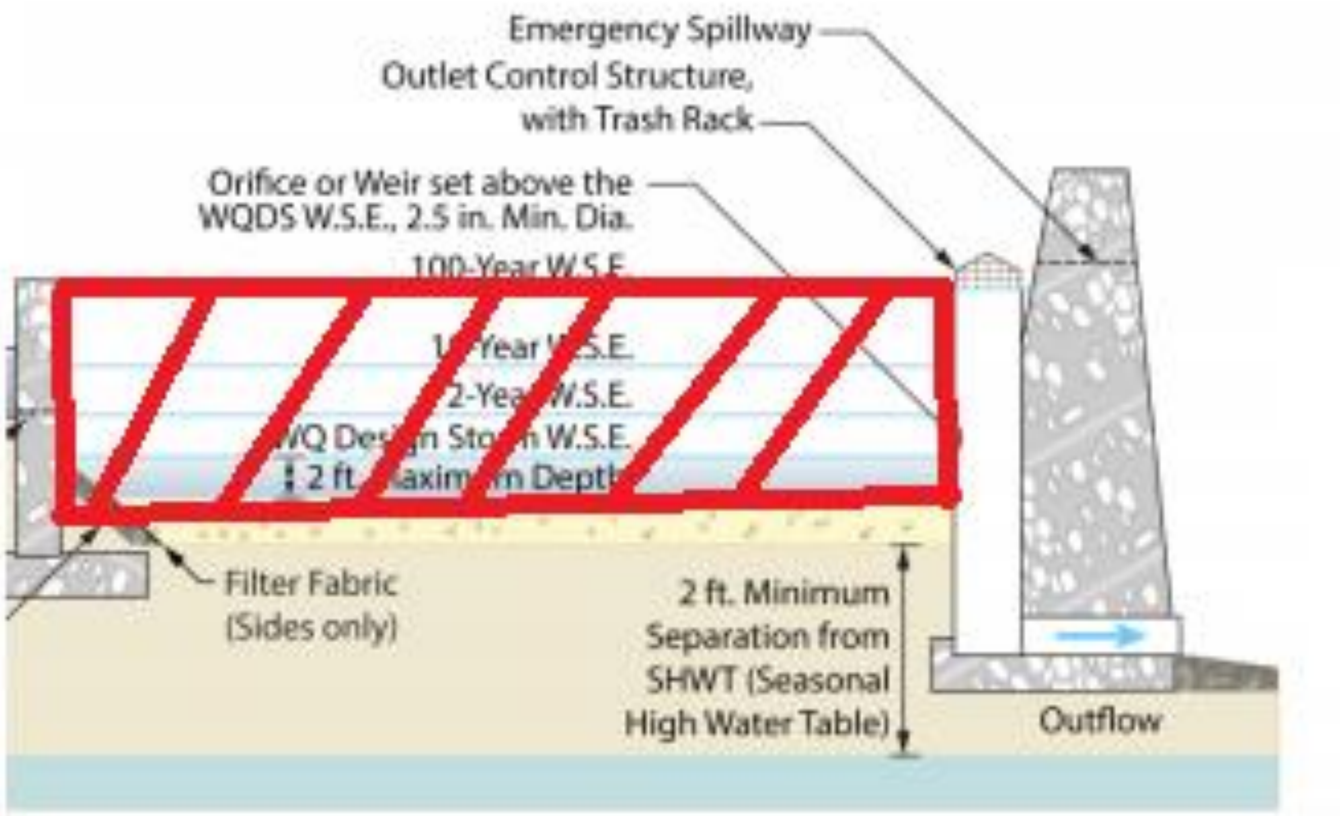
- Infiltration Background
- How to use USGS groundwater mounding spreadsheet
- Soil testing modifications
- Pre-treatment requirement
- Impacts of seasonality
- Impacts of chemical makeup & salinity
- Column B issues

What does a basin do?

- Water Quality
  - Basins can provide anywhere from 40-90% TSS removal depending on type
- Groundwater Recharge
  - Basins with infiltration components can be used to maintain existing recharge
- <u>Water Quantity</u>
  - <u>Basins store stormwater runoff and slowly release it to prevent increases in flowrates</u>

How does a basin store runoff?

Inflow volume = average inflow rate X storm duration



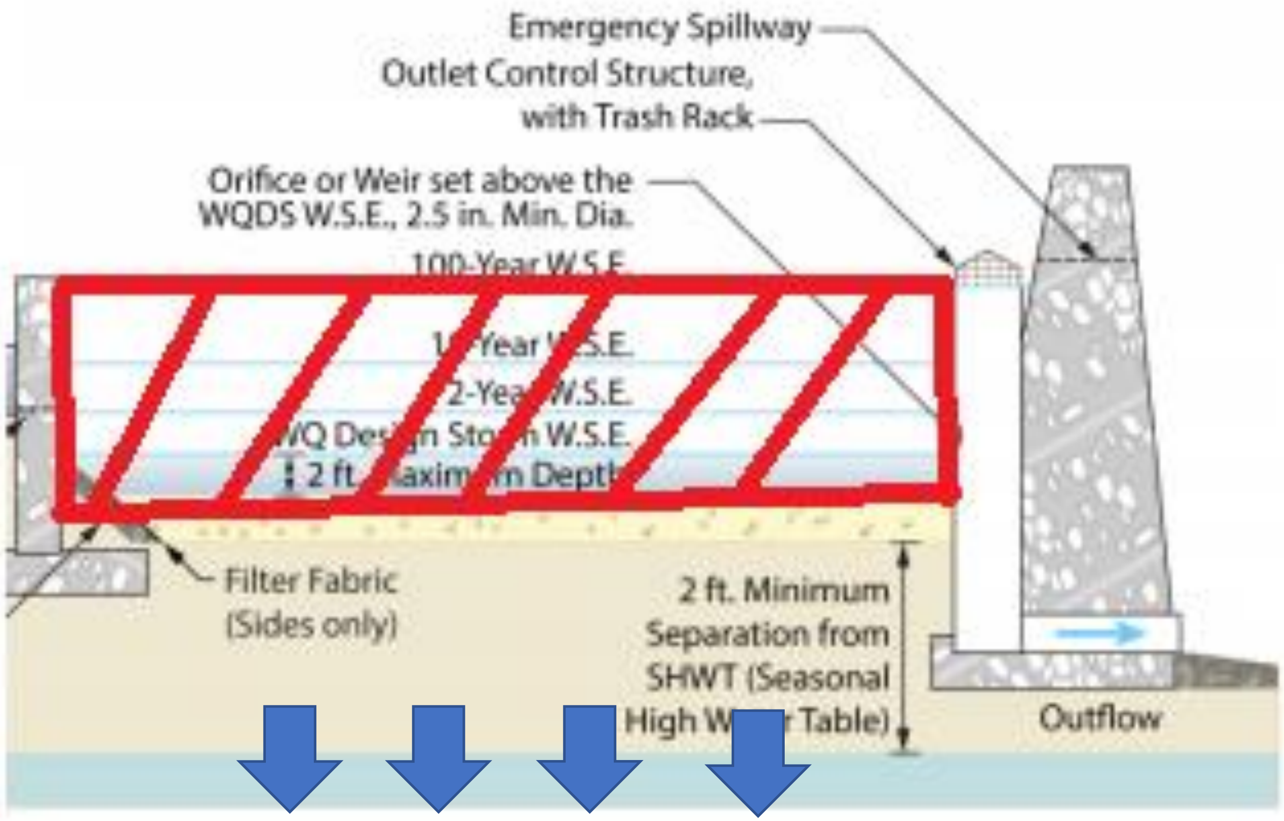
Outflow volume = average outflow rate X outflow duration

Basin storage volume = inflow volume – average outflow rate x storm duration

Infiltration

- NJ Stormwater BMP Manual does not allow infiltration during 2-, 10-, and 100-year storm routings
- Infiltration is allowed for smaller storm events, such as the Water Quality Design Storm (1.25" of rain)
    - When infiltration is used, the designer must assume ½ of the slowest field tested rate
- Similar standards present in previous version of the Stormwater BMP Manual (1986 manual)
- This issue was discussed at BMP Manual Committee Meetings (early 2000s), these meetings acted as BMP Manual stakeholder process

How does infiltration change that?



Inflow volume = average inflow rate X storm duration

Outflow volume = average outflow rate X outflow duration

Infiltration volume = infiltration rate x infiltration duration

Basin storage volume = inflow volume – (average outflow rate + infiltration rate) x storm duration

Infiltration Rate	BMP Area	100-year depth	peak outflow rate	outflow volume	Outflow rate if inf. fails
0 in/hr	14,641 sf	5.10'	12.93 cfs	149,736 cf	n/a
1 in/hr	13,225 sf	5.09'	12.84 cfs	120,146 cf	14.77 cfs
2 in/hr	12,100 sf	5.09'	12.85 cfs	103,084 cf	16.29 cfs
4 in/hr	10,609 sf	5.09'	12.85 cfs	81,888 cf	18.43 cfs
6 in/hr	9,604 sf	5.09'	12.90 cfs	69,947 cf	19.99 cfs
8 in/hr	8,836 sf	5.10'	12.95 cfs	62,089 cf	21.10 cfs
10 in/hr	8,281 sf	5.09'	12.86 cfs	56,003 cf	21.96 cfs

USGS Groundwater Mounding Spreadsheet

		use consistent units (e.g. feet & days **or** inches & hours)
Input Values		
1.3300	*R*	Recharge (infiltration) rate (feet/day)
0.085	Sy	Specific yield, Sy (dimensionless, between 0 and 1)
6.00	K	Horizontal hydraulic conductivity, Kh (feet/day)*
33.630	x	1/2 length of basin (x direction, in feet)
33.630	y	1/2 width of basin (y direction, in feet)
1.500	t	duration of infiltration period (days)
10.000	hi(0)	initial thickness of saturated zone (feet)
20.530	h(max)	maximum thickness of saturated zone (beneath center
10.530	Δh(max)	maximum groundwater mounding (beneath center of b

USGS Groundwater Mounding Spreadsheet

- Input Parameters
  - Recharge (infiltration) rate
  - Specific yield
  - Horizontal hydraulic conductivity
  - Basin dimensions
  - Duration of infiltration
  - Initial saturated thickness of the aquifer

Recharge Rate and Infiltration Duration

- “Recharge Rate” is the field-measured soil permeability/vertical hydraulic conductivity (Kv)
- Factor of Safety (1/2 measured Kv) is required for some calculations
- “Duration” for a typical stormwater infiltration calculation is the total volume divided by the recharge rate
- “Duration” when evaluating infiltration during the storm to get credit allowing reduction in basin size is the duration of the design storm

Specific Yield

- Amount of void space available for storage after soil/aquifer saturated in previous recharge event has drained
- Default value is 0.15
- Can provide testing to use a higher value
  - Cap of 0.20
- What test method is most appropriate? ASTM D425?

Horizontal Hydraulic Conductivity

- Typically measure vertical hydraulic conductivity (Kv, soil permeability)
- Use ratio of 5Kh:1Kv in coastal plain and 1Kh:1Kv outside coastal plain
- Vertical should be measured in accordance with appendix E and FOS applied to field tested rate
- Horizonal hydraulic conductivity could be field tested instead of assuming a 5:1 or 1:1 ratio—should this be allowed/recommended?

Initial Saturated Thickness of the Aquifer

- distance between SHWT and 1st restrictive layer
- Default value of ~10' – TBD based on USGS research project
- Maximum value of ~75 – TBD based on USGS research project
- In order to exceed the default value, on-site testing would be required
  - One continuous boring per 20 acres of site area
  - Boring(s) can be located anywhere on the site. They should be distributed if more than one is required.
  - Data from a pre-existing boring (e.g. from a nearby, earlier project) can be used if within 1,000 ft and in the same hydrogeologic unit

USGS Groundwater Mounding Spreadsheet

- Multiple runs
  - With and without FOS applied to vertical hydraulic conductivity
  - With and without FOS applied to horizontal hydraulic conductivity
  - Requires 4 total runs
  - Must demonstrate that BMP drains within 72 hours and does not adversely impact any nearby structures, other BMPs, septic systems, etc.

USGS Groundwater Mounding Spreadsheet

- Combination Infiltration-Extended Detention Basins
  - More complicated analysis – will require a routing as well
  - Routing with exfiltration based on constant hydraulic conductivity applied over infiltration surface
  - Volume of stormwater infiltrated in routing must match volume in mounding analysis (recharge rate * area * time)
  - Time of infiltration in the routing must match time used in mounding analysis
  - As on previous slide, 4 total runs must show the BMP drains in 72 hours and no adverse impacts

Updates to Soil Testing Criteria

Objectives:

- Remove old, unused, or unreliable test methods
- Add new test methods
- *Better descriptions, standardized worksheets*
- Add new method for multiple small scale BMPs
- Add detailed test descriptions and methodology, no substitutions.

Current Appendix E Test Methods

- Percolation Test
- Pit Bailing Test
- Tube Permeameter Test
- Basin Flood Test
- Other tests which are mentioned include:
  - Pump Test
  - Double Ring Infiltrometer
  - USBR 7300-89 (constant head)

Test Methods Suggested for Removal

- Percolation Test
  - Rarely used, even in the septic field.
  - There are difficulties with the application of the test presoak.
  - Might be a good initial screening test but the group did not feel this test should be used for design purposes and therefore should be removed.
- Double Ring Infiltrometer
  - Does not provide a direct estimate of the hydraulic conductivity.
  - Adds unnecessary complications which impact results.
- USBR 7300-89
  - Never used and has a significant equipment burden.

Test Methods Suggested for Removal

- Pit Bailing Test
  - Rarely used, but might be more common in portions of Hunterdon and Mercer Co.
  - Tests within the *saturated* zone.
  - Likely only used where there are no other options.
  - *Potentially remove*, or at least add criteria restricting the conditions where is can be used (fractured rock).
- Basin Flood Test
  - Rarely used.
  - Provides the ability to test in fractured bedrock.
  - *Potentially remove*, or at least add criteria restricting the conditions where is can be used (fractured rock).

Current Appendix E Test Methods

- Tube Permeameter Test
  - Most widely used test which uses an “undisturbed” sample?
  - Suggested improvements include better guidance on the sample dimensions, multiple hydraulic gradient runs per sample, alternative test configuration similar to ASTM-2434.
- Pump Test
  - Tests the *saturated* zone.
  - Largest “sample size” of all the methods.
  - Widely used and well documented test/analysis methods, which can be somewhat affordable.

Test Methods Suggested for Addition

- Single Ring Infiltrometer
  - Simple in-field test apparatus of predetermined and fixed dimensions, provides real-time feedback on presoak status and hydraulic conductivity.
  - Analysis based on a variably saturated finite difference numerical model, applied simply with a look up table.
- Slug Test
  - Well documented method and analysis.
  - Tests the *saturated* zone. No depth restriction/test pit entry.
- Cased Borehole Test (Unsaturated Slug Test)
  - No depth restriction/test pit entry required.
  - Test is applied in a manner that is significantly different than it was originally intended.
  - Detailed procedures and test limitations will be outlined.

Proposed Appendix E Test Methods

- Single Ring Infiltrometer
- Tube Permeameter Test
- Cased Borehole Test
- Pump Test (saturated)
- Slug Test (saturated)
- Pit Bailing Test (saturated)
- Basin Flood Test
- Specific Yield

New Soil Testing Procedure for Small GI

- Would apply to GI BMPs below a specific footprint threshold
  - Is 5,000 sq. ft. or 3,500 sq. ft. an appropriate threshold?
- 1 test pit required in each Small GI BMP, unless Multiple Small GI procedure used
- All BMPs must have the required test pits within infiltration area, or within 50 feet of the infiltration area perimeter
  - Is 50 feet an appropriate distance?

New Soil Testing Procedure for Multiple Small GI

- Would apply to BMPs below a specific footprint threshold & not in udorthent/disturbed mapping unit areas
  - Is 5,000 sq. ft. or 3,500 sq. ft. an appropriate threshold?
- Total number must be at least 1 test pit per 5,000 square feet of BMP area
- A minimum of 3 test pits would be required
- All BMPs must have a test pit within a required distance of infiltration area
  - 200’ if test pit and BMP are in same soil mapping unit
  - 50’ if test pit and BMP are in different soil mapping units
  - Are 200’ and 50’ appropriate distances?
- Test pits must be distributed across area where BMPs are located (e.g. triangular distribution)
- Lowest permeability rate must be used in all of the Small BMPs covered
  - Can a higher rate be used if the test pit is located inside a specific GI BMP?

New Soil Testing Procedure for Large GI

- Would apply to BMPs above a specific footprint threshold
  - Is 5,000 sq. ft. an appropriate threshold?
- Total number must be at least 2 test pits up to 10,000 sq. ft. of BMP infiltration area, + 1/10,000 sq. ft additional
- All BMPs must have the required test pits within infiltration area, or within 50 feet of the infiltration area perimeter
  - Is 50 feet an appropriate distance?
- Test pits must be distributed to provide adequate characterization of infiltration area
- Lowest permeability rate within BMP must be used

New Soil Testing Procedure Misc.

- All soil profile pit and boring logs shall reference a common elevation datum as utilized on the BMP design/construction plan relying on the soil logs.
- Eliminate (replace – see above) current “multiple infiltration” BMP size criteria of 500 sf and make mandatory boring requirement optional.
- Maintain “Where soil and/or groundwater properties vary significantly between soil explorations, additional soil profile pits shall be conducted as necessary to resolve such differences and accurately characterize the mapping unit’s soils. For drywells associated with single family residential development, only one soil boring is required per lot.”

New Soil Testing Procedure Misc.

- Maintain current “linear” BMP requirements.
  - Have the option to use Multiple Small GI procedure if criteria met.
  - Can use linear requirements if current applicability met.
- Add clarification that a test pit can always replace a boring.

Pre-treatment Requirement

- BMPs with drainage areas of greater than 1 acre would require pre-treatment in order to use infiltration to meet water quantity requirements
- Pre-treatment may consist of a forebay or any other structural BMP in the NJ Stormwater BMP Manual
  - Not necessary for BMP to provide 80% TSS removal
  - Consistent with current requirement for pre-treatment for sand filters
  - Forebay would be sized to hold volume of equal to or greater than 10% of water quality storm

Impacts of Seasonality

- Viscosity of water varies by a factor of two (2) from near freezing to summer temperatures.
- Lower temperature results in higher viscosity which decreases the hydraulic conductivity.
- Simple temperature correction factors can be applied to the test results to account for this known variation.
- Look up table can be used to normalize result to reference temperature.

Impacts of chemical makeup and salinity

- Viscosity change resulting from the salt content of stormwater is not significant.
- Winter salt application can cause degradation (slaking and dispersion) of soil aggregates and overall soil structure.
  - Not a significant concern in sandy soils.
  - Improved with increased soil organic matter.
  - More of an Operation and Maintenance issue.
- Not expected to be a significant contributor to basin performance.

Next Steps

- Send any additional comments on today's discussion by January 31 to Gabriel.Mahon@dep.nj.gov
- Initiate BMP revisions consistent with current BMP process – several chapters impacted by this issue
- Stakeholder Column B issues
  - Design
  - Approval
  - Construction
  - Maintenance

Next Steps: Stakeholdering Column B Issues

The Division of Water Quality intends to commence stakeholder workgroup meetings in the upcoming weeks on the topics of stormwater design, approval, construction & maintenance. If you are interested in participating in a workgroup on one of these 4 topics please contact Julie.Krause@dep.nj.gov.

Please briefly state your familiarity/experience with the topic, as we are seeking participants with diverse representation. If you are interested in more than one workgroup please indicate your preference.

We may have to limit the number of participants in each workgroup.