VERMONT

Overview of the *Advanced Stormwater Standards Compilation*

Vermont Stormwater Management Manual Update, Meeting #1

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Room 11, Vermont Statehouse, Montpelier

September 26, 2013

STONE ENVIRONMENTAL INC

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Meeting Facilitation and Mediation Services






Key Topics

1. Site characterization standards and guidelines for infiltration-based practices
2. Channel Protection Volume (CPv)– alternatives and potential conflicts
3. Integrating Low-Impact Development (LID) concepts into the Manual
4. Maintenance plans (requirements for, and implementation of, in other jurisdictions)

Organization and Opportunities

- Current practice as stated in VSMM
- Current practice in other jurisdictions and options to consider
- Questions, ideas, and comments






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Site Characterization Current Practice: Appendix D-1

- Minimum field infiltration rate of 0.5 inches / hour required
- If infiltration rates higher than 2 inches / hour, upstream treatment required
- Testing by qualified professionals (VT licensed P.E., soil scientist, geologist)
- Minimum # tests for initial feasibility and concept design, to 4 ft below practice
- Simple borehole infiltration test prescribed—no percs

Site Characterization: Table D-1

Type of Facility	Initial Feasibility Testing	Concept Design Testing (initial testing yields a rate greater than 0.5”/hr)	Concept Design Testing (initial testing yields a rate lower than 0.5”/hr)
I-1 (trench)	1 field percolation test, test pit not required	1 infiltration test and 1 test pit per 50’ of trench	practice not acceptable
I-2 (basin)	1 field percolation test, test pit not required	1 infiltration test* and 1 test pit per 200 sf of basin area	practice not acceptable
F-1 (sand filter)	1 field percolation test, test pit not required	1 infiltration test and 1 test pit per 200 sf of filter area (no underdrains required**)	underdrains required
F-5 (bioretention)	1 field percolation test, test pit not required	1 infiltration test and 1 test pit per 200 sf of filter area (no underdrains required**)	underdrains required

***feasibility test information already counts for one test location**
**** underdrain installation still strongly suggested**

7 Key Areas of Practice

1. Minimum infiltration rates
2. Minimum depths to groundwater and bedrock
3. Horizontal setback requirements
4. Characterization frequency/type requirements
5. Test pit / boring depth requirements
6. Acceptable infiltration testing methods
7. Required credentials for site characterization professionals

1. Minimum Infiltration Rates

State (and date of manual)	Minimum infiltration rate (inches/hour)
Vermont (2002)	0.5 (unless designed as underdrained, day-lighting facility). If over 2 in/hr, upstream pretreatment required for half the WQv
Pennsylvania (2008)	0.1 - 10
Massachusetts (2008)	0.17; if over 2.4, upstream pretreatment may be required
Minnesota (2008)	0.2
Washington (2012)	Measured native Ksat less than 0.3 in/hr (underdrain required for lower Ksat)
New York (2010)	0.5 (identical to VSWMM)
Maine (2006)	0.5; no greater than 2.41
New Hampshire (2008)	0.5; greater than 10 inches per hour requires pretreatment or soil amendment
Rhode Island (2010)	0.5
North Carolina (2007)	0.52
Virginia (1999)	0.52 - 8.27

2. Minimum Depths to Groundwater and Bedrock

State (date of manual)	Minimum depth to groundwater/bedrock for infiltration practices
Vermont (2002)	3 feet from bottom of practice to seasonal water table or bedrock
Washington (2012)	1 foot from bottom of facility to groundwater, bedrock, or impervious for systems serving drainage areas: 1) less than 5,000 sq. ft. of pollution- generating impervious surface, and 2) less than 10,000 sq. ft. of impervious surface; and, 3) less than 3/4 acre of pervious surface. 3 feet from bottom of facility to groundwater, bedrock, or impervious for facilities larger than the above thresholds
Pennsylvania (2008)	2 feet to seasonal high groundwater and bedrock
Massachusetts (2008)	2 feet from bottom of practice to seasonal high water table, bedrock, and/or impermeable layer
North Carolina (2007)	2 feet to seasonal high groundwater and bedrock (4 feet recommended)
Virginia (1999)	2 to 4 feet between bottom of infiltration facility and the existing water table or bedrock
New York (2010)	3 feet from bottom of practice to seasonal water table or bedrock
Rhode Island (2010)	3 feet to seasonal high groundwater or bedrock
Minnesota (2008)	3 feet from bottom of practice to seasonally high water table or bedrock
New Hampshire (2008)	≥ 3 feet to seasonal groundwater or bedrock from bottom of BMP, except: ≥ 4 feet if within groundwater or water supply intake protection area ≥ 1 foot if runoff has been treated prior to entering the BMP
Maine (2006)	3 feet from bottom of practice to seasonal water table 5 feet of saturated overburden above bedrock for practices with contributing areas of one acre or more of impervious area

3. Horizontal Setback Requirements

State (date of manual)	Environmental Features			Development Features						
	Slope 15% or Greater	Slope 20% or Greater	Surface water	Property Lines	Soil Absorption System	Private/ individual well	Surface drinking water supply	Public/ community well	Building foundation (upslope)	Building foundation (downslope)
Vermont (2002)					35	100			35	35
New York (2010)					35	100			35	35
Maine (2006)	50		75	25	100	300		Outside Zone II	100	20
Massachusetts (2008)	50	100	50			100	Outside Zone A	Outside Zone I	100	10
Minnesota (2008)	Not allowed	200		10	35	50		50	10	10
New Hampshire (2008)	Not allowed									
North Carolina (2007)						100				
Pennsylvania (2008)		Avoid			50	50		100	100	10
Rhode Island (2010)	25-50		50		15-25	50-100	100-200	200-400	10-50	10-25
Virginia (1999)	50				Consult local HD	100			100	20
Washington (2012)*		50			10+					

*Additional setbacks: 100 feet from closed or active landfill; 10 feet from UST with capacity less than 1,100 gal; 100 feet from UST with capacity over 1,100 gal; for large septic systems see separate rule for setbacks

4. Soil Characterization Requirements

- Minimum requirements for test pit / infiltration test spacing are substantially more conservative than most other states surveyed
- Widely adopted minimum spacing is 1 test per 5,000 square feet of basin or 2 tests/trench
- Consider minimum # tests per practice, mounding analysis for marginal sites and/or large practices

5. Test Pit / Boring Depth Requirements

State (date of manual)	TP/Boring depth requirements
Vermont (2002)	Minimum 4 feet below proposed facility bottom
Maine (2006)	None in manual
Massachusetts (2008)	None in manual
North Carolina (2007)	None in manual
Virginia (1999)	3 feet below the bottom of the facility
New York (2010)	Minimum 4 feet below proposed facility bottom
Rhode Island (2010)	4 ft below the proposed facility bottom
Minnesota (2008)	Minimum 5 feet below the bottom elevation of proposed infiltration practice.
New Hampshire (2008)	5 feet below expected practice bottom, or to ESHGW or bedrock
Pennsylvania (2008)	72-90 inches or until bedrock or fully saturated conditions are encountered
Washington (2012)	At least 5 times the maximum design depth of ponded water proposed for the infiltration facility, and not less than 10 feet below the base of the facility; continuous sampling required for at least the first 10 feet. If groundwater is less than 15 ft. from facility bottom and mounding analysis needed, determine thickness of the saturated zone.

6. Acceptable Infiltration Testing Methods

State (date of manual)	Ksat adjusted for design?	Estimation Methods			Field Measurement Methods					
		Soil Survey Ksat	Rawls et al 1982 (or similar)	Soil grain size analysis	VSWMM method	Guelph permeameter	Falling head permeameter	Double ring permeameter/ infiltrometer	Amoozegar permeameter	Basin flooding or pit scale infiltration test
Vermont (2002)	No				X					
New York (2010)	No				X					
Virginia (1999)	No				X					
Maine (2006)	No			X				X		
Massachusetts (2008)	No		X			X	X	X	X	
Minnesota (2008)	Yes		X					X		
New Hampshire (2008)	Yes	X			X	X		X	X	
North Carolina (2007)	No							X		X
Pennsylvania (2008)	Yes				X	X		X	X	
Rhode Island (2010)	Yes		X			X	X	X	X	
Washington (2012)	Yes			X						X

7. Required Credentials for Site Characterization Professionals

State (date of manual)	Required credentials for site characterization professionals
Vermont (2002)	Registered Vermont professional engineer, licensed soil scientist, or licensed geologist
Maine (2006)	Not specified
North Carolina (2007)	Not specified
Virginia (1999)	Not specified
Minnesota (2008)	Highly Recommended that field verification be conducted by a qualified geotechnical professional
Pennsylvania (2008)	Qualified professionals who can substantiate by qualifications/experience their ability to carry out the evaluation
Massachusetts (2008)	Competent Soils Professional (an individual with demonstrated expertise in soil science, including, but not limited to, a Massachusetts Registered Professional Engineer, Engineer in Training (EIT certificate) with a concentration in civil, sanitary or environmental engineering, or Bachelor of Arts or Sciences degree or more advanced degree in Soil Science, Geology, or Groundwater Hydrology from an accredited college or university.)
New York (2010)	Registered NY professional engineer, licensed soil scientist, or licensed geologist
New Hampshire (2008)	Qualified professional (certified soil scientist, a professional geologist, or an engineer)
Rhode Island (2010)	Qualified professional (DEM-licensed Class IV soil evaluator or RI-registered PE)
Washington (2012)	Appropriate licensed professional (e.g., engineer, geologist, hydrogeologist)






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Channel Protection (CPv) Current Practice: Section 1.1.2

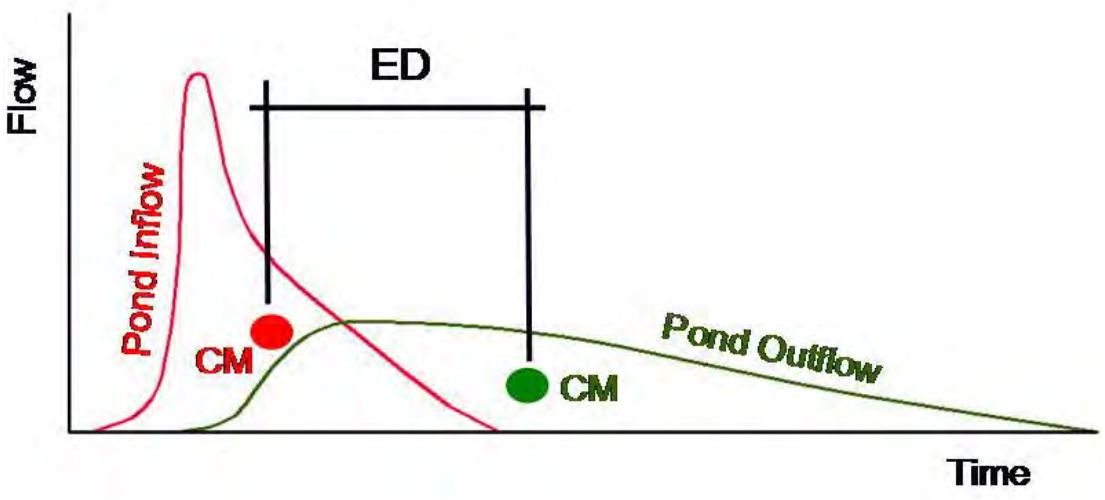


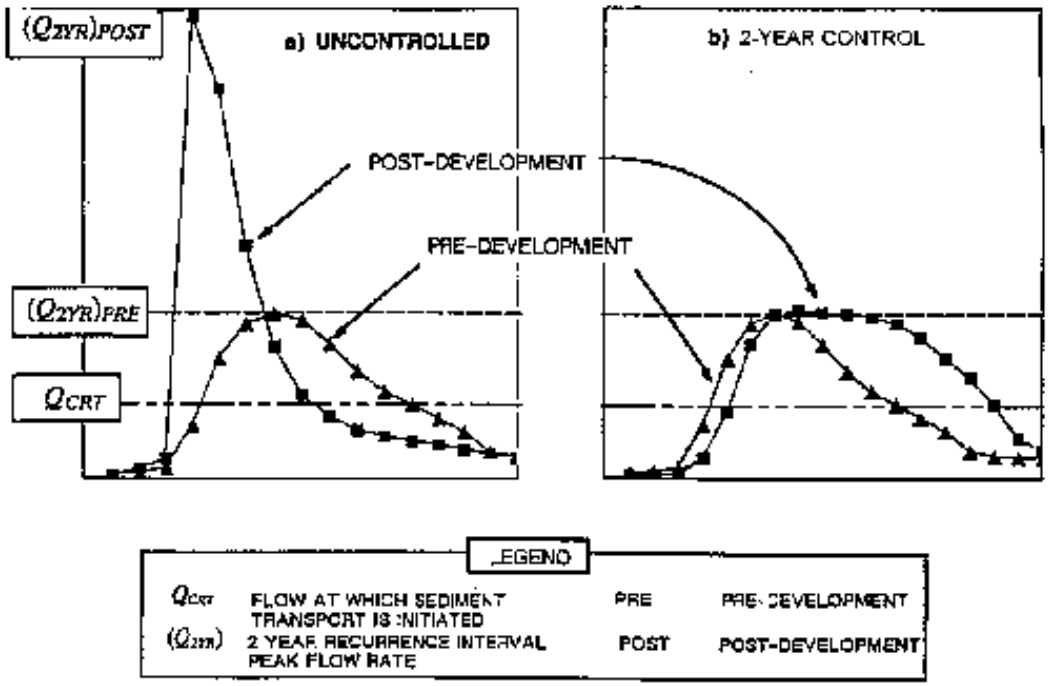
Image credit: http://www.elizabethton.org/government/stormwater/

- Extended detention storage for 1-year, 24-hour storm (depths of 2.1-2.3 inches)
  - 12 hours for cold water fishery
  - 24 hours for warm water fishery
- Release CPv at uniform rate
- Include runoff from on-site and off-site contributing drainage areas

3 Key Areas of Practice

1. Design criteria for protecting downstream channels
2. Rainfall depths used in channel protection calculations
3. Strategies to reduce thermal stress to cold water fisheries

1. Design Criteria – Common Approaches



MacRae and Rowney 1992, image credit www.stormwatercenter.net

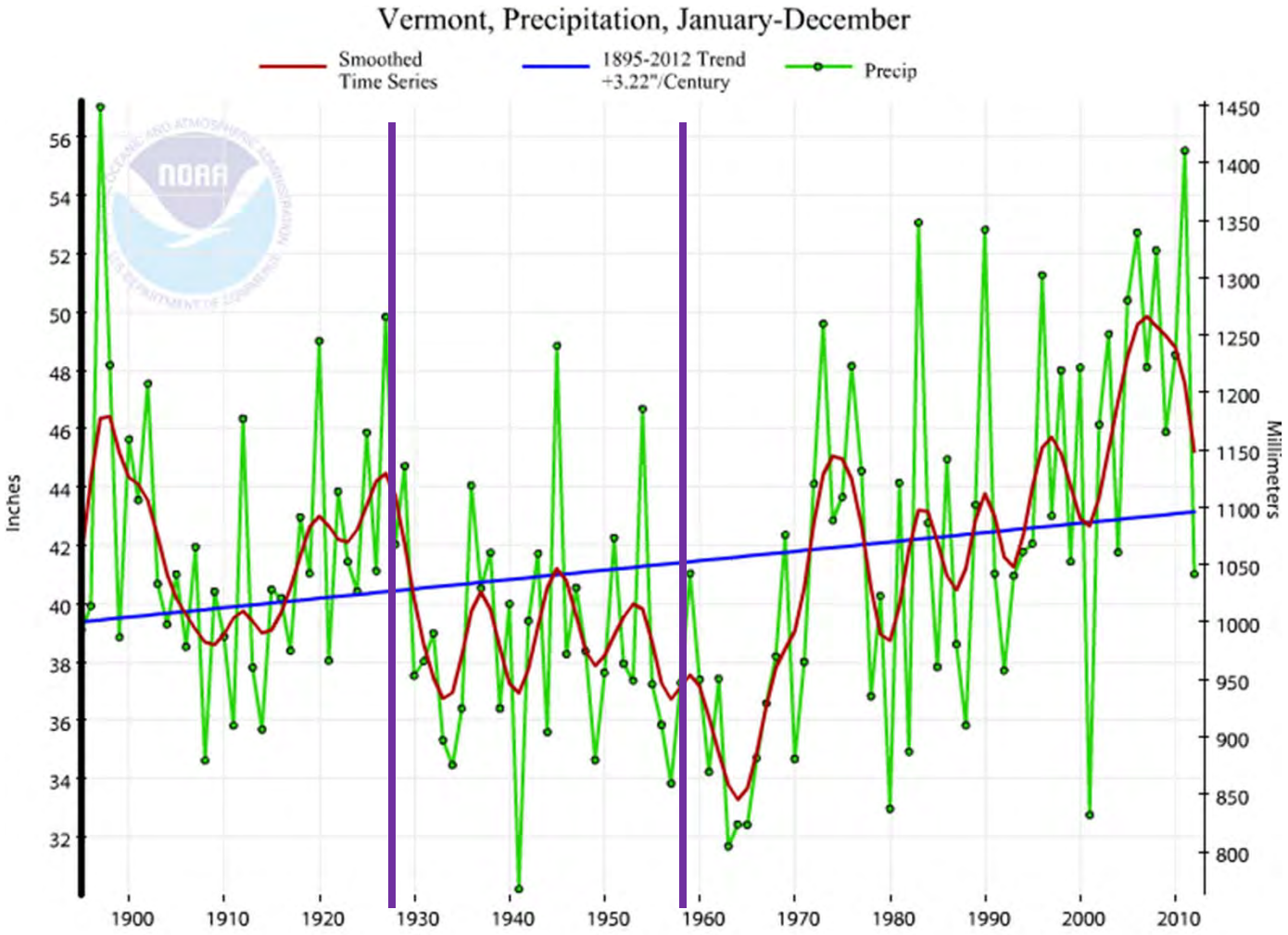
- Two-year control (holding post-development peak rate to two-year pre-development levels)
  - Can extend duration of erosive velocities, illustrated at left
- Extended detention of the one-year storm event
  - Improvement over 2-year control, but inherent conflict with LID / GSI approaches

1. Design Criteria – Issues to Consider

This pilot wet meadow and infiltrating bioswale facility at Spring Creek MTA Bus Terminal in NYC is retaining 100% of measured inflow for storm depths up to 4 inches.
www.nyc.gov/html/dep/html/stormwater/gi_pilot_monitoring_report.shtml

- Keep CPv, but consider approaches that integrate RR
- Performance-based RR goal (like retaining first inch using LID and GSI) with credits/ incentives?
- Track near-term progress and performance in states implementing RR (for example VA, NY, MN)

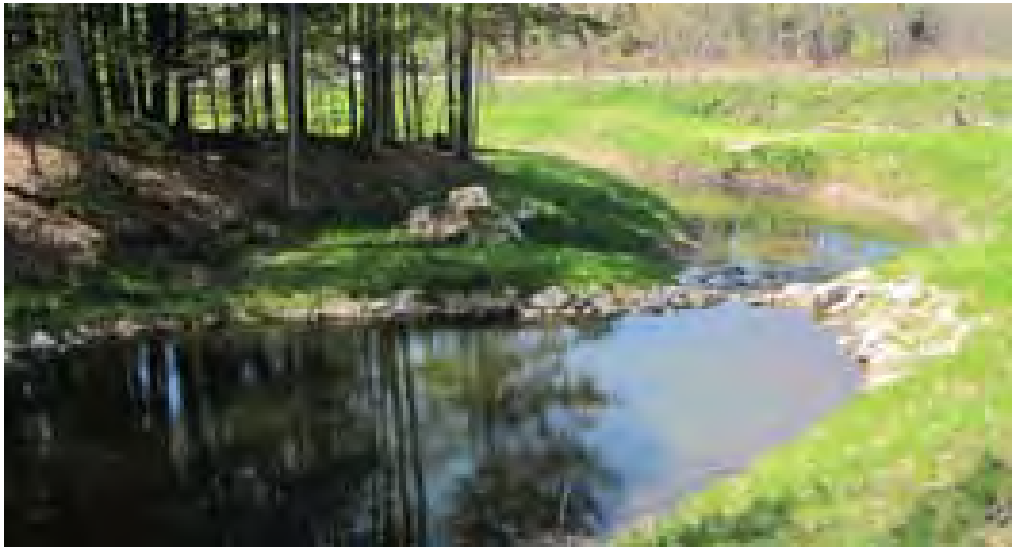
2. Rainfall depths used in CPv calculations



- 1-yr, 24-hr depths drawn from TP-40 (published 1961)
- Update of precip frequency estimates for New England (NOAA Atlas 14) not available until Sept. 2015

Annual rainfall for Vermont, 1895-2012.
Purple lines indicate approximate data collection period for TP-40.
Source: www.ncdc.noaa.gov/cag/time-series/us/

3. Strategies for cold-water fishery protection



Stormwater detention pond in South Burlington, Vermont. www.sburlstormwater.com/stormwater-projects/twin-oaks-stormwater-pond/

- Longer ED time ≅ warmer water
- Over 60% of Vermont's streams are cold-water habitats
- Impairments for temperature, and overall danger of thermal stress, increasing

3. Strategies for cold-water fishery protection

- UNH Stormwater Center: gravel wetlands and bioretention tend to buffer runoff temperatures
- Deep permanent pools in ponds can buffer if deep water is released
- Other measures: infiltration, underground storage, reuse
- Maine: must design for stormwater discharges cooler than 22ºC



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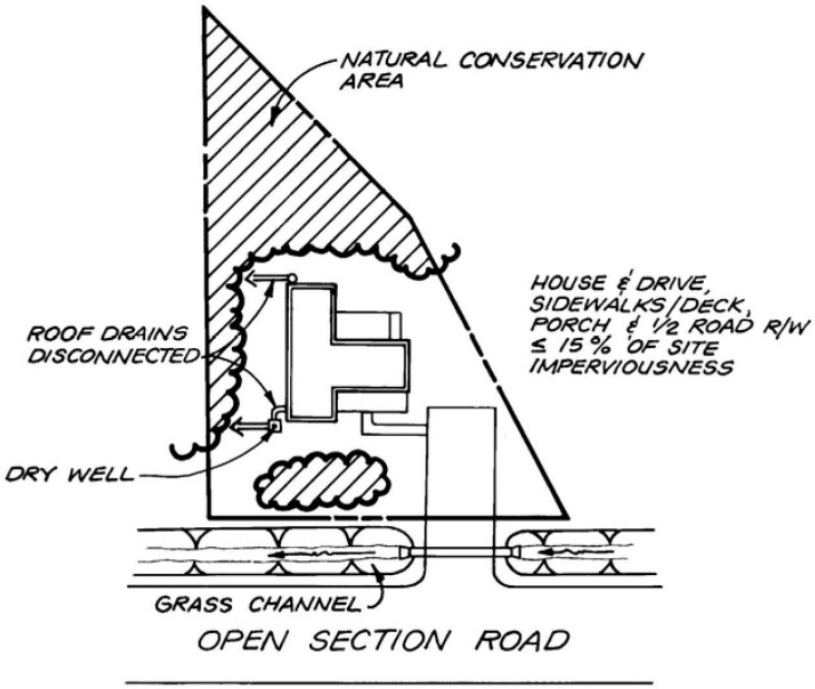
LID Current Practice in VSMM



Schematic of Environmentally Sensitive Rural Development Credit

- No explicit mention of LID
- Six voluntary, non-structural practices for credits to reduce WQv and REv:
  - Natural Area Disconnection
  - Disconnection of Rooftop Runoff
  - Disconnection of Non-Rooftop Runoff
  - Stream Buffers
  - Grass Channels
  - Environmentally Sensitive Rural Development
- "Alternative design standard" for CPv in 5th printing (if majority of site disconnected)

GSI Current Practice in VSMM

- No specific mention, but several structural GSI practices included:
  - Stormwater wetlands (including gravel, extended detention)
  - Infiltration practices (basins, trenches)
  - Filtering systems (sand filters, organic filters, and bioretention, e.g., “rain gardens”)
  - Open channels (dry swales, wet swales, grass channels)
  - Filter strips (only as “limited applicability” practice)

5 Key Areas of Practice

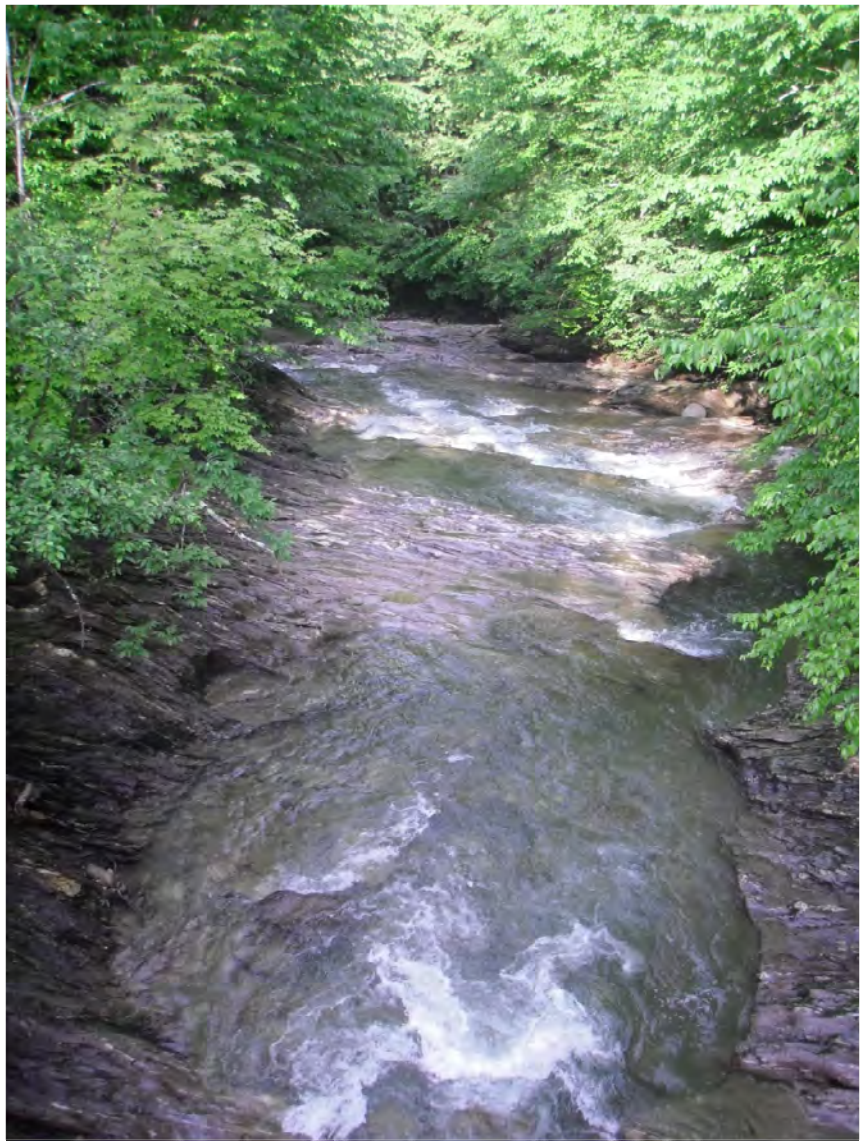
1. Overall strategies for integrating LID concepts into regulations and manuals
2. Regulatory requirements for using non-structural (LID) strategies or practices to meet stormwater treatment standards
3. Credit systems or incentives for implementing LID strategies and practices
4. Range of non-structural (LID) BMPs included in manuals
5. Range of structural (GSI) BMPs included in manuals

Also: Separate, specific guidance for pre-treatment practices?

1. Overall strategies for integrating LID

- Included in state stormwater manual but not in regulations; application of LID principles encouraged but no incentives or requirements included in regulations/manuals
- Included in stormwater manual and in regulations; optional credit systems offered (particularly for non-structural design strategies)
- Integrated through BMP manual, regulations, permit application/NOI forms, and other related state-level policy guidance

1. Overall strategies for integrating LID



- Include non-structural LID techniques more explicitly in VSMM
- Add content on LID benefits to Volume 1 and/or add LID site design practices to Accepted STPs in Vol. 1 Section 2
- Continue to convene and engage with a broad-based advisory group

2. Regulatory requirements for using LID

- Progressing more slowly and with great variability
- Three main regulatory approaches:
  - Single NOI and application for construction and post-construction, LID tightly integrated
  - Separate NOIs and applications/ permitting processes for construction and post-construction, LID tightly integrated
  - Separate NOIs and applications/ permitting processes for construction and post-construction, LID site design credits offered

3. Credit systems or incentives for implementing LID

- Progress towards implementing credits or incentives highly variable
- States range from no credits or incentives to LID being integral and mandatory

3. SW Treatment Standards Eligible for Credits / Incentives

State	Stormwater Treatment Standard				WQv depth
	WQv	REv	CPv	Qp10	
Vermont	X (partial)	X			0.9 inches
New Hampshire	No credits or incentives offered				
New York	X (required as RRv)	X (required as RRv)	X (RRv can be subtracted)		90% event (0.8-1.3 inches)
Maine	X	X	Only applies to larger sites	Only applies to larger sites	1.0 inch for impervious area plus 0.4 inch for developed landscaped area
Massachusetts	X	X	X (LID can be used but no incentives)	X (LID can be used but no incentives)	1.0 inch for impervious with higher pollutant loads; 0.5 inches for other impervious
Minnesota	X (partial)	No separate standard			0.5 inches in normal watersheds; 1.0 inch for Special or impaired waters Moving towards retaining 1.1 inches from post-dev impervious
Pennsylvania	X (up to 25% of required volume)	X (up to 25% of required volume)	X (up to 25% of required volume)	X (up to 25% of required volume)	1.0 inch from new impervious surfaces
New Jersey	Non-structural LID strategies required to be used to MEP				
Rhode Island	Non-structural LID strategies required to be used to MEP				

3. Non-Structural LID practices Eligible for Credits or Incentives

State	Non-Structural LID Practice						
	Natural Area Conservation	Disconnection of Rooftop Runoff	Disconnection of Non-Rooftop Runoff	Stream Buffers	Grass Channels	Environmentally Sensitive Rural Development	Other
Vermont	X	X	X	X	X	X	
New Hampshire	None						
New York	X	X	X	X			Many other LID practices count towards RRv
Maine	X	X	X				Buffers based on development type
Massachusetts		X	X			X	
Minnesota	X	X	X	X	X		Site Reforestation or Prairie Restoration
Pennsylvania		X	X				Minimum Soil Compaction, Protect Existing Trees
New Jersey	Non-structural LID strategies required to be used to MEP						
Rhode Island	Non-structural LID strategies required to be used to MEP						

3. LID credit systems or incentives – options to consider

- Enhance existing system - develop explicit guidance on applying for multiple credits, worksheets for non-structural practices
- Increase prominence of “alternate design standard” option for CPv
- Allow combinations of non-structural LID credits to apply fully to WQv and REv in cases other than ESRD?
- Add guidance on adjusting CN for larger storms?

4. Range of non-structural (LID) BMPs included in manuals

- Wide variety of non-structural LID BMPs in use
- Table on next slide includes practices used in VT and other states reviewed for:
  - avoiding impacts
  - reducing impacts
  - Managing remaining impacts at source

4. Summary of non-structural LID BMPs included in manuals

State	Natural area conservation	Riparian buffer/ floodplain protection	ESD/ESRD/Open Space Dev.	Limit site clearing/ grading	Minimize soil compaction	Drainage to stream or shoreline buffer	Minimize impervious areas	Rooftop disconnection	Non-rooftop disconnection	Minimize connected impervious	Filter Strips / Vegetated buffers	Grass Channels	Water-retaining landscaping	Manage stormwater at source	Reforestation/ revegetation	Soil restoration
Vermont			X			X		X	X		X	XX				
Maine				X			X			X	XX			X		
Massachusetts			X					X	X							
Minnesota	X		X			X	X	X	X	XX	XX	X		X	X	X
New Hampshire	X			X	X		X	X	X	X	XX					
New Jersey	XX	XX		XX	XX		XX			XX	XX	XX	XX	XX		
New York	XX	X	X	X			X	XX			XX	X		X		X
Pennsylvania	X	X		X	X			X	X		XX				XX	XX
Rhode Island	XX	XX	XX	XX			XX	XX	XX					XX	XX	

X — Design technique/practice eligible for incentive, or described in manual but not necessarily a standard practice or part of a mandated approach

XX — Standard design technique/practice

4. Non-structural / LID BMPs – options to consider

Vegetated swale. Image credit www.vtwaterquality.org/stormwater/htm/sw_gi_bmp_vegetatedswales.htm

- Add a broader range of practices eligible for incentives?
  - Natural area conservation, riparian/lakeshore/floodplain preservation
- Robust description of strategies to minimize impervious?
- Shift Stream Buffer Credit to incentivize floodplain protection?
- Strengthen Grass Channel Credit (only wet/dry swales eligible)?
- Add filter strips as Acceptable STP (with robust guidance)?

5. Range of structural (GSI) BMPs included in manuals

Green roof at Heritage Aviation in South Burlington. Image credit www.vtwaterquality.org/stormwater/htm/sw_gi_bmp_greenroofs.htm

- Less variability on structural BMPs in use
- Table on next slide includes practices used in VT and other states reviewed:
  - Volume reduction w/o infiltration
  - Stormwater wetlands
  - Infiltration
  - Filtering practices
  - Open channels

5. Summary of structural (GSI) BMPs included in manuals

	Green roofs	Rainwater harvesting for use	Constructed SW Wetland	Infiltration basin/trench	Infiltration planters	Trees / tree boxes	Porous pavements	Dry well	Subsurface structures	Leaching catch basins	Bioretention +rain gardens	Sand Filter	Vegetated soil / organic filter	Vegetated swales/ bioswales	Level spreader	Stream daylighting
Vermont			XX	XX							XX	XX	XX	XX		
Maine	X	XX		XX			XX				XX		XX	XX	XX	
Massachusetts				XX			XX	XX	XX	XX	XX					
Minnesota	XX	XX	XX	XX			XX		XX		XX			XX		
New Hampshire	XX	XX		XX			XX				XX			XX		
New Jersey	X		XX	XX			XX	XX			XX	XX	XX			
New York	XX	XX	X	XX	XX	XX	XX	XX	XX		XX	XX		XX		XX
Pennsylvania	XX	XX	XX	XX		X	XX	XX			XX		XX	XX	XX	
Rhode Island	XX	X	XX	XX	XX	XX	XX		XX		XX	XX	XX	XX		XX

X — BMP endorsed in manual, but detailed guidance for implementing not provided

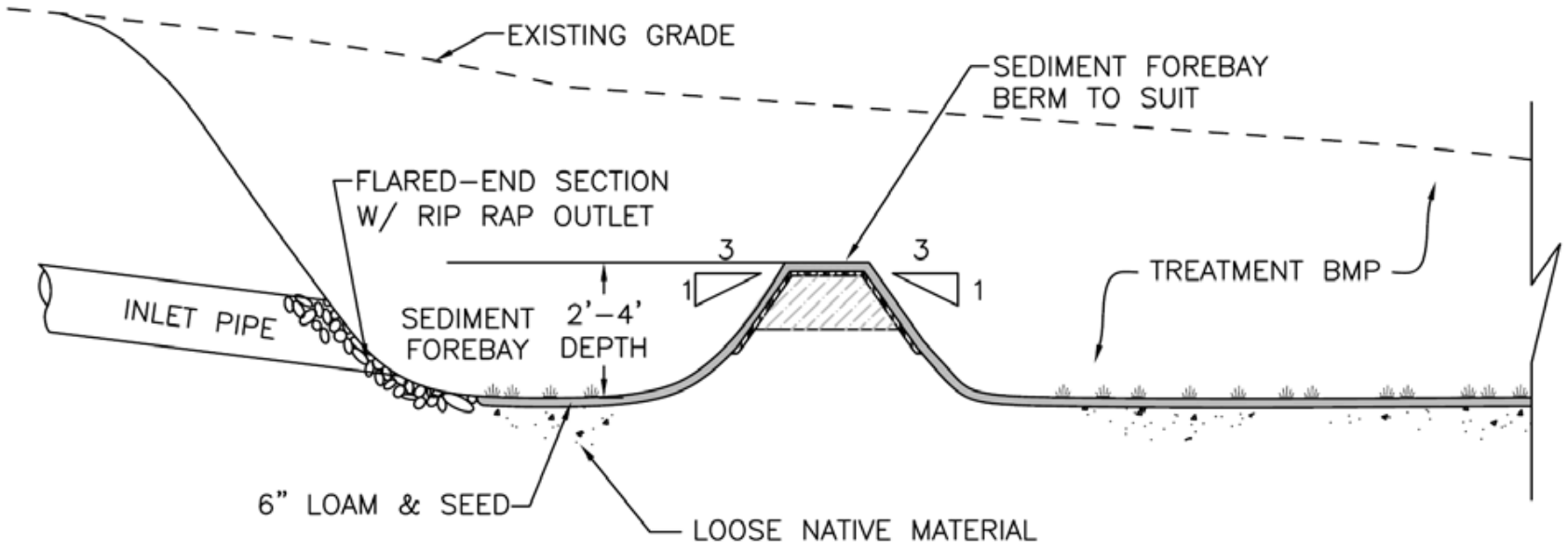
XX — Standard design technique/practice

5. Structural / GSI BMPs – options to consider

- Add green roofs, rainwater harvesting, permeable pavement
- Expand bioretention to include infiltrating and filtering “rain gardens”
- Remove grass channels as STP
- Update treatment effectiveness / pollutant removal efficiencies (Appendix D3)
- Separate practice descriptions for each STP (esp. for filtering practices)?
- Add drywells? Tree box filters? Infiltration planters? Level spreaders?

Also: Pre-treatment for GSI BMPs

- Becomes more necessary as incentive (or need) for designers to use less familiar GSI increases
- Consider creating VSMM section dedicated to pre-treatment



Sediment forebay practice schematic from the pretreatment chapter of the RI Stormwater Design and Installation Standards Manual (December 2010)



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Current Inspection & Maintenance Requirements

- General Permits 3-9015 and 3-9010: semi-annual inspections (submitted by June 1 and Dec. 1) using checklists (VSMM App. D8)
  - Stormwater Pond / Wetland
  - Infiltration Trench
  - Sand / Organic Filter
  - Bioretention
  - Open Channel
- Not consistent with general inspection forms at vtwaterquality.org/stormwater/docs/
- General Permit 3-9030 (stormwater-impaired waters not included in MS4 permits): annual inspections before June 15, annual report by Dec. 31
  - No guidance or requirements for inspections
  - No mention of App. D8 guidelines and templates

Maintenance & operation strategies in other states

- Some degree of maintenance usually required, but wide variation:
  - General requirement in permit conditions
  - Periodic inspection / maintenance explicitly required, general guidelines provided
  - Periodic inspection / maintenance explicitly required, specific guidance plus templates & checklists provided

Summary of maintenance & operation strategies in other states

State	Site Specific O&M Plan	General Maintenance Plan	Vegetated Swale	Tree Box Filter	Media Filter	Bioretention	Infiltration Trench	Extended Detention/Dry Pond	Rain Garden/ Flow-Through Planters	Wet Pond	Sand Filtration	Infiltration Basin	Filter Strip	Underground Detention	Constructed Wetland	Riparian Buffer	Permeable Pavement	Rooftop Runoff Management	Proprietary Systems	Open Channels
Vermont	X					T	T					T			T					T
California	T		T	T	T	T	T	T	T											
Connecticut	X																			
Delaware	G	G				T	T	T		T	G	T	G	T						
New Hampshire	G																			
New Jersey	X																			
New York	G					T	T			T	T									
North Carolina	T		T			T	T	T		T	T		T		T	T	T	T	T	
Pennsylvania	X																			
Rhode Island	G					T	T	T		T	T						T			T
Washington	X																			
West Virginia	X																			

X general requirement for proper maintenance included in permit conditions

G inspection and maintenance explicitly required, some guidelines provided

T inspection and maintenance explicitly required, standard templates provided

Maintenance and inspection strategies to consider

- Ensure consistency in inspection / maintenance requirements across permits
- More specific information regarding designing for maintenance in VSMM Section 2.7
- Expand inspection forms in VSMM Appendix D8; fillable PDF or Word forms?
- Practice-specific inspection / maintenance plans?

Questions?