PENNSYLVANIA PCSM MANUAL Updates

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Commonwealth of Pennsylvania

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Pennsylvania Post-Construction Stormwater Management (PCSM) Manual

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Protect Waters of the Commonwealth

Purpose:

"This guidance establishes standards for the management of stormwater through the implementation of SCMs and other measures to comply with the regulatory requirements under 25 Pa. Code Chapter 102. This guidance may also be used for other purposes where the intent is to design, install, and maintain SCMs."

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pennsylvania
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Pennsylvania Post-Construction Stormwater Management (PCSM) Manual

Bureau of Clean Water
Pennsylvania Department of Environmental Protection
400 Market Street, P.O. Box 8774
Harrisburg, PA 17105-8774
www.dep.pa.gov

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Bringing Better Science to Stormwater Management

- Updated Hydrology to Include Climate Change
  - Separate rate control for large sites
  - Larger rainfall for small storms
  - Inlet capacity and dual-path design
- Clarifies that Diverse Professionals are Required
  - Professional Engineer must oversee PCSM calculations
  - Professional assessment of infiltration capability
  - Experienced professional needed for design in karst geology
  - Experienced professionals needed for floodplain restoration
  - Owner, contractor, and Licensed Professional agreement encouraged
  - Experienced contractor encouraged for infiltration facility construction
- Establishes PCSM Objectives
  - Includes Incentives for Natural Landscapes
  - Continues emphasis on recharge SCMs wherever practicable
  - Clarifies path to justify use of Managed Release Concept
- Stipulates Pre-Development Site Analysis
  - Defines that "Project Site Boundary" includes "Natural Landscapes"
  - Includes pre-development infiltration testing for whole site
  - Changes emphasis of "Limit of Disturbance" to proving minimization of impacts
- Includes design guidance for SCMs
  - Chapter 3 organized by PCSM Objective
  - Appendix J organized by SCM Component

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PCSM System Approach

- Right expertise
  - Design
  - Better construction, inspection & maintenance
- Right SCM(s) for the job
  - Understand site infiltration capabilities
  - Promote resilient, correctly sized SCM tailored to the soil capacity, precipitation patterns and watershed
  - Landowner must be able to maintain
  - Focus on "**Manage the 2-year storm**"
  - Requires site evaluation
- Separate Volume/Water Quality from Rate Control
  - Protect infiltrating surfaces

Nothing works when not designed, built, and maintained correctly…
or
When Designed, Constructed, and Maintained correctly we expect it to work


Rochester Times
PAID FREE
FEMA probe reveals rain caused floods

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General Stormwater Manual Layout

Chapters
- 1: Introduction
- 2: PCSM Requirements
- 3: SCM Technical Guidance

Appendices
- A: Precipitation
- B: Soil Physics, Characterization, and Infiltration Testing
- C:Karst Terrain
- D: Evapotranspiration
- E: Hydrologic Budget and Water Balance
- F: Volume Management Analysis Methods
- G: Water Quality Analysis Methods
- H: Peak Rate Analysis Methods
- I: Vegetation for Use in Stormwater Management
- J: SCM Components and Specifications
- K: Construction Inspection, Operation and Maintenance
- L: Definitions and Acronyms
- M: Errata Sheet

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Better Science at All Stages

- Design Includes Licensed Professionals
- PCSM Plan Preparer – "*Trained and Experienced*" Chapter 102.8(e)
  - Not required to be a "Licensed Professional."
  - Must engage Licensed Professionals
    - Professional Engineers – Must oversee computati
    - Land Surveyors
    - Geologists
    - Soil Scientists
- Certain Designs Require Professional Serv
  - Karst
  - Infiltration "Under Certain Circumstances"
  - Floodplain Restoration
  - Structural SCMs

Engineer, Land Surveyor And Geologist Registration Law
Act of May 23, 1945, P.L. 913, No. 367 Cl. 63

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Construction Inspection of PCSM SCM's

- **Purpose**
  - Ensure site conditions match assumptions
  - Ensure SCMs are constructed as designed

- **Licensed Professional Oversight**
- **Critical Stages** – Per 25 Pa. Code 102.8(f)(7), PCSM plan must identify inspection schedule for all critical stages, performed by a licensed professional

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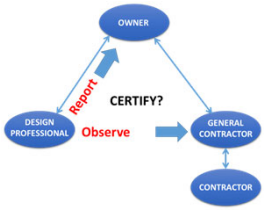
Better Experience at All Stages

- Licensed Professional Oversight of Construction

The *permittee should enter into an agreement with the licensed professional* that specifies how the licensed professional will act as the permittee's representative and how the owner will assure that the operator addresses any concerns raised by the licensed professional promptly and completely.



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Operation & Maintenance of PCSM SCM's

- **Routine Inspection** – Each SCM should be inspected annually and after storm events exceeding 2.5 inches of rainfall.
- **Routine Maintenance** – Performed on a scheduled basis; grass & vegetation management, sediment & trash removal
- **Corrective Maintenance** –Repairs that are typically more involved than what occurs during regular maintenance.

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Changing Rainfall Patterns

"Each 1 degree C we warm the planet adds an additional 7% increase in moisture into the atmosphere."

Sierra Club 2021, Emily Williams, PhD

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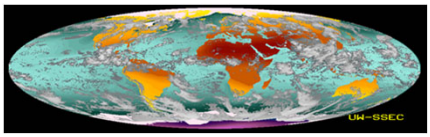
Global Climate Change 2022 to 2050

Mid-Century Rainfall Projections

- 8% Increased Annual Rainfall in Pennsylvania
  - 14% increase in winter precipitation
- More Extreme Storm Events (storms larger than 1.2-inches of rainfall in one day)
  - Climate change is expected to increase the intensity and frequency of cloudburst events.



Pennsylvania Climate Impacts Assessment 2021

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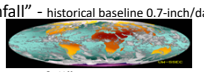
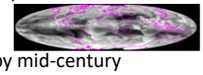
Individual Rain Event Projections

- 12% and 18% increase "very heavy rainfall" – historical baseline 0.7-inch/day
  - Rises to 0.78-inch/day by mid-century
  - 0.83-inch/day by end-of-century.



- 13% and 20% increase "extremely heavy rainfall" – historical baseline 1.2-inch/day
  - Rises to 1.3-inch/day by mid-century
  - 1.4-inch/day by the end-of-century.



- 24% more days of "very heavy" by mid-century
- 42% more days of "extremely heavy" by mid-century
- The number of days with more than 3 inches of rainfall is projected to increase by 52% by mid-century and 93% by end-of-century.

Pennsylvania Climate Impacts Assessment 2021

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Predicted Change in Design Storm Depth

Mid-Level Estimate of Global Warming

Return Period, yr	Modeled Historical Value (in).	Mid-term [2045]		Long-term [2075]	
		Value, in.	% change	Value, in.	% change
1	1.4	1.6	**+14%**	1.7	**+21%**
2	3.2	3.7	**+16%**	3.7	**+16%**
5	4.4	4.9	+11%	4.9	+11%
10	5.4	5.8	+7%	5.8	+7%
20	6.5	6.7	+3%	6.7	+3%
50	8.0	7.9	-1%	8.0	0%
100	9.4	8.9	-5%	9.2	-2%

Dewberry 2018

Conclusion: Increase the size of WQ/Volume Management SCMs.

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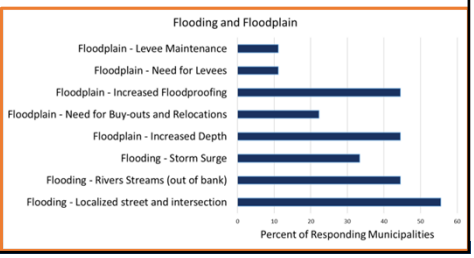
Effect of Climate Change on Each SCM Components Is Different

- Inflow Components
  - Storm Drain
  - Overland flow path
- SCM - (a.k.a. BMPs)
  - Natural SCMs
  - Water Quality/Volume Management SCMs
  - Rate Control SCMs
- Outfall Components
- Receiving waters

Inventory of Municipal Preparedness
DELAWARE BASIN REGIONAL WATER RESOURCE COMMITTEE
2022 STATE WATER PLAN Source: NTM 2022



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Key Take-Aways for SCM Sizing in a Changing Climate

- Rainfall for storms up-to the 2-year/24-hour storm will need to be adjusted to account for climate change.
- Storms above the 2-year/24-hour storm managed as follows:
  - In a separate basin when feasible.
  - Using the current NRCS design storm
    - Those guidelines are conservative!
  - Using the NOAA Median Value of Rain Depth

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Extreme Rainfall Adjustment

- Use 90% confidence level event rainfall depth
  - NOAA Atlas 14 Point Precipitation Frequency Estimates
  - 10% to 20% higher than what is used today
  - Inlet design
- Chesapeake Bay IDF Curves – Rand Corp. 2021
- EPA SWMM Climate Adjustment Tool (SWMM-CAT)

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES
WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION

PF tabular | PF graphical | Supplementary information | Print page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
24-hr	2.70 (2.50-2.93)	3.26 (3.01-3.54)	4.12 (3.80-4.47)	4.84 (4.45-5.24)	5.90 (5.40-6.37)	6.80 (6.18-7.32)	7.77 (7.03-8.36)	8.84 (7.93-9.49)	10.4 (9.22-11.2)	11.7 (10.3-12.6)

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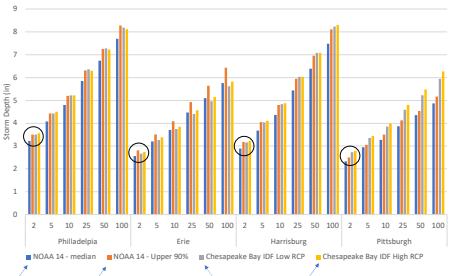
Climate Change Incorporation – Design Storm

- NOAA 14 is outdated (no change since 2006)
- **Use upper 90% confidence interval for 2-year/24-hour storm for NOAA**

PDS-based

Duration	1	2
5-min	0.347 (0.320-0.378)	0.414 (0.380-0.451)
24-hr	2.70 (2.50-2.93)	3.26 (3.01-3.54)



https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

https://midatlantic-idf.rcc-acis.org/

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NRCS Design Storm Example

2-year Rainfall	2.91 in.
2-year Upper 90% Rainfall	3.21 in.
% Change	9%
Area	4.567 ac.
SCM Footprint	9,754 SF

		2-year Volume to Manage		% Change	Storage Volume Required		% Change
HSG	Infiltration Rate	2-yr WQV	2-yr Upper 90% WQV	-	2-yr WQV	2-yr Upper 90% WQV	-
A	1.43	31,018	34,480	10%	16,800	20,300	17%
B	0.75	28,606	31,003	8%	20,500	22,750	10%
C	0.5	23,518	25,040	6%	17,500	19,000	8%

NTM 2022

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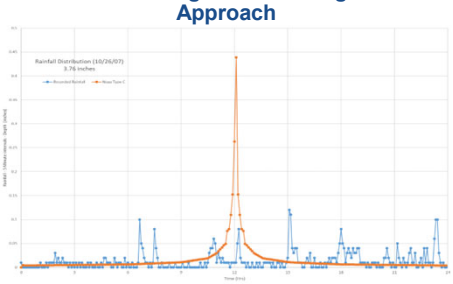
Peak Rate Management – Design Storm Approach

- **PA Code § 102.8.(g)(3):** *"manage the net change in peak rate for the 2-, 10-, 50-, and 100-year/24-hour storm events in a manner not to exceed preconstruction rates."*
- Real storm events are often not well represented by the center peaking distribution
- Median NOAA-14 depths for the 24-hour storms above the 2-year



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Summary of Basin Sizing Recommendations – NRCS Design Storm

- Use Upper 90% confidence level NOAA Depths climate adjustment for up to the 2-year (50% exceedance storm).
- Provide separate rate control facilities when feasible and for larger sites
  - Use NRCS design storm procedures for analysis
  - Design rate control SCM's based on median NOAA rainfall depth

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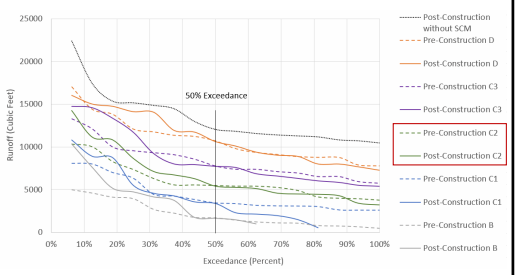
Volume Analysis Approach – Continuous Simulation

Percent exceedance vs. runoff volume



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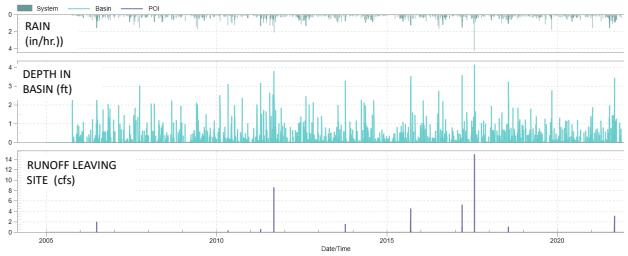
Continuous Simulation Modeling Example



EPA SWMM with Climate Adjustment Tool (SWMM-CAT)

NTM 2022

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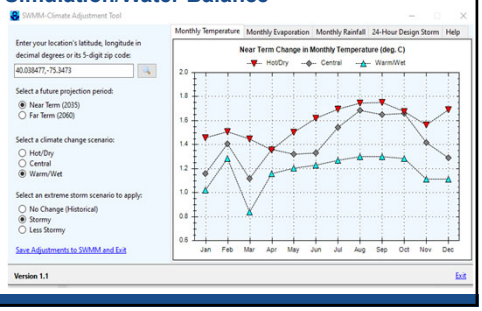
Climate Change Incorporation – Continuous Simulation/Water Balance

- Recommends monthly SWMM CAT 1.1 Adjustments (near term & Warm/Wet) applied to precipitation
- Includes temperature impact on ET and infiltration



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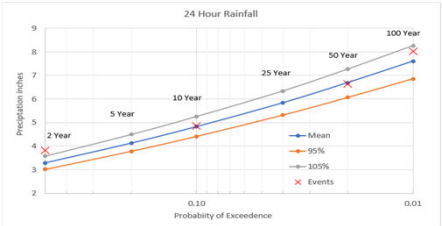
Peak Rate – Storm of Record Approach

- Select storms from the period of record to represent the 2-, 10-, 50, and 100-year/24-hour NOAA-14 volume.
- 2-,10-, 50-year/24-hour storms must fall within the 90% CI of the NOAA 14 data
- 100-year/24-hour storms
  - use a value that exceeds the mean
  - If not available, use one within the 90% CI
  - If not available, use next largest storm greater then 50-year frequency
  - Or use design storm



Goal is to be able to run data from one data set to address peak.

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Poll #2

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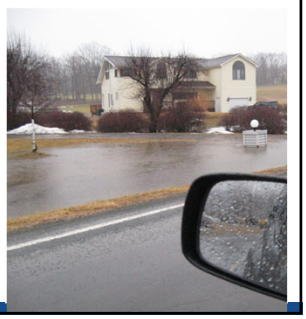
Recommendations
for
Inflow Design
in
DRAFT PCSM Manual



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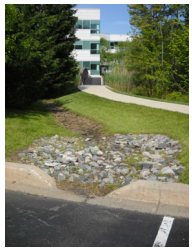
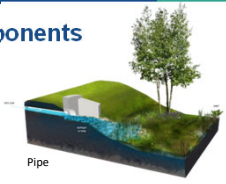
Types of inflow Components



Curb-Cut

Sheet Flow



Pipe

Storm Drain Inlet

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Peak Intensity

Summary of precipitation intensity and return period estimates for a July 31, 2016 thunderstorm event in Virginia Beach – 100 to 200-year event.

Duration	Maximum Rainfall Amount (in)	Estimated Return Period (yr)
15 min	1.18	5-10
30 min	1.97	10-25
1 hour	3.38	50-100
2 hour	6.66	500-1000
3 hour	7.19	500-1000
6 hour	7.19	100-200

The longer duration of intense rainfall rate is particularly striking.

Dewberry 2018

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Inflow Limitation – Climate Change

- The storm that the SCM is designed to manage must reach the basin. The inflow component must be sized to accept the SCM design storm.

OR

- A flow path for flows in excess of storm drain capacity is needed.
- Discharge from the SCMs should also be considered with respect to Climate Change

DUAL DRAINAGE CONCEPT

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NOAA 14 Tabular Form – Inlet Design

PDS-based precipitation frequency estimates with 90% confidence

Duration	Average recurrence interval (years)						
	1	2	5	10	25	50	
5-min	**3.90** (3.50-4.32)	**4.63** (4.18-5.15)	**5.44** (4.90-6.02)	**6.04** (5.42-6.67)	**6.76** (6.02-7.45)	**7.27** (6.46-8.02)	**7** (6.8
10-min	**3.11** (2.80-3.44)	**3.70** (3.34-4.10)	**4.35** (3.91-4.81)	**4.82** (4.33-5.33)	**5.37** (4.80-5.93)	**5.78** (5.13-6.38)	**6** (5.4
15-min	**2.59** (2.33-2.87)	**3.10** (2.79-3.44)	**3.67** (3.30-4.06)	**4.06** (3.65-4.49)	**4.54** (4.05-5.01)	**4.88** (4.33-5.38)	**5** (4.6
30-min	**1.77** (1.59-1.96)	**2.14** (1.93-2.37)	**2.60** (2.34-2.88)	**2.94** (2.64-3.25)	**3.36** (3.00-3.71)	**3.67** (3.26-4.05)	**3** (3.5
60-min	**1.11** (0.993-1.22)	**1.34** (1.21-1.49)	**1.67** (1.50-1.84)	**1.9** (1.72-2.11)	**2.23** (1.99-2.47)	**2.48** (2.20-2.74)	**2** (2.4

2.94 (2.6 -3.25)

Precipitation Intensity – Partial Duration Series

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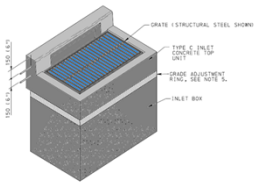
Inlet Limited

- Inlets are designed based on roadway inundation.
- Efficiency of inlets is low.



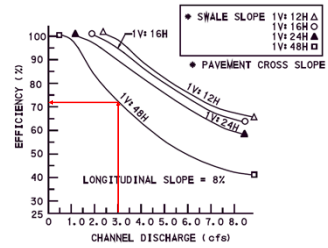


FIGURE 10.3.4 (ENGLISH)
EFFICIENCY CURVES: CAPACITY OF TYPE C INLET OR TYPE M INLET (MOUNTABLE CURB)

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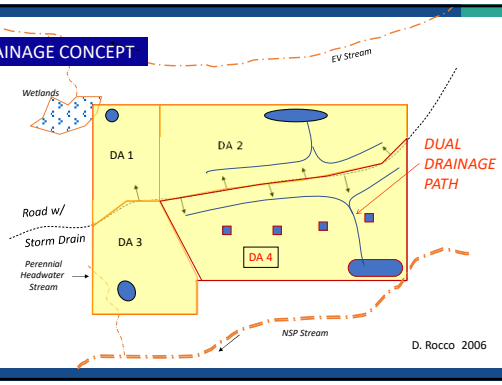
DUAL DRAINAGE CONCEPT



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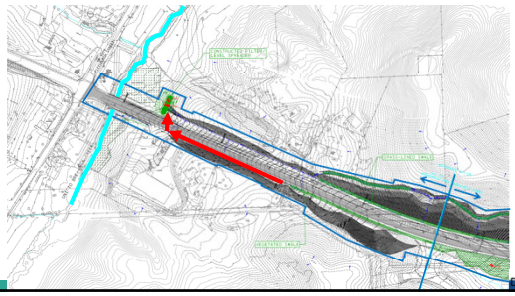
Dual Drainage Concept



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Key Take-aways for Inflow Design

- Under sizing inflow components is an existing problem.
- The problem will become more pronounced with climate change.
- The design procedure proposed can be used to retrofit existing basins.

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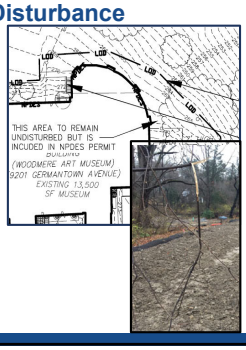
Project Site & Limit of Disturbance

- **Project Site (Chapter 102.1)**
  - The entire area of activity, development, or sale including:
    - the area of an earth disturbance activity
    - the area planned for an earth disturbance activity
    - and **other areas which are not subject to an earth disturbance activity**
- **Limit of Disturbance (LOD)**
  - The boundary within which it is anticipated that earthmoving, including installation of BMPs, will take place.
  - **Emphasis in new manual is on minimizing land clearing and grading**



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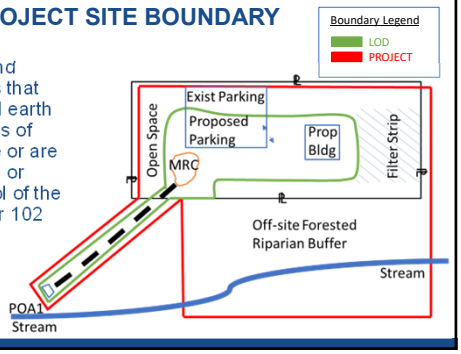
PROJECT SITE BOUNDARY

- Must enclose all earth disturbance, SCMs, and conveyances to SCMs that manage runoff from all earth disturbance, regardless of whether the SCMs are or are not on property owned or under the direct control of the applicant for a Chapter 102 permit.

Natural Landscape SCMs in NPDES Boundary



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Pre-Development Site Characterization

- Examine: Hydrology, Geology, Soils, Plants, Protected Species, Natural Landscapes, Surface Waters, Environmental Hazards
- Preliminary infiltration testing needed for entire site
  - One test for every 40,000 square feet
  - Geologic and Soils information needed
  - Groundwater information needed
- Identify areas that "Protect Surface Waters"
  - Riparian Buffers
  - Natural Landscape

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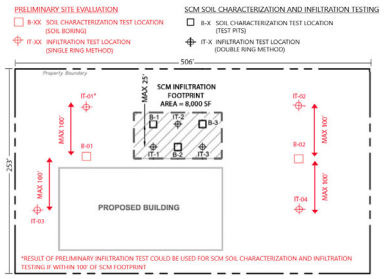
Infiltration Testing & Soil Characterization

Testing for infiltration capacity and Soil characterization is required during:

- Preliminary Site Evaluation
- SCM-Specific

Post construction confirmation testing required



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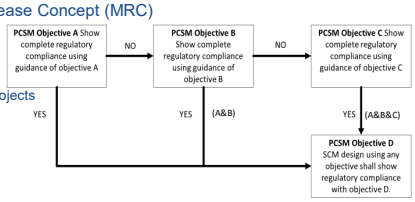
PCSM Objectives

- **Objective A** – Natural Landscape SCM's - wherever practicable
- **Objective B** – Volume/quality management
  - Through infiltration, evapotranspiration, and natural landscape SCMs
- **Objective C** – Managed Release Concept (MRC)
  - Includes a wider variety of SCM
- **Objective D** –Rate Control
  - Minimized by A through C
  - In separate facility for larger projects



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PCSM Objectives by SCM

A	3.3	PROTECT AND PRESERVE NATURAL LANDSCAPE PROCESSES
	3.3.1	Protected Natural Stormwater Features
	3.3.2	Preserved Natural Open Spaces
	3.4	ENHANCED NATURAL LANDSCAPE SCMs
	3.4.1	Disconnection of Impervious Surface with Filter Strip
	3.4.2	Riparian Buffer Establishment and Enhancement
	3.4.3	Floodplain Restoration
	3.4.4	Revegetation and Soil Restoration
	3.4.5	Retentive Grading
	3.4.6	Vegetated Conveyance
B	3.5	INFILTRATION-BASED SCMs
	3.5.1	Bioinfiltration
	3.5.2	Surface Infiltration Basin
	3.5.3	Permeable Pavement
	3.5.4	Infiltration Trench
	3.5.5	Underground Infiltration Basin
B	3.6	NON-INFILTRATION SCMs
	3.6.1	Bioretention
	3.6.2	Green Roof
	3.6.3	Regenerative Step Pool Systems
	3.6.4	Stormwater Capture and Use
	3.6.5	Blue Roof
	3.6.6	Engineered Stormwater Treatment Wetland
	3.6.7	Water Quality Filtration and Treatment
C	3.7	MANAGED RELEASE CONCEPT
	3.7.1	MRC Bioretention
	3.7.2	MRC Storage Systems
	3.7.3	MRC Karst
D	3.8	RATE CONTROL SCMs
	3.8.1	Wet Basin
	3.8.2	Naturalized Detention Basin
	3.8.3	Underground Detention

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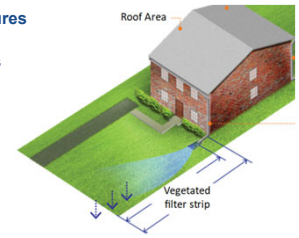
Objective A: Protect & Preserve Natural Landscape Processes

Areas within the project boundary, or otherwise included in a stormwater permit application, that are preserved and protected by a recorded long-term stipulation for the purposes of providing stormwater management benefit.

- **Protected Natural Stormwater Features**
- **Preserved Natural Open Spaces**
- **Enhanced Natural Landscape SCMs**



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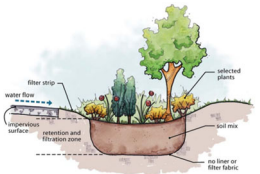
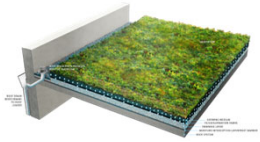
Objective B: Infiltration and Non-infiltration based

- Manage the net change for storms up to and including the 2-year/24-hour storm event for runoff volume and water quality (or Act 167 Plan) through SCMs that provide infiltration, ET, or capture and use SCMs to the extent practicable
- *Provide pretreatment in accordance with the guidance provided for each SCM*
- *Bypass of runoff from storm events that exceed the design capacity of PCSM Objective B SCMs is recommended.*





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Objective C: MRC

- **Volume and Water Quality Management (Management)**
  Mitigating the net change in stormwater runoff volume and pollutant loads

§ **102.8. PCSM requirements. (g) PCSM Plan stormwater analysis.**
(2) . . . Manage the net change for storms up to and including the 2-year/24-hour storm event when compared to preconstruction runoff volume and water quality.

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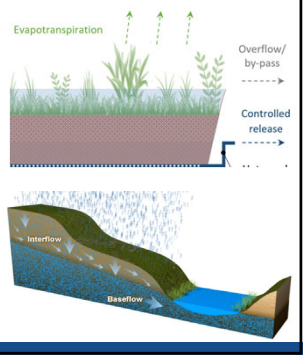
Objective C: MRC

A PCSM strategy involving the capture, filtration, treatment, and controlled release of runoff from an SCM that may be used when there are environmental limitations on a project site and where natural landscape processes, ET and infiltration are implemented to the maximum extent practicable.

Managed Release includes both:

- **Controlled Release**
- **Geomorphologic Protection**

- **Internal Water Storage (IWS)**



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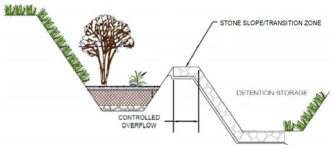
Resilience - Separate Volume/Water Quality (A,B,C) from Rate Control (D)

- Referred to in the 2006 Manual as "offline"
- Why?
  - Preserves the function of Volume and Water Quality devices to target storms smaller than design volume (typically 2-year/24-hour storm)
  - Reduces maintenance, promotes longevity
  - Reduces the footprint of the basins needed for peak rate control
- Manual acknowledges that this is not always possible



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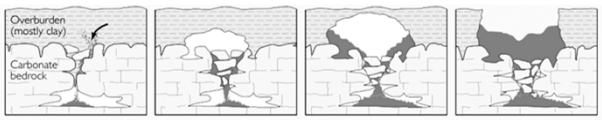
PCSM in Karst Terrain

- Intensive predevelopment site investigation required
  - Desktop study including map of topography, soils, geography, etc.
  - Field investigation including documentation of any features not shown in desktop study, and search for local testimony from neighboring properties
  - Downstream analysis
- Full geotechnical and/or engineering report is required to be submitted to PADEP that includes findings of site investigation and approach to PCSM design



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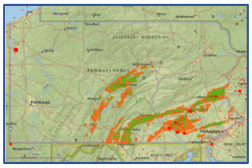
PCSM in Karst Terrain

- **Pre-development analysis**
  - Analysis of existing Infiltration
  - Analysis of depression storage
  - Evaluation of open caves
  - Actual cover condition (not assumed meadow)
- **Post development**
  - Pretreatment and filtration
  - Limit infiltration to pre-development
  - Limit off-site discharge to historic flow
  - Separate rate control
  - Karst MRC



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PCSM in Karst Terrain

- Minimum release rates may be used in areas where release rates are not achievable due to predevelopment karst losses

Table C-1: Allowable minimum post-construction peak rates

RETURN PERIOD	EQUATION
1-YEAR	$Qp_{min} = 0.018 * (DA) + 0.2$
2-YEAR	$Qp_{min} = 0.03 * (DA) + 0.4$
10-YEAR	$Qp_{min} = 0.09 * (DA) + 1.0$

- Must have a safe overland flow path.
- Water quality must be protected by using natural soil, or other media products before stormwater runoff is directed underground

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Water Quality

- 2006 version:
  - Build BMP according to manual
  - Assumed percent removal
  - Treatment train adds removals – not appropriate.
  - Example Bioinfiltration

Water Quality Functions

TSS: 85%
TP: 85%
NO3: 30%

- 2022 Version
  - Mass Loading - TSS, TP, TN
  - Using International ASCE BMP Database outflow concentrations (mg/l) for the last water quality SCM
  - Using National Water Stormwater Quality Database for watershed quality concentrations (mg/l)
  - PA has already adopted this new method (PCSM Spreadsheet)

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Water Quality for Land Use

- National Stormwater Quality Database (NSQD)
  - Based on land use from MS4 communities – adapted into BMP database (http://www.bmpdatabase.org/nsqdstat.html)
  - Provides median concentrations of pollutants

Figure 1. Communities from which data has been obtained and entered in the NSQD, along with EPA Rain Zones.

	Area (acres)	% Imperv.	Precip. Depth (in)	Runoff Depth (in)	Cond. (uS/cm @25°C)	Hardness (mg/L CaCO3)	Oil and Grease (mg/L)	pH	Temp. (C)	TDS (mg/L)	TSS (mg/L)	NH3 (mg/L)	N02+NO3 (mg/L)	Nitrogen, Total Kjeldahl (mg/L)	Phos., filtered (mg/L)	Phos., total (mg/L)
Open Space (49)																
Number of observations	49	37	41	11	2	8	19	19	2	45	44	32	44	45	44	46
% of samples above detection	100	100	100	100	100	100	36.8	100	100	97.8	95.5	18.8	84.1	71.1	79.6	84.8
Median	85	2.0	0.52	0.05	113	150	1.3	7.70	14.6	125	48.5	0.18	0.59	0.74	0.13	0.31
Coefficient of variation	1.5	1.0	1.2	1.4	0.5	0.6	0.7	0.08	0.7	0.7	1.5	1.24	0.9	0.9	0.9	3.5

*TN : TKN + NO2/3

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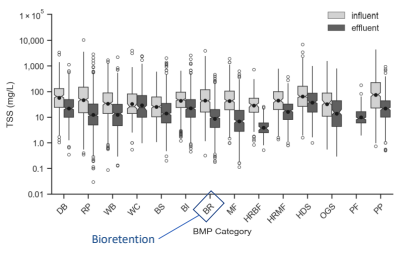
Water Quality for SCM

- International Stormwater Best Management Practices Database (BMP Database)
  - Based on SCM type
  - Effluent median concentrations of pollutants



https://www.waterrf.org/system/files/resource/2020-11/DRPT-4968_0.pdf

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Questions?

Mark Bowen, PE, CFM, CCR, NTM Engineering

November 2023

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Evaluation & Certificate Link

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