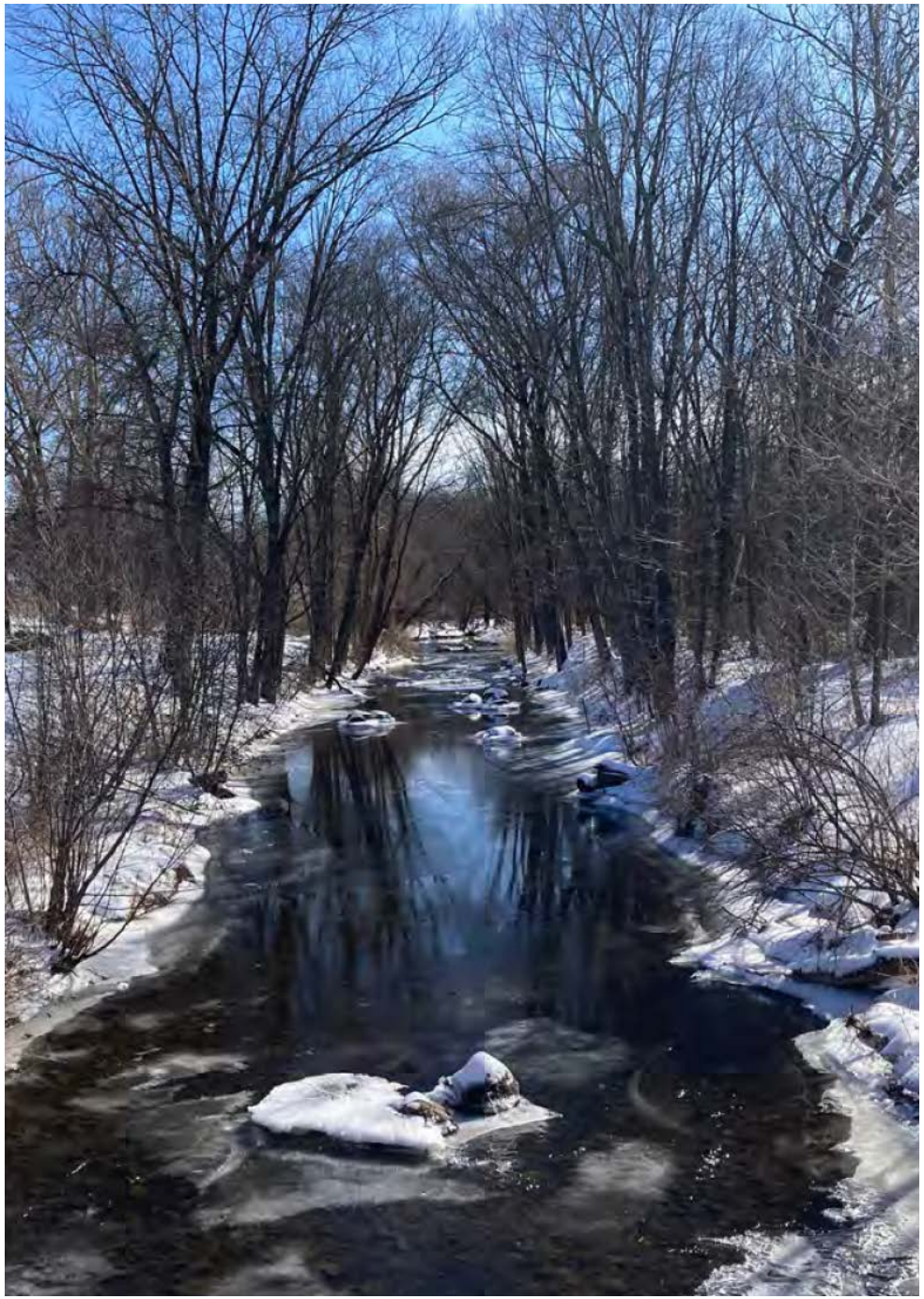
Storm Sewer Standards Workshop

October 21st, 2025



Agenda

1. Introduction
2. Boundary Conditions
3. Baseline Standards
4. Enhanced Standards
5. Resilient Design Principles

Introduction

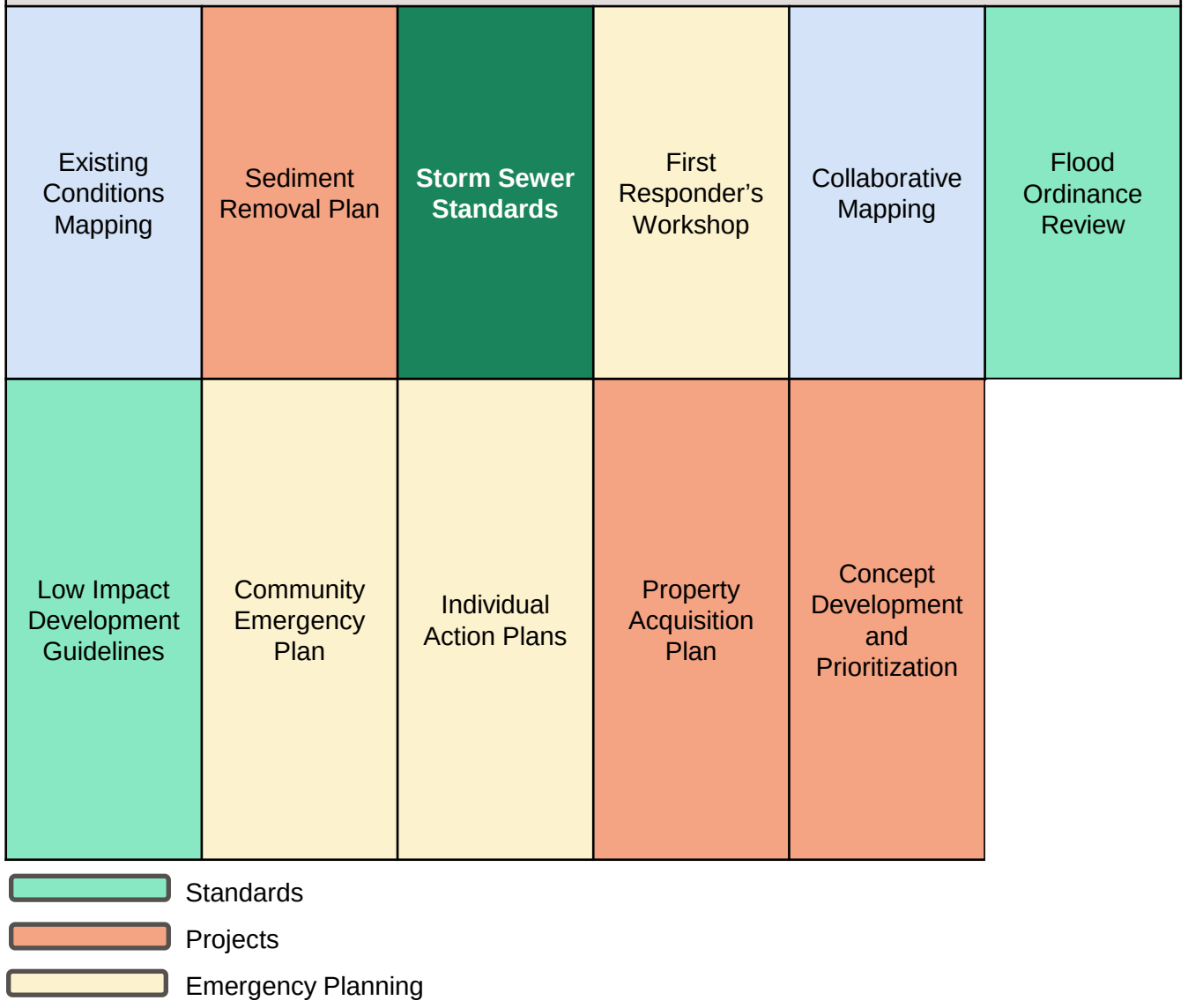
Storm Sewer Standards

- Standards for City storm sewer improvements that are flood resilient
- Can be applied to private development
- Distinguished from flood ordinances and LID strategies

Workshop goals

- Review typical components and exemplar communities
- Gather feedback on examples, understand the City's needs and appetite for standards

Project Components Overview



Boundary Conditions

A design storm frequency can be adjusted for the area or asset served

Classic design storm is 10-year / 24-hour event

NOAA Atlas 15 to be published in 2026

Storm Frequency

Bristol

The stormwater runoff system for all driveways, parking areas and loading areas shall… Be sized to accommodate runoff from a 25-year design storm.

Stamford

Unless otherwise specified by the Engineering Bureau, the 24-hour design storm rainfall amounts and distributions shall be obtained from the latest NOAA Atlas 14 Point Precipitation Frequency Estimates and storm distributions.

Facility	South of Merritt Parkway	North of Merritt Parkway
Local Streets and Parking Lots	25-Year	10-Year
Collector and Major Roads	25-Year	25-Year
Watercourse Channels	50-Year	50-Year
Major Culverts	50-Year	50-Year
Bridges	100-Year	100-Year

Bridgeport

Table 2
Design Storm Frequencies

Drainage System	Design Storm
Storm Drains	25-year
Flood Zone	25-year
Ditches and Channels	50-year
Detention Basins	2-, 10-, 25, 50-year[1]
Drywells	10 year[2]
Private Driveway Cross Culvert	10-year
Public Roadway Cross Culvert or Watercourse[4] Watershed <1 mi² Watershed >1 mi²	 50-year 100-year
Bridges/Box Culvert	100-year[3]
Pumping Stations	25-year

Greenwich

Type of Facility	Design Frequency (Years)
Storm Drains and Inlets	
Local Streets and Parking Lots	10
Local Streets and Parking Lots at Sags*	25
Secondary and Major Roads	10
Secondary and Major Roads at Sags*	25
Local Drainage Channels and Ditches	25
Watercourse Channels	50
Culverts**	
Watershed Area <1 square mile	50
Watershed Area ≥1 square mile	100
Bridges	100
Storage (Detention/Retention) Facilities	See Section 6.7

Boundary Conditions

Changes in precipitation can be viewed through different lenses

Climate Change Considerations

Stamford

- Designers shall consult the latest climate change projections for the site and evaluate a 50-year facility planning horizon
- Potential climate change impacts include sea level rise, increased storm intensity and frequency including storm surge in coastal areas, increased annual precipitation amounts, higher groundwater elevations that may impact structural BMP selection, siting, design, and operation/maintenance of facilities
- Structural BMP vulnerabilities include sea level rising and submerging outfalls, rising groundwater and reduced infiltration, storm surge inundation of facilities, and additional wind, sand, and salt exposure.

Boundary Conditions

Massachusetts uses 24-hour precipitation projections developed by Cornell University's Northeast Regional Climate Center

Assets are also assessed for a planning horizon

**https://journals.ametsoc.org/view/journals/hydr/23/3/JHM-D-21-0183.1.xml).*

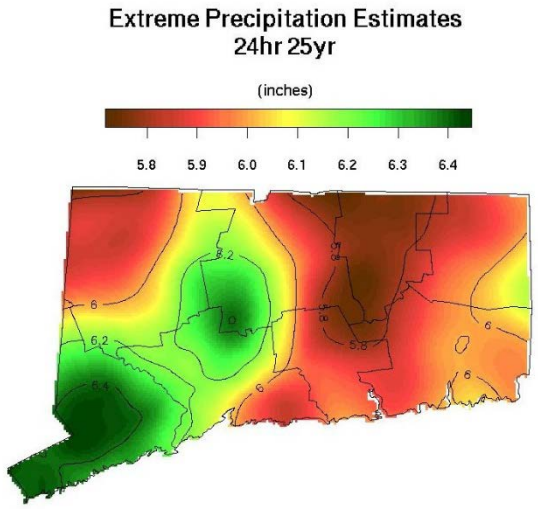
Storm Frequency with Climate Projections

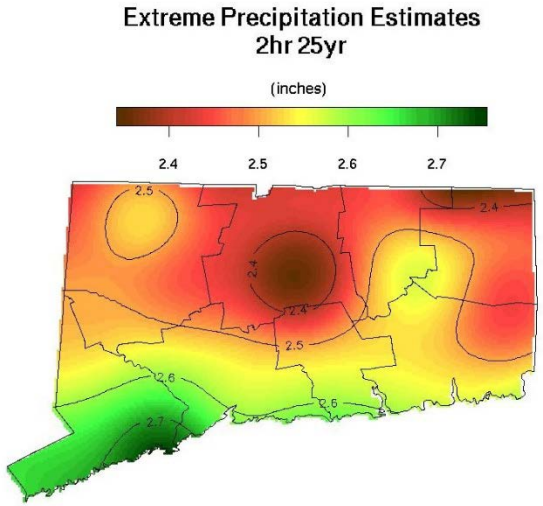
Massachusetts State Agencies

Table 4.11. Recommended Return Periods Provided by the Tool for the Extreme Precipitation Climate Parameter

	Criticality	Useful Life	BUILDINGS / FACILITIES	INFRASTRUCTURE			
				Transportation	Dams & Flood Control Structures	Utilities	Green Infrastructure[1]
			Return Period (Annual Probability)				
EXTREME PRECIPITATION	High	51-100 years	100-yr (1%)	100-yr (1%)	500-yr (0.2%)	100-yr (1%)	N/A
	Medium	51-100 years	50-yr (2%)	50-yr (2%)	100-yr (1%)	50-yr (2%)	N/A
	Low	51-100 years	25-yr (4%)	25-yr (4%)	50-yr (2%)	25-yr (4%)	N/A
	High	11-50 years	50-yr (2%)	50-yr (2%)	100-yr (1%)	50-yr (2%)	5-yr (20%)
	Medium	11-50 years	25-yr (4%)	25-yr (4%)	50-yr (2%)	25-yr (4%)	5-yr (20%)
	Low	11-50 years	10-yr (10%)	10-yr (10%)	25-yr (4%)	10-yr (10%)	5-yr (20%)
	High	10 years or less	25-yr (4%)	25-yr (4%)	50-yr (2%)	25-yr (4%)	5-yr (20%)
	Medium	10 years or less	10-yr (10%)	10-yr (10%)	25-yr (4%)	10-yr (10%)	5-yr (20%)
	Low	10 years or less	5-yr (20%)	5-yr (20%)	10-yr (10%)	5-yr (20%)	5-yr (20%)

https://resilient.mass.gov/climateresiliencestandardstool/docs/CRDST_Section4_V1.4.pdf





Northeast Regional ClimateCenter

Boundary Conditions

Communities may adopt projections from other sources, typically academia or research groups

Storm Frequency with Climate Projections

Naugatuck Valley Council of Governments

Table 1-2: 24-Hour Rainfall Amounts by Annual-Chance Occurrence

Source	24-Hour Rainfall Amount (inches) by Annual-Chance Occurrence		
	10%	4%	1%
Technical Paper No. 40	4.7	5.5	6.9
NRCC	5.0	6.4	9.0
NOAA Atlas 14	5.7	7.1	9.1

By 2050, Bristol can expect the 24-hour rainfall amount for a 10% annual-chance storm to be around 5.1 to 6.2 inches or greater

UCONN
UNIVERSITY OF CONNECTICUT

Boston Water and Sewer Commission

NOAA Atlas 14 10y / 24h event is increased for the 2030 and 2070 time horizon, based on climate projections for intensifying rainfall published by the Woods Hole Group

WOODS HOLE GROUP
A CLS COMPANY

Boundary Conditions

Rainfall Distribution

Stamford

Hydrologic models shall be prepared utilizing the SCS Runoff Curve Number Method from NRCS TR-55 .

Tailwater

FEMA Publications

FEMA mapping publishes surface water elevations for 10-year and larger events.

Boston Water and Sewer

Drains are initially engineered for free discharge condition. The impact of NOAA tidal conditions (mean low, average, mean high) plus an increase for 2070 climate horizon as published by Woods Hole Group is then examined, and collection systems are optimized to the maximum extent practical.

Baseline Standards

Statewide standards can serve as a jumping-off point for enhancing flood resiliency.

These standards serve as the floor, not the ceiling.

To what extent are these standards being applied to the City's own projects?

Conveyance Protection: Design the conveyance system leading to, from, and through structural stormwater BMPs based on the post-development peak flow rate associated with the 10-year, 24-hour or larger magnitude design storm.

Emergency Outlet: For on-line stormwater quantity control BMPs, size the emergency outlet of stormwater quantity control structures to safely pass the post-development peak flow rate from the 100-year storm event or larger storm in a controlled manner without eroding the outlet and downstream drainage systems.

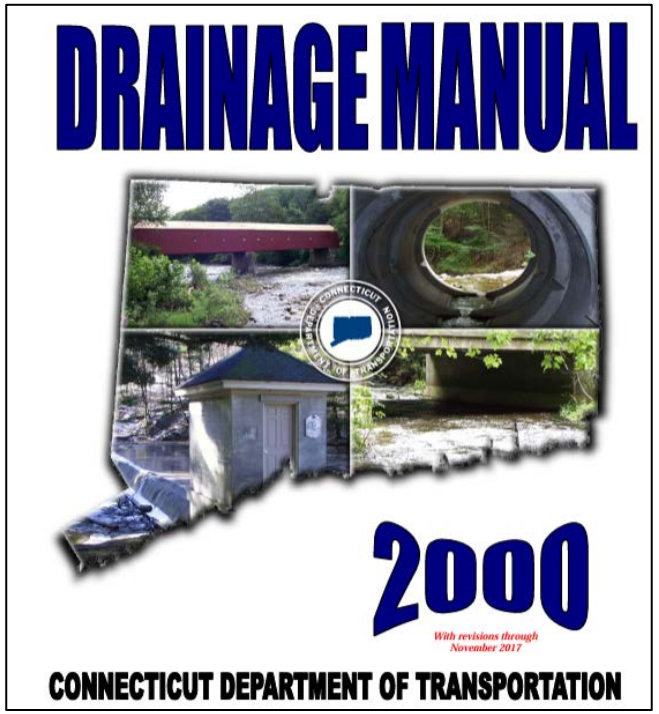


Table 11-2 Pavement Drainage Design Criteria

ROADWAY	ADT	SPEED km/hr (mi/hr)	DESIGN FREQUENCY yr	ALLOWABLE DESIGN SPREAD
State Arterial Highways and Expressways	≥ 3000 ≥ 3000 < 3000	≥ 80 (≥ 50) ≤ 70 (≤ 45) ---	10 10 10	shoulder ½ of lane ½ of lane
Sag Condition	any	any	50*	all except one lane width
State Collector Highways and State-owned service Roads	≥ 3000 ≥ 3000 < 3000	≥ 80 (≥ 50) ≤ 70 (≤ 45) ---	10 10 10	shoulder ½ of lane ½ of lane
Sag Condition	any	any	25*	all except one lane width
Town Roads	≥ 3000 < 3000	any	10 5	½ of lane ½ of lane
Sag Condition	≥ 3000 < 3000	any	25 10	all except one lane width
One Lane Ramps	any	any	10	0.3m (1 ft) of lane
Ramps > one lane	any	any	10	m (3 ft) of lane

Baseline Standards

Stamford, CT

Stream Channel Protection

Stamford

- The 2-year, 24-hour post-development peak flow rate shall be: (a) less than or equal to 50 percent of the 2-year, 24-hour storm pre-development peak flow rate, or (b) less than or equal to the 1-year, 24-hour storm pre-development peak flow rate.
- This stormwater management standard is required for all stormwater flows (except sites with less than or equal to one acre of impervious cover) which discharge directly or indirectly into a water body or watercourse including those discharges which enter a storm sewer system prior to discharging to the water body or watercourse. This standard may be waived under certain conditions, at the discretion of the Engineering Bureau, as described in the Connecticut Stormwater Quality Manual.

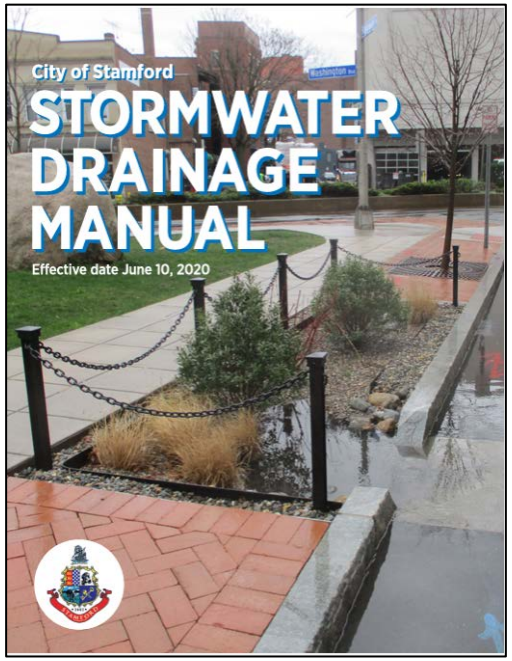
Peak Flow Control

Stamford

- The post-development peak flow rates from the 1-year, 2-year, 5-year, 10-year, 25-year, and 50-year, 24-hour storms shall be controlled to the corresponding pre-development peak discharge rates.
- Peak runoff attenuation for the 100-year, 24-hour storm may be required at the discretion of the City. The City may also, at its discretion, require the applicant to evaluate pre- and post-development peak runoff rates associated with more intense, shorter-duration storm events or less intense, longer-duration storm events to reflect potential changes in rainfall characteristics due to climate change or other factors.

Stamford's standards are applied to both developers and internal projects

Baseline Standards

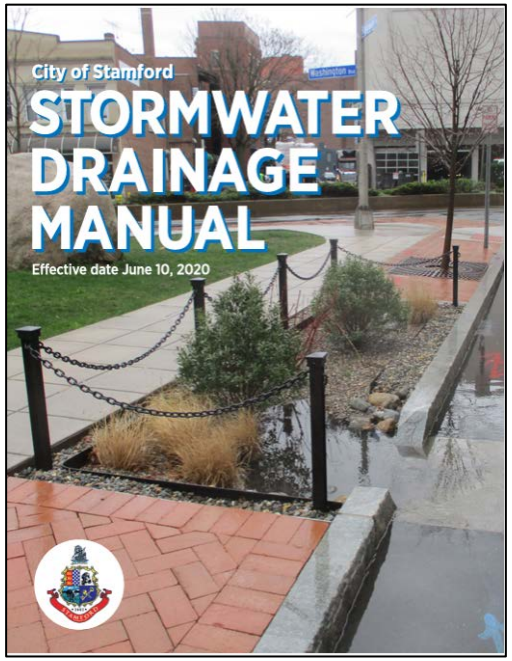


Stamford

Catchment Requirements

- Catch basins shall conform to City of Stamford Standard Detail:
  - Bell traps are required on structure outlets. PVC elbows are acceptable on private property.
  - Minimum sump depth is 2 feet for any catchment structure, measured from the invert of the lowest outlet to the floor of the basin.
- For uncovered, lower level ingress/egress basement areas, exterior drains with an uncovered drainage area less than 50 square feet shall have a minimum sump of 12 inches. Drainage areas greater than 50 square feet shall have a minimum sump of 24 inches. Sumps shall be measured from the invert of the lowest outlet out to the floor of the drain.
- Double catch basins shall have a minimum outlet pipe diameter of 15 inches.
- Catch basin spacing shall not exceed 300 feet.
- Catchment structure to catchment structure connections are not permitted.
- Roof drains, footing drains, and exterior drains are prohibited from connecting directly to a catchment structure.
- Inlet analysis shall be provided to conform to the criteria established in Section 11.8 of the CTDOT Drainage Manual.
- Gutter Flow Calculations are required for all catch basins constructed as part of road improvements or new road construction. Gutter spread shall not exceed ½ the travel-way in either direction.

Baseline Standards

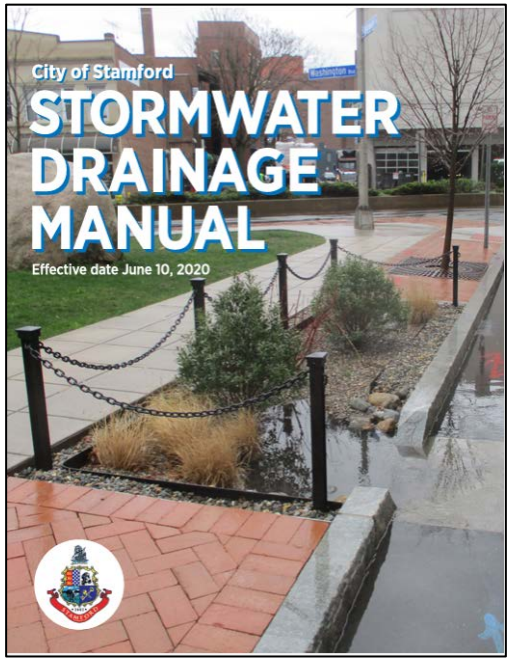


Stamford

Storm Sewer Conveyance System

- Pipes shall be designed with a minimum self-cleansing velocity of 2.5 feet per second, and a maximum velocity not to exceed 15 feet per second.
- Storm drains shall be designed as open channels, where there is a free water surface (just full or less than full), or for pressure or pipe flow under surcharged conditions. The design shall account for backwater effects and all energy losses in the system. Only circular pipes of 12 inches or greater diameter shall be used within the City Right of Way per CTDOT Drainage Manual Section 11.11.
- Provide a minimum of 24 inches of cover over drainage pipes. Less than 24 inches of cover is permitted on private properties provided the drainage piping is certified by its manufacturer for the proposed depth of fill above the pipe and anticipated loading.
- Where storm sewers cross sanitary sewers, water mains, gas mains or other utilities, minimum clearance shall be 12 inches.
- Direct or pressure connections to the City drainage system are prohibited.
- Drainage pipes shall be installed in straight alignments, both horizontally and vertically, with manholes providing access at all angles points and junctions of two or more drainage pipes.
- Horizontal bends may be permitted on private residential properties provided they do not exceed 45 degrees and include appropriate cleanouts.

Baseline Standards

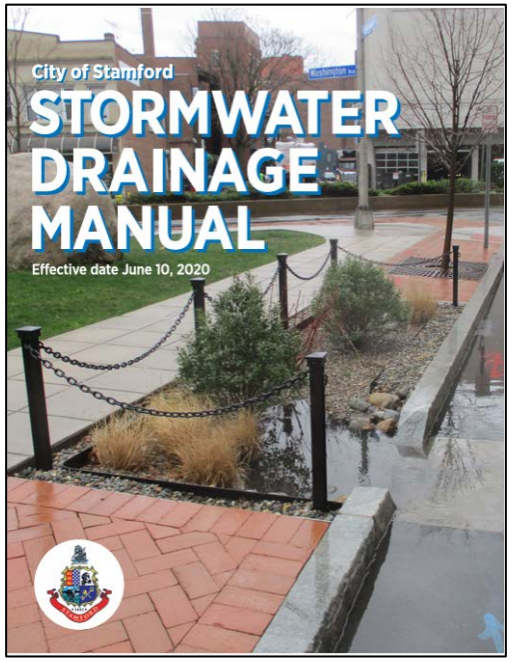


Stamford

Culverts

- Culverts shall be designed to convey discharges resulting from design storm frequencies.
- The water surface used at the inlet of the culvert to determine culvert size shall be based upon the allowable headwater (AHW), allowing for at least one foot of freeboard.
- Where a culvert is proposed downstream of an existing or proposed detention basin, the culvert sizing shall assume that zero upstream storage exists; i.e., the culvert is designed as if the stormwater detention facility did not exist.
- The locations and alignment of culverts shall be consistent with the flow tendency of existing streams. New culverts or replacement culverts over streams shall comply with the CTDEEP Stream Crossing Guidelines.
- Where successive culverts are utilized and the flow in the upper culverts is affected by headwaters in the lower culverts, a water surface profile and appropriate computations shall be submitted for review.
- Scour protection shall be provided in accordance with Section 11.13 of the Connecticut Department of Transportation Drainage Manual.

Baseline Standards

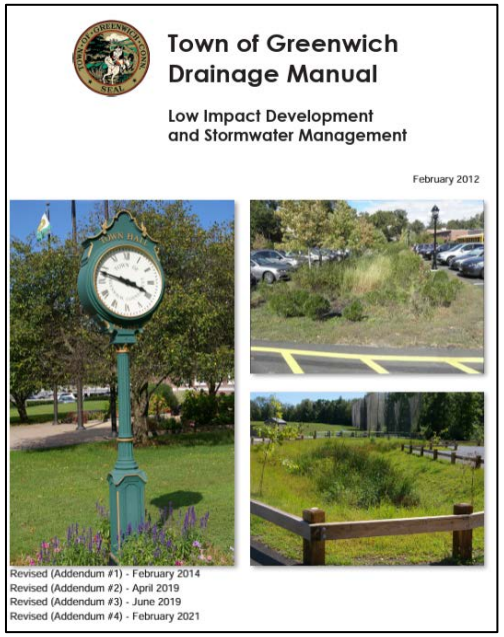


Stamford

Drainage Channels

- Channel side slopes shall not exceed the angle of repose of the soil and/or lining and shall be 1V:2H or flatter in the case of rock-riprap lining and 1V:3H in the case of vegetative lining.
- The use of flexible linings (grass, other vegetation, riprap, keyed riprap, and gabions) is preferred over rigid linings such as riprap revetments. Flexible linings shall be designed according to the method of allowable tractive force. Preference shall be given to vegetation-lined channels where possible.
- The use of impervious linings (concrete, asphalt, etc.) is discouraged except for very high velocity flow and steep slopes.
- The design discharge for permanent roadside ditch linings shall have a 10-year frequency while temporary linings shall be designed for the 2-year frequency flow.
- Channel freeboard shall be a minimum of 1 foot or two velocity heads, whichever is larger. Freeboard allowances shall be provided in proportion to the potential damages that could occur in the event of overtopping.
- Where velocities in swales, ditches or channels exceed 5 fps, riprap or other protective treatment must be installed to prevent erosion.

Baseline Standards



Greenwich

Regulations for Industrial and Sensitive Locations

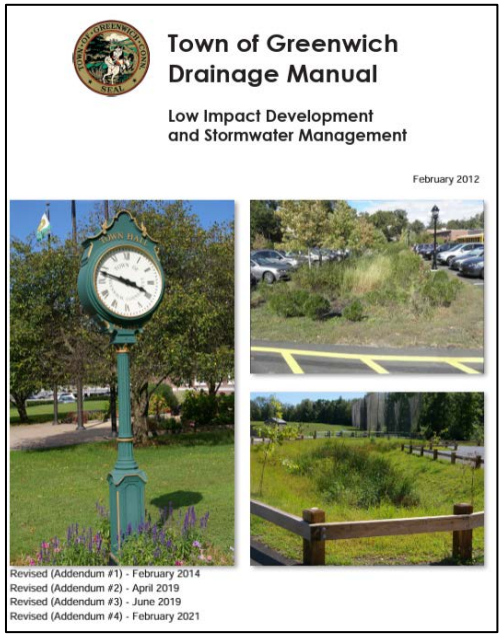
High Load Areas

- Stormwater discharges from land uses with higher potential pollutant loads (referred to as “High Load Areas”) require the use of specific source controls, pollution prevention measures, and stormwater BMPs, approved by the approving authority for such use.
- High-load areas shall include a stormwater pollution prevention plan (SWPPP) describing methods for source reduction and pretreatment. Infiltration of stormwater from high-load areas is prohibited within critical areas.
- Examples: Industrial uses, auto fueling, road salt storage, salvage yards.

Critical Areas

- Stormwater discharges to or near critical areas require the use of source control and pollution prevention measures and structural stormwater BMPs that are suitable for managing discharges to such areas. Infiltration of stormwater runoff from land uses with higher potential pollutant loads (high load areas) near or within a critical area is prohibited.
- Examples: Public Water Supply watershed, sensitive wetlands or streams with TMDLs.

Baseline Standards



Greenwich

Construction Erosion and Sediment Control

- A plan to control construction related impacts, including erosion, sedimentation, and other pollutant sources during construction and land disturbance must be developed and implemented.

Construction Inspections

- Periodic inspections of the stormwater management system construction shall be conducted by the approved professional engineer of record.

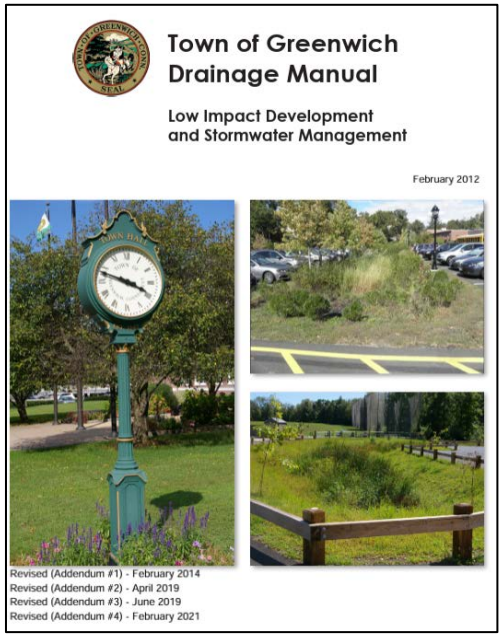
Operation and Maintenance

- A long-term Operation and Maintenance (O&M) Plan shall be developed and implemented to ensure that stormwater management systems function as designed.

Stormwater Management Report

- A Stormwater Management Report shall be prepared for all development and redevelopment activities that are subject to the Stormwater Management Standards

Baseline Standards



Impervious Surface

Greenwich

Directly Connected Impervious Area Tracking Worksheet
City of Stamford Drainage Manual

Note to user: complete all cells of this color only, as indicated by section headings

Part 1: General Information (All Projects)

Project Name	Roxbury School
Project Address	715 W Hill Drive
Project Applicant	
Title of Plan	
Revision Date of Plan	2-Oct-25
Tax Account Number	

Part 2: Project Details (All Projects)

1. What type of development is this? (choose from dropdown) — Redevelopment
2. What is the total area of the project site?
3. What is the total area of land disturbance
4. Does project site drain to High Quality Wa
within 500 ft. of Tidal Wetlands? (Yes/No)

Does Standard 1 apply based on information

Part 3: Water Qualit

5. What is the current (pre-development) *DC*
6. Will the proposed development increase
proposed stormwater management)? (Yes/N
7. What is the proposed-development *total*

Water Quality Volume (WQV)
Standard 1 requirement
Required retention volume
Provided retention volume for proposed dev

Part 4: Proposed D

Pre-development ***total impervious area***
Current ***DCIA***
Proposed-development ***total impervious ar***
Proposed-development ***DCIA*** (after stormw
Net change in ***DCIA*** from current to propos

Part 5: Post-Development (As-Bu

Post-development (per as-built) ***total imper***
Post-development (per as-built) ***DCIA*** (after
Net change in ***DCIA*** from current to post-de

I hereby certify that the information contained in this worksheet is true and correct.

Engineer's Signature _____ Date _____ Engineer's Seal _____

Part 3: Water Quality Target Total (Only for Standard 1 Projects)

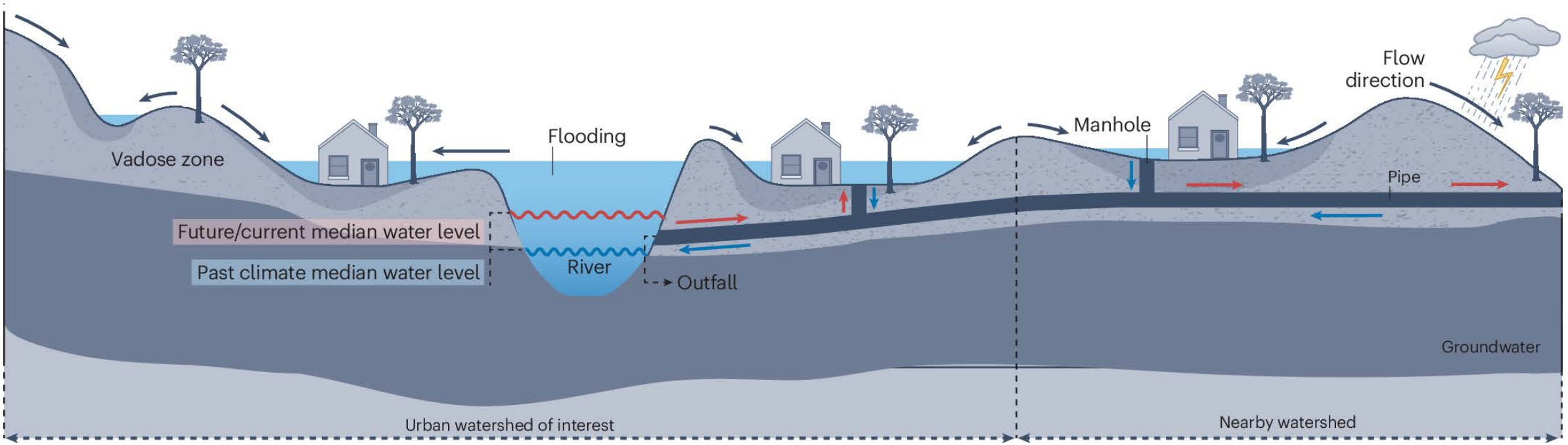
5. What is the current (pre-development) ***DCIA*** for the site?	211,680	ft^2
6. Will the proposed development increase ***DCIA*** (without consideration of proposed stormwater management)? (Yes/No)	Yes	
7. What is the proposed-development ***total impervious area*** for the site?	237,581	ft^2
Water Quality Volume (WQV)	20249.5	ft^3
Standard 1 requirement	Retain WQV on-site	
Required retention volume	20249.5	ft^3
Provided retention volume for proposed development	57,754.0	ft^3

Part 4: Proposed DCIA Tracking (Only for Standard 1 Projects)

Pre-development ***total impervious area***	211,680	ft^2
Current ***DCIA***	211,680	ft^2
Proposed-development ***total impervious area***	237,581	ft^2
Proposed-development ***DCIA*** (after stormwater management)	146,054	ft^2
Net change in ***DCIA*** from current to proposed-development	-65,626	ft^2

Enhanced Standards for Development

- Baseline standards establish **best practices** for collection system design, without a specific practices for climate change considerations
- The modern approach for strengthening standards involves directly **inserting flood resilience measures into the standards**. In some cases, standards have been re-written with flood relief as a primary driver
- The following slides highlight **enhanced standards** imposed by exemplar communities. While some of these standards **focus on developers**, they can also be **applied to City projects**.



Enhanced Standards

Bridgeport, CT

Aurora, IL

Flood Control Requirements Specific to Developments Located in Flood Prone Areas

Bridgeport

Substantial storm water volumes in portions of the storm sewer system result in surface and basement flooding in many areas. For these reasons, it is important to limit the quantity of storm water entering the drainage system, and development projects in flood prone areas are subject to the requirement to infiltrate and retain storm water on-site to zero

**applied primarily to developers, intermittently to internal projects*

Standard Specifications for Improvements

Aurora, IL

- Requires on-site detention storage for 110% of the 100-Year frequency event runoff volume
- Restricts calculated flood depths in parking lots and at building openings (doors/windows)

Enhanced Standards

Milwaukee, WI

Virginia Beach, VA

Stormwater Rules of the District

Milwaukee Metropolitan Sewerage District

- Impervious surfaces 5,000 SF to 1/2 acre must include GI to detain 0.5" rainfall
- Impervious surfaces > 1/2 acre restrict runoff per optional procedures:
  - 0.5 CFS per acre for 100-year event / 0.15 CFS per acre for 2-year event
  - not exceed pre-development for the 100- and 2-year event during a "critical time period"
  - watershed analysis
- Disturbed areas > 2 acres must reduce existing runoff by 10-20% based on a tiered scale

**Buffalo and Brooklyn NY also adopting GI en masse*

DPW Design Standards Manual

Virginia Beach

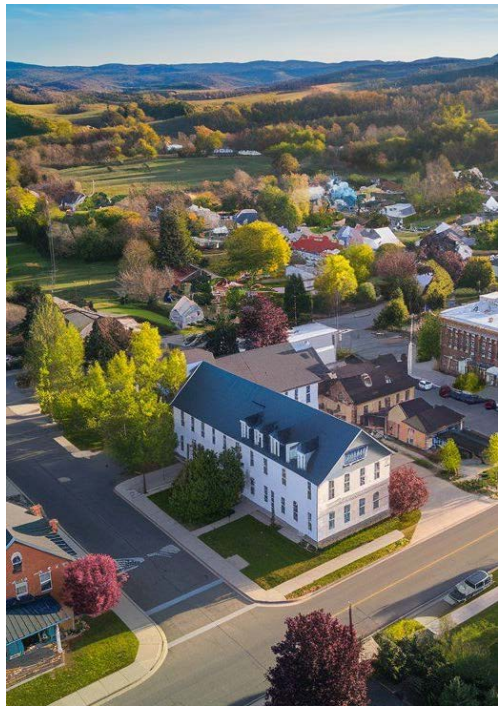
- Tailwater is discharge invert elevation + 80% pipe diameter
- 100-year check storm analysis, HGL shall not increase upstream nor downstream

Table VIII-1
Design Storm Frequency

Contributing Drainage Area	Design Storm Frequency
< 300 Acres	10-year
≥ 300 Acres and < 500 Acres	25-year
≥ 500 Acres	50-year
Critical Infrastructure Projects*	100-year

* Emergency Management Centers, Evacuation Routes, Hospitals, Fire and Rescue Stations, Police Stations, Shelters, Principal Highways and Major Roadways, Public Works, Public Utilities, Emergency Operations Centers, Etc.

Resilient Design Principles



Risk Assessment

- Criticality of facility – stormwater assets, buildings, transportation
- Time horizon - use appropriate climate projections that align with the projected lifetime of the asset

Maximizing Available System Capacity

- Cross-connection of drainage catchments for shared capacity
- Delaying runoff from upstream systems (e.g. strategic throttling of flow)
- Engineered infiltration within public ROW (e.g. leaching catch basins, infiltration trenches along gutter lines, perforated storm drains)
- Engineer roadways and undeveloped lands for flooding
- Recognize resilience opportunities across all city projects (paving, athletic fields, roadway re-alignment, pedestrian/cyclist improvements)

Protecting Assets during 100-year events

- Unobstructed overland flow paths
- Emergency outlets for drainage assets
- Publicize areas prone to damaging flooding

Stantec

Discussion