FDC PHASE 2, TASK ORDER B:

NEXT-GENERATION WATERSHED MANAGEMENT PRACTICES FOR CONSERVATION DEVELOPMENT

FINAL REPORT - October 2022

Prepared for:

U.S. Environmental Protection Agency, Region 1 (EPA R1)

Prepared by:

Great Lakes Environmental Center, Inc.
Waterstone Engineering
Paradigm Environmental
JVL Planning

Funded by:

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Submitted By: Great Lakes Environmental Center, Inc.
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ACKNOWLEDGMENTS

1. INTRODUCTION

This report was prepared as part of a second phase and continuation of EPA's Flow Duration Curve (FDC) project entitled, Holistic Watershed Management for Existing and Future Land Use Development Activities: Opportunities for Action for Local Decision Makers: Phase 1 – Modeling and Development of Flow Duration Curves (FDC1 Project). EPA's second phase FDC project employs two separate but related task orders. The report here is based on FDC2 Task Order B: Next-Generation Watershed Management Practices for Conservation Development.

The Next-Generation Watershed Management Practices for Conservation Development project is about envisioning a different future of watershed management. The project will evaluate a range of new and redevelopment (nD/rD) approaches to better understand and communicate the future impact upon watersheds and the potential for enhanced site design and management for optimal sustainability and resilience. This includes examining green infrastructure practices, the minimization, reduction and removal of existing impervious cover, and next-generation municipal bylaws / ordinances.

This project examines headwater stream segments in the Taunton River Watershed to understand the impacts of, and potential approaches for managing impervious cover (IC). This will examine a pre-development condition, the current built state, a scenario with MS4 requirements, next-generation Conservation Development (CD) practices, and a number of future scenarios that consider potential climate change conditions (flooding and drought) and future buildout. Scenarios will be used to illustrate the effect of land use decision making at the watershed and site scale and the importance of next-generation municipal bylaws / ordinances. Project results will demonstrate how nD/rD impacts water quality, flooding frequency and duration, channel stability, ecohydrological function, and hydrogeomorphology.

Next-generation CD practices will include a de-emphasis of impervious cover (IC) (e.g., primarily access roads, driveways, parking lots and hardened or bare rooftops), and increased reliance on practices that emphasize next-generation site design and development practices (e.g., soil management practices), architecture (e.g., green roofs, Low Impact Development (LID)) and landscape architecture – in general, CD practices that promote conservation of site-scale functional attributes and ecosystem services to help ensure preservation of pre-development-like hydrology, hydrogeology, and ecological diversity and vitality. In addition, it is envisioned that such CD practices will incorporate agriculture to increase sustainability of food systems and foster an increased appreciation and use of forest canopy and landscape architecture to promote evapotranspiration to offset the "heat island effect" that results from excessive IC.

The project includes the development of technical support documents and a webinar for the Southeast New England Program (SNEP) Technical Assistance Network (TAN) to facilitate transfer of the project outputs. The project develops a municipal engagement 'toolbox' of next-generation SW management and CD practices that include:

1. Conceptual Site-Development Plans representing a range of hypothetical new and redevelopment projects that are representative of realistic MA development projects for illustrating site management scenarios including "business as usual" (i.e., conventional) site design practices and CD practices.
2. Next-Generation Model Ordinance and Bylaw recommendations addressing local government requirements for SW management and site-development practices that incorporate the findings of FDC1 Project and concurrent FDC2A work. This includes the development

of a Watershed Protection Standard for the Development to maintain predevelopment hydrology and nutrient load, and resilient landscapes.

3. A Compendium of Advanced SW Management and Conservation-Based Site-Scale Design practices to primarily inform local municipal government officials and decision makers, and secondarily, site-development practitioners (architects, site engineers, landscape architects).
4. Communications Materials that demonstrate the impacts at the watershed and site-scale levels to inform local land use regulatory decision making, and that are tailored to the needs of the municipal governments.

1.1. Project Team

The Project Team lead by the Great Lakes Environmental Center (GLEC) Team has decades of experience working with EPA to successfully manage projects of all sizes and scopes. Mick DeGraeve will serve as the Program Manager, Robert Roseen will serve as Project Manager, and Khalid Alvi, will serve as the Project Advisor. All will stay in contact with EPA and will ensure the team adheres to all schedules and provides high-quality deliverables. The following highlights our approach to completing the subtasks identified in the workplan.

The Project Team was a collaboration of three specialty water resources and environmental consulting firms – Great Lakes Environmental Center, Waterstone Engineering (Waterstone), and Paradigm. The combined expertise in watershed and nutrient control planning, stormwater management and design, and community outreach and education provided an exceptionally qualified and capable team with a successful track record of similar accomplishments.

Municipal Project Partners and Collaborators involved municipal planning staff and experts from within the Taunton River Watershed.

Municipal Project Partners included:

- Tricia Cassidy, Middleboro
- Katelyn Gonyer, Mansfield
- Jenn Carlino, Easton
- John Thomas, Norton

Project Collaborators included:

- Sara Burns, Ducks Unlimited (Remote)
- Danica Belknap, SRPEDD
- Kimberly Groff, SNEP
- Scott Horsley, Consultant, Tufts University

Project member bios are listed below.

Ray Cody, Senior Policy Analyst, Water Division, EPA Region 1
Ray Cody, Ray is a senior policy analyst in the USEPA Region 1's Office of Ecosystem Protection's Surface Water Branch. Since 2009, his work has focused on stormwater implementation with an emphasis on impervious cover disconnection, green infrastructure stormwater control measures (SCM)

for nutrient pollution (i.e., nitrogen and phosphorus) and approaches for control of volumetric stormwater discharges (i.e., flooding). Prior to his work under the Clean Water Act, Ray spent 20+ years in EPA's remedial programs and as a consultant for Fortune 100 and 500 companies. Ray has a Bachelor of Science (B.S.), a Master's in Business Administration (M.B.A.) and a Juris Doctorate (J.D.).

Mark Voorhees, Environmental Engineer, Water Division, EPA Region 1
Mark Voorhees is an environmental engineer in the stormwater permitting program at the U.S. EPA in New England. Currently, Mark focuses on developing information/tools to assist permittees in building technical program capacity for implementing technically sound and economically viable stormwater management programs to restore stormwater impaired surface waters. At EPA, he has worked extensively in the TMDL and the Stormwater permitting programs involved with conducting water quality modeling, watershed management analyses and developing representative reduction credits for a variety of stormwater control measures. Prior to EPA, he worked in the private sector as a Professional Engineer conducting environmental modeling studies and developing abatement plans to address combined sewer overflows and urban stormwater discharges.

Michelle Vuto, Stormwater Permits Section, Water Division, EPA Region 1
Michelle Vuto is an Environmental Scientist in the Stormwater and Construction Permits Section at EPA R1. She serves as a permit writer for MS4s, provides technical assistance related to MS4 implementation, and manages the Construction General Permit in MA and NH.

Khalid Alvi, Water Resources Engineer, Paradigm Environmental
Alvi is a water resources engineer with extensive experience in the development of linked watershed and stormwater BMP modeling systems. He leads teams of computer programmers and watershed modelers to produce applications and software for federal, state, and municipal agencies. Alvi has authored foundational software for stormwater and watershed modeling. Alvi's leadership and innovative problem-solving are an asset across all phases of our modeling workflow, including problem formulation and simplification of computational complexities. He is a registered Professional Engineer in the state of Virginia.

Robert Roseen, PHD., D.WRE, PE
Dr. Roseen is the Principal and Founder of Waterstone Engineering. Dr. Roseen provides over 30 years of experience in water resources investigations. Rob is a recognized industry leader in green infrastructure, watershed management, and nutrient control planning and the recipient of Environmental Merit Awards by the US Environmental Protection Agency Region 1 in 2010, 2016, and 2019. He consults nationally and locally on stormwater management and planning and directed the University of New Hampshire Stormwater Center for 10 years. Rob is deeply versed in the practice, policy, and planning of stormwater management. He is a licensed professional engineer in NH, MA, and ME.

Julie LaBranche, JVL Planning
Julie LaBranche has worked as a private consultant in New Hampshire since 2021 engaging in projects including Master Planning, Open Space Planning, planning technical services to Planning Boards and Zoning Boards of Adjustment, and technical services for EPA MS4 Stormwater Permit compliance. Previously, she served as a senior planner with the Rockingham Planning Commission from 2009-2021 and a regional Planner with the Strafford Regional Planning Commission from 2007-2009. LaBranche is a member of the NH Coastal Adaptation Workgroup and former NH Representative and Vice President of the Northern New England Chapter of the American Planning Association. Her previous employment includes city planning, natural resource management with the Maryland Department of the Environment and planner for the Maryland Chesapeake Bay Critical Area Commission. She holds a B.S. in Geological Sciences from Salem state University and a M.S in Earth Sciences/Geology from Montana State University.

1.2. Funding Statement

This project has been financed with federal funds from the Environmental Protection Agency Region 1 (EPA-R1) through the Southern New England Program (SNEP) under a project titled FDC Phase 2, Task Order B: Next-Generation Watershed Management Practices for Conservation Development, Blanket Purchase Agreement: BPA-68HE0118A0001-0003, Requisition Number: PR-R1-21-00225, Order: 68HE0122F0003.

2. MUNICIPAL ENGAGEMENT PROCESS

The Team conducted a Municipal Engagement Process primarily through a series of working meetings working directly with municipal partners to share key project interim results, gain local input and support interim decision making. This engagement process fostered collaboration among the Project and Municipal Teams to translate and share information amongst FDC1, FDC2A, and FDC2B. This was to ensure project deliverables are developed in a manner that reflects input and perspectives of the municipal partners and the overall communication objectives of the project. Municipal Engagement working meetings were strategically planned and scheduled to take advantage of the technical discussions for the FDC2A project so that interpretation of continuous simulation hydrologic modeling and FDC results relating to ecosystem elements and/or conservation development stormwater control measures shall be used to inform the development and evaluation of local site-development regulatory options, as well as effective communication and outreach strategies to support sound decision making on land use and site-development activities at the local government level.

2.1. Municipal Engagement Working Meetings

The Team conducted 3 Municipal Engagement Working Meetings with the Municipal Partners and Project Team. This included the following meetings.

1. Municipal Meeting #1 –December 18, 2021 (See Appendix A). This included project introduction, background information on FDC1 and 2A and the role of 2B. It included the discussion of the municipal toolbox elements and site development concepts.
2. Municipal Meeting #2 – June 30, 2022 (See Appendix B). The goal of this meeting was to review progress on the municipal engagement toolbox and specific examples and work products. The project will evaluate a range of new and redevelopment approaches to better understand and communicate the future impact upon watersheds and the potential for enhanced site design and management for optimal sustainability and resilience. Project partners provided input on the development of municipal engagement outreach materials to ensure the materials effectively address a municipal audience of land use practitioners. The intended audience is local municipal government officials and decision makers, and secondarily, site-development practitioners (architects, site engineers, landscape architects). This meeting was graciously held and hosted at the Public Safety Building in Mansfield.
3. Municipal Meeting # 3– September 13, 2022 (See Appendix C). The goal of this meeting was to discuss the last stages of the project including the concept development plans for costing and performance, bylaw review, and outreach materials, etc. This meeting was graciously held and hosted at the Public Safety Building in Mansfield.

2.2. SNEP Webinar

The Project Team prepared a webinar to present the FDC2B study results and findings (See Appendix D). The webinar was targeted for the Municipal Partners to convey the critical information about Concept Plans, Next Generation Municipal Bylaws, and Enhanced Stormwater Management and Conservation Development Design Standards. This included a balance of artistic graphics, technical design information, watershed health data, BMP performance, costing, and maintenance.

3. CONCEPT DEVELOPMENT PLANS FOR HYPOTHETICAL NEW AND REDEVELOPMENT PROJECTS

Under the directives of Task 4 of the FDC2, hypothetical real-world site-development plans were produced and subsequently employed in concept for modeling simulations and for demonstrating alternative site development designs and levels of potential local regulatory control for addressing water resource and watershed health impacts (hereafter referred to as "Concept Development Plans"). The Project Team has extensive experience in developing both concept plans in graphic form for use as an outreach product, as well as construction level designs. In both cases the Project Team has deep expertise in design and science-translation. Of equal importance is the Teams' knowledge of feasible and buildable designs based on decades of BMP construction experience. EPA's expectation was for the Contractor to derive these initial Concept Development Plans from either (a) actual completed projects (having as-built design plans (or equivalent)) that the Contractor may have completed itself or (b) from completed projects that may be available from one or more municipalities (e.g., Appendix C of workplan). EPA is sensitive to projects that may be identifiable as sourced from one or more of the Taunton municipalities. As such, EPA employed the descriptor "hypothetical." Lastly, and particularly for plans that incorporate CD Practices, EPA's anticipation was that they be visually appealing, suggesting collaboration with a graphic artist and landscape architect (note: The Boston Society of Landscape Architects is an FCD1, and possibly also an FDC2A TSC participant). EPA envisioned the initial Concept Development Plans would contain enough detail (e.g., approximate 25% level plans (as compared to typical final as-built design plans)) in conveying important site information, such as topography, location and extent of IC – and that such would be sufficient to support FDC2A modeling simulations and subsequent plans incorporating various levels of CD Practices (as described further below).

It is expected that the completed Concept Development Plans developed under Task 4 will serve as a future reference to the SNEP region for illustrating alternative site-development designs for a range of typical land use site-development activities that comply with alternative levels of local regulatory control focused on SW management and next-generation site design practices (i.e., CD Practices). The Concept Development Plans include estimates of water resource and watershed health impacts associated with development activities such as conversion of permeable vegetated surface to IC (i.e., IC conversion), as well as estimates of the benefits associated with depicted CD Practices and SW controls, which overall would achieve the specific level of on-site control being demonstrated and could be required or incentivized in local bylaws. The GLEC Team will also develop planning level cost estimates (if needed, based on a generalized cost/unit management area, e.g., cost per square or cubic foot) of site work including SW management and GI SCMs (excluding costs for buildings) for each Concept Development Plan further developed under this task (described below).

Municipal practitioner understanding and appreciation is a critical goal of this Project: one of the goals of developing the Concept Development Plans is to visually compare a "business as usual" site development approach with an approach that incorporates various levels and combinations of CD Practices. This visual side-by-side comparison was used as the primary vehicle for demonstrating, in a visceral manner, the imperative for municipal consideration and adoption of bylaws and policies that de-emphasize IC and incorporate CD Practices. In brief, presented with the past/current and a potential alternative future, the municipal practitioner will be rhetorically asked: "What future do you envision?"

FDC2A also used the Concept Development Plan design scenarios to inform development of subwatershed modeling simulations for providing the FDC2B Contractor with estimates of overall cumulative effects at a subwatershed scale (e.g., Upper Hodges Brook in the Wading River watershed). The subwatershed modeling results were used by FDC2B to inform the Municipal Partners of the cumulative outcome of applying MS4s to applicable new and redevelopment project across a watershed.

Accordingly, the Project Team developed Concept Development Plans depicting real-world conventionally designed development projects that are and/or would be representative of typical new and redevelopment projects likely to be encountered by municipalities participating in the project. Overall, the selected Concept Development Plans capture a range of realistic new and redevelopment site-development conditions assuming conventional development approaches (i.e., "business as usual") that collectively represent a range of on-site percent IC, hydrologic soil types, natural vegetated areas before and after development, and extent of soil disturbance. The Project Team developed Concept Development Plans for **two (2) hypothetical new residential development projects** and **one (1) hypothetical commercial redevelopment project.** As part of the Municipal Engagement process (Task 3), the Team sought input from the Municipal Partners on the selection of these new and redevelopment concept projects. The focus involved simple, low-maintenance systems that are identified by the TSC as feasible to implement for common new development and redevelopment applications. An essential element of the Concept Development Plans was the development of designs that can easily be replicated and maintained. This includes the use of readily implementable and standardized designs that can be pulled from a shelf and do not involve substantial additional analysis or engineering. Designs contained relevant information about sizing, pretreatment, specifications, and estimated costs per unit construction. Additionally, systems balanced ease of maintenance and the cost to construct with optimal performance for recharge and water quality treatment.

The Concept Development Plans for each new/redevelopment alternative incorporated analyses at four (4) different levels of local control, which included:

(i) A pre-development scenario.

(ii) A post-development scenario with no controls.

(iii) A post-development scenario with minimum LID per Massachusetts Department of Environmental Protection (MADEP) standards (MS4 General Permit).

(iv) A post-development scenario with LID infiltration designed for water quality and peak control.

Each Concept Development Plan that incorporates a post-development scenario with minimum LID per MADEP standards (iii above) focused on the application of SW management controls to comply with the MA MS4 permit. Additionally, with each Concept Development Plan featuring a post-development scenario with LID infiltration designed for water quality and peak control (iv above), the Team considered a range of CD practices. These included non-structural BMPs, structural BMPs, and LID planning such as reductions in on-site IC footprints (e.g., buildings and parking area) compared to conventional site development.

The purpose of considering CD Practices with MS4 scenarios is to understand whether or to what extent MS4 standards may be achieved via use of CD Practices. Consequently, these scenarios emphasized minimization of untreated IC (e.g., underground parking garages, dispersed GI like green roofs, passive hydrologic disconnection of IC to undisturbed natural vegetated areas, parking area reductions, use of overflow permeable parking areas, and to include consideration of enhanced post-construction permeable vegetated areas through soil augmentation and tree plantings). Systems balance ease of maintenance and cost to construct with optimal performance for recharge and water quality treatment.

Municipal practitioner understanding and appreciation is a critical goal of this Project

All Concept Development Plans were designed for a target audience of engaged lay persons, municipal volunteers, and municipal staff and incorporated an appropriate scale with sufficient user-friendly information to facilitate understanding of key design aspects and take-away messages related to alternative local control requirements. EPA envisioned the Concept Development Plans could employ rendering techniques used by landscape architects. The plans provide an overall summary of quantified impacts and potential benefits for the site (to be provided by the FDC2A team). TheProjectTeam has extensive experience in both developing conceptual designs and working with target audiences to ensure an appropriate match of problems, solutions, and local community. The Project Team specified a graphic designer to ensure Concept Development Plans are technically accurate, visually understandable, and capable of clearly conveying the intended information.

3.1. Concept Development Plans: Overview and Results

The GLEC team designed three, hypothetical real-world Concept Development Plans and performed four scenario analyses under each (for a total of 12 examples) to demonstrate the efficacy of next-generation watershed management practices. The Concept Development Plans were designed and applied to three different development types and varying landscapes, both developed and undeveloped. An overview of the Concept Development Plans and scenario analyses are presented in Table X, below.

Table 1. Summary of Concept Development Plans

3.1.1. Concept Development Plan 1

Concept Development Plan 1 is a high-density residential site within a larger residential neighborhood that incorporates seven homes in a cul-de-sac.

Figure X, below, depicts the three alternative site designs (CD1.2, CD1.3, CD1.4) of Concept Development Plan 1 and highlights the results of continuous simulation hydrologic modeling of each site design compared to a pre-development site hydrology (CD1.1).

Concept Development Plan	Development Type	Land Use Type	Scenario Analyses	Stormwater Management Practices
1	New Development	High Density Residential	**CD1.1:** Pre-development	N/A
			CD1.2: No controls	None
			CD1.3: Minimum LID (per MADEP)	GI and CD practices
			CD1.4: LID infiltration for water quality and peak control	GI and CD practices
2	Redevelopment	High Density Commercial	**CD2.1:** Pre-development	N/A
			CD2.2: No controls	None
			CD2.3: Minimum LID (per MADEP)	GI and CD practices
			CD2.4: LID infiltration for water quality and peak control	GI and CD practices
3	New Development	Low Density Residential	**CD3.1:** Pre-development	N/A
			CD3.2: No controls	None
			CD3.3: Minimum LID (per MADEP)	GI and CD practices
			CD3.4: LID infiltration for water quality and peak control	GI and CD practices

Figure 1. Concept Development Plan 1 (CD1) for High Density Residential under 3 Scenario: No Controls, Minimum LID, LID for Watershed Protection Standard

3.1.1.1. Site Design CD1.2

CD1.2 (no controls) assumes no BMPs which is common for projects that don't trigger state or federal requirements, including municipalities with weak stormwater management regulations.

Figure 2. Concept Development CD1.2 No Controls for High Density Residential

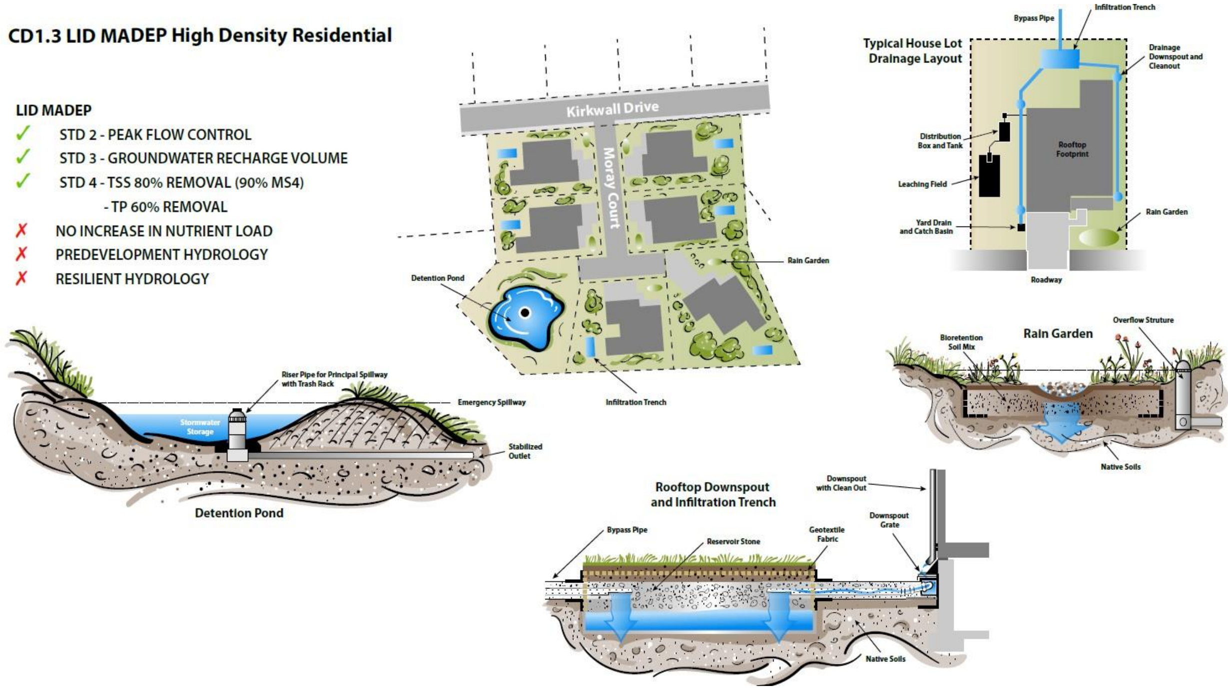
3.1.1.2. Site Design CD1.3

CD1.3 (LID MADEP) was designed with minimal LID use consistent with MADEP standards for the MS4 General Permit and incorporated three BMP types:

- Rain gardens (driveways)
- Subsurface infiltration trenches (rooftops)
- Detention pond (roadways)

The rain gardens and subsurface infiltration trenches for CD1.3 were designed with 0.5" WQV to satisfy MADEP standards 3 (GRV) and 4 (nitrogen and phosphorous). The detention pond was designed to satisfy MADEP standard 2 (Q-peak). Additionally, to include enough space for the detention pond, it was necessary to remove one house from the site design.

Figure 3. Concept Development CD1.3 MADEP LID for High Density Residential



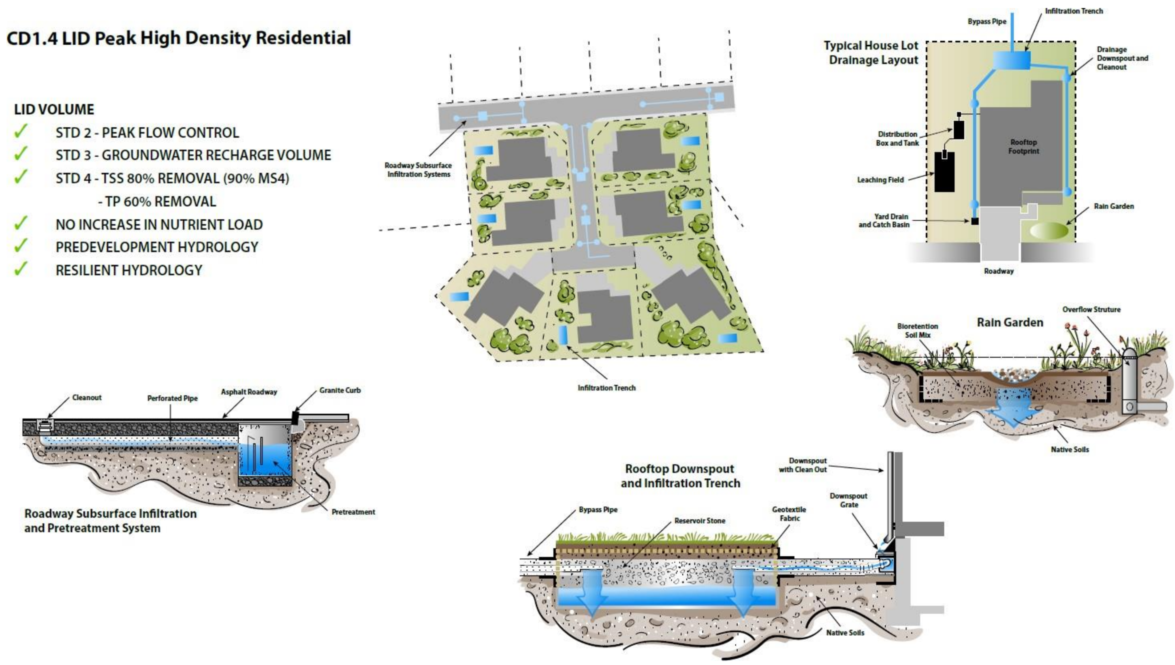
3.1.1.3. Site Design CD1.4

CD1.4 (LID Peak) was designed with two BMP types:

- Subsurface infiltration trenches (rooftops)
- Roadway subsurface infiltration systems (driveways and roadways)

The subsurface infiltration trenches were designed with 1" WQV to satisfy MADEP standards 3 (GRV) and 4 (nitrogen and phosphorous). The roadway infiltration trenches were designed to satisfy MADEP standard 2 (Q-peak).

Figure 4. Concept Development CD1.4 LID to Achieve the Watershed Protection Standard for High Density Residential



The simulation results for CD1.2, CD1.3, and CD1.4 are shown in the following figures.

Figure 5: Water Quality Performance and Costing for CD1.3 Minimum LID and CD1.4 LID to Achieve the WPS for High Density Residential

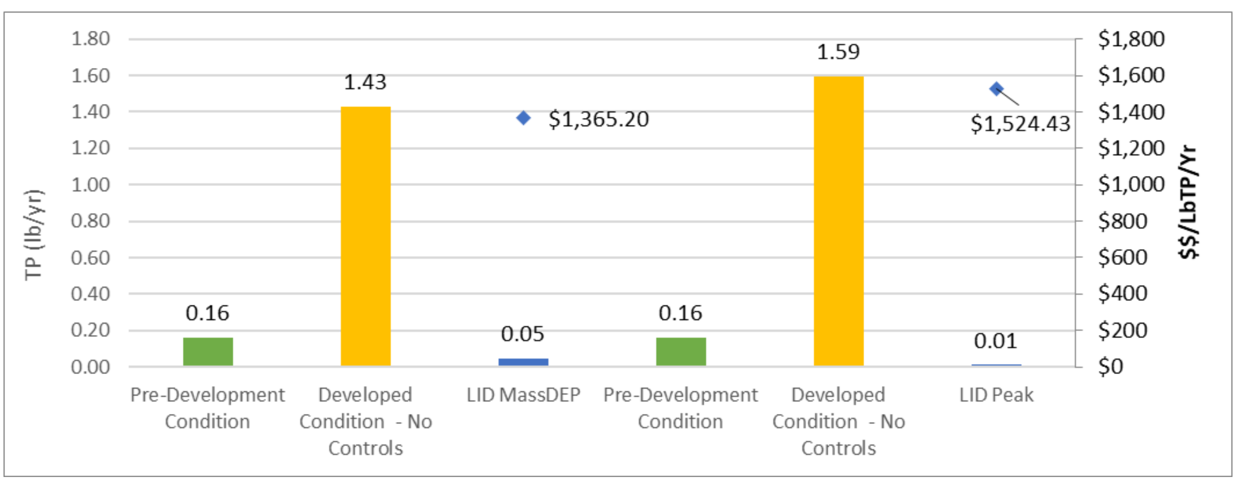


Figure 6: Runoff Duration Curves for CD1.3 Minimum LID and CD1.4 LID for High Density Residential

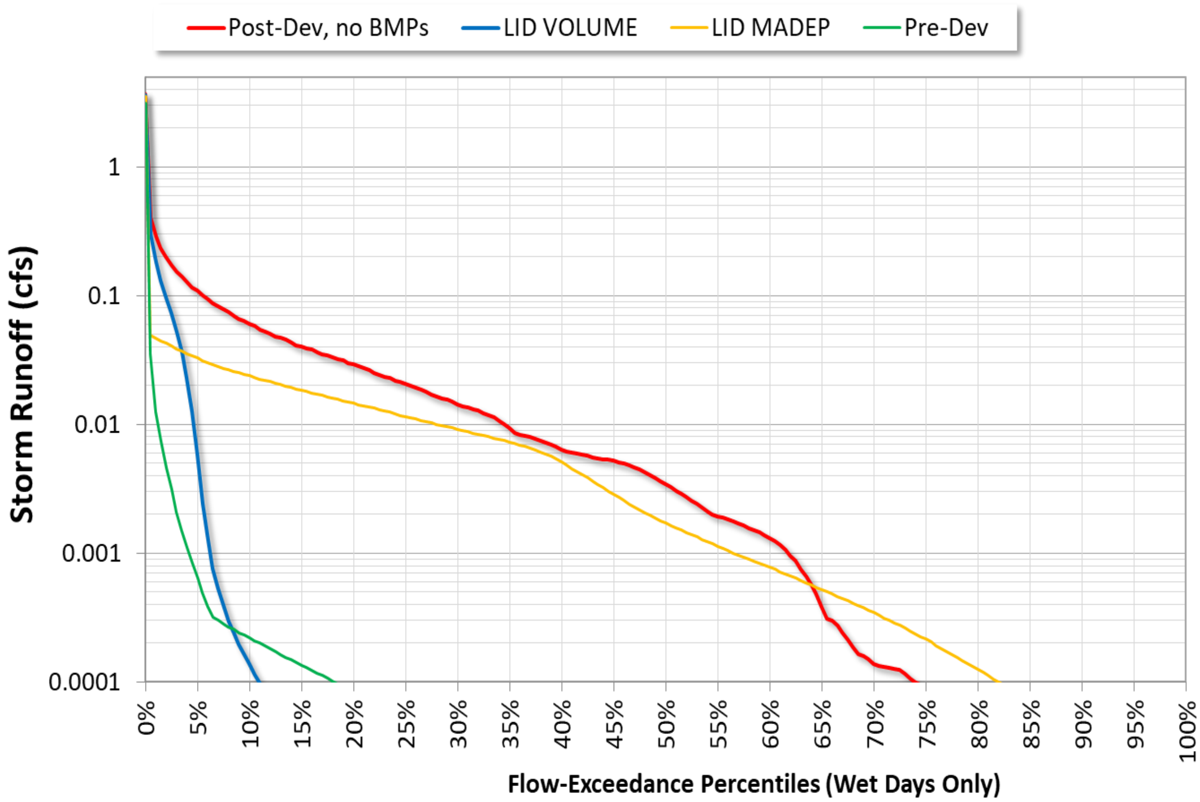
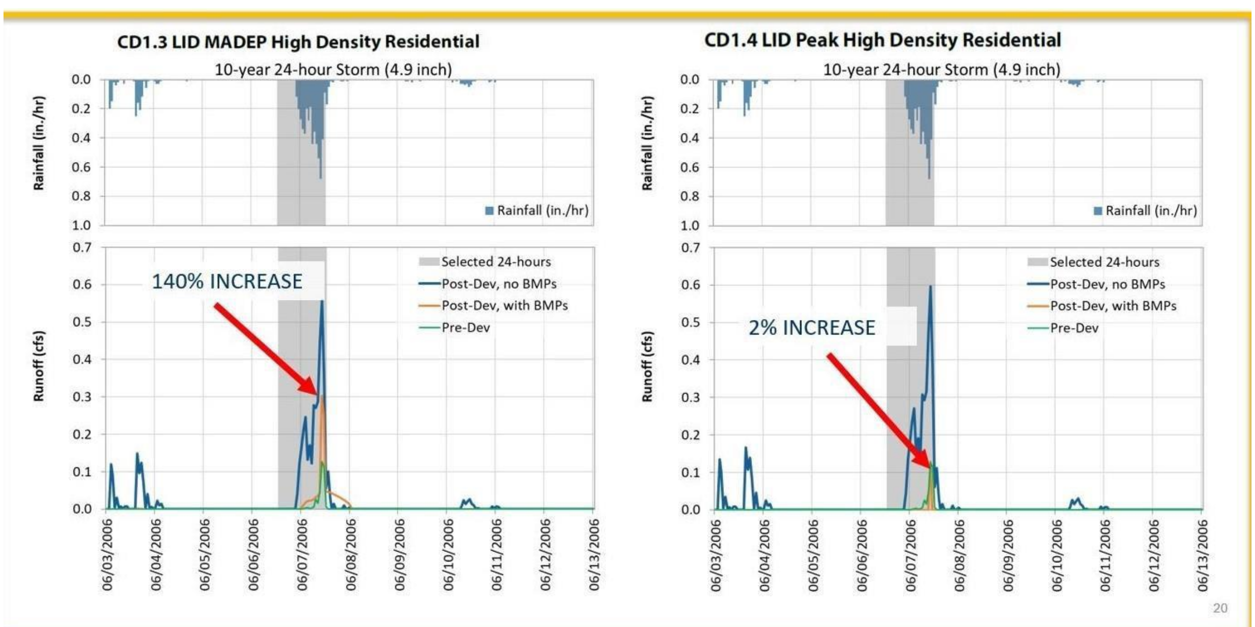


Figure 7: Climate Resiliency Performance for CD1.3 Minimum LID and CD1.4 LID for High Density Residential



3.1.2. Concept Development Plan 2

Concept Development Plan 2 is a high-density commercial redevelopment that includes both residential and retail uses.

Figure X, below, depicts the three alternative site designs (CD2.2, CD2.3, CD2.4) for Concept Development Plan 2 and highlights the results of continuous simulation hydrologic modeling of each site design compared to a pre-development site hydrology (CD2.1).

Figure 8. Concept Development Plan 2 (CD) for Commercial Redevelopment Residential under 3 Scenario: No Controls, Minimum LID, LID for Watershed Protection Standard

3.1.2.1. Site Design CD2.2

CD2.2 (no controls) assumes no BMPs which is common for commercial projects that don't trigger state or federal requirements. Site Design CD2.2 is also consistent with municipal jurisdictions with weak stormwater management regulations.

Figure 9. Concept Development CD2.2 No Controls for Commercial Redevelopment

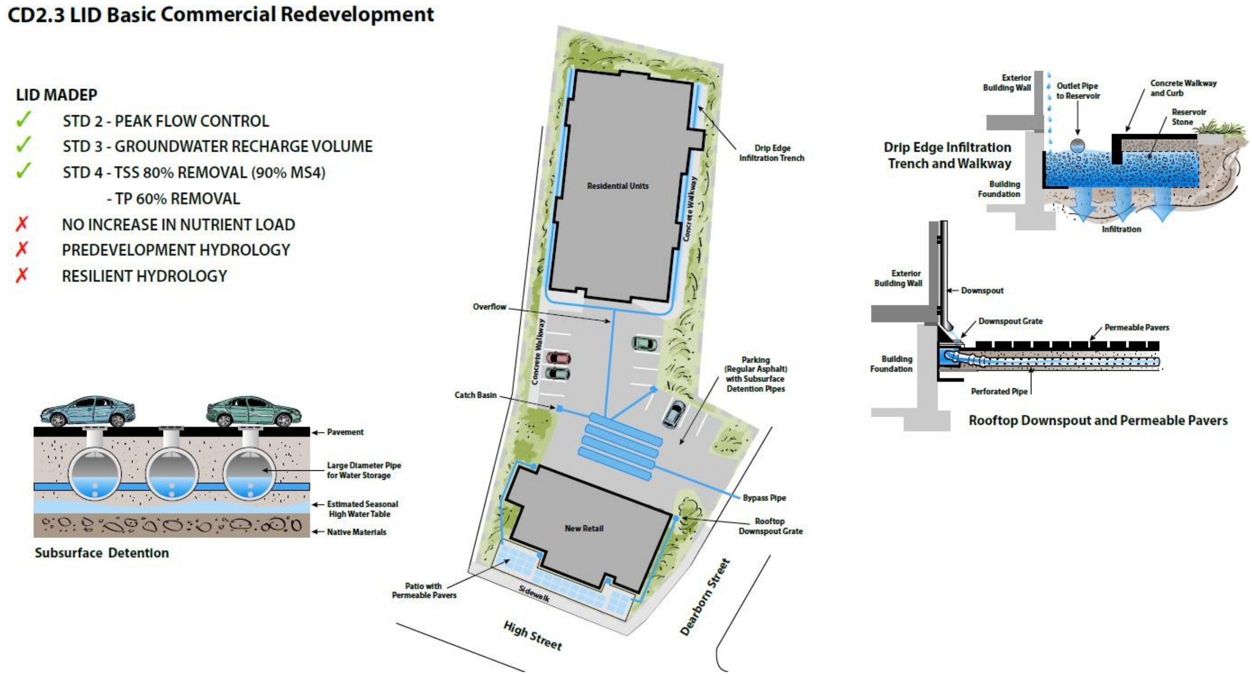
3.1.2.2. Site Design CD2.3

CD2.3 (LID MADEP) incorporates minimal LID designs consistent with MADEP standards for the MS4 General Permit. The range of BMP types for CD2.3 include:

- Drip edge infiltration (rooftop)
- Permeable patio and subsurface infiltration (rooftop)
- Subsurface detention system (parking lot)

The drip edge infiltration and permeable patio and subsurface infiltration with CD2.3 both incorporate 0.5” WQV and were designed to satisfy MADEP standards 3 (GRV) and 4 (nitrogen and phosphorous). The subsurface detention system was designed to satisfy MADEP standard 2 (Q-peak).

Figure 10. Concept Development CD2.3 MADEP LID for Commercial Redevelopment



3.1.2.3. Site Design CD2.4

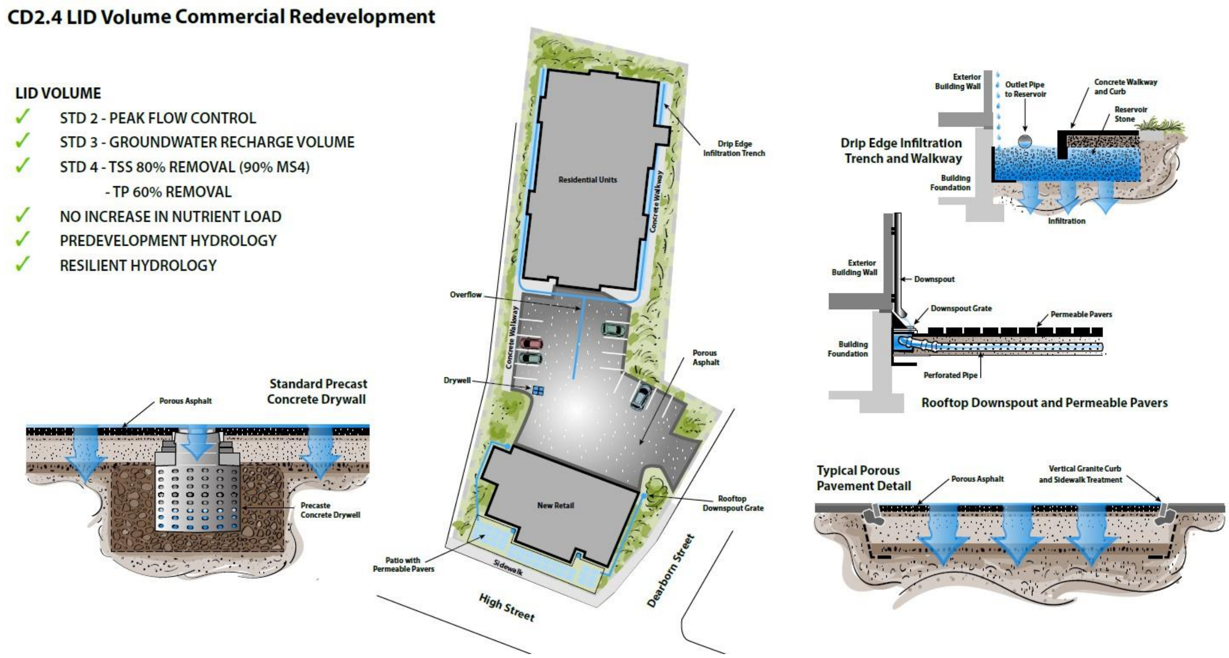
CD2.4 (LID Volume) was designed with four BMP types:

- Drip edge infiltration (rooftop)
- Permeable patio and subsurface infiltration (rooftop)
- Porous asphalt pavement (parking lot)
- Dry well (pervious surface runoff and redundancy)

The subsurface infiltration trenches were designed with 1" WQV to satisfy MADEP standards 3 (GRV) and 4 (nitrogen and phosphorous). The roadway infiltration trenches were designed to satisfy MADEP standard 2 (Q-peak).

The drip edge infiltration and permeable patio and subsurface infiltration were both designed with 0.5" WQV and satisfy MADEP standards 3 (GRV) and 4 (nitrogen and phosphorous). The porous pavement satisfies MADEP standard 2 (Q-peak).

Figure 11. Concept Development CD2.4 LID to Achieve the Watershed Protection Standard for Commercial Redevelopment



The simulation results for CD2.2, CD2.3, and CD2.4 are shown in the following figures.

Figure 12: Water Quality Performance and Costing for CD2.3 Minimum LID and CD2.4 LID to Achieve the WPS for Commercial Redevelopment

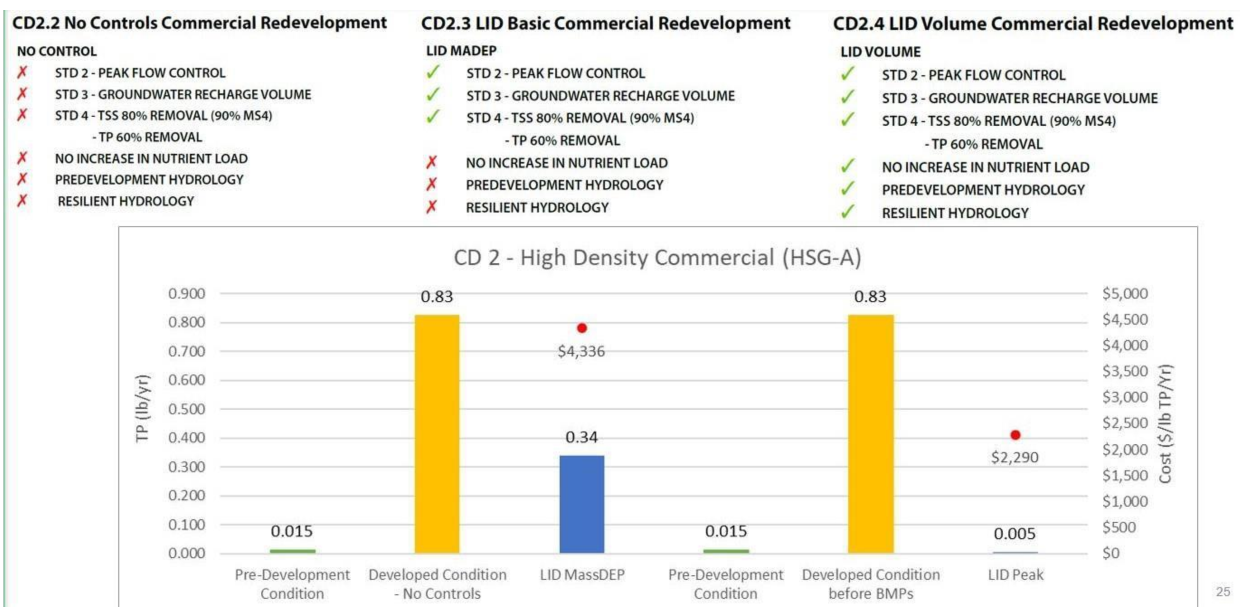


Figure 13: Runoff Duration Curves for CD2.3 Minimum LID and CD2.4 LID for Commercial Redevelopment

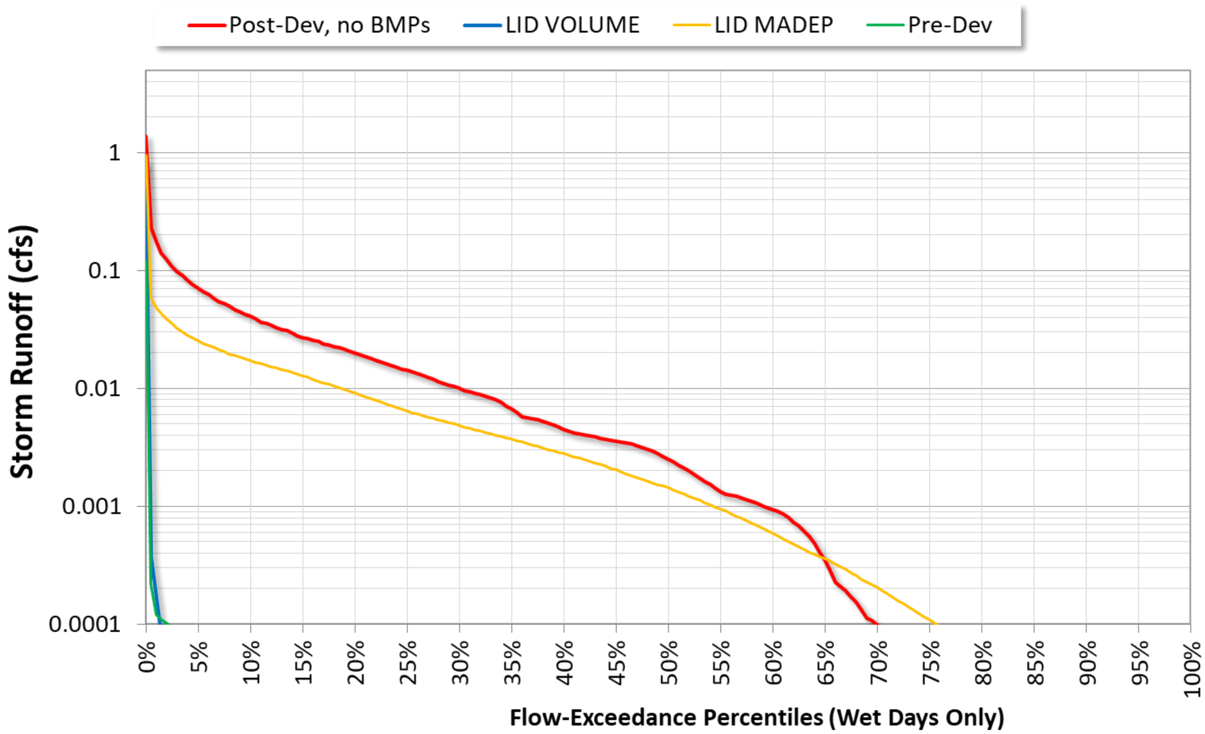
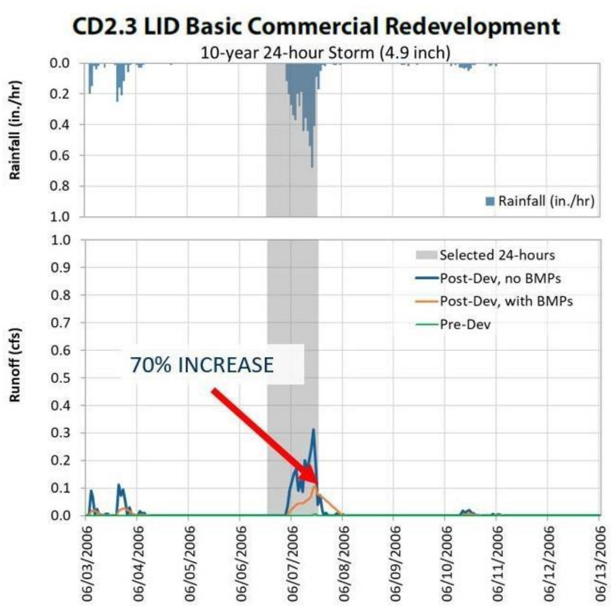
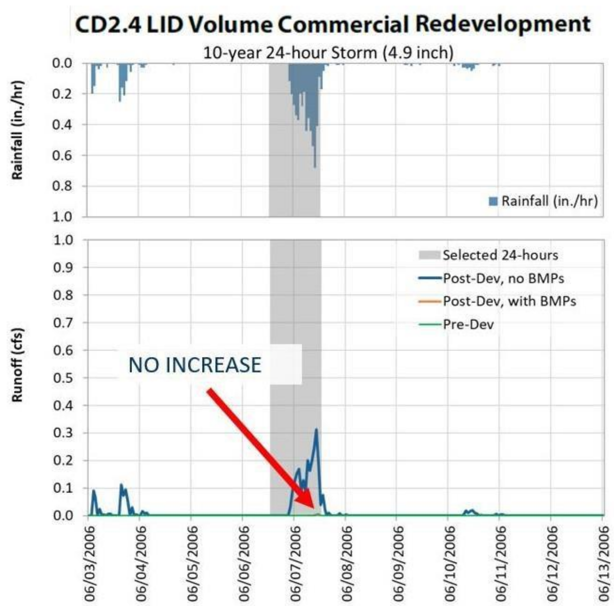


Figure 14: Climate Resiliency Performance for CD2.3 Minimum LID and CD2.4 LID for Commercial Redevelopment



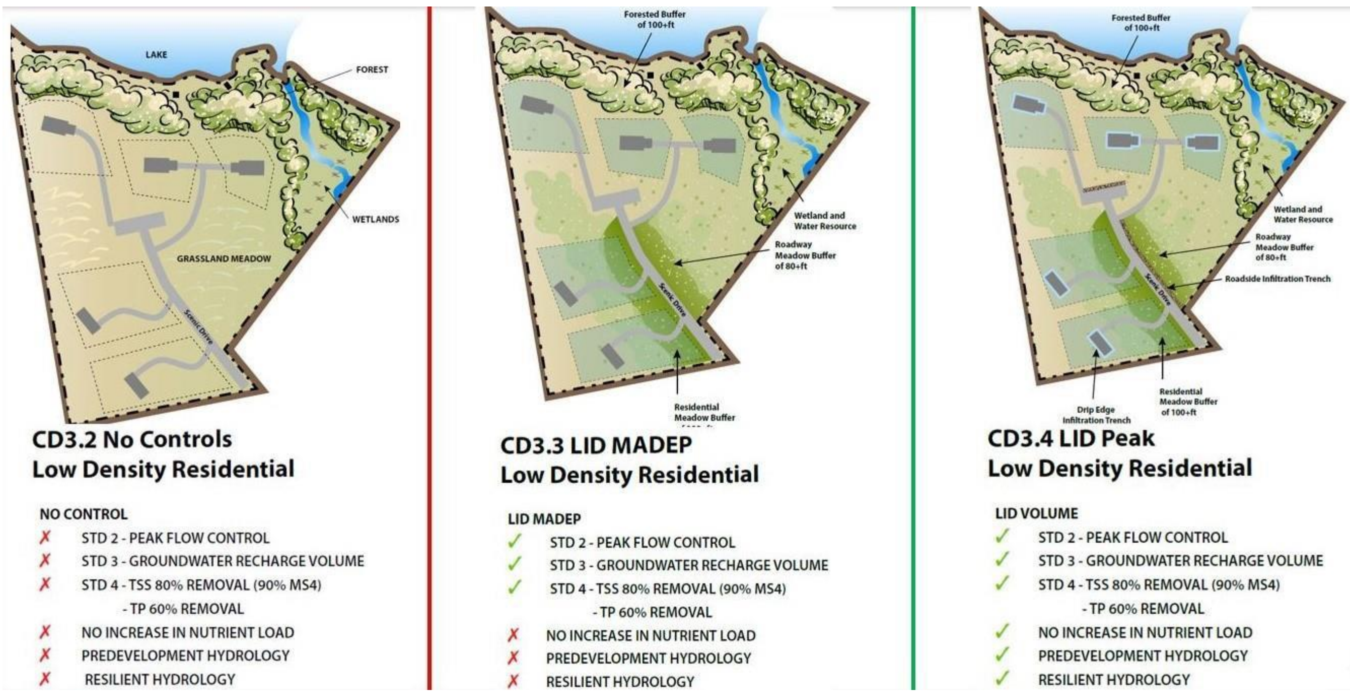


3.1.3. Concept Development Plan 3

Concept Development Plan 3 is a low-density residential site incorporating five homes with a lake bordering the site to the north.

Figure X, below, depicts the three alternative site designs (CD3.2, CD3.3, CD3.4) corresponding to Concept Development Plan 3 and includes the results of continuous simulation hydrologic modeling of each site design compared to a pre-development site hydrology (CD3.1).

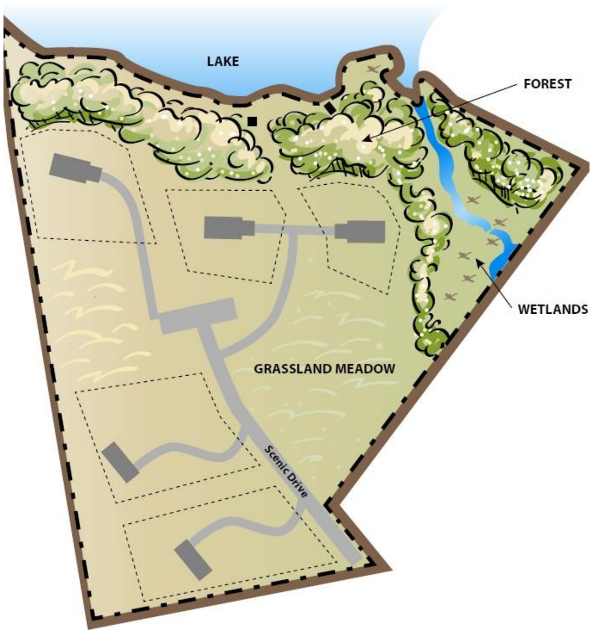
Figure 15. Concept Development Plan 3 (CD3) for Low Density Residential under 3 Scenario: No Controls, Minimum LID, LID for Watershed Protection Standard



3.1.3.1. Site Design CD3.2

CD3.2 (no controls) assumes no BMPs which is common for projects that don’t trigger state or federal requirements, including municipalities with weak stormwater management regulations.

Figure 16. Concept Development CD2.2 No Controls for Commercial Redevelopment



3.1.3.2. Site Design CD3.3

CD3.3 (LID MADEP) was designed with minimal LID use that is consistent with MADEP standards for the MS4 General Permit and incorporated the following BMPs:

- Forested buffers as qualifying pervious areas for lakeshore properties (ESSD credit #7)
- Meadow buffers as qualifying pervious areas for residential house lots (ESSD credit #3)
- Meadow buffers as qualifying pervious areas for residential roadways (ESSD credit #4)

The forested buffers earn ESSD credit 7 and the meadow buffers achieve ESSD credits 3 and 4. Cumulatively, the ESSD credits address MADEP standards 2 (peak), 3 (GRV), and 4 (TSS/TP).

Figure 17. Concept Development CD3.3 MADEP LID for Low Density Residential

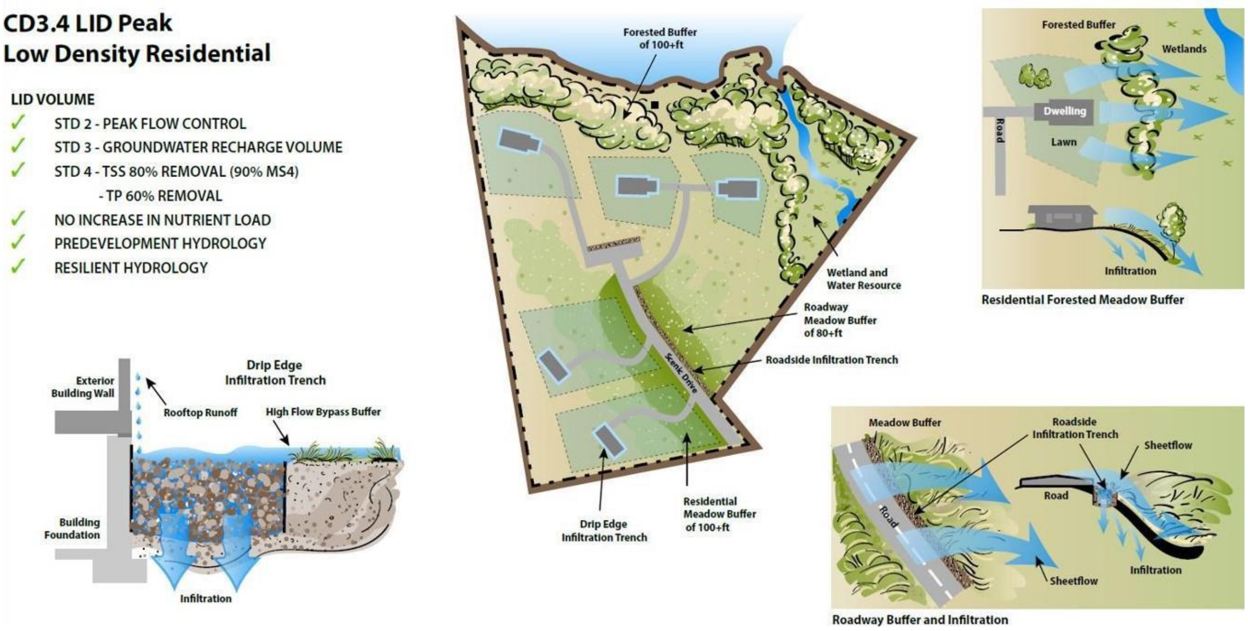
3.1.3.3. Site Design CD3.4

CD3.4 (LID Peak) was designed with the following BMP types:

- Forested buffers as qualifying pervious areas for lakeshore properties (ESSD credit#7)
- Meadow buffers as qualifying pervious areas for residential house lots (ESSD credit#3)
- Meadow buffers as qualifying pervious areas for residential roadways (ESSD credit#4)
- Drip edge infiltration (rooftop)
- Roadway infiltration trench

Similar to CD3.3, CD3.4 incorporates forested buffers to earn ESSD credit 7 with the meadow buffers achieving ESSD credits 3 and 4. Cumulatively, the ESSD credits address MADEP standards 2 (peak), 3 (GRV), and 4 (TSS/TP). Both the drip edge infiltration and the roadway infiltration trench were designed with 1" WQV.

Figure 18. Concept Development CD3.4 LID to Achieve the Watershed Protection Standard for Low Density Residential



The simulation results for CD3.2, CD3.3, and CD3.4 are shown in the following figures.

Figure 19: Water Quality Performance and Costing for CD3.3 Minimum LID and CD3.4 LID to Achieve the WPS for Low Density Residential

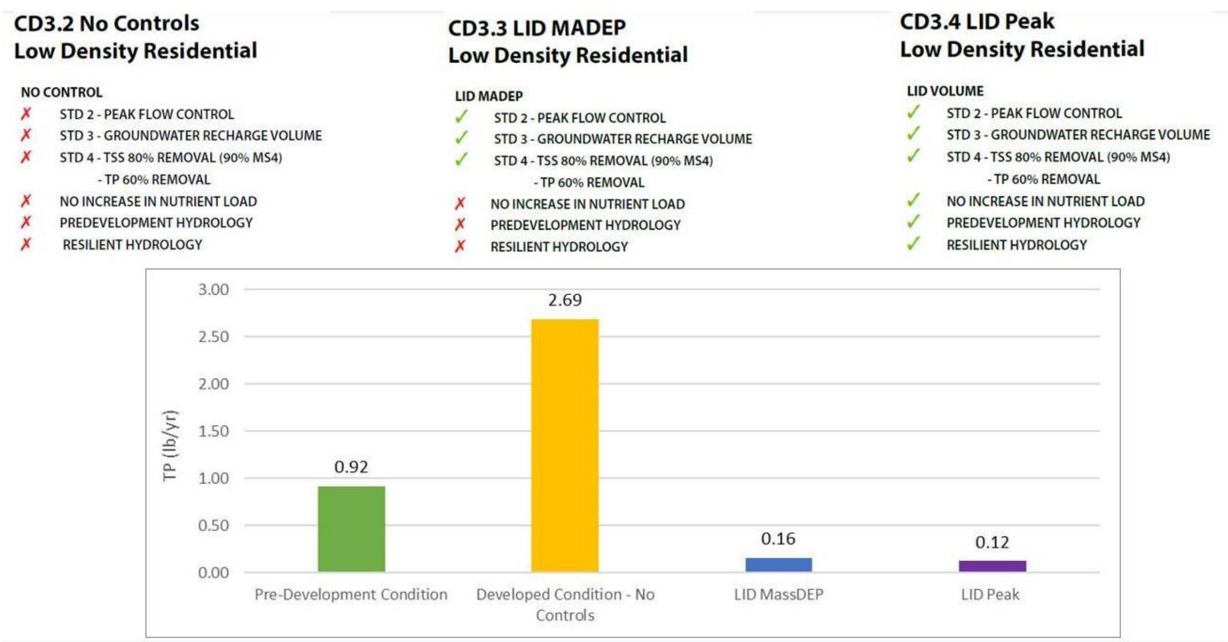
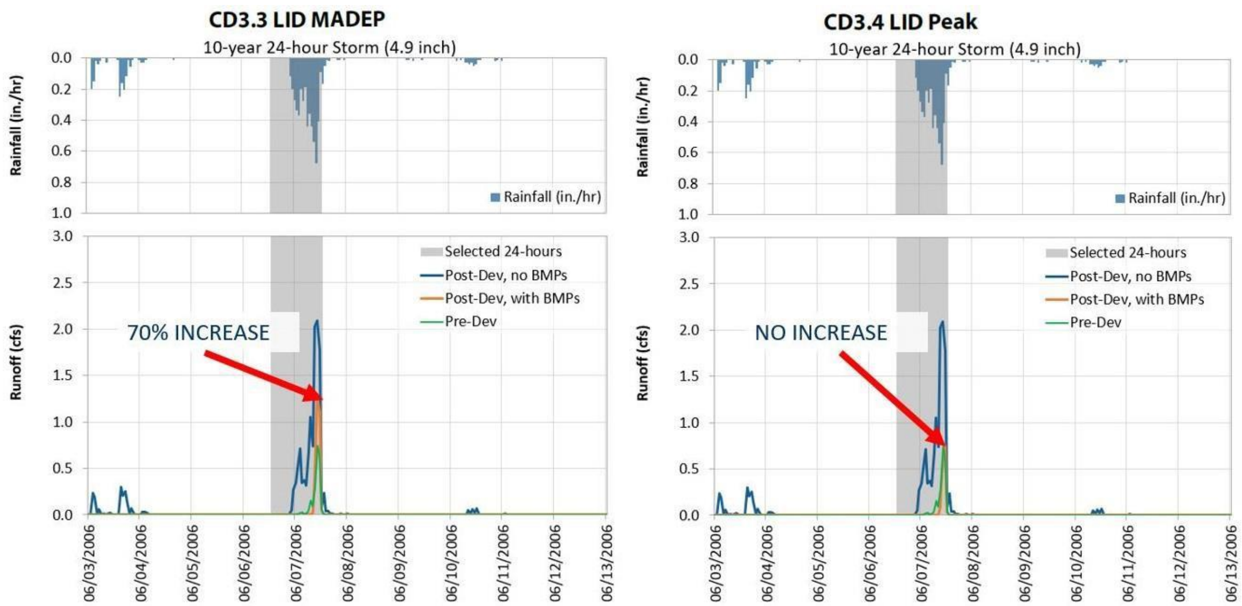


Figure 20: Climate Resiliency Performance for CD3.3 Minimum LID and CD3.4 LID for Low Density Residential



4. MUNICIPAL REGULATORY AUDITS, REVIEW, AND RECOMMENDATIONS

4.1. Local Bylaw Review

The purpose of this task was to provide a review of local by-laws and regulations, an audit framework based on the MA Audubon Regulatory Audit Tool, and recommendations to improve implementation of stormwater management and water quality protections at the local level.

Additionally, this will identify and proposed alternative local regulatory control requirements (i.e., bylaws, regulations municipal operation procedures and policies) focused on site design and development practices and on-site stormwater management for new and redevelopment projects that may impact or protect watershed health and function. Municipalities may consider adopting specific regulatory provisions that meet the goals of the community such as those detailed in the town's Master Plan, conservation-based plans, Hazard Mitigation Plan, and operational plans.

This includes local regulatory approaches along with examples, discussion of how, why or to what extent such provisions are currently employed or may be best implemented. Additionally, it is important to identify those sets of State and federal regulations that most directly control the local-regulatory elements of site-development activities and stormwater management. Finally, this task will highlight preliminary potential areas for improvements to local regulations, provide recommendations for how best to implement updates based on review of existing model regulatory language that could used as part of bylaw updates.

4.2. MA Audubon – Municipal Zoning By-Laws, Subdivision and Site Plan Review Regulations, and Stormwater Audit Tool And Overview

The review was conducted based on an adaptation of the Massachusetts Audubon Bylaw Review for LID & Climate-Smart, Nature-Based Solutions[1]. The review adapted the bylaw audit tool which is organized around 5 goals. The regulatory audit tool can be customized to the users' needs and can produce a generalized snapshot of how a community regulates stormwater, water quality, environment and natural resources. The 5 goals are described below.

Goal 1: Protect Natural Resources and Open Space

The focus of this section is to limit clearing and grading and encourage soil management, the use of native species. and revegetation of disturbed areas. Often. communities have language such as "due regard shall be shown for natural features" without any specific limitations or guidelines that can be used by local boards to ensure developers are following the true intent of the community. The retention of natural vegetation and soils is the single most efficient means of reducing development impacts on water resources. avoiding costs associated with piping and other "grey" stormwater management features as well as the need for irrigation. There are also many other benefits — including habitat for birds and pollinators. trees for shade and clean air. and protection of natural scenery that contributes to property values and a high quality of life.

[1] Massachusetts Audubon Bylaw Review for LID & Climate-Smart, Nature-Based Solutions https://www.massaudubon.org/our-conservation-work/policy-advocacy/shaping-climate-resilient-communities/publications-community-resources/bylaw-review

Goal 2: Promote Efficient Compact Development Patterns and Infill

Often. making dimensional requirements such as setbacks, lot size. and frontage more flexible as well as allowing common drives will help allow the community to encourage efficient. compact designs. These help to decrease impervious surfaces and increase infiltration. while still supporting new development.

Goal 3: Smart Designs that Reduce Overall Imperviousness

This section reviews site design such as street location, road width. cul-de-sac design, curbing, roadside swales, and sidewalk design and location. There are many opportunities for communities to minimize impervious surfaces and allow for infiltration through curb cuts. swales. and cul-de-sacs with bioretention, among other things.

Goal 4: Adopt Green Infrastructure Stormwater Management Provisions

This section looks to explicitly discuss LID as a preferred method. such as requiring roof runoff to be directed into vegetated areas. and a preference for infiltration wherever soils allow or can be amended. Bylaws and/or regulations should clearly specify what LID is and which BMPs are preferred or required. Communities should also require an operations and maintenance plan to encourage effective use of LID methods. Adopting a specific LID bylaw can help clearly define and incorporate LID as a preferential stormwater management technique. Defining LID within this bylaw also decreases the need to explain LID throughout each of the Zoning bylaws. SPR. and subdivision rules and regulations and reduce the potential for any conflict between regulations and bylaws. This section also includes additional stormwater management considerations relevant to the MS4 permit.

Goal 5: Encourage Efficient Parking

Parking accounts for a large amount of impervious surface within new and redevelopment projects and offers an enormous opportunity for using LID. By reducing the amount of required parking - or even including parking maximums instead of minimums. communities can drastically reduce their impervious surfaces and runoff. Many communities already require landscaping in parking areas, which also offers an opportunity to allow curb cuts and infiltration in these areas - improving water quality and reducing the need for irrigation.

Visit www.mass.gov/guides/municipal-compliance-fact-sheet-stormwater for more informational resources.

4.3. Regulatory Audit Profiles – Easton, Mansfield, Middleborough

A review was completed of municipal by-laws and land development regulations relating to storm-water management and water quality standards. Below is a summary of findings from the review of 3 towns.

Findings of Topics Not Addressed	Recommendation(s)
Municipalities rely heavily on references to the MA DEP Stormwater Handbook [2] and Standards for the majority of their stormwater management requirements	Suggest addition of a brief summary of the major elements of the MA DEP Stormwater Handbook along with definitions of key terms. Suggest annual refresher training on MA DEP Stormwater Handbook and Standards for the Planning Board and Conservation Commission.
Low Impact Development is rarely if at all mentioned or defined	Include a paragraph or two with a definition to alert Board members and applicants to the benefits of an LID approach.
Climate Change impacts such as current extreme and future increased precipitation	Include a paragraph or two with a definition to alert Board members and applicants to the benefits of applying new precipitation data and future projections in the siting and design of stormwater infrastructure.
Private roads and their stormwater infrastructure maintenance and inspection is not addressed	For the purposes of public health and safety and access for emergency services, stormwater infrastructure should have an Operations and Maintenance Plan in place and annual or semi-annual inspections conducted.
Erosion and Sediment Control Plans are not mentioned or detailed significantly	These Plans may be required under the MA DEP Stormwater Manuals and Standards. Pre-construction site inspections should be completed and documented to ensure controls are in place.
Operation and Maintenance (O&M) Agreements are standard management procedure for storm-water infrastructure	O & M Agreements are important to protect the municipality and ensure stormwater infrastructure is functioning properly during construction and post-construction. These agreements also allow the municipality to make emergency repairs if necessary.
Written procedures and for site inspections, reporting, follow up, and processing violations are absent. Municipal representative(s) responsible for coordinating activities should be identified.	This record keeping is a requirement of the EPA MS4 Permit. Most of these documents would reside either in the Code Enforcement or Planning Offices. Suggest a centralized system either on paper or digitally compiled and staff should be knowledge and access of its location.

Refer to additional audit results and resources in the attached Audit Tool-Excel spreadsheet.

[2] MassDEP (2008). Massachusetts Stormwater Handbook, Massachusetts Department of Environmental Protection.

4.3.1. Easton Regulatory Audit Results (See Appendix F for full checklist)

SWM – WQ STANDARD/REQUIREMENT	BY-LAW OR REGULATION	FINDINGS
Stormwater Management Plan	Chapter 501-34-35	Plan required; Reference to MA DEP Stormwater Manuals and Standards; threshold for applicability 40,000 square feet
SWM Site Redevelopment Standards	Chapter 200, Part E	Requirements for pollutant removal and volume controls
Infiltration/Recharge Rate and Volume Req.		Reference to MA DEP Stormwater Manuals and Standards
Discharge Volume Req. for Post-Construction		
Water Quality Treatment Standards (P, N, TSS)		
LID – Site Planning and Design Strategies		Reference to MA DEP Stormwater Manuals and Standards
LID – Recommended Technical Manual/Design Materials		
LID – Subsurface Infiltration Practices		
LID – Impervious Cover Minimized		
LID – Impervious Cover Maximum limit as % of parcel		
LID – Capture and Reuse of Runoff on site		
LID – Bio-Retention Infiltration Practices		
LID –SWM Systems Distributed on Site		
LID – Pervious Pavement/Materials		
LID – Retention of natural cover, managed turf		
Climate Change – Use current Extreme Precipitation data		No standards or references
Climate Change – Use Projected Increases in PPT		
Climate Change – Upgrade existing for PPT Conditions		
Construction Bond/Escrow for Review	Article X 501-48-52	
Erosion and Sediment Control Plan		Not specified
Pre-Construction Site Inspection, Controls in Place		Not specified
Site Inspections During Construction	Chapter 501-41	Inspection and Control requirements
Process for Construction Site Violations		Not specified
Post Construction Site Inspection & Reporting	Chapter 501-41	Inspection and Control requirements
Process for Post-Construction Site Violations		Not specified
Operations & Maintenance Agreement – Public Roads	Chapter 501-35.B(6) O&M Plan	Also see Chapter 501-36.A Compliance, Chapter 501-41.E.2(e) Road Acceptance
Operations & Maintenance Agreement Recorded		Not specified
Written Procedure for Site Reporting & Follow up	Chapter 501-37 Annual Report	No submission date or process specified
Submission of final As-Built Plans (w/in 2 years)	Chapter 501-36.B	

SWM = Stormwater Management   WQ = Water Quality   LID = Low Impact Development   PPT = Precipitation

4.3.2. Mansfield Regulatory Audit Results

SWM – WQ STANDARD/REQUIREMENT	BY-LAW-REGULATIONS	FINDINGS
Stormwater Management Plan	Ch. 185-15 {B6}	Conservation Commission Regulations and review apply MA Stormwater Management Policy (MA Clean Waters Act) [MGLC.21, sections 23-56]
SWM Site Redevelopment Standards		Reference to MA DEP Stormwater Manuals and Standards
Infiltration/Recharge Rate and Volume Req.		
Discharge Volume Req. for Post-Construction		
Water Quality Treatment Standards (P, N, TSS)		
LID – Site Planning and Design Strategies		Reference to MA DEP Stormwater Manuals and Standards
LID – Recommended Technical Manual/Design Materials		
LID – Subsurface Infiltration Practices		
LID – Impervious Cover Minimized		
LID – Impervious Cover Maximum limit as % of parcel		
LID – Capture and Reuse of Runoff on site		
LID – Bio-Retention Infiltration Practices		
LID –SWM Systems Distributed on Site		
LID – Pervious Pavement/Materials		
LID – Retention of natural cover, managed turf		
Climate Change – Use current Extreme Precipitation data		Not specified
Climate Change – Use Projected Increases in PPT		
Climate Change – Upgrade existing for PPT Conditions		
Construction Bond/Escrow for Review	Ch. 185-25	Surety may be required by Conservation Commission review
Erosion and Sediment Control Plan	Ch. 185-15 & 21.11	Conservation Commission Regulations apply
Pre-Construction Site Inspection, Controls in Place	Ch. 185-24	Completed by Conservation Commission
Site Inspections During Construction	Ch. 185-27	Completed by Conservation Commission
Process for Construction Site Violations		
Post Construction Site Inspection & Reporting		
Process for Post-Construction Site Violations	Ch. 185-23	Conservation Commission
Operations & Maintenance Agreement – SWM	Ch. 185-23	
Operations & Maintenance Agreement Recorded		Not specified
Written Procedure for Site Reporting & Follow up		Not specified
Submission of final As-Built Plans (w/in 2 years)	Ch 185-26	Date/timing not specified

SWM = Stormwater Management WQ = Water Quality LID = Low Impact Development PPT = Precipitation

4.3.3. Middleborough Regulatory Audit Results

SWM – WQ STANDARD/REQUIREMENT	BY-LAW-REGULATIONS	FINDINGS
Stormwater Management Plan	Ch. 271	Reference to MA DEP Stormwater Manuals and Standards. 5,000 square foot applicability threshold. City Engineer assigned authority to review stormwater management plans.
SWM Site Redevelopment Standards		Reference to MA DEP Stormwater Manuals and Standards
Infiltration/Recharge Rate and Volume Req.		
Discharge Volume Req. for Post-Construction		
Water Quality Treatment Standards (P, N, TSS)		
LID – Site Planning and Design Strategies		Reference to MA DEP Stormwater Manuals and Standards
LID – Recommended Technical Manual/Design Materials		
LID – Subsurface Infiltration Practices		
LID – Impervious Cover Minimized		
LID – Impervious Cover Maximum limit as % of parcel		
LID – Capture and Reuse of Runoff on site		
LID – Bio-Retention Infiltration Practices		
LID –SWM Systems Distributed on Site		
LID – Pervious Pavement/Materials		
LID – Retention of natural cover, managed turf		
Climate Change – Use current Extreme Precipitation data		Not specified
Climate Change – Use Projected Increases in PPT		
Climate Change – Upgrade existing for PPT Conditions		
Construction Bond/Escrow for Review		Not specified
Erosion and Sediment Control Plan		Not specified
Pre-Construction Site Inspection, Controls in Place		Not specified
Site Inspections During Construction		
Process for Construction Site Compliance/Enforcement	Ch. 271-8.B, Ch. 271-11	
Post Construction Site Inspection & Reporting		Not specified
Process for Post-Construction Site Violations	Ch. 271-8.B, Ch. 271-11	
Operations & Maintenance Agreement – Public Roads		Not specified
Operations & Maintenance Agreement Recorded		Not specified
Written Procedure for Site Reporting & Follow up		Not specified
Submission of final As-Built Plans (w/in 2 years)		Not specified

SWM = Stormwater Management WQ = Water Quality LID = Low Impact Development PPT = Precipitation

4.4. Recommended Zoning By-Laws and Regulations Amendments for Watershed Protection

A finding of the regulatory audit process revealed several deficits in translating state and federal level permitting requirements to implementation at the municipal level. The following observations are offered to clarify how connections can be made across multiple jurisdictions.

- Local By-laws and land development regulations lack connection to, follow through and translation from state stormwater requirements to implement approved plans and applications.
- By-laws and Regulations lack clear and detailed written procedures for how approved plans, agreements and other legal documents will be implemented by municipal staff and officials, boards and commissions, engineering reviewers, town counsel and others. Suggest a process for transfer/access to application reports and documents to all local representatives who need to review them.
- By-laws and Regulations lack an "end point" when all conditions have been met and who makes that determination and what is the process to finalize a municipal permit (e.g. a final site inspection and sign off on all elements of the application).
- Create organizational processes (e.g. flow charts and reporting schedules) to coordinate from State and federal permitting to local implementation would be extremely helpful to enhance efficiency and accuracy and to ensure stormwater management and water quality are protected.

4.4.1. Municipal Stormwater By-Law and Land Development Standards

EPA Minimum Standards for Municipal Separate Storm Sewer System (NPDES MS4) Phase II Permits
An important component of the EPA MS4 Permit is to address and regulate redevelopment projects. Many sites being redeveloped have either no stormwater management controls or undersized and underperforming infrastructure. In many communities, redevelopment represents the largest percentage of development applications. Existing water quality impairments result from development already on the landscape. The best most efficient way of reversing this is to require redevelopment sites to make stormwater management improvements as part of the development application process.

Site Redevelopment Projects
Regulatory requirements for Site Redevelopment Projects should include measurable standards for water quality protections and/or improvements (refer to redevelopment standards in the EPA MS4 Permit section 2.3.6.e). Such standards may include reduction of site impervious cover, implementation of water quality measures such as pre-treatment and infiltration and retrofitting of existing unmanaged site runoff from rain and snow melt.
References:
MA DEP Stormwater Manuals and Standards
New Hampshire Southeast Watershed Alliance Model Stormwater Standards
Massachusetts Metropolitan Area Planning Council – Low Impact Development Toolkit
Maryland Critical Area Commission for the Chesapeake and Atlantic Coastal Bays – Stormwater
New Hampshire Southeast Watershed Alliance Model Stormwater Standards
Massachusetts Metropolitan Area Planning Council
New Hampshire Department of Environmental Services - Alteration of Terrain Bureau
New Hampshire Department of Environmental Services Volume 2 Post-Construction Best Management Practices: Selection and Design
City of Portland, Maine – Stormwater Manual

SAMPLE LANGUAGE

Definition of Redevelopment

Redevelopment (as applicable to this stormwater regulation) means:
a. Any construction, alteration, or improvement that disturbs existing impervious area (including demolition and removal of road/parking lot materials down to the erodible subbase) or expands existing impervious cover by any amount, where the existing land use is commercial, industrial, institutional, governmental, recreational, or multifamily residential.
b. Any redevelopment activity that results in improvements with no increase in impervious area shall be considered redevelopment activity under this regulation if capital cost of improvements is greater than 30% of the appraised property value.
c. Any new impervious area over portions of a site that are currently pervious.

The following activities are not considered redevelopment:

- Interior and exterior building renovation.
- Resurfacing of an existing paved surface (e.g. parking lot, walkway or roadway).
- Pavement excavation and patching that is incidental to the primary project purpose, such as replacement of a collapsed storm drain.
- Landscaping installation and maintenance.

Reference: New Hampshire Southeast Watershed Alliance Model Stormwater Standards

4.4.2. Stormwater Management General Application Requirements

Municipal approval of development projects contain many complex layers of agreements, easements, legal documents and financial agreements that require follow up actions and municipal implementation of procedures, approvals and processing. Recommendations contain administrative processes that can help organize the post-approval process.

SAMPLE LANGUAGE

Project Engineer Certification of Intent

Project applications will include a Project Engineer Certification of Intent that certifies compliance with the stormwater regulations as detailed below:

> I certify under penalty of law that this document and all attachments were prepared under my direction or supervision, in accordance with an approach designed to be consistent with municipal Stormwater Management Engineering Standards and to the maximum extent feasible, to promote decentralized stormwater management systems modeled after natural hydrologic features and infiltration practices that facilitate local groundwater recharge using Low Impact Development, and will further compliance with the {insert name of waterbody} Total Maximum Daily Load (TMDL) and the Municipal Separate Storm Sewer System (NPDES MS4) Phase II permit. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I have no personal knowledge that the information submitted is other than true, accurate, and complete. I am aware that there are significant penalties for submitting false information for knowing violations. The certification shall be stamped and dated by a professional engineer licensed in the state of Massachusetts.

Stormwater Management Performance Enhancements

Existing stormwater management regulations, street design standards and stormwater management design standards should: 1) be updated based on the guidance document {select a technical guidance document relevant to the area/region} to include all projects under municipal review, private and public sector developments, including public and capital improvements, and 2) require a Project Engineer Certification of Intent.

SAMPLE LANGUAGE

Administrative Implementation of Approval Requirements

Stormwater Management Plan Approval and Recordation

1. Plan Approval and Review. The Planning Board shall approve the Stormwater Management Plan if it complies with the requirements of these regulations and other requirements as provided by law. At the discretion of the Planning Board, a technical review by a third party may be required of any stormwater management and erosion control plan prepared under these regulations. The technical review shall be performed by a qualified professional consultant, as determined by the Planning Board, and the expense of which shall be the full responsibility of the applicant.

2. Recordation of Approved Stormwater Management Plan. After final Planning Board approval, and established as a condition of such approval, the owner of record of the property shall record at the Registry of Deeds documentation sufficient to provide notice to all persons that may acquire any property subject to the requirements of and responsibilities described in the approved stormwater management plan (see RSA 477:3-a). The notice shall comply with the applicable requirements for recording contained in RSA 477 and 478.

Operations and Maintenance Criteria

Stormwater management and sediment and erosion control plans shall be incorporated as part of any approved site plan or subdivision plan. The owner of record of the property shall record a Notice of Decision of these plans at the Registry of Deeds. The Notice of Decision shall be attached to the property deed and apply to all persons that may acquire any property subject to the approved stormwater management and sediment control plans. The Notice of Decision shall reference the requirements for maintenance pursuant to the stormwater management and erosion and sediment control plans as approved by the Planning Board.

Post-Construction Stormwater Infrastructure – Inspection and Responsibility

Municipal staff or their designated agent shall have site access to complete routine inspections to ensure compliance with the approved stormwater management and sediment and erosion control plans. Such inspections shall be performed at a time agreed upon with the landowner. If permission to inspect is denied by the landowner, municipal staff or their designated agent shall secure an administrative inspection warrant from the district or superior court under RSA 595-B Administrative Inspection Warrants. Expenses associated with inspections shall be the responsibility of the applicant/property owner.

The applicant shall bear final responsibility for the installation, construction, inspection, and disposition of all stormwater management and erosion control measures required by the Planning Board. Site development shall not begin before the Stormwater Management Plan receives written approval by the Planning Board.

The municipality retains the right, though accepts no responsibility, to repair or maintain stormwater infrastructure if: a property is abandoned or becomes vacant; and in the event a property owner refuses to repair infrastructure that is damaged or is not functioning properly.
<u>Reference</u>:

New Hampshire Southeast Watershed Alliance Model Stormwater Standards

Creation of New Streets – Public or Private

Review and approval of street and road development plans can present different challenges depending on the road status as private or public (municipally owned and maintained). If a development proposes a public street or road, in both instances, that infrastructure needs to meet the municipal standards for design and construction but also the municipalities anticipated maintenance requirements and costs for maintenance of the infrastructure (e.g. whether the municipality require open drainage or allow closed drainage systems).

SAMPLE LANGUAGE

If a development proposes a private street or road, the municipality should enact an Operations and Maintenance (O&M) Agreement with the developer/landowner at the time of application approval. This O&M agreement is critical to carrying forward any conditions of approval, site inspection schedules, other site maintenance obligations, particularly in the event the property is sold, and finalizing any financial interests such as an Escrow Account or Bond being held for property development.

If a development proposes a public street or road, an O&M Agreement should be in place until such time the street or road is accepted by the municipality as a public way under their jurisdiction. Such O&M Agreements can be extended for a period of 1-2 years to capture a variety of storm conditions whereby site inspections are conducted to ensure proper functioning of the roadway and its infrastructure as approved, designed and constructed. This may include water quality testing for any EPA MS4 Permit jurisdictional outfalls, connections to the municipal storm sewer system (if applicable) and direct discharges to surface waters.

4.4.3. EPA NPDES MS4 Permit Inspection Requirements

An important aspect of compliance with the EPA Municipal Separate Storm Sewer System (NPDES MS4) Phase II Permit is conducting and documenting site inspections both during construction and post-construction. Often inspections are part of a municipal approval of erosion and sediment control plans and stormwater plans by the Planning Board, Town Engineer or Conservation Commission and in some cases the Zoning Board.

Site Inspections During Construction

Site inspections during construction ensure proper erosion and sediment control and control of stormwater runoff. This is often implemented through a Sediment and Erosion Control Plan that includes stringent perimeter controls and treatment of any discharges from the development site (if any). Inspections during critical steps in the construction sequence can prevent unintended consequences such as infrastructure failure and improperly installed infrastructure. Results of inspections should be filed with the municipality and any site violations forwarded to the appropriate staff or officials for processing.

SAMPLE LANGUAGE

Site Inspections During Construction shall be based on an agreement between the developer/property owner and the municipality. An inspection schedule will be based on a construction sequence of activities that require inspection before construction can resume. The construction site inspection schedule is highly site specific, so a template is not suitable except for the following basic elements:

- Establish a sequence of construction and associated inspections. This is often part of a construction cost estimate for a surety or bond however the details may change during the course of application review and approval.
- Designate a municipal representative to perform site inspections. Document their contact information on the inspection agreement.
- Document information about the site construction manager(s) (e.g. name, address, phone number(s), email address).
- Attach a complete set of approved application plans to the site inspection agreement. Include a sign-off sheet to record when and who performed each site inspection, weather conditions, time of day, who was present, and observation notes. Note also if site photographs were taken and by whom and store them in a secure location with the municipality.

Post-Construction Municipal Inspections

Post-construction inspections are often part of a municipal approval and construction agreement that may include site specific conditions be met before an occupancy permit is issued. These inspections are intended to verify that site construction has been implemented according to the approved plans, infrastructure is functioning as designed, and that submission of As-Built Plans will accurately reflect site conditions. The bulleted items listed under Site Inspections During Construction apply.

Site inspections should address any conditions of the municipal approval document. A final inspection report from the municipal inspector should be provided to the municipal approval authority (Planning Board, Conservation Commission, Code Enforcement Officer, Building Inspector).

Regional Approaches to Site Inspections

There has been interest in recent years by municipalities to work together to create a "regional" inspection program for both during construction and post-construction. Below are some ideas provided by several municipalities participating in this project.

SAMPLE GUIDANCE/LANGUAGE

Municipalities may work together to create an administrative and funding mechanism to streamline site inspections by developing the following tools and processes:

- Creation of a regional inspector position to provide services and would be funded by multiple communities. Funding sources may include fee at time of application, fee paid from an escrow or bond account, or time of service fee.
- An example of a regional approach is being tested in Westborough, Massachusetts (unconfirmed)
- Implement a self-inspection and reporting program that requires submission of an annual inspection report signed by a licensed engineer.

Sources: SNEP Workshop Participants on September 19, 2022; Town of Westborough Building Department

4.4.4. Water Quality and Watershed Health and Function

Municipal By-Law and Land Development Standards should include clearly identified stormwater management, water quality protection and mitigation of existing water quality impairments for surface waters and jurisdictional outfalls. By-Laws and Land Development Regulations should consider and include basic provisions for landscape level conditions that influence stormwater flows and water quality:

- Groundwater Recharge and Drinking Water Supply Contribution Areas
- Factors that may impair water quality such as shallow bedrock and steep slopes

- Floodplains and Areas Subject to Flooding (refer to municipal Hazard Mitigation Plan)
- Wetlands and Riparian Areas
- Wildlife and Plant Habitats

Open Space Residential Development

The goal of Open Space Residential Development (OSRD) (sometimes referred to as Conservation Subdivision Development) is to conserve and protect valuable natural and other resources that provide environmental benefits and tangible benefits to the health and safety of the community. OSRD ordinances and regulations may include specified modifications to zoning dimensional requirements, subdivision and site plan review requirements, and an expedited review process. OSRD applicability may be scaled to the size of the development parcel (e.g. a minimum acreage) and requirements for open space land conservation.

Objectives of OSRD are to:

- Include resource protection as part of the land development process
- Inventory site specific resources before a development plan is prepared
- Implement safeguards that maintain natural processes in the post-development condition
- Safeguard against flooding, erosion, damage to infrastructure and impacts to life and property

The OSRD application process often requires a preliminary consultation with the Planning Board and the municipal technical advisory committee (if the municipality has one). The OSRD process typically incorporates a 4-step process for site development applications:

1. Prepare an existing conditions plan that details all man-made, natural features and environmentally sensitive areas on the development site
2. Prioritize areas for conservation and increased protection from development impacts by creating a "development area" that incorporates all required setbacks, buffers, including stormwater and surface drainage, and other conditions required by the approval board
3. Prepare a draft plan showing development areas and/or subdivided lots, roads, utilities and stormwater infrastructure
4. Finalize the development plan with feedback from approval boards and others detailing any conditions required as part of the approval

The final development plan application should have all agreements, easements and legal documents in place and reviewed by municipal representatives before approval and these documents should be officially recorded to run with the land.

References:

Newburyport OSRD https://library.municode.com/ma/newburyport/codes/code_of_ordinances?nodeId=APXAZOORNE_SXIVOPSPREDEOS

Conservation Subdivision Handbook https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=0CAMQw7AJahcKEwiQ5O7V5-z6AhUAAAAAHQAAAAAQAw&url=https%3A%2F%2Fwww.ncufc.org%2Fuploads%2FConservation_subdivision.pdf&psig=AOvVaw3AlrMwxn3o4mdYRpVSGfQq&ust=1666286657378667

High Risk Land Uses

There are any number of common land uses that pose a high risk of contamination to surface water and groundwater when exercised improperly. Even small spills and spills that occur over an extended period undetected can lead to irreversible contamination. Prevention is far less costly than mitigation after the fact. By prohibiting high risk uses in sensitive areas particularly those areas that serve as drinking water supplies public health and safety and land values are protected. Stormwater management plays a critical role in protecting water quality on developing and developed sites. However, strict land use controls along with stringent stormwater management standards can prevent contamination.

SAMPLE GUIDANCE LANGUAGE

The table below describes the sources and impacts from common environmental pollutants. Ensuring that adequate testing is performed at high risk land use sites and that uses that produce these pollutants are limited in scope, location and are required to implement safeguards to prevent release of pollutants. An inventory of active sites and annual inspections of high risk land uses is recommended.

STORMWATER POLLUTANTS, SOURCES AND IMPACTS		
Pollutant	**Sources**	**Impacts**
Sediment	Construction sites; eroding stream banks and lakeshores; winter sand and salt application; vehicle/boat washing; agricultural sites.	Destruction of plant and fish habitat; transportation of attached oils, nutrients and other pollutants; increased maintenance costs, flooding.
Nutrients (phosphorus, nitrogen)	Fertilizers; malfunctioning septic systems; livestock, bird & pet waste; vehicle/boat washing; grey water; decaying grass and leaves; sewer overflows; leaking trash containers, leaking sewer lines.	Increased potential for nuisance or toxic algal blooms; increased potential for hypoxia/anoxia (low levels of dissolved oxygen which can kill aquatic organisms).
Hydrocarbons (petroleum compounds)	Vehicle and equipment leaks; vehicle and equipment emissions; pesticides; fuel spills; equipment cleaning; improper fuel storage & disposal.	Toxic to humans and aquatic life at low levels.
Heavy Metals	Vehicle brake and tire wear; vehicle/equipment exhaust; batteries; galvanized metal; paint and wood preservatives; batteries; fuels; pesticides; cleaners.	Toxic at low levels; drinking water contamination.
Pathogens (Bacteria)	Livestock, bird and pet wastes; malfunctioning septic systems; sewer overflows; damaged sanitary lines.	Risk to human health leading to closure of shellfish areas and swimming areas; drinking water contamination.

PCBs: Polychlorinated Biphenyls

An ***inventory of active sites and annual inspections of high risk land uses*** is recommended: vehicle service and repair shops, general service and repair shops, metalworking shops, manufacturing facilities, waste and scrap processing and storage, laboratories and certain professional offices (medical, dental, veterinary), salt storage and use, cleaning services, food processing plants, fueling and maintenance of earth moving equipment, concrete, asphalt and tar manufacturer, hazardous waste facilities.

The following ***high risk uses are not recommended*** in a drinking water supply source area or other environmentally sensitive area: hazardous waste disposal facilities, solid waste landfills, outdoor bulk storage of road salt, junkyards, snow dumps, and wastewater or septage lagoons.

Reference:
Guidelines and Standard Operating Procedures Illicit Discharge Detection and Elimination and Pollution Prevention/Good Housekeeping
NH Department of Environmental Services, Environmental Fact Sheet DWGB-22-3 (2020)

Vegetated Buffers

The land along the water's edge serves as a buffer against the impact of human activity on a water body, river, stream, or wetland. The term buffer is applied widely to landscapes with different characteristics, ranging from naturally vegetated landscapes to undisturbed areas to those where mowing and landscape management is allowed. Vegetative buffers offer effective water quality treatment and a low cost.

References:
MA Audubon
New Hampshire Buffer Options for the Bay
Maryland Critical Area Commission for the Chesapeake and Atlantic Coastal Bays – Vegetative Buffers

SAMPLE LANGUAGE

Definition:
A vegetated buffer is an undisturbed naturally vegetated area of land located on the development site. The vegetated buffer can contribute to removal of pollutants when situated directly adjacent to surface waters or a water resource, such as a lake, stream, river, pond, estuary, or a wetland.

Stormwater runoff and snow melt shall be directed to the vegetated buffer via sheet flow, collection and distribution by a level spreader or other mechanical devise, or subsurface through perforated pipe. Stormwater discharges to slopes greater than 10 percent are discouraged.
Reference: New Hampshire Buffer Options for the Bay

4.4.5. Climate Change Standards and Requirements

Municipalities and applicants should utilize the best available climate change science and reports to successfully manage current stormwater runoff volumes and frequency and projected future increases in rainfall to achieve required water quality standards and environmental protection. Recent studies of future extreme precipitation project a minimum of a 20 percent increase in rainfall by 2050 [New Hampshire Climate Assessment 2021]. Redevelopment sites pose a particular challenge in that the existing stormwater infrastructure (if any) is undersized to meet state and local standards and accommodation of current rainfall volumes and water quality treatment requirements.

References:
Cornell University Northeast Region Climate Center – Extreme Precipitation Atlas
New Hampshire Climate Assessment 2021
Metropolitan Area Planning Council – Climate Resilient Land Use Strategies

SAMPLE LANGUAGE

Applicants shall apply the best available climate change science to siting and designing development projects {reference a data source or have applicant choose}. Stormwater infrastructure shall be engineered to accommodate current and projected future precipitation volumes and plans should explicitly reference the source of future climate precipitation data relied upon for design of the plans or in conformance to design standards specified by the municipality.

Stormwater runoff shall be retained on the development site to maximum extent practicable using infiltration practices to recharge groundwater and maintain the pre-development hydrology of surface waters and wetlands.

Climate Resilience
The Metropolitan Area Planning Council (MAPC) has created an interactive website "Climate Resilient Land Use Strategies: Regulatory Language and Policy Examples" (see reference link below). The MAPC poses this question "why address climate change through land use planning?". Most development occurs at the individual parcel level and it's often not until a community experiences very large

developments or reaches a watershed moment when development seems to envelop the community in major change. Being proactive about land use planning is "playing the long game" that over time may yield significant benefits. Data trends and science give us clues to our future environmental conditions so why not use them to our advantage to protect our communities and their important irreplaceable resources. Explore the topics on the MAPC website realizing that not all will resonate with your community, but many will. Refer to the MAPC website reference for Sample/Model Language modules.

Reference:

Metropolitan Area Planning Council https://www.mapc.org/resource-library/site-plan-review/

4.5. Development of a Watershed Protection Standard for New and Redevelopment Projects

A Watershed Protection Standard (WPS) was developed to provide communities with resilient alternative site development stormwater (SW) management performance standards designed to protect and restore watershed and water resource health from impacts associated with future development activities. Appendix G provides a memorandum that describes development of the WPS that defines post-construction SW management performance standards for controlling SW runoff from impervious cover (IC) associated with new and redevelopment activities. The WPS specifies SW control levels to achieve predevelopment average annual groundwater recharge volumes and predevelopment SW nutrient load export (total phosphorus (TP) and total nitrogen (TN)). The WPS is intended to emphasize dispersed Green Infrastructure (GI) and Low Impact Development (LID) techniques including minimizing the disturbance of area with natural soils and vegetation, preservation of hydrologic function for on-site areas of soil disturbance, and the importance of maintaining on-site predevelopment drainage patterns. Therefore, the WPS not only specifies levels of SW control to achieve predevelopment recharge and SW nutrient load export on site but emphasizes the importance of the adopting the following site design principals for minimizing impacts and preserving natural watershed functions:

- Maintain predevelopment drainage and groundwater recharge patterns.
- Apply dispersed green infrastructure (GI) across site to achieve WPS performance standards prior to finalizing design to manage for peak flow control.
- Minimize disturbance of natural soils, and restore all disturbed soils not built on to predevelopment hydrologic conditions.

The WPS provides two options related to on-site SW runoff management for communities to consider:

1. Right sizing of infiltration SW control measures (SCMs) based on varying soil permeability using EPA region 1's SCM performance curves based on long-term continuous simulation modelling (Boston, MA, 1992-2020); and
2. Simple one-inch (1") retention design standard for which all controls are designed to have a Design Storage Volume (DSV) equal to 1" depth of runoff from contributing IC.

The WPS SW performance standards are derived from examining how natural vegetated land with varying soil conditions functions under existing climatic conditions over long-periods of time. A combination of continuous simulation hydrologic modeling, climatic data, research conducted in the development of SW nutrient load export rates for the MA and NH MS4 permits, and literature on evapotranspiration were used to estimate SW runoff volumes, groundwater recharge, and nutrient export conditions associated with predevelopment natural conditions and post development IC.

The conversion of natural vegetated pervious land area to IC results in lost groundwater recharge, the process in which precipitation is captured and infiltrated into the ground. Groundwater recharge is an essential source of water to subsurface groundwater reservoirs that supply baseflows and moisture to surface waters and wetlands and deeper aquifer storage commonly relied upon for potable water consumption. This section presents the magnitude of lost groundwater recharge volumes due to the creation of IC and the level of control needed in postconstruction SW management to replenish groundwater recharge to predevelopment conditions.

Continuous simulation hydrologic response unit (HRU) modelling was conducted using the EPA supported Stormwater Management Model (SWMM) to estimate average annual runoff volumes for predevelopment natural vegetated land cover conditions with HSGs A, B, C and D. For this analysis, HRU models represent unique combinations of homogenous land cover and HSG (e.g., meadow –

HSG A). Two continuous simulation modelling approaches available in SWMM were used to estimate annual predevelopment HRU runoff volumes for the period of interest (1992 – 2020) using Boston, MA climatic data consisting of hourly precipitation and daily temperature data.
Table 2 summarize the results of the estimated annual groundwater recharge estimates derived from the water balance equation. This includes summary statistics of the estimates for the 29 year period from 1992-2020 analysis period. There is considerable variability in annual precipitation and estimated runoff and recharge values for the period of analysis (1992 to 2020). For example, annual precipitation ranged from a minimum of 28.26 inches to a maximum of 54.46 inches and ranges of similar magnitude are shown for runoff and recharge volumes.

Table 3 identifies the recommended DSVs, predevelopment recharge, and the associated cumulative SW nutrient load reduction performances for both surface bio/infiltration and subsurface infiltration SCMs to achieve the WPS.

Table 2: Summary statistics of estimated annual runoff and groundwater recharge volumes for unit area predevelopment conditions by hydrologic soil groups (HSG) for Boston, MA climatic conditions (1990 – 2022)

Measure	Precipitation Boston		HSG A		HSG B		HSG C		HSG D	
			Runoff,	Recharge,	Runoff,	Recharge,	Runoff,	Recharge,	Runoff,	Recharge,
	Inches	MG/ac/yr	MG/ac/yr	MG/ac/yr	MG/ac/yr	MG/ac/yr	MG/ac/yr	MG/ac/yr	MG/ac/yr	MG/ac/yr
Average	42.78	1.16	0.017	0.56	0.076	0.50	0.16	0.43	0.25	0.33
Median	43.67	1.19	0.005	0.59	0.061	0.50	0.14	0.42	0.25	0.33
Minimum	28.26	0.77	0.000	0.38	0.001	0.37	0.04	0.32	0.08	0.24
Maximum	54.46	1.48	0.098	0.72	0.21	0.65	0.34	0.55	0.44	0.42
90th%	51.61	1.40	0.052	0.67	0.16	0.61	0.27	0.51	0.37	0.40

Table 3: Watershed protection standard for impervious cover stormwater management: Infiltration SCM design storage volumes (DSVs) to achieve predevelopment groundwater recharge and SW nutrient load export

SCM Category	SCM Types	HSG	Infiltration Rate, in/hr	Controlling DSV, in.	PreDevel. Recharge* DSV*, in.	Pre Development TP Export**, DSV, in.	Pre Development TN Export,** DSV, in.	WPS Recommended DSV,in
Surface Infiltration	Basin, swale, raingarden (i.e., bioretention), permeable pavement	A	8.27	**0.39**	0.16	0.39	0.39	**0.4**
		A	2.41	**0.67**	0.32	0.67	0.60	**0.7**
		B	1.02	**0.59**	0.37	0.59	0.39	**0.6**
		B	0.52	**0.73**	0.45	0.73	0.42	**0.75**
		C	0.27	**0.60**	0.40	0.60	0.33	**0.6**
		C	0.17	**0.69**	0.49	0.69	0.35	**0.7**
		D	0.1	**0.60**	0.50	0.60	0.25	**0.6**
		D	0.05	**0.86**	0.86	0.80	0.30	**0.9**
Subsurface Infiltration	Trench, Chambers, drywell, tree filter retention	A	8.27	**0.60**	0.23	0.60	0.60	**0.6**
		A	2.41	**1.00**	0.46	1.00	0.80	**1.0**
		B	1.02	**0.86**	0.49	0.86	0.53	**0.9**
		B	0.52	**0.99**	0.60	0.99	0.53	**1.0**
		C	0.27	**0.81**	0.55	0.81	0.38	**0.85**
		C	0.17	**0.93**	0.68	0.93	0.39	**0.95**
		D	0.1	**0.79**	0.72	0.79	0.25	**0.8**
		D	0.05	**1.25**	1.25	1.00	0.22	**1.25**

*Predevelopment Recharge based on Water Balance method for Boston MA, 1992-2020 using average annual runoff yields from continuous simulaltion hydrologic SWMM HRU models of meadow and forested lands for HSGs A, B, C and D. Predevelopment recharge conditions will be met when Infiltration practices are sized (DSVs) to capture 66%, 63%, %51% and 40% of average annual IC runoff volumes for HSGs A, B, C and D, respectively.

**Predevelopment Nutrient export is the nutreint load delivered in surface runoff from natural wooded and meadow lands according to HSG. Required % Reductions to IC runoff TP export are 98%, 93%, 86% and 77%, for predevelopment HSGs A, B, C, and D. Required % Reductions to IC runoff TN export are 98%, 91%, 82% and 71%, for predevelopment HSGs A, B, C, and D.

5. COMPENDIUM OF SITE-DEVELOPMENT STORMWATER MANAGEMENT SOLUTIONS FOR WATER RESOURCE PROTECTION

The "Compendium" is intended to be a useful handbook that provides clear and concise guidance on stormwater management strategies for site development activities to mitigate long-term impacts associated with the creation of impervious cover (IC) and to preserve/maintain natural function of vegetated permeable on-site areas. The target audience for the compendium is local government officials with responsibilities of reviewing and approving site plans. The Compendium will emphasize dispersed Green Infrastructure (GI) and Low Impact Development (LID) techniques including minimizing the disturbance of area with natural soils and vegetation, restoration of hydrologic function to on-site areas of soil disturbance and the importance of maintaining on-site predevelopment drainage patters. Examples of using the natural or restored vegetated permeable areas as part of the on-site management of SW runoff through passive IC disconnection designs will also be displayed. A range of scalable GI and LID Stormwater Control Measures (SCMs) will be presented on partial conceptualized site plans at scale to illustrate the sizing(s) and location of dispersed GI LID SCM and techniques. The purpose of the Compendium is to provide users with a range of "plug and play" SCM options that could easily apply in many site development situations to treat various types of IC with varying site constraints. The conceptualized GI LID designs will illustrate enough detail to display the location and size(s) of scalable SCMs relative to IC area targeted for management. The conceptual partial site plan will emphasize the SCM aspect of the site plan and may only display a portion of the IC to be treated but shall include a design summary table that includes total IC area to be treated along with key defining design information of the SCMs sized for varying Hydrological Soil Groups (HSGs) A, B, C, and D.

The design capacity or Design Storage Volume (DSV) of the SCMs depicted on the conceptual plans will be set to achieve a protective level of control equal to matching predevelopment average annual stormwater (SW) runoff nutrient load export and groundwater recharge. This level of control is approximately equal to a one (1) inch retention standard for IC runoff that would both achieve at least a 95% reduction in average annual post-construction total phosphorus (TP) and total nitrogen (TN) load export and predevelopment recharge targets (to be provided by EPA R1). The proposed retention standard will include minimum infiltration requirements for attaining recharge targets. A secondary design table will be provided on the concept plan to provide the DSV and footprint dimensions of the illustrated control for complying with the MA MS4 post- construction requirements for TP and total suspended solids (TSS) reductions of 60% and 90%, respectively and MassDEP's existing groundwater (GW) recharge Standards. The Compendium will provide a section that illustrates how the depicted SCMs are scalable so that users could downsize or upsize SCM footprints to treat varying IC drainage areas (e.g., maintain SCM DSV and performance but treat a smaller IC area (e.g., 1/10th acre). The compendium will also provide the method of calculating SCM performance for adjusted DSVs to better suit site conditions using SCM performance curves to encourage use of multiple SCMs across a site to achieve the overall performance standard for predevelopment drainage areas on the site (e.g., use of undersized and oversized SCMs on site).

The sizing of the SCMs and estimations of cumulative performances will be accomplished by EPA R1 Opti-Tool and SCM performance curves. The conceptualized SCM plans will provide in addition to the design details and planning level cost estimates of cumulative performances for GW recharge, and reductions in runoff volume, and pollutant export reductions (TP, TN and TSS).

Compendium Outline:

1. Introduction and Purpose
2. Innovative Site Design Approach
3. Introduction to Watershed Protection Standard
4. Innovative Stormwater Control Measure Examples for Watershed Protection
5. Appendix A – Precipitation and Runoff By Soil Type
6. Appendix B – Rethinking Estimated Seasonal High Water Tables Limitations for Stormwater Management