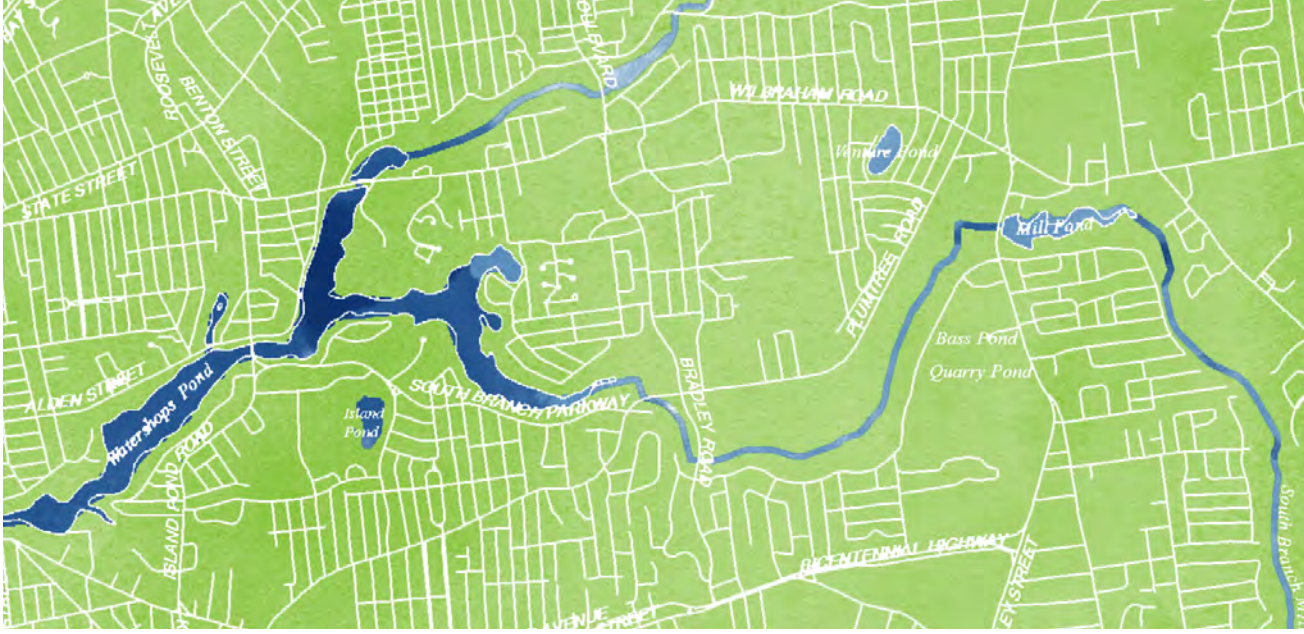
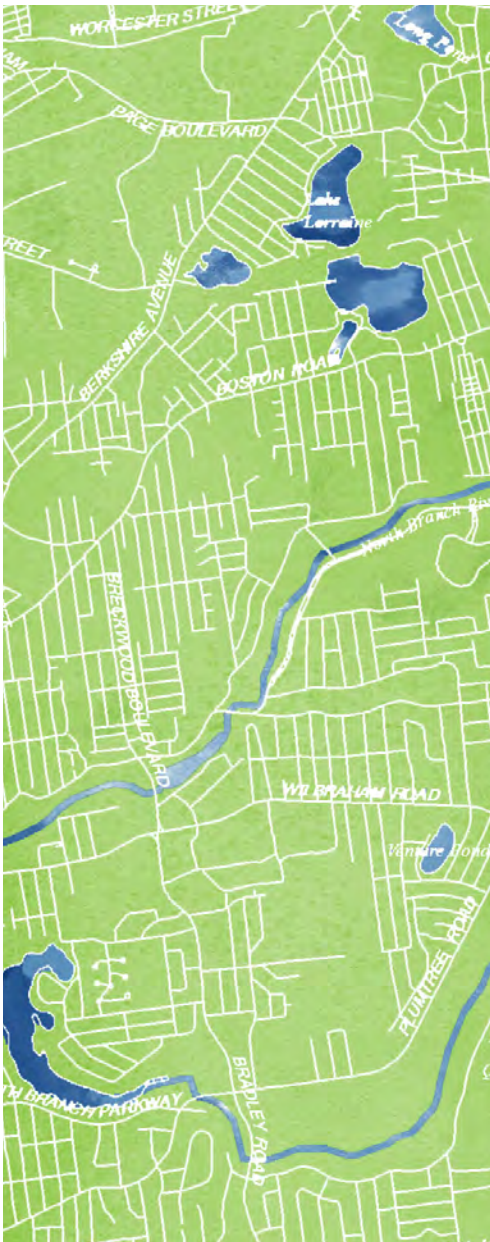


CITY OF SPRINGFIELD

GREEN INFRASTRUCTURE TECHNICAL GUIDELINES



ACKNOWLEDGEMENTS

The City of Springfield's Green Infrastructure Technical Guidelines was inspired by and adapted from the Toronto Green Streets Technical Guidelines. The City of Springfield, Pioneer Valley Planning Commission, and VHB, Inc extend special thanks to the City of Toronto for allowing the adaptation of their Guidelines. Patrick Cheung (Principal Engineer for Toronto Water), especially, provided his encouragement and support. The City of Springfield's Green Infrastructure Technical Details were adapted from the San Francisco Public Utilities Commission.

The City of Springfield's Green Infrastructure Technical Guidelines was funded through separate grants from the Massachusetts Executive Office of Energy and Environmental Affair's Municipal Vulnerability Preparedness program and Land Use Planning Assistance program.

PIONEER VALLEY PLANNING COMMISSION STAFF

Corrin Meise-Munns (Senior Land Use and Environment Planner) prepared these guidelines with support from Patty Gambarini (Principal Environment Planner) and Catherine Ratté (Principal Land Use Planner). Jacob Dolinger (Senior Planner/GIS Specialist) created the City-wide Reference Maps.

VHB, INC STAFF

Gordon Daring (Managing Director) prepared the City of Springfield's Paving Specification updates. Lori Kennedy (Water Resources Specialist) adapted the City of Springfield Green Infrastructure Typical Details and the Green Infrastructure Selection Tool.

SPRINGFIELD GREEN INFRASTRUCTURE TECHNICAL GUIDELINES WORKING GROUP

The Green Infrastructure Technical Guidelines working group comprises an inter-departmental team of City staff:

Matthew Sokop	*City Engineer*
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Luca Mineo	*Civil Engineer*
Alex Sherman	*City Forester*
Michael Tully	*Senior Parks Projects Manager*
Kevin Chaffee	*Natural Resources Manager*

With participation from the Springfield Water & Sewer Commission's Steve Frederick, Deputy Director of Wastewater Operations.

ACRONYMS

BMP	Best Management Practice
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DEP	Massachusetts Department of Enivronmental Protection
EPA	US Environment Protection Agency
ESC	Erosion & Sediment Control
GHG	Greenhouse Gas
GI	Green Infrastructure
GIS	Geographic Information System
LARP	Landscape Architecture & Regional Planning
LID	Low Impact Development
MGL	Massachusetts General Laws
MS4	Municipal Separate Storm Sewer System
NCA	National Climate Assessment
NECSC	Northeast Climate Science Center
NPDES	National Pollution Discharge Elimination System
PVPC	Pioneer Valley Planning Commission
SBBS	Sand-Based Structural Soil
SWQS	Surface Water Quality Standards
TGSTG	Toronto Green Streets Technical Guidelines
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UHI	Urban Heat Island
UMASS	University of Massachusetts
WPA	Wetlands Protection Act

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0 EXECUTIVE SUMMARY

The City of Springfield's Green Infrastructure Technical Guidelines (the Guide) provides direction for the planning, design, integration, and maintenance of a range of green infrastructure (GI) options appropriate for Springfield street types, development history and projections, and existing conditions.

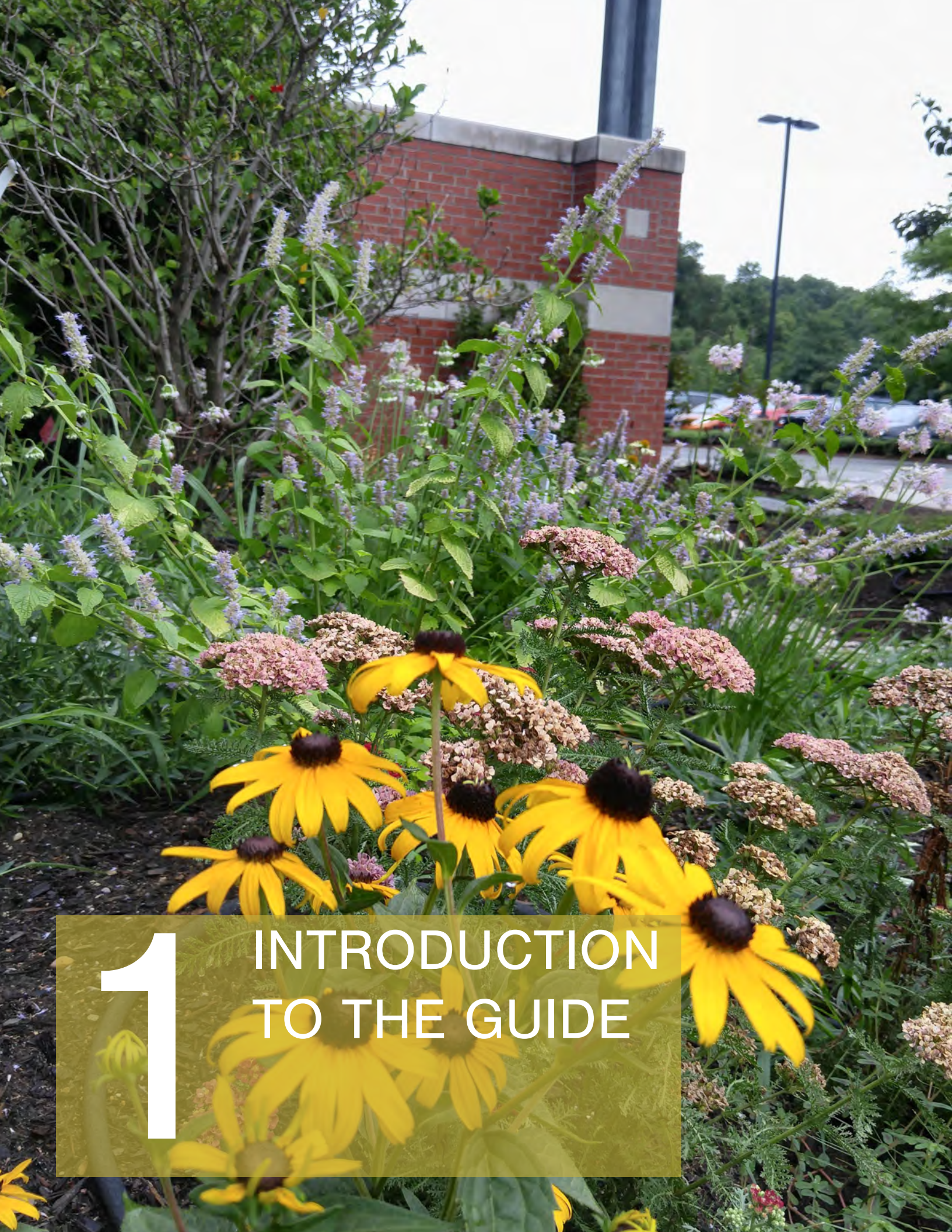
The need for a city-wide GI design guide was identified during the planning process for Strong, Healthy & Just, Springfield's 2017 climate action and resilience plan. The guide is informed by a thorough review of City policy documents, such as the Stormwater Management Ordinance, Hazard Mitigation Plan, Complete Streets Implementation Guide, and Growing for the Future Urban Forestry Plan. The project team also took guidance from several regional and state-wide planning and policy documents, such as the Pioneer Valley Green Infrastructure Plan, Massachusetts Department of Environmental Protection (DEP) Stormwater Handbook, and the US Environmental Protection Agency (EPA) 2016 Massachusetts MS4 Permit.

Research included an analysis of precedent manuals and guidelines from municipalities across North America, including the Toronto Green Streets Technical Guidelines (TGSTG). The Springfield GI Technical Guidelines working group was so impressed with the research and breadth of the TGSTG that they sought and obtained permission to adapt the TGSTG format and tools to meet Springfield's needs.

TGSTG's precedent study produced a "long list" of 72 green infrastructure techniques, which the Springfield working group adapted to develop a list viable for implementation in Springfield's specific geographical, climatic, road right-of-way, and public and private development conditions. The associated GI Selection Tool was developed to simplify the process of identifying specific GI options for implementation in road rights-of-way and/or in public or private developments and redevelopments. Techniques are screened using nine key parameters, with recommendations provided for scenarios with limited options.

In the Appendices to the Guidelines, a comprehensive set of technical drawings provide direction on the configuration and layout, construction profile, drainage, conveyance/overflow, monitoring provisions, and plant material to assist with design of the GI facilities. The Appendices also address considerations such as operations and maintenance protocols and monitoring recommendations, as these are critical to the long-term effectiveness of any GI practice.

Finally, although not technically considered green infrastructure, the Guide and Appendices house updated paving specifications for the City of Springfield's use in its maintenance and construction of roadways and paved surfaces. The paving specifications have been updated to reduce greenhouse gas emissions associated with City projects and to improve natural resource protection. Because this Guide targets the use of GI systems to reduce negative water quality and emissions impacts, the updated paving specifications are considered a tandem strategy in greening the City of Springfield.



1 INTRODUCTION TO THE GUIDE

1.1 BACKGROUND ON THE TECHNICAL GUIDELINES

In the summer of 2017, the City of Springfield adopted a climate action and resilience plan to reduce the community's greenhouse gas (GHG) emissions and adapt to the effects of the changing climate. A cross-cutting strategy identified in the Strong, Healthy & Just (PVPC, 2017) plan is the implementation of green infrastructure (GI) throughout the city's public and private properties. GI has the ability to mitigate flooding, improve air quality, reduce ambient air temperature, provide more comfortable and safer conditions for pedestrians and cyclists, and increase the aesthetic value of neighborhoods. As such, GI can offer cost effective solutions to the urban problems posed at the intersection of environmental quality and public health and safety while providing significant co-benefits to any infrastructure project.

The Springfield Green Infrastructure Technical Guidelines (the Guide) was adapted from the City of Toronto's Green Streets Technical Guidelines and further developed on behalf of the City of Springfield by a working group of representatives from the City's Department of Public Works, Division of Parks and Recreation, and Division of Forestry, and from engineering firm VHB and the Pioneer Valley Planning Commission. The purpose of the Guidelines is to demonstrate why and how GI can be applied to development projects in the City of Springfield to improve water quality and increase environmental and social resilience.

1.2 THE PURPOSE OF THIS DOCUMENT

The Guide supports new standards for development and redevelopment of public and private properties and streets within the city. It describes GI solutions that can yield significant environmental benefits to relieve urban pressures on ecological systems, improve air quality, achieve energy efficiency, and enhance water quality, while ensuring that Springfield's streets and parcels remain efficient conduits for vital infrastructure and beautiful, functional corridors for pedestrians, transportation, and transit.

The Guide addresses the use of GI across three types of private and public development projects:

- new developments and redevelopments of private sites;
- new developments and redevelopments of municipal properties, including parks, schools, and other public sites; and
- construction and reconstruction of roadways.

The Guide assists City staff, developers, and consultants to better understand planning, design, operation and maintenance, and monitoring requirements for GI systems, and to lay out options for design solutions that have the greatest net co-benefits for a site. The GI Selection Tool and GI Vegetation Palette that accompany the document are designed to first identify site-specific GI options that are viable for implementation as part of parcel development or redevelopment or street construction or reconstruction

and then determine plant species that would be context appropriate. Guideline drawings provide direction on integration of GI facilities into project components, such as parking areas, buffers, or road rights-of-way. The Guide was informed by precedents and innovative solutions from around North America; therefore, as technology evolves, so too should the Guidelines.

In addition to guiding both private and municipal designers and engineers in resolving stormwater concerns on site, the Guide summarizes Springfield's current stormwater regulations and policies in one location to clearly map the permitting process.

1.3 REGULATORY CONTEXT

Two major regulatory drivers require improved control of point source and non point source stormwater pollution. These are the National Pollutant Discharge Elimination System (NPDES) program, established under the federal Clean Water Act, and the Massachusetts Wetland Protection Act.

1.3.1 CLEAN WATER ACT AND NPDES PROGRAM

NPDES Wastewater Permit

EPA has issued a NPDES permit to Springfield Water and Sewer Commission to regulate point sources that discharge pollutants into waters of the United States. "Point sources" are generated from a variety of municipal and industrial operations, including treated wastewater, process water, cooling water, and stormwater runoff from drainage systems. The NPDES Stormwater Program regulates discharges from Municipal Separated Storm Sewer Systems (MS4s), construction activities, industrial activities, and those designated by the U.S. Environmental Protection Agency (EPA) due to water quality impacts.

NPDES MS4 Permit

Springfield is among twenty-four Pioneer Valley communities with "urbanized areas" that are currently regulated by the EPA to control the amount and quality of stormwater discharges from their MS4 systems into lakes, ponds, rivers, streams, and wetlands. The program's first permit was issued in 2003 and included requirements for public education and outreach, public involvement and participation, illicit discharge detection and elimination, construction site stormwater runoff control, pollution prevention, and good housekeeping in municipal operations.

The new 2016 EPA Massachusetts Small MS4 permit came into effect on July 1, 2018, and places expanded stormwater management requirements on private and municipal developments in all regulated communities. At the time of this Guide's publication, Springfield is working to update its Stormwater Management Ordinance to comply with the new permit, and has begun the required process to select five publicly owned parcels for green infrastructure retrofits. While the City may regulate in favor of stricter policies, the EPA requires any developments an acre or more in size to retain the first inch of stormwater onsite, while redevelopment projects are required to retain the first 0.8 inches. EPA also requires all redevelopments and developments to remove 80-90% of total suspended solids (TSS) from runoff, respectively, and meet advanced nitrogen and phosphorus removal goals. For the current list of Springfield's impaired water bodies, contact Springfield's Natural Resources Manager's office.

THE EFFECT OF COMBINED SEWER OVERFLOWS ON RIVERS

CSOs are significant sources of bacteria contamination and contribute to both losses of water quality and economic and recreational uses for up to 48 hours after the discharge event. There are many negative effects from discharges of untreated sewage and stormwater into a water body, including:

- Public health concerns due to exposure to viruses, bacteria, pathogens, and other CSO-related pollutants from untreated sewage and stormwater
- Bans on swimming, canoeing, fishing, and other economic and recreational activities
- Erosion and overflow of river banks
- Flooded basements and properties
- Unpleasant odors
- Decreased property values for landowners near or downstream from a combined sewer outlet
- Dying fish and wildlife in and around the river
- Loss of scenic beauty

Springfield CSO Outfall Number 3.

EPA Administrative Orders Regarding Combined Sewer Overflows

Springfield has active combined sewer overflow (CSO) outfalls, and Springfield Water and Sewer Commission (SWSC) maintains jurisdiction over combined sewers. Rain events can cause combined sewer systems to overflow so that untreated sewage is discharged directly into receiving waters. The more impervious surfaces, such as streets, sidewalks, and parking lots, the greater the volume and velocity of stormwater runoff in urban areas. Even small amounts of rainfall in Springfield can trigger CSOs into the Connecticut River.

During wet weather, CSOs have dramatic impacts on bacteria concentrations in the Connecticut River. Below the Holyoke Dam, where CSOs are present, average pathogen concentrations during wet weather rise by as much as 12,678%.

Massachusetts 303D List

The Federal Water Pollution Control Act of 1972 and subsequent Amendments in 1977, 1981, and 1987 are collectively known as the Clean Water Act (CWA). The objective of this statute is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. As one step toward meeting this goal, each state must administer a program to monitor and assess the quality of its surface and groundwater and provide periodic status reports to the EPA, the U.S. Congress, and the public. Section 305(b) of the CWA codifies the process whereby waters are evaluated with respect to their capacity to support designated uses as defined in each of the states' surface water quality standards (SWQS). These uses include aquatic life support, fish and shellfish consumption, drinking water supply, and primary (e.g., swimming) and secondary (e.g., boating) contact-recreation. The 305(b) process entails assessing each of these uses for rivers, lakes and coastal waters. Causes and sources of impairment are identified wherever possible.

Section 303(d) of the CWA and the implementing regulations at 40 CFR 130.7 require states to identify those water bodies that are not expected to meet SWQS after the implementation of technology-based controls and to prioritize and schedule them for the development of total maximum daily loads (TMDLs). A TMDL establishes the maximum amount of a pollutant that may be introduced into a water body and still ensure attainment and maintenance of water quality standards. Furthermore, a TMDL must also allocate that acceptable pollutant load among all potential sources. The formulation of the 303(d) List includes a more rigorous public review and comment process than does reporting under Section 305(b), and the final version of the list must be formally approved by the EPA.

All of Springfield drains to the Connecticut River, either directly or through the flow of tributaries, such as the Chicopee River. The Connecticut River flows into the Long Island Sound, for which EPA has finalized a TMDL for nitrogen. Under the MS4 Permit, EPA requires all regulated communities within the Connecticut River watershed to reduce the discharge of nitrogen through the municipal drainage infrastructure into the River or its tributaries. For Springfield, that means that stormwater treatment facilities must be optimized to remove nitrogen from stormwater runoff.

1.3.2 MASSACHUSETTS WETLANDS PROTECTION ACT (MA WPA)

The WPA (Massachusetts General Laws [MGL] Chapter 131, Section 40) protects wetlands and wetland resource areas, such as 100-year floodplains, riverfront areas, and wetland buffers, and the services wetlands provide. The MA WPA encompasses protection of flood control, prevention of pollution and storm damage, and protection of public and private water supplies, groundwater supply, fisheries, land containing shellfish, and wildlife habitat. On the municipal level, Springfield's Conservation Commission administers the WPA. In the event that a development or redevelopment project is sited within a wetland resource area or requires disturbance within a resource area, the Springfield Conservation Commission has authority over stormwater permitting.

WATER QUALITY AND RECREATION ON THE CONNECTICUT RIVER

The Connecticut River in Massachusetts is a Class B Waters, meaning that the River is designated as habitat for fish, other aquatic life and wildlife, and for primary and secondary contact recreation (Massachusetts State Water Quality Standards [314 CMR 4.00]). However, the Connecticut River is also a Category 5 Waters, as it does not support one or more of the intended uses due to the unnatural presence of one or more pollutants.

Category 5 Waters require a TMDL process to establish the maximum allowable loading of pollutants that a water body can receive and still meet the State Water Quality Standards established for protecting public health and maintaining the designated uses of the water body. Although as of 2018 a TMDL has not been developed for the Connecticut River, MassDEP has identified the pollutants for which the Connecticut River needs to be regulated. For the nearly 16 miles from Holyoke to the Connecticut state line, those pollutants include Escherichia coli (fecal coliform bacteria E. coli) and TSS (solid materials, including organic and inorganic, that are suspended in the water). (MA DEP, "Proposed Massachusetts Year 2008 integrated List of Waters. April, 2008)

A girls rowing team enjoys active recreation in the Connecticut River. As a Category 5 Waters, the river can sometimes be unsafe for recreation.

1.4 GREEN INFRASTRUCTURE & GREEN STREETS

1.4.1 GREEN INFRASTRUCTURE

Green infrastructure is an approach to stormwater management that protects, restores, or mimics the natural water cycle. GI strategies are those natural or engineered systems that promote capture and control of rainfall near to where it falls. GI can refer to both pre-existing natural features, such as forests and wetlands, and site-scale practices ranging from reduction of impervious cover to stormwater best management practices (BMPs). In these facilities, stormwater can be cleaned as it: moves through soils and the roots of plants; returns through soils to groundwater (infiltration); returns to the air (evapotranspiration); and/or is captured to irrigate plants or flush toilets (reuse).

The benefits of GI extend beyond mitigation of flooding and water quality impacts. Other co-benefits include ecosystem services such as:

- increasing air quality, as trees' leaves and branches sink particulates and gaseous pollutants;
- reducing ambient air temperatures, as trees provide shade and evapotranspiration,
- providing carbon sinks, and
- recharging groundwater supplies by increasing infiltration of stormwater runoff.

Locally in the Pioneer Valley, economic co-benefits have proven to be just as attractive to municipal officials as the ecosystem services GI can provide. Investing in GI can:

- reduce costs for combined sewer separation, by slowing and infiltrating stormwater runoff;
- mitigate the runoff of polluted urban stormwater;
- reduce energy costs;
- create green jobs;
- improve public health outcomes;
- enhance the quality and quantity of urban habitat; and
- increase neighborhood aesthetics and property values and foster a sense of community.

In fact, green infrastructure's co-benefits are a main reason it can be considered a more efficient investment than traditional gray infrastructure. The Center for Clean Air Policy estimates that:

> "...for every full vegetated acre of green infrastructure, there will be total annual benefits of $8,522 in reducing reducing energy demand, $166 in reduced CO2 emissions, $1,044 in improved air quality, and $4,725 in increased property value (Center for Clean Air Policy, 2011, p. iv).

1.4.2 GREEN STREETS

Green Streets are road rights-of-way that incorporate green infrastructure to complement or replace traditional gray infrastructure. While traditional streets and stormwater infrastructure are designed to shed rainfall from impervious surfaces and convey it through pipes to nearby surface waters, Green Streets capture and control stormwater close to where it falls. Green infrastructure elements of Green Streets can include permeable pavement, bioswales, street trees, and vegetated curb bump outs.

Green Streets can increase neighborhood aesthetics, such as this residential example in the High Point neighborhood of Seattle, WA.

Vegetated stormwater systems are considered best practice design elements in the 2014 Complete Streets Implementation Guide for the City of Springfield and in fact, the design goals of Green Streets often complement and support those of Complete Streets. Street trees and vegetated buffers can increase pedestrian and cyclist comfort and safety by providing shade and a physical barrier between vehicular traffic and bike lanes or sidewalks. GI systems such as curb bump outs and vegetated medians can be traffic calming, and increased vegetation as a whole can improve neighborhood aesthetics and property values. See Section 3.2 for more on the integration of Complete Streets and GI design elements in this Guide.

1.4.3 WHY GREEN INFRASTRUCTURE & GREEN STREETS MATTER IN THE CITY OF SPRINGFIELD

1.4.3.1 Springfield's Past and Present

Impervious cover makes up approximately 40% of the City of Springfield's land area. With traditional storm sewer pipe conveyance, even a light rainfall event results in significant concentrations of pollutants entering the City's streams and, ultimately, the Connecticut River. As climate changes, the Northeast is experiencing storms of greater intensity, duration, and frequency. This means Springfield will generate a greater quantity of stormwater runoff, resulting in increased flooding and decreased water quality. Springfield's high rates of impervious cover mean that a 10 year storm can generate the same amount of flooding as a 25 or 100 year storm in a less impervious watershed.

During 2011 through 2013, Springfield witnessed the impacts of climate change and the need to find ways to live with water and the changing environment firsthand. In those three years, the city experienced five presidentially-declared disasters, the most of any municipality in the country during that time period. The most severe event involved an EF3 tornado on June 1, 2011, which tore a half-mile wide, six-mile long swath of destruction through the heart of the city's downtown and residential neighborhoods. Tornado damage to structures, including leaking roofs, was exacerbated by wind and rains of Tropical Storm Irene in August 2011. Another freak storm, the October 2011 record-early snowstorm, decimated the City's tree canopy which was vulnerable because trees were still fully-leafed out. Springfield's other disasters were a 2011 blizzard and the 2013 Superstorm Nemo.

The 2011 storms destroyed an estimated 100,000 trees citywide. Research indicates that trees serve as critical green infrastructure contributing to rainfall interception; in urban settings a single tree can intercept up to 1,600 gallons of water per year (North East Community Tree Guide, 2007). According to this research, Springfield's extensive overall tree loss now contributes an estimated 40 million gallons of additional stormwater runoff annually. While this analysis includes the tree impact city-wide, the impact from the total tree damage disproportionately affects the ultra-urban neighborhoods along the Connecticut River. The loss of trees contributes to flood risk in these neighborhoods, which are at low elevation, and crossed by tributaries that flow to the river. These heavily developed neighborhoods include residential areas with small lots and limited vegetation.

1.4.3.2 Springfield's Future: Climate Change Adaptation

According to the "Springfield Climate Action & Resiliency Plan Vulnerability and Resilience Analysis" (PVPC & UMass LARP, 2017), over the coming decades, the city will experience much of the same variability in weather patterns as the rest of the region. The Northeast Climate Science Center (NECSC) projects the region will see increases of 3.6-5.04°F in average

Two rain gardens in the Abbey Brook watershed are part of a larger effort to restore this stream system that drains a highly urbanized part of Springfield. The rain garden at the Renaissance School (left) and the rain garden at the Springfield Housing Authority's St. James Commons housing development (right) are two important demonstration projects.

Springfield is already home to several inspiring precedents for nature-based stormwater management solutions. Here, find four examples on both public and private parcels.

Designed by Regenerative Design Group, the rain gardens located at Gardening the Community (left) and the Springfield Museums (right) were installed with the help of volunteers. The 2,900 ft^2 system at Springfield Museums has an 11,800 gallon capacity, while the 1,000 ft^2 rain garden at Gardening the Community can hold up to 3,740 gallons.

summer temperatures, and 3.78-5.76°F in winter temperatures in the years between 2020 and 2039. These temperature changes will mean longer, hotter summers and shorter, warmer winters with less snow and more rainfall (Karmalkar and Bradley, 2017).

Longer, hotter summers mean that extreme heat events are also projected to increase. As predicted by the 2014 National Climate Assessment (NCA), the region could reasonably experience an additional 30-40 days per year above 90°F—double to quadruple the 10-15 days per year the region faced historically (Easterling, et. al., 2014). Due to urban heat island effect (UHI), these conditions will be more intense in cities such as Springfield, where high concentrations of impervious surfaces trap and retain more heat than their more vegetated surroundings. UHI poses a unique risk to low income and more vulnerable populations, as consecutive hot nights make it more difficult to recover from daytime heat in the absence of air conditioning.

In the years between 2020 to 2039, the Northeast will experience 0-5% more precipitation in the summers and 5-15% more precipitation in the winter, with more of that precipitation falling as rain rather than snow. Heavy rainfalls will also be more common, and so will consecutive days without rain, increasing the frequency of both floods and drought conditions (Easterling, et. al., 2014).

Based on these predictions, the City must take aggressive action immediately to not only reduce GHG emissions, but also to adapt to the changes that are forecasted for the coming decades. The Guide will contribute to the development of a resilient city by providing a new vision and standards for design, implementation, and care of GI within Springfield.

Guiding future development with recommended practices to achieve greener city infrastructure will assist in addressing climate change adaptation challenges by:

- Mitigating the effects of climate change by attenuating and infiltrating stormwater runoff; and,
- Facilitating a reduction in GHG emissions that contribute to climate change.

1.4.4 RESILIENT SPRINGFIELD

In 2014, as part of the Phase II National Resilience Design Competition grant award, the City designated the Urban Watershed Resilience Zone, made up of all or portions of Springfield's disaster-impacted and most economically distressed neighborhoods (Brightwood, Memorial Square, lower Liberty Heights, Metro Center, South End, Six Corners, Old Hill, and a portion of Forest Park). According to the City's 2009 urban forest master plan, Growing for the Future, the neighborhoods with the lowest amount of trees per capita include many of those in the Urban Watershed Resilience Zone: Old Hill, Memorial Square, Brightwood and Six Corners. At the time of that plan's publishing, Old Hill had 265 newly planted and established trees since 2005, Memorial Square had 33, Brightwood had 26, and Six Comers had nine. As trees provide significant ecosystem services by slowing and reducing the quantity of stormwater runoff, increasing the quality of stormwater runoff, increasing air quality, and reducing ambient temperatures, they form an integral part of any GI system.

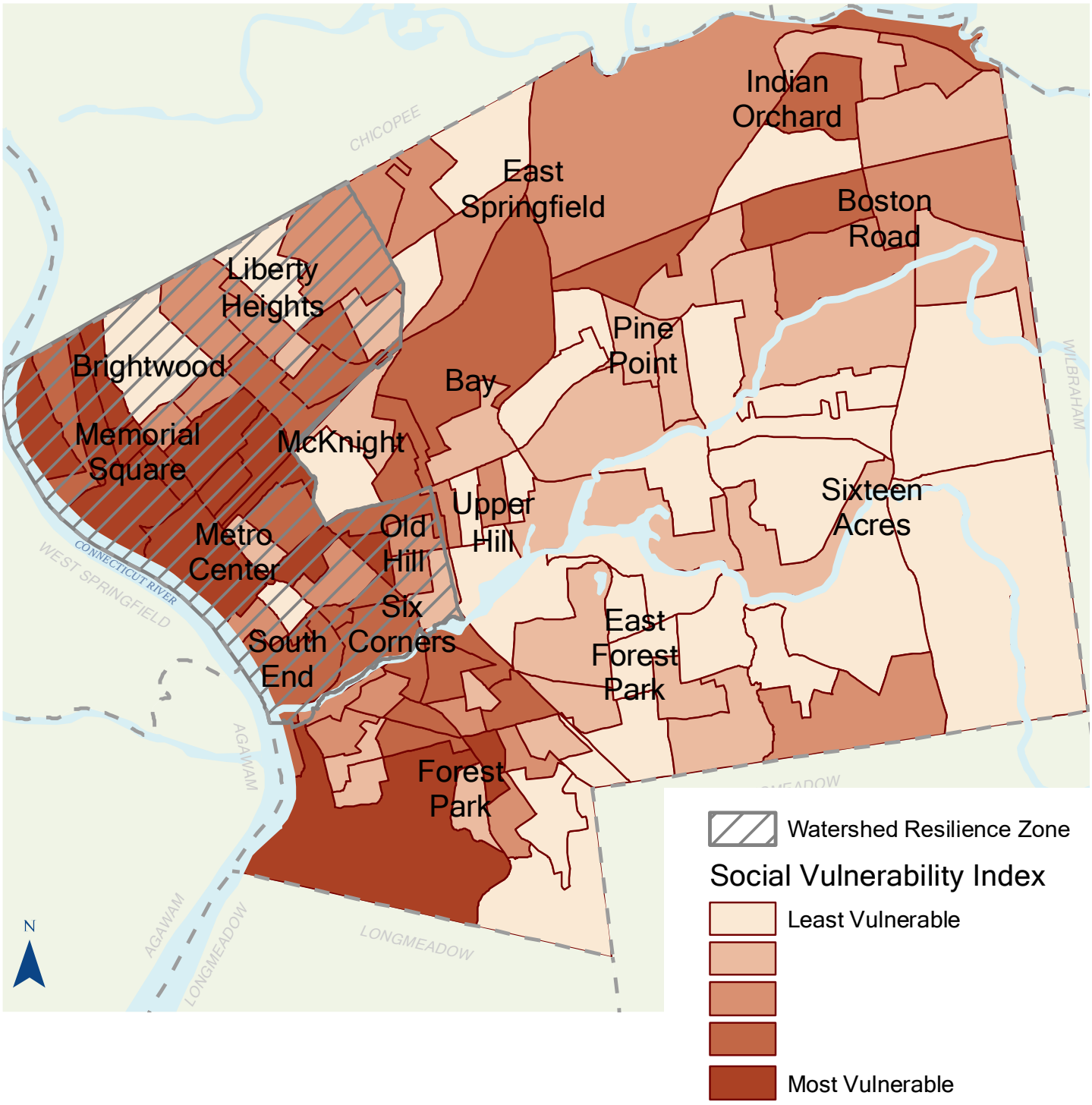
> "We want to sustainably manage Springfield's community forest for maximum environmental, economic, and neighborhood benefit, to result in savings to overall costs and an enhanced quality of life for all residents." (Growing for the Future, 2009)

The "Springfield Climate Action & Resiliency Plan Vulnerability and Resilience Analysis" (PVPC and UMass LARP, 2017) revealed Springfield's neighborhoods with the highest amounts of overlapping vulnerabilities, including low social capacity from such issues as low income, limited English proficiency and car ownership, and other related demographic characteristics. The vulnerabilities also include higher geographic risk based on location in floodplains, high levels of impervious surface, and/or low tree canopy cover. The Vulnerability and Resilience Analysis strongly supports Springfield's emphasis on the Urban Watershed Resilience Zone for climate action and resilience projects. The existing combination of environmental and economic poverty leaves residents open to increased risk of urban heat island effect, flash flooding, and poor air quality. As such, the Strong, Healthy & Just climate action plan and associated vulnerability analysis recommends the City identify projects that provide public health, economic, and environmental benefits, and to cluster these resilience interventions in the most distressed, low income, impacted area, in order to increase the revitalization impact of the projects. These Guidelines especially encourage siting nature-based infrastructure with co-benefits shown to increase environmental and public health in the Urban Watershed Resilience Zone.

The Strong, Healthy & Just climate action plan seeks to not only prepare the City for resilience, but also to mitigate the extent of climate change by providing a path to reduce Springfield's GHG emissions by 80% by 2050. The urban forest, including all vegetated green infrastructure systems, provides a powerful carbon sink capable of offsetting the city's emissions. If the City achieves its climate goal of planting 66,000 new trees by 2060 (Strong, Healthy, & Just, 2017), it will reduce its emissions by 1,320 million tons of carbon dioxide (MT CO2e) per year from those new trees alone.

In the summer of 2018, the Massachusetts Executive Office of Energy and Environmental Affairs certified Springfield as a Municipal Vulnerability Preparedness community. To achieve this certification, the City held two Community Resilience Building workshops to inventory the City's existing vulnerabilities and assets and define appropriate strategies to mitigate or eliminate the risks posed by climate change. Participants, including key stakeholders from across City departments, anchor institutions, academic institutions, the small business sector, utilities, and community organizations, identified developing and adopting a green infrastructure

Municipal and community stakeholders patricipate in the May 2018 CRB.



SOCIAL VULNERABILITY INDEX

The Urban Watershed Resilience Zone encompasses many of the City's neighborhoods must vulnerable to the impacts of climate change.

manual and policy as a top strategy to address multiple vulnerabilities within Springfield. This Guide will serve as that manual.

1.4.5 OBJECTIVES FOR GREEN INFRASTRUCTURE AND GREEN STREETS

Specific objectives that can be achieved through the implementation of GI and Green Street practices include:

- managing stormwater runoff to mitigate flooding and enhance water quality,
- promoting infiltration to sustain shallow groundwater systems and maintain interflow patterns,
- enhancing the extent and longevity of the urban forest,
- mitigating urban heat island effect,
- enhancing air quality, and
- conserving energy usage.

1.5 HOW TO USE THE GUIDELINES

1.5.1 INTENDED AUDIENCE

Integration of GI into Springfield's rights-of-way, public facilities, and private parcel projects will require renewed attention to how developments and streets are planned, designed, constructed, operated, and maintained. The Guide has been formatted to provide guidance to developers, consultants, City staff, and others who are involved in designing, operating, and maintaining Springfield's private and public inventory of stormwater facilities.

1.5.2 APPLICABILITY

The Guidelines are intended to address:

- New development and redevelopment projects requiring a stormwater permit (see Section 2.2: Drainage and Stormwater Permitting Processes)
- Public roadway projects which disturb one or more acres of land or which include widening the road by more than the width of a single lane
- Projects at City facilities (including schools, parks, and other City properties) that meet the threshold to trigger stormwater review
- Projects disturbing land under WPA jurisdiction

Designers should go through the process of using the Tool to screen for GI options on a site specific scale. As part of the site plan and stormwater permit application review processes, or in preparation for a pre-application meeting, the City Stormwater Authority may also use the Tool to review site conditions for applicable GI BMPs so both parties are starting from the same design criteria to inform their negotiations. Municipal and utility engineering staff and consultants involved in reconstructing or retrofitting streets should use the Tool in the same way.

1.6 DOCUMENT OUTLINE

The Guide comprises two main components:

- the Guideline document, which provides technical guidance regarding GI options
- the GI Tool, which provides an initial level of site screening that will help users to identify a palette of GI options (and appropriate plant species, where applicable, via the GI Vegetation Palette) that would be viable given specific site conditions and circumstances.

The following outlines the remained of the Guide.

Section 2.0 | Springfield Stormwater Permitting Processes

The City's stormwater management permitting processes are described in this section. This section does not attempt to reproduce the City's rules, regulations, and ordinances relevant to stormwater in order to avoid conflict as the code is updated or amended. Instead, it outlines the permitting process with references to authorizing code.

Section 3.0 | Green Infrastructure Solutions

Green Infrastructure Solutions considers all of the GI systems listed in the Selection Tool that would be viable within a site given its specific characteristics and circumstances. Section 3.0 provides background on the process of defining a list of GI options that would be viable within Springfield's parcels and road rights-of-way. This chapter also provides description for each GI option identified in the Selection Tool. Construction considerations and Guideline Drawings are also addressed in this chapter.

Section 4.0 | The Selection Tool Outline

As a key element of the Guide, the GI Selection Tool provide efficient means of identifying the most appropriate GI options for a given parcel or street condition and context. The Tool is described in Section 4.0.

Section 5.0 | Operations and Maintenance

Proper operations and maintenance is required in order to ensure the longevity and function of GI options. Section 5.0 describes considerations, costs, repairs, replacement, and expansion for GI techniques.

Section 6.0 | Springfield Paving Specifications

Section 6.0 highlights the opportunity to realize climate mitigation and natural resource protection benefits through the implementation of sustainable practices in the City's paving program. This section describes the updates to the City's paving specifications, with the specifications themselves illustrated in Appendix F.

2 STORMWATER PERMITTING PROCESS IN THE CITY OF SPRINGFIELD

2.1 POLICY SUPPORT AND TARGETS

The Guide has been developed as a tool to assist the City of Springfield achieve its climate mitigation, adaptation, and justice goals as articulated in its official plans, policies, and guides, and to meet its water quality targets as required by the regulatory drivers of the Clean Water Act. Throughout the years, the City has continually identified the need to prioritize GI/ Low Impact Development (LID) in stormwater management. This section calls out that explicit support from City documents.

It is an objective of the City's Stormwater Management Ordinance to:

> "Encourage the use of low-impact development (LID) practices, such as reducing impervious cover, treating and infiltrating stormwater at the source, utilizing environmentally sensitive site design and the preservation of open space and natural areas, to the maximum extent practicable.

In Strong, Healthy, & Just, the Department of Public Works Director Chris Cignoli stated,

> "...Green Infrastructure, making use of natural systems for environmental benefits (in addition to traditional infrastructure) is a good idea, [with] implementation decisions [being] made on a site-specific basis.

The top strategy identified in the Resilient Infrastructure goal of Strong, Healthy & Just is to:

> "Develop a Springfield-specific Green Infrastructure (GI) policy and design manual with city-wide and location-specific standards and a set of criteria to assist developers and the City in determining what type of infrastructure system is appropriate for a given location and project type. This set of criteria should set GI as the standard, requiring developers to prove they have completed a thorough site analysis and alternatives assessment regarding infrastructure systems design.

—in other words, to the maximum extent practicable. The *Massachusetts Stormwater Handbook* states:

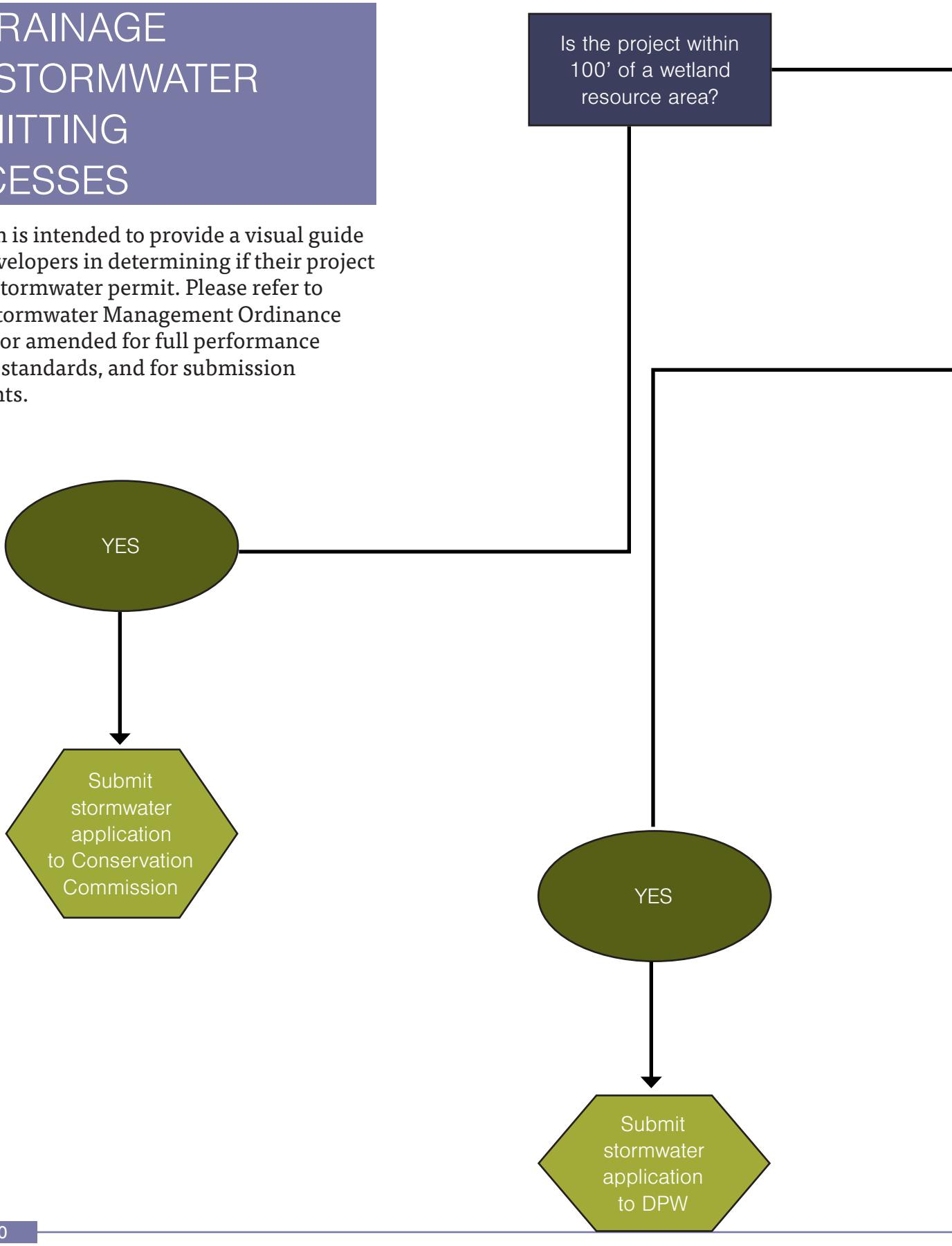
> "'to the maximum extent practicable' means that:
> (1) The applicant has made all reasonable efforts to meet the Standard;
> (2) The applicant has made

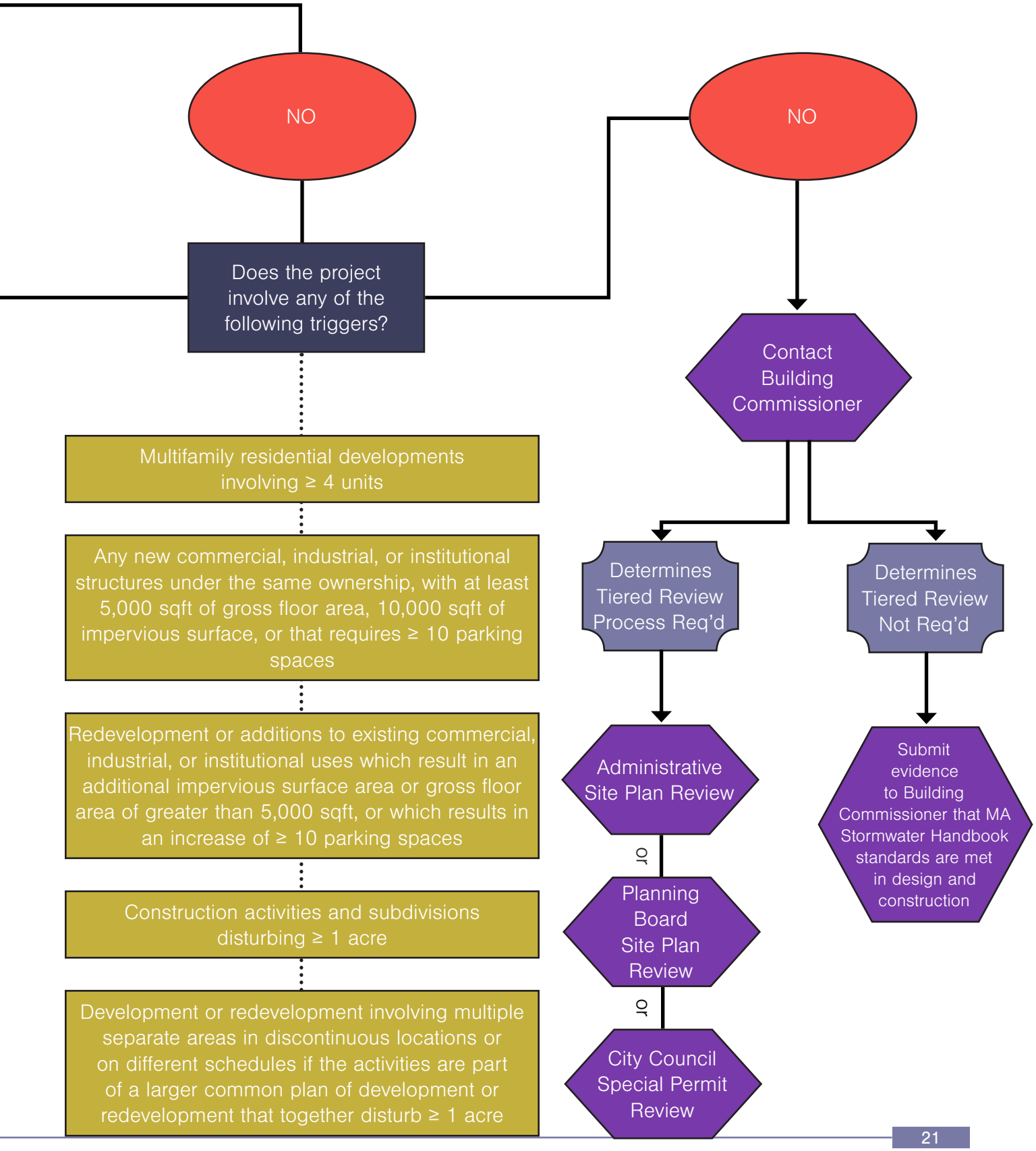
a complete evaluation of all possible applicable infiltration measures, including environmentally sensitive site design that minimizes land disturbance and impervious surfaces, low impact development techniques, and structural stormwater best management practices; and

(3) If the post-development recharge does not at least approximate the annual recharge from pre-development conditions, the applicant has demonstrated that s/he is implementing the highest practicable method for infiltrating stormwater.

2.2 DRAINAGE AND STORMWATER PERMITTING PROCESSES

This section is intended to provide a visual guide to assist developers in determining if their project requires a stormwater permit. Please refer to the City's Stormwater Management Ordinance as updated or amended for full performance and design standards, and for submission requirements.




NO
NO
Does the project involve any of the following triggers?
Contact Building Commissioner
Multifamily residential developments involving ≥ 4 units
Any new commercial, industrial, or institutional structures under the same ownership, with at least 5,000 sqft of gross floor area, 10,000 sqft of impervious surface, or that requires ≥ 10 parking spaces
Redevelopment or additions to existing commercial, industrial, or institutional uses which result in an additional impervious surface area or gross floor area of greater than 5,000 sqft, or which results in an increase of ≥ 10 parking spaces
Construction activities and subdivisions disturbing ≥ 1 acre
Development or redevelopment involving multiple separate areas in discontinuous locations or on different schedules if the activities are part of a larger common plan of development or redevelopment that together disturb ≥ 1 acre
Determines Tiered Review Process Req'd
Determines Tiered Review Not Req'd
Administrative Site Plan Review
or
Planning Board Site Plan Review
or
City Council Special Permit Review
Submit evidence to Building Commissioner that MA Stormwater Handbook standards are met in design and construction

2.3 CHECKLISTS

Multiple departments in the City of Springfield use the term Site Plan Review. Under the context of development or redevelopment, the Department of Public Works has developed a checklist as a guide for anyone proposing a project in Springfield. The checklist requirements are expected to be modified during the review process and final requirements will ultimately depend upon the size and scope of the development. The City's current checklists can be found in online on the City's website at [https://www.springfield-ma.gov/dpw/index.php?id=174#c232]; however, anyone engagaging in project necessitating Site Plan Review and/or a Stormwater Management Plan should always check with DPW to ensure they are using the most up-to-date guidance and checklists available.

The MA Department of Conservation and Recreation's Greening the Gateway Cities program plants trees in urban areas across Massachusetts. This tree was installed on Lucretia Avenue in Chicopee in 2018. Image Credit: MA DCR.

3 GI SOLUTIONS & TECHNICAL GUIDELINES

3.1 LOW IMPACT DEVELOPMENT

LID is a site planning and design process aimed at maintaining the site's natural capacity to manage rainfall. LID strategies include:

- maintaining natural drainage flow paths,
- minimizing and disconnecting impervious surfaces,
- retaining major trees and other existing vegetation/minimizing clearing of existing vegetation, and
- clustering built structures.

The GI options described in Section 3 and listed in the Tool are systems meant to manage the flow of rainwater from impervious surfaces that cannot be avoided in site design layout. Developers should first employ LID design techniques to minimize runoff overall, and then design GI stormwater systems to manage that runoff that cannot be avoided.

3.2 INTEGRATION OF GREEN STREETS WITH COMPLETE STREETS

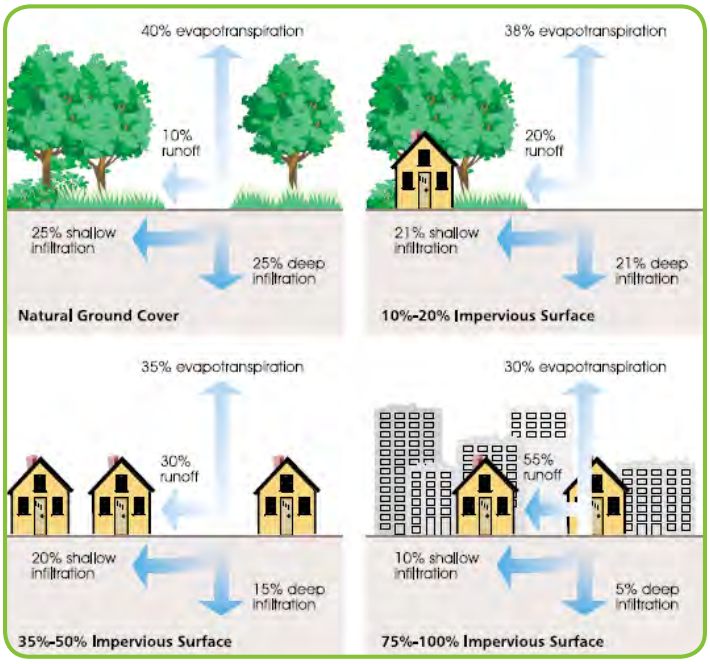
In 2016, the City passed a Complete Streets Policy, committing to consider all streetscape projects (whether new, maintenance, or reconstruction) as opportunities to provide for a comprehensive and integrated street network of facilities for people of all ages, abilities, and modes of travel. To facilitate implementation of the Policy, the City hired PVPC to develop the Springfield Complete Streets Implementation Guide, which identifies context-sensitive applications to provide for multi-modal transportation and traffic calming techniques.

Complete Streets and GI strategies are both important tools available to municipalities in the effort to reduce the impacts of, and adapt to, the effects of the changing climate. Complete Streets contribute to the mitigation of climate change and the reduction of greenhouse gasses through the promotion of transportation modes that generate little or no emissions. In turn, GI can sequester carbon and reduce energy usage in adjacent buildings providing all of the environmental and public health benefits discussed in Section 1.4.

There is sometimes concern that providing for increased bicycle and pedestrian amenities, such as separated bicycle lanes and wider sidewalks, conflicts with the goals of LID (namely, a reduction in impervious surfaces). However, as this Guide and the Complete Streets Implementation Guide depict, with smart design Complete Streets strategies and LID are not mutually exclusive. Complete Streets and LID share a common goal of context-sensitive design solutions at a comfortable, human scale. The Springfield Complete Streets Policy recognizes that "stormwater runoff from streets, roads, parking lots, and other impervious surfaces can be a potential source of water pollution" to local water resources, and emphasizes the potential for "practical infrastructure solutions" to manage stormwater runoff and reduce localized flooding. Following the Policy, the Complete Streets Implementation Guide describes how appropriate nature-based stormwater treatment for each of the four identified Springfield street types (Downtown Commercial, Downtown

Cross Street, Neighborhood Connector, and Residential) can fit into the existing roadway typologies. While new or reconstructed sidewalks or bicycle facilities can be built with porous paving materials, a good GI/LID design can further stack the functions of any one system to provide for attractive pedestrian and cyclist amenities (increased shade, vegetated buffers between vehicular traffic and bicycle lanes and/or sidewalks) while also providing traffic calming benefits (curb bump-outs, vegetated medians, or chicanes).

The GI options appropriate to any applications in or adjacent to street rights-of-way in the GI Selection Tool have been cross-referenced with the streetscape zones and standards defined in the Complete Street Implementation Guide. When incorporating any of the GI options included in the Selection Tool palette into a streetscape (or parking lot) design, designers should consider methods of maximizing multi-modal safety and human comfort while attending to LID stormwater management goals.



Higher rates of impervious cover generate greater volume of stormwater runoff.

3.3 GREEN INFRASTRUCTURE TECHNIQUES AND GUIDANCE

The following section provides a description of GI options. Each of the GI options in the list below is labeled by feasibility of project type for:

- Development or redevelopment of Private Sites (PrS);
- Development or redevelopment of Public Facilities managed by the municipal Parks, Buildings, and Recreation Management department (PuF); and/or
- Construction, reconstruction, or retrofitting/rehabilitation of Public Street Rights-of-Way (PuR).

3.3.1 GREEN WALLS (PrS)

Green walls can provide valuable green infrastructure within confined urban spaces. They can feature plants rooted in the ground and trained to grow up a vertical wall, known as a "green facade," or plants that are rooted in a vertical modular, composite, or custom substrate system that is affixed directly to an existing structural wall, known as a "living wall."

Green walls provide numerous environmental, social and economic benefits including:

- Promoting biodiversity
- Providing habitat and nesting opportunities
- Encouraging ecological linkages
- Improving air quality and reducing ambient air temperature
- Providing water quality and quantity benefits.

Green walls serve to slow and filter stormwater

runoff from rooftops and the sides of buildings as the first element in a treatment train. Selecting the appropriate green wall system and the appropriate plant materials for a particular site is critical to the long-term sustainability of the green wall. Refer to the GI Vegetation Palette for an appropriate palette of green wall plant material.

A green wall in Mexico City filters runoff and cools the urban environment, all while making an artistic statement.

3.3.2 URBAN FOREST CANOPY (PRS / PUF / PUR)

Urban tree canopy is defined as the layer of leaves, branches and stems that cover the ground when viewed from above. Foliage within the canopy slows stormwater runoff, and trees naturally store and direct water into the soil through their trunks and roots and transpire water back into the atmosphere, therefore reducing overall volume. The following planting options proposed for the Guide have been designed to enhance the quantity and quality of the urban forest canopy.

3.3.2.A Street Trees and Shade Trees

Street trees can be planted in a variety of landscape conditions including parking areas, buffer zones, pedestrian areas, and on road rights-of-way within the frontage zones, furnishing zones or medians of most street types.

Planting trees increases the overall urban forest canopy and can improve air quality, reducie the urban heat island effect, and provide wildlife habitat. Suitable species can be identified by contacting the City Forester.

Planting in grassed areas is easier than in paved conditions, where special construction methods are required. Key areas of concern include the interface between trees and utilities, adequate soil volumes (20 - 30 m^3/tree) in order to grow trees to maturity, and the provision of appropriate structural support in conjunction with non-compacted soils while avoiding the destruction of sidewalks and other pedestrian amenities.

3.2.2.B Trees in Soil Cells

Soil cell systems can be used when street trees are desirable in locations where surface areas are limited.

Soil cells are rigid modular systems that increase the soil volume under paved surfaces in ultra-urban areas. They provide the structural integrity required to support vehicular load on paved surfaces while

offering up to 92% porous space in order to accommodate underground services and utilities.

Soil cells can be used under conventional concrete or unit pavers as well as under pervious interlocking concrete pavers. In addition, given their structural integrity, soil cells be used under vehicular load bearing sidewalks, parking lay-bys, or cycling infrastructure to increase soil volumes.

Paved surfaces should be designed to withstand loads from sidewalk plows and midsize service vehicles; therefore, structural soil can be used under paved areas to allow for roots to grow into adjacent soil volumes.

3.2.2.C Trees in Sand-Based Structural Soils

Sand-Based Structural Soil (SBSS) is a non-proprietary mix of stone and soil that supports the sidewalk while allowing tree roots to grow normally. A SBSS system, located adjacent to tree wells, typically includes sidewalks set on a minimum of six inches of open graded crushed stone over a minimum of 30 inches SBSS. Aeration of the overlying stone and source of water are essential to promoting healthy trees; therefore SBSS is often paired with permeable pavement or diversion of gutter flow into a depressed tree well.

3.2.2.D Stormwater Tree Pits

Stormwater tree pits are a variation of the traditional tree pit that receives stormwater runoff from the surrounding landscape or road through curb inlets. They consist of a tree installed in filter media with an open bottom to promote infiltration into the surrounding native soils.

Stormwater tree pits are well-suited to ultra-urban areas and street types, where they are typically installed within the furnishing zone. Where large mature trees are desired, additional soil volume can be provided using soil cells.

3.2.5.E Stormwater Tree Trenches

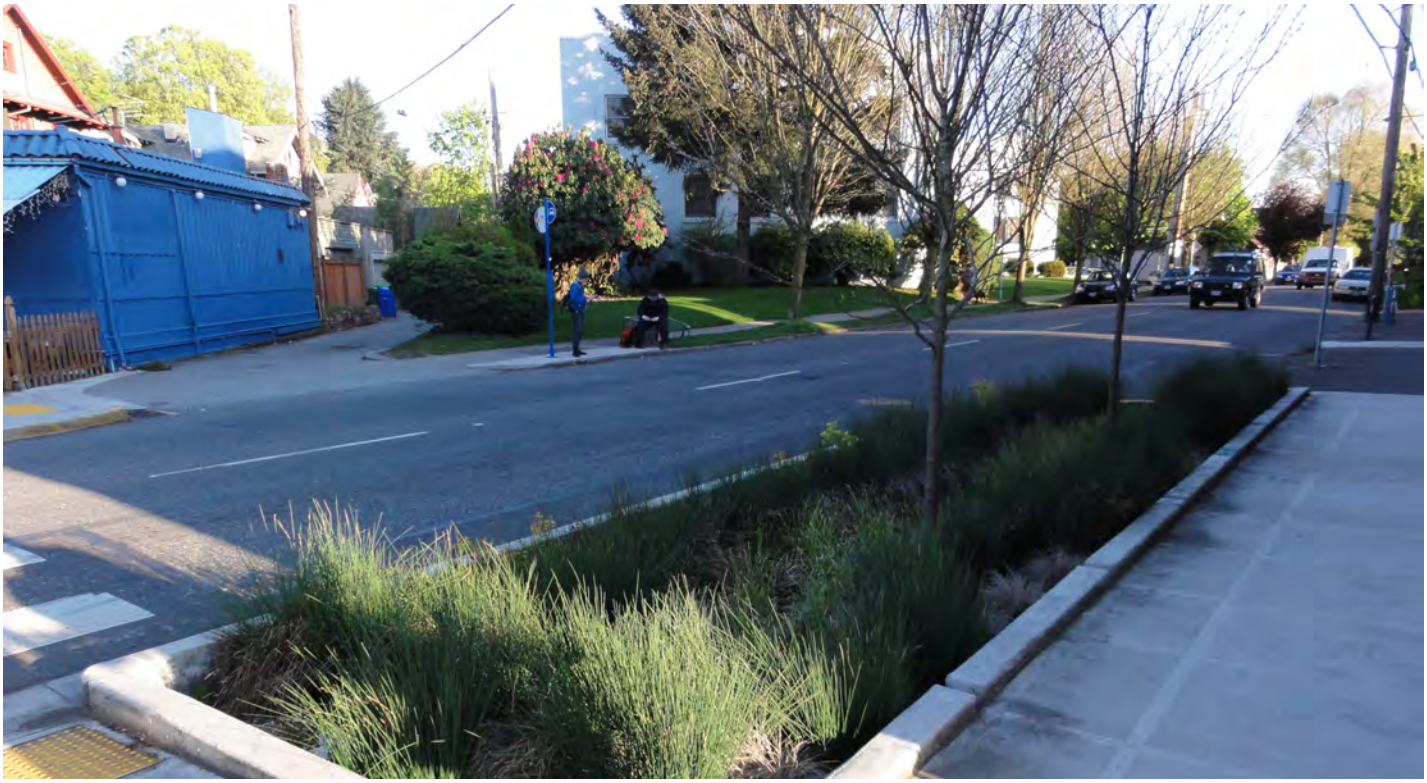
Stormwater tree trenches consist of a series of stormwater tree planters connected through the underground trench system. The excavated trenches are backfilled with engineered soil. Soil volumes can be further augmented by installing soil cells.

Stormwater tree trenches are well-suited to ultra-urban street types and are typically installed within the furnishing zone. Permeable pavement is an optional appropriate surface treatment over a stormwater tree trench as this type of pavement allows for air circulation and water infiltration into the tree trench.

3.3.3 BIORETENTION (PrS / PuF / PuR)

Bioretention facilities are designed to provide temporary storage, filtration, and infiltration of stormwater runoff. Although the physical design of a bioretention facility can vary, the construction profile generally consists of the following: a crushed stone reservoir layer, a choker layer, a bioretention media layer, a mulch layer, and a vegetation layer.

A critical component of any bioretention facility is its drainage system. Proper design of the drainage system will depend on the infiltration rate of existing native soils. Sites with highly permeable soils (>0.17 in/hr) can facilitate bioretention practices that are designed with no underdrain to provide full infiltration. Infiltrating bioretention facilities must be designed to drain fully within 72 hours. Bioretention facilities designed for sites with less permeable soils (<0.17 in/hr and/or draining in >72 hours) will require an underdrain for partial infiltration. In cases where contaminated soils exist or where the water table is less than 2 feet below bottom of the facility, an impermeable liner and underdrain can be integrated into the bioretention cell to create a facility designed for filtration only. This type of



A bioretention planter in Portland, OR displays a textural planting of graminoids, blending in with the yards in the neighborhoods.

bioretention facility is also known as a biofilter.

When considering an infiltration or partial infiltration bioretention option, practices should be located a minimum of 10 feet from the foundation of any building in order to reduce the risk of seepage. Underdrained biofiltration techniques are suitable within 10 feet of a foundation.

Bioretention practices are designed to capture and treat runoff from small storm events. The maximum ponding depth after a storm event depends on its location: adjacent to pedestrian traffic areas (e.g., streetscapes), ponding should not exceed 6 inches; bioretention facilities in other areas can pond up to 18 inches. Larger events are handled by an overflow/bypass structure, such as a standpipe or catch basin with a domed "beehive" grate.

The physical form of bioretention practices can vary to provide a complementary aesthetic within any street or site context. Bioretention basins within municipal street rights-of-way should be planted with grasses or other low-maintenance plants.

Types of bioretention facilities include:

3.3.3.A Bioretention Stormwater Planters

Bioretention planters are constructed with vertical walls, are often narrow and rectangular and can be installed in close proximity to utilities, driveways, trees, lighting, and other street features. Bioretention planters receive landscape and roadway runoff through curb inlets and by overland flow from the surrounding paved surfaces and sidewalk. Underdrained bioretention planters can also be located adjacent to a building to receive runoff from roof downspouts and surrounding sidewalks.

They are well-suited for ultra-urban street types and can be adapted to fit within furnishing zones and medians. As a result of their context, bioretention planters require hardy, aesthetically pleasing plant materials that tolerate harsh urban conditions and winter maintenance protocols.

Bioretention planters are often located in higher pedestrian traffic areas, therefore design solutions should consider planting, curb or railing options that will impede pedestrians from inadvertently stepping into a planter bed.

3.3.3.B Bioretention Curb Extensions

Curb extensions, also known as bump-outs, can be located at intersections, mid-block areas and at transit stops within the edge and roadway zones of various street types. In addition to stormwater management functions, curb extensions can also enhance biodiversity, offer visual appeal and provide traffic calming benefits. Curb extensions are ideal for street retrofit projects as they can usually be installed within the limits of existing street cross-sections.

Curb extensions are typically on-line stormwater management practices, meaning that they are in the direct flow path of runoff that is conveyed along the curb. This is an important consideration as it affects the pretreatment design and maintenance protocols for these options.

3.3.3.C Bioretention Basins

Bioretention basins provide a design variation that is suitable for open spaces, within medians and islands, adjacent to parking lots and driveways, at the back of sidewalks, and on suburban street types within furnishing / planting zones or medians where space is not as constrained. This form of bioretention often receives overland flows from the surrounding landscape and, if in a street project, from the roadway through curb cut inlets. Bioretention basins typically have sloped sides and ponding up to 18 inches. The size and shape can fit the available space.

3.3.4 SWALES (PrS / PuF / PuR)

Swales typically require a large area and are therefore well-suited for installation within open landscaped areas or within planting zones and medians in suburban street cross-sections such as neighborhood residential and connector streets. They consist of linear vegetated channels that convey, treat, and attenuate stormwater runoff. Vegetation and check dams may be integrated into swales to slow the velocity of runoff, allowing for sedimentation, filtration, evapotranspiration and infiltration (depending on soil infiltration rates). Swales should be densely planted to discourage weed pressure, and will need regular maintenance until the vegetation is fully established.

3.3.4.A Enhanced Grass Swales

Enhanced grass swales feature a slightly altered parabolic form and incorporate amended soils that slow runoff and assist in contaminant removal. Enhanced grass swales can serve as a pretreatment option for infiltration practices, particularly on low traffic parking lots, paved areas, or roadways that do not receive high loads of de-icing compounds in the winter. Check dams can be integrated into the design in order to maximize infiltration benefits.

3.3.4.B Bioswales (PS only)

Bioswales are similar to enhanced grass swales in their linear and cross-sectional surface geometry, however their subsurface profile is more reflective of a bioretention cell, with filter media and/or a storage gallery and optional underdrain (depending native soil permeability) below. Bioswales can either be planted with grasses or finished with more elaborate combinations of plant and aggregate materials.

These additional components help to slow the velocity of runoff and assist in sedimentation, filtration, evapotranspiration, and infiltration. As a result of their bioretention profile, bioswales have the potential to be more effective at removing pollutants, reducing runoff, and protecting downstream channels from erosion than enhanced grass swales. Bioswales are also referred to as dry swales or infiltration swales.

3.3.4.C Bioswales with Stone Gutter (PS only)

Bioswales with stone wells provide a formal aesthetic that can be integrated into urban street types. They feature the longitudinal surface geometry and subsurface profile of a bioswale, but also include stone filled wells installed at equidistant spacing along the length of the bioswale to draw stormwater into highly permeable (>0.17 in/hr) native subsoils more efficiently. This type of bioswale can also be fitted with curb outlets to direct overflows downstream to an existing catch basin. A variation on this design can also include a stormwater inlet at the upstream end that funnels runoff directly to the stone layer of the cell.

3.3.5 FILTER STRIPS (PrS / PuF / PuR)

Filter strips are gently sloping, heavily vegetated areas that treat runoff from adjacent impervious surfaces including roadways, sidewalks, parking lots, and driveways. They can be stand-alone stormwater management practices or they can function as pretreatment for other infiltration practices. Filter strips are well-suited to streets with a suburban cross-section or connector streets where no curbs presently exist.

Filter strips should be planted with native material in order to provide maximum ecological and water quality benefits. In the winter months, these areas are well-suited to provide snow storage capacity as they have an excellent capability to filter and infiltrate snow melt in the spring. Filter strips are also referred to as buffer strips.

3.3.6 UNDERGROUND INFILTRATION SYSTEMS (PrS / PuF / PuR)

Underground infiltration systems have little to no surface footprint and can therefore be integrated within almost any site plan or the planting zone or vehicle lanes of almost any street type. The primary function of these systems is to capture, (occasionally) convey, and infiltrate stormwater; therefore, these systems should only be used in locations with permeable (>0.17 in/hr) native soils. Due to the fact that infiltration is a primary function of underground infiltration systems, care should be taken to avoid contributing drainage areas that may be contaminated or that may receive high volumes of de-icing compounds in the winter. Pretreatment should also be integrated into all systems that receive roadway runoff that may contain large quantities of sediments.

3.3.6.A. Leaching Basins

Leaching basins are concrete honeycomb structures surrounded by drainage stone and filter fabric that are installed under a paved surface and gradually allow stormwater to discharge into the surrounding native soils. They overflow to inlets along the street or site and because they treat roadway runoff, a pretreatment system is required. Due to their relatively small surface footprint, leaching basins can easily be implemented throughout a variety of site plans and street types, including ultra-urban contexts, in both new construction and retrofit scenarios. Care must be taken throughout the design and construction processes to ensure that there are no conflicts with existing utilities in retrofit scenarios.

3.3.6.B Perforated Pipe Systems

Perforated pipe systems are connected to catch basins and receive runoff from paved surfaces. The system itself consists of perforated pipes that are installed horizontally along a gradually sloping subsurface trench that is filled with granular and wrapped in geotextile fabric. They can be used in place of, or as a complement to, conventional pipe systems. Due to their relatively small surface footprint, perforated pipe systems can be implemented in almost any street type. However, because of the many constraints inherent to a retrofit scenario, perforated pipe systems are ideally-suited to new construction projects.

3.3.6.C Infiltration Trench

Infiltration trenches consist of a linear trench lined with geotextile fabric and filled with clear granular stone. Infiltration trenches are well-suited for areas where space is limited to a narrow strip including medians, planting zones or low volume vehicle lanes. They can be covered with stone, vegetation, or paving depending on context. Infiltration trenches are also referred to as linear infiltration galleries or linear soakaways.

3.3.6.D Infiltration Chamber

Infiltration chambers are a design variation on infiltration trenches, and incorporate prefabricated modular chambers that are installed under medians, planting zones, or low volume paved surfaces to store runoff temporarily before infiltrating it into the underlying native soils. The chambers typically have an open bottom and perforated side walls and are usually placed over a stone reservoir. They can be installed individually or in series depending on available space. Infiltration chambers are well-suited to new construction scenarios, but can also be integrated into retrofit projects with careful planning. Infiltration chambers may also be referred to as infiltration tanks.

3.3.7 PERMEABLE PAVEMENTS (PRS / PUF)

Unlike traditional impervious surfacing materials, permeable pavement allows stormwater to infiltrate through the surface into a subsurface stone reservoir rather than collecting and being conveyed as surface runoff. Stormwater is temporarily detained and, in most cases, infiltrated into the native subsoils. Similar to other infiltration-based practices, the requirement for an underdrain relates directly to the permeability of underlying native soils.

Permeable pavements are suited to several applications within streets, including: decorative paving, cycling infrastructure, parking lay-bys and on-street parking areas, as well as on the roadway surfaces of low traffic streets such as lanes and shared streets. Permeable pavements can be used in both new and retrofit scenarios. Existing or predicted vehicle use will determine if permeable pavement is an appropriate solution for a given site. Areas that experience high traffic volumes, or use by heavy-duty vehicles, may be less suitable this strategy. The following types of permeable pavements are recommended for use within private sites and municipal properties.

3.3.7.A Pervious Concrete

Pervious concrete has fewer fines then conventional concrete, creating void spaces (15%-35%) within the material. This material provides a suitable replacement for conventional concrete throughout all street types for use in sidewalk applications and is ideally-suited to applications within sites where space is limited.

3.3.7.B Porous Asphalt

Porous asphalt features air pockets that are created as a result of the inclusion of fewer fines and less sand content than traditional impervious asphalt. These void spaces allow water to filter

through to the aggregate layer below. Porous asphalt provides a suitable alternative to conventional asphalt and can be used within parking lots and road rights-of-way in areas such as cycling infrastructure, parking lay-bys, and multi-use recreational trails.

3.3.7.C Permeable Interlocking Precast Concrete Pavers

Permeable concrete paver systems have expanded joints that allow for 5%-10% of a paved surface area to be filled with porous aggregate material. These voids allow water to filter through to the aggregate layer below. Permeable concrete pavers can be used in a variety of applications such as for parkscapes, areas of recreation, lane paving, decorative paving treatments, and parking lay-bys within various street types.

3.3.7.D Flexipave Porous Rubber

Flexible porous paving is heavy-duty porous pavement made from recycled passenger tires. The product can infiltrate up to 3,000 gallons per square foot per hour. Flexible porous paving is an option for paving around street trees, for soft play surfaces and sporting surfaces, or as a lower impact recreational trail surface.

This attractive example of permeable concrete pavers in Golden, CO won the 2012 Hardscape North America Hardscape Project Award.

3.3.8 RAINWATER CISTERNS (PRS / PUF)

Rainwater cisterns intercept, convey and store rainfall for future use. Cisterns can be above or below grade, and capture runoff to reuse rainwater for irrigation and maintenance purposes. This type of system can be effective in reducing demands on the municipal potable water system.

3.4 DESIGN & CONSTRUCTION CONSIDERATIONS

3.4.1 DESIGN CONSIDERATIONS

GI projects are complex and require the expertise of knowledgeable professionals with experience in GI design and construction, who understand the project objectives as well as the complexities of the site. The first step in the design process for any GI project is to establish environmental objectives based on the project priorities and regulatory requirements. These objectives will guide the design and implementation process. Subsequently, a palette of GI options must be defined based on site specific criteria using the GI Selection Tool. Once a palette of GI options is identified, utility locations and site testing should be undertaken immediately in order to confirm the applicability of selected GI options for the given site. Testing and time requirements can vary for each GI option. The creation of an appropriate design solution will require input from team members representing the various disciplines, and, for municipal projects, from representatives from the relevant departments within the City prior to implementation.

3.4.2 CONSTRUCTION CONSIDERATIONS

3.4.2.1 Contractor Selection

Contractors selected to undertake work on GI projects should have extensive knowledge and experience in the design and construction of GI options.

3.4.2.2 Construction Oversight

Construction oversight by the design engineer is required to ensure all installations occur as designed and function properly. The design engineer must also be present at all inspections so that they can certify as-built plans when project is completed.

3.4.2.3 Site Preparation

Requirements for site preparation will vary based on the types and complexity of GI options proposed and whether the work is part of an extensive parcel development or street reconstruction project, or a less intensive retrofit project. For example: If a proposed bioretention planter is designed to incorporate an infiltration component, then it will be important to ensure that appropriate barrier fences and erosion and sediment control measures are established around the perimeter of the site prior to construction in order to avoid any potential for compaction or contamination of the profile during construction. In addition, any contributing stormwater runoff should be diverted away from the installation until construction is complete. Finally, it will be important to have an erosion and sediment control plan (to comply with the City Stormwater Management Ordinance, as updated) in place in order to mitigate the potential effects of heavy storm events. This plan must be implemented by the contractor in order to reduce the risk of site contamination.

3.4.2.4 Construction Sequence

The following are typical steps for constructing GI practices aimed at achieving stormwater management objectives. This process may vary depending on the exact specifications and performance requirements of the design.

1. Verify locations of underground services and utilities;
2. Perform infiltration testing to confirm the permeability of the subsoils;
3. Confirm that the designed capacity of the GI option will accommodate the volume of stormwater anticipated from the contributing drainage area;
4. Establish an erosion and sediment control plan and install ESC measures;
5. Divert contributing runoff temporarily;
6. Stage construction materials in a clean and secure location in close proximity to the installation site. This will minimize the risk of material compaction or contamination;
7. Implement traffic controls (pedestrian and / or vehicular) where required;
8. Where applicable, isolate pretreatment installations until the main facility is complete;
9. Wherever possible, excavate installation using equipment located outside of the area of disturbance;
10. Scarify the base of the excavation for infiltration-based GI facilities;
11. Install the sub-base profile (if applicable) as per construction drawings;
12. Install premixed filter media (if applicable) in maximum 12" lifts. Apply water to pack material without excessive compaction;
13. Apply mulch layer (if applicable) as per construction drawings;
14. Install plant material (if applicable) as per the landscape plan;
15. Install surface material (if applicable) per construction drawings;
16. Confirm that all elevations are in accordance with the detailed design drawings including inlets/outlets, pretreatment, and overflow;
17. Ensure that the GI installation is functional prior to redirecting contributing stormwater runoff into it.

3.4.2.5 Additional Considerations

Inspect the installation weekly for 3-6 months after construction (as well as after heavy rainfall) to ensure that the facility is functioning as designed.

Consider options for reducing the carbon footprint of a project during construction by sourcing local products and specifying lower carbon or recycled materials and components.

3.5 GUIDELINE DRAWINGS

Guideline Drawings have been prepared for most of the options listed in the GI Selection Tool. It is important to note that these drawings are not City of Springfield Standard Drawings. The goal of Springfield DPW is not to dictate design, but to guide project plans to align with the Guide objectives. The guideline drawings included herein contain the information necessary to develop site specific construction details. The Guideline Drawings are located in APPENDIX C.

4 THE SELECTION TOOLS

4.1 THE GI SELECTION TOOL

The GI Selection Tool assists users to identify a palette of GI options for a site given its specific characteristics. A GI Vegetation Palette has also been provided as part of this guideline to identify appropriate plant material for vegetated GI options. The GI Selection Tool is a Microsoft Excel-based system that comprises the following four tabs:

Tab 1.0 | How to Use the Tool
This is a quick reference that provides a detailed description of the Tool and guidance on its use. Refer to Appendix D of this guideline document for a complete description of methods for utilizing the Selection Tool.

Tab 2.0 | Key Criteria
An additional quick reference that defines each of the screening parameters that are built into the Selection Tool.

Tab 3.0 | Projects Selection Tool
This tab should be used for initial screening of projects in Public Rights-of-Way, Public Facilities, and Private Sites.

The Selection Tool provides a comprehensive database of all City-approved GI options that could be implemented within Springfield Public Rights-of-Way, Public Facilities, and Private Sites. The data can be filtered based on any single, multiple, or all nine key selection parameters. This screening process allows the user to indentify a palette of viable GI options based on site-specific site criteria. Criteria relevant to a specific GI option (or permutation) are denoted by an "X" in the appropriate cell. As the database is progressively filtered, a refined list of relevant GI options is provided.

4.1.1 GI OPTIONS

GI options have been selected for their compatibility with the City's climate and context. Each potential GI practice is described in detail in Section 3.0. Several of the GI practices listed include various permutations of the same option. For example, in the category of Permeable Paving the following permutations exist:

1. Permeable Paving with underdrain - Pervious Concrete
2. Permeable Paving with underdrain & Impermeable Liner - Pervious Concrete
3. Permeable Paving with underdrain - Porous Asphalt
4. Permeable Paving with underdrain & Impermeable Liner - Porous Asphalt
5. Permeable Paving with underdrain - Interlocking Precast Concrete Pavers
6. Permeable Paving with underdrain & Impermeable Liner - Interlocking Precast Concrete Pavers

Each of these variations exist because they provide a functional solution related to certain specific conditions, therefore each has been listed as a separate line item. In addition, each GI option can be used in various project "Applications"; therefore, individual line items have also been created for the various permutations of a GI option within each relevant "Application".

4.1.2 SCREENING CRITERIA

Relevant GI options are identified through a screening process using the "filter" function. Users are to work from left to right through the screening parameters to arrive at a

GREEN INFRASTRUCTURE SELECTION TOOL

GREEN INFRASTRUCTURE OPTIONS

- GREEN WALLS
- GREEN ROOFS
- BLUE ROOFS
- URBAN FOREST CANOPY
  - Street and Shade Trees
  - Trees in Soil Cells
  - Trees in Sand-based Structural Soils
  - Stormwater Tree Pits
  - Stormwater Tree Trenches
- BIORETENTION
  - Bioretention Stormwater Planters
  - Bioretention Curb Extensions
  - Bioretention Basins
- SWALES
  - Enhanced Grass Swales
  - Bioswales
  - Bioswales with Stone Gutter
- FILTER STRIPS
- UNDERGROUND FILTRATION SYSTEMS
  - Leaching Basins
  - Perforated Pipe Systems
  - Infiltration Trenches
  - Infiltration Chambers
- PERMEABLE PAVEMENTS
  - Pervious Concrete
  - Porous Asphalt
  - Permeable Interlocking Precast Concrete Pavers
  - Flexible Porous Rubber
- RAINWATER CISTERNS

PROJECT SPECIFIC INPUT

- PRIVATE SITE
- MUNICIPAL SITE
- ROAD ROW

SELECTION CRITERIA

- PROJECT TYPES
- APPLICATIONS
- PHYSIOGRAPHY
- STORM SEWER INFRASTRUCTURE
- URBAN FOREST CANOPY COVER
- WATERSHED CONTEXT
- OPERATION AND MAINTENANCE

PALETTE OF VIABLE PROJECT SPECIFIC GREEN INFRASTRUCTURE OPTIONS

suite of GI options that are suitable to specific site conditions. The remainder of this chapter focuses on describing the screening parameters incorporated within the GI Selection Tool.

4.2 SELECTION PARAMETERS

4.2.1 TYPE OF WORK

Although technically the last user input when using the Selection Tool, the first step in the process is to identify whether the proposed work is a Public Street Right-of-Way, Public Facility, or Private Site development. Applications in the GI Selection Tool have been developed for each scenario since there are different opportunities and constraints that apply to each.

4.2.2 SELECTION PARAMETER A: PROJECT TYPES & THEIR APPLICATIONS

4.2.2.1 Public Street Rights-of-Way

Selecting street applications is of critical importance to the Tool process as they not only dictate the types of systems viable within a street, but also the form and aesthetics of the GI techniques. Best practices for street zone design elements and dimensions are defined in the Springfield Complete Streets Implementation Guide, and zones and facilities follow National Association of City Transportation Officials (NACTO) defintions.This Guide includes the following applications:

- Frontage Zone
- Amenity Zone
- Cycling Facilities (Separated)
- Cycling Facilities (Integrated)
- On-Street Parking
- Vehicle Lanes
- Medians/Raised Islands
- Crosswalks
- Intersections
- Mid-Block
- Bridges

4.2.2.2 Public Facility Applications

To be considered viable in Public Facility applications, GI systems must have maintenance needs that can be met by current City staffing and programatic capabilities. This Guide considers the following types of Public Facility applications:

- Parks and Open Space
- Driveways
- Public Parking Lots
- Public Sidewalks and Paths
- Public Buildings

4.2.2.3 Private Sites

GI systems within private sites are limited only by the imagination and operations and maintenance capabilities of the site owner. While the application categories mirror those of public facilities, Private Sites have an expanded palette of viable GI systems to encourage flexible and creative design options. Types of Private Site applications include:

- Open Space
- Private Driveways
- Private Parking Lots
- Private Sidewalks and Paths
- Private Buildings

4.2.3 SELECTION PARAMETER B: PHYSIOGRAPHY

An understanding of the landscape character of a site provides direction critical to the development of functional GI options that complement the neighborhood and fulfill the City's environmental objectives. The physiographic, biophysical, and hydrologic conditions of a site will not only determine the types of GI options that are possible, but also the permutation of the option that will produce a functional solution. For example, on sites with highly permeable soils, infiltration-based GI options will provide the optimal solution. However, on a site with impervious soils, a practical permutation to the option would include an underdrain (and impervious barrier when required) to provide a solution that relies on a combination of attenuation, conveyance, and filtration practices.

4.2.3.1 Characterization Parameters

Physiographic, topographic, and hydrogeological characteristics determine the palette of potential GI options (or permutations thereof) that would be viable within a given site. Physiographic factors such as soil permeability and depth to bedrock determine whether infiltration based GI options would be viable on a particular site. If certain tolerances are not met then alternative permutations (underdrains) are considered. Topography refers to the change in gradient over a site and can affect factors such as discharge rates, runoff velocities, and flow patterns. Certain GI options are not well-suited to steep slopes and therefore can be excluded from consideration based on this parameter. Hydrogeological factors, including depth to water table and bedrock, can also impact the design and function of various GI options.

4.2.3.2 Reference Maps

In order to expedite the screening process, reference maps have been developed for each of the following parameters:

- Topography
- Depth to Water Table
- Depth to Bedrock
- Soil Permeability
- Areas of Known Soil Contamination

These maps were developed based on City and MassGIS data and are included in Appendix D to allow for quick referencing throughout the process. Reference maps should only be used for preliminary screening purposes. Site specific investigations will be required in order to produce optimized site specific design solutions.

A. Topography

Topography is another key factor in determining whether infiltration-based GI options are appropriate for a given site. Topographical gradients are divided into the following range classes:

- Area TG-1 = Slope 0-5%
- Area TG-2 = Slope 5-10%
- Area TG-3 = Slope >10%

The topographic gradient ranges throughout the City are illustrated in Map 1.

B. Depth to Water Table

Shallow water table conditions (<3 ft) can present challenges for the location, design and function of infiltration-based GI options. The potential for discharge of contaminated runoff into ground water resources is the primary concern, however this does not eliminate the opportunity to implement GI options. Infiltration-based GI options will require design adjustments that will allow the facility to perform attenuation, filtration and conveyance functions, rather than infiltration. Depth to Water Table has been subdivided into the following three categories in the GI Selection Tool:

- Area WT-1 = <3 ft
- Area WT-2 = 3-5 ft
- Area WT-3 = >5 ft

Water table depths throughout the City are illustrated in Map 2.

C. Depth to Bedrock

Bedrock influences the ability to implement infiltration-based options and options that require deeper excavation. Depth to Bedrock has been subdivided into the following three categories in the Selection Tool:

- Area BE-1 = <3 ft
- Area BE-2 = 3-5 ft
- Area BE-3 = >5 ft

Bedrock depths throughout the City are illustrated in Map 3.

D. Soil Permeability

Permeability is a key factor in determining whether infiltration-based GI options are suitable for a given site. All projects must review NRCS soil survey information and perform on site soil percolation testing. Soil types and infiltration rates will determine if infiltration capacity for design standards can be reduced for a particular site. A general map of Soil Permeability throughout the City is illustrated in Map 4.

E. Contamination

This map refers to areas of existing soil contamination within the City. Contamination could be on private property, within the road right-of-way or on sites associated with former landfills. The screening options for this category are simply 'Yes' or 'No'. Contaminated sites generally provide limited green stormwater management opportunities. Site contamination mapping for the City of Springfield is represented in Map 5.

4.2.4 SELECTION PARAMETER C: STORM SEWER INFRASTRUCTURE

Traditional stormwater drainage systems were designed to collect runoff from impervious surfaces and convey it as quickly as possible through a system of underground pipes or surface ditches to outlet in the nearest river, stream, or water body. The two common types of conveyance infrastructure include combined sewer systems and separated sewer systems. Combined systems collect and transport sewage water and runoff within the same pipe, whereas separated systems convey sewage independently from stormwater runoff. Combined systems are of particular concern since flows that exceed the capacity of the system in large storm events discharge untreated effluent into the receiving watercourse or water body.

GI can help to relieve pressure on conventional conveyance infrastructure through the implementation of options that control and treat stormwater runoff as close to the source as possible. In areas where combined sewers exist, stormwater management priorities include attenuation and infiltration in order to reduce runoff volumes, therefore GI options identified through application of the GI Selection Tool are focused on quantity control.

Rural systems comprise open swales or ditches that are well-suited to retrofitting to include bioretention, infiltration or storage. Urban streets generally employ piped systems and therefore different GI options are more appropriate due to the presence of curbs and catch basins (CBs). Areas serviced by combined and separated sewers are illustrated on Map 6.

4.2.5 SELECTION PARAMETER D: URBAN FOREST

Enhancing urban forest canopy is a key priority since it will improve air quality and help to reduce urban heat island effect. Within the GI Selection Tool, urban forest canopy is considered in terms of its general health and abundance in an area. In areas where the quality and extent of the urban forest canopy is low, GI options that incorporate extensive tree planting are a priority. Where urban forest canopy quality is high, priorities may shift to focus on other higher priority GI options. See Map 7 for canopy cover throughout the city.

4.2.6 SELECTION PARAMETER E: WATER BODY IMPAIRMENTS

Although watershed context is not a selection parameter included in the GI Selection Tool, it is a parameter that should be considered to identify GI options that will help to mitigate impairments in a receiving watercourse. Therefore, Appendix D includes a map of waterbodies (Map 8) to illustrate areas of impairment according to the Massachusetts Year 2016 303(d) List of Impaired Waters within the City. Where impairment vulnerability is high, priority should be placed on designing BMPs to clean and control contaminated runoff. In areas that do not drain to impaired waters, quality control may not be as important as quantity control or other environmental priorities.

4.2.7 SELECTION PARAMETER F: OPERATIONS AND MAINTENANCE

Siting for GI options must consider existing operations and maintenance regimes in order to be practical. Therefore, the following maintenance and operations criteria have been incorporated into the GI Selection Tool.

Winter Maintenance Protocol

- Salt Application
- Sand Application

Garbage /Solid Waste

- Curbside Waste Removal – GI options cannot obstruct access for garbage removal.

4.3 GI SELECTION TOOL NIL RESPONSE

The GI Selection Tool is designed to provide no 'nil' response. In other words, there should be at least one GI option available for every site. If the tool provides a 'nil' response, then adjustments to the following selection parameters should be considered:

1. Soil amendments
2. Alterations to site grading
3. Use of impervious liners
4. Relocation of utilities

4.4 SELECTION PRIORITIES

Objectives related to project priorities should be established prior to application of the Selection Tool on any GI project. Once City staff or the project designers have arrived at a site-appropriate palette of GI options using the GI Selection Tool, options should be assessed to determine the relative priority based on their

ability to satisfy the related project objectives. The selection of a preferred option should not simply default to the least expensive solution, but rather should optimize benefits while achieving cost efficiency.

4.5 IMPLEMENTATION

The process of generating the Guide included a review of the various implementation programs that have been adopted by several municipalities within the United States and Canada. The review identified a number of commonly adopted initiatives, including the following:

Dedicated Green Infrastructure (GI) Team:
Every city studied had assembled a GI team that is dedicated to implementing GI projects.

Interdepartmental Communication and Coordination:
For municipal projects, interdisciplinary coordination was identified as a key objective to address multi-departmental implementation and operations/maintenance issues.

Consistent Funding:
All of the municipalities that were researched had allocated consistent and appropriate funding to complete the design, implementation and monitoring of GI installations for municipal projects.

Policy Support:
All of the municipalities that were researched had implemented policies to support the implementation of GI works.

Partnerships:
For municipal systems, the establishment of partnerships with BIDs, stakeholder groups, and community groups was identified as a necessary step to catalyze the implementation, maintenance and monitoring of GI.

Cost/Benefit:
Many of the municipalities had identified a need to confirm the cost and benefit of each GI option.

Training:
The need to implement a comprehensive education and training program was identified as essential to ensure that the City staff that are involved in the design, construction, and maintenance of GI are fully aware of the objectives, functions, and unique attributes and requirements associated with GI.

In addition to these general findings, the following specific implementation initiatives have been identified for municipal consideration to support the implementation of GI.

1| Coordination

- Develop a dedicated Green Infrastructure Team to administer the Guide;
- Confirm infrastructure ownership/ responsibility;
- Update design and construction standards to include GI specifications;
- Refine the permitting process to accommodate GI applications;
- Coordinate municipal works implementation with utility and infrastructure life-cycle estimates to ensure that new GI installations are not damaged or destroyed due to scheduled

maintenance or replacement;

- Review and update the Guide and Selection Tool as required;
- Create and maintain a concise inventory database of GI projects throughout the City.

2| Education and Training

- Undertake outreach to engage consultants and contractors;
- Investigate the potential to require mandatory professional training and certification for consultants and contractors involved in GI projects;
- Investigate the potential to develop professional training and certification programs;
- Develop demonstration projects to showcase different GI options.

3| Public Consultation

- Enable community engagement and education to enhance public awareness of the number and locations of GI options implemented throughout Springfield as well as the environmental benefits of each;
- Promote participation in conferences and workshops that heighten public awareness and youth engagement;
- Explore expanded partnerships with community and resident groups for management of GI installation.

4| Design Process

- Identify project objectives from the outset;
- Integrate GI and Complete Street goals in any roadway projects.

5| Operations and Maintenance

- Develop an appropriate operations and maintenance plan for each GI option;
- Explore the merits of alternative methods that could assist with maintenance of public GI practices such as citizen reporting (via an app), maintenance agreements with neighborhood residents or community groups.

5 OPERATIONS AND MAINTENANCE

5.1 OPERATIONS AND MAINTENANCE

5.1.1 OPERATIONS AND MAINTENANCE CONSIDERATIONS

It is critical that the requirements for the operations and maintenance (O&M) of GI options be considered from inception of the conceptual design through the extent of their life-cycle. Designers must understand the capabilities of O&M staff and the available inventory of equipment and should design GI facilities in accordance with these considerations. At the same time, GI will soon become the "new normal" within Springfield's parcels and road rights-of-way; therefore, adjustments will be required to O&M policies and procedures, budgets, staffing, and equipment in order to accommodate these evolving technologies moving forward. Key areas of focus will include:

- Updating of the City's O&M strategies, policies, and procedures (including winter maintenance);
- Planning and designing both municipal and private GI systems with maintenance and monitoring strategies in mind; and
- Ensuring a long term O&M Plan that meets City and DEP requirements is confirmed for each GI project prior to implementation/ installation.

Appendix E provides a general outline of O&M requirements for each GI option listed within the Selection Tool. The database identifies tasks, timing/frequency, equipment, personnel and training that will be required. Appendix E also addresses inspection and monitoring, repair and replacement, access to utilities infrastructure, and life-cycle requirements.

5.1.2 OPERATIONS AND MAINTENANCE COSTS

O&M costs are a significant consideration for both the City and owners of private systems. Additional budget considerations should include:

- Any increase in costs to maintain GI options over and above what would have been required in a "business-as-usual" case;
- Opportunities to synthesize GI and routine maintenance regimes;
- Additional equipment and staffing requirements; and,
- Education and training for all O&M staff.

For municipal systems, opportunities exist for cost savings through creative partnerships with neighborhood residents and volunteer community groups, where resident groups might care for the plant material with the City maintaining responsibility for inspections, flushing, vacuuming, etc. In order to capitalize on these partnership opportunities, an initial investment would be required to address outreach and education; however, with established maintenance expectations identified and partnership agreements in place, this initial effort and investment can prove beneficial to reduce maintenance efforts.

5.2 GI REPAIRS, REPLACEMENT, AND EXPANSION

5.2.1 REPAIRS

Repairs are inevitable throughout the life-cycle of most GI options. Repairs are typically required less frequently than routine maintenance and are often discovered during annual visual or performance inspections of the GI installation. In rare cases, repairs can be required due to impacts from outside forces including:

- extreme weather events;
- contamination of the contributing runoff area;
- failure of erosion and sediment control systems associated with an adjacent exposed site;
- failure of drainage, inlet, or pretreatment devices; or,
- requirements to access utilities that are in need of repair, replacement, or augmentation.

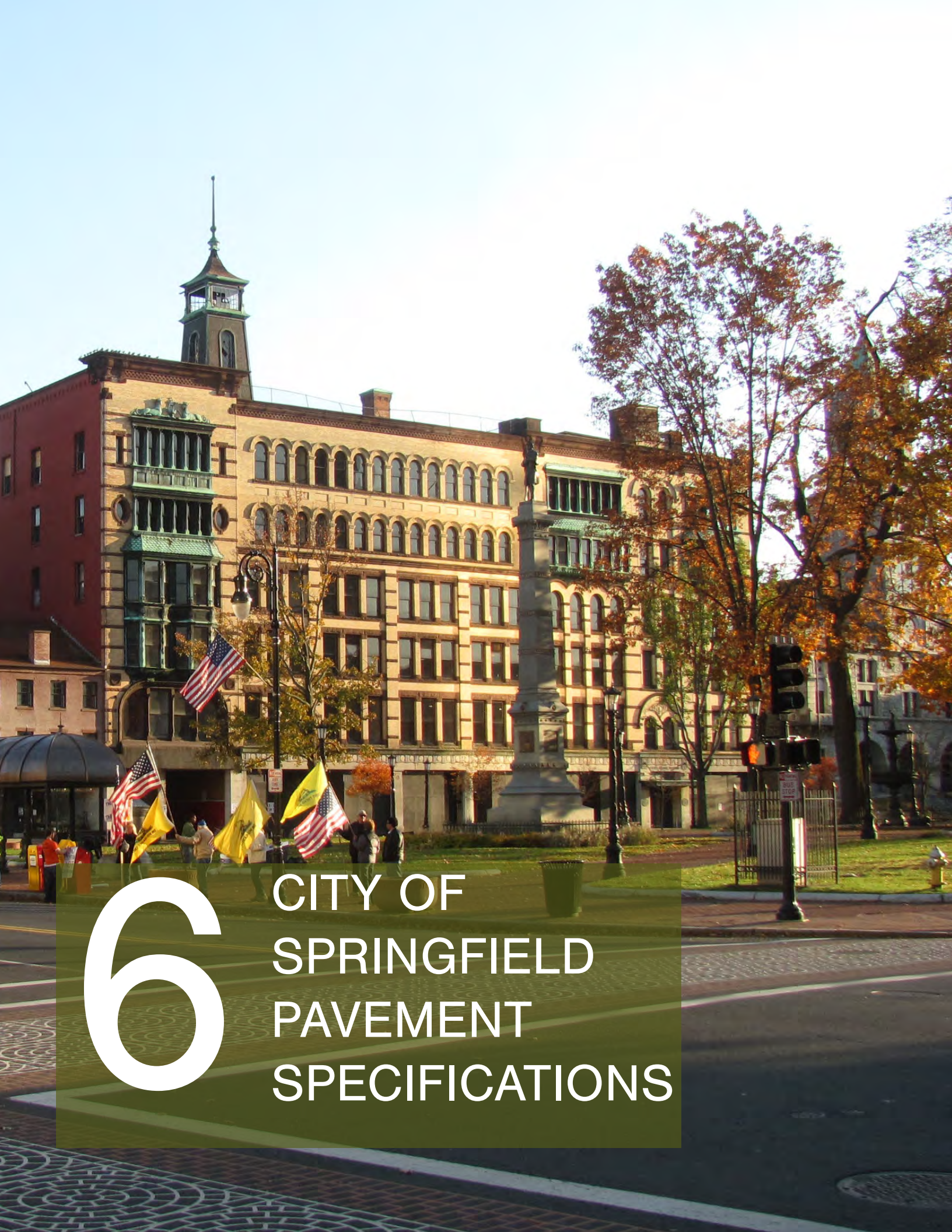
5.2.2 REPLACEMENT

Replacement refers to complete reinstatement of the GI option at the end of its life-cycle; however, in rare cases, full or partial replacement may also be required partway through a life-cycle due to failure of a key component. During replacement, some structural elements can be salvaged and reused; however, materials such as soils, geotextiles, pavements, aggregates, plant materials & pipe generally cannot. Other elements such as plant material and mulch may be required to be replaced throughout the normal course of a GI life-cycle without disrupting the function of the GI feature. Appendix E outlines routine repair and replacement items that can be anticipated throughout the lifecycle of each GI option.

5.2.3 EXPANSION

Unlike conventional stormwater management systems, some GI options have the potential to be expanded to provide additional storage capacity. This will be of critical importance for ensuring that Springfield remains a resilient city in spite of potential future changes in precipitation volumes and weather patterns that may occur as a result of climate change.

Left and above: Green infrastructure provides a double function as public art on Vine Street in Seattle, WA.



6 CITY OF SPRINGFIELD PAVEMENT SPECIFICATIONS

6.1 PAVEMENT PRACTICES & NATURAL RESOURCE PROTECTION

Millions of dollars are spent each year in Springfield to maintain and improve the City street pavements. The opportunity to realize benefits through the implementation of sustainable practices in the City's paving program is great, so the Guide includes updated pavement specifications to direct paving projects in City rights-of-way.

A 2011 study commissioned by the Northeast Region of the National Park Service estimated significant savings in cost, natural resource usage, greenhouse gas emissions, and energy usage from the implementation of sustainable paving practices like those included in pavement specifications recently developed for use by the City of Springfield in its annual road program.

The specifications developed include:

- Hot Mix Asphalt (HMA), including the use of:
  - * Recycled Asphalt Pavement (RAP)
  - * Warm Mix Asphalt (WMA)
  - * Quality Assurance (QA)
- Reclaimed Pavement
- Cold in Place Recycling
- Preservation Treatments
  - * Ultra-Thin Bonded Wearing Course
  - * Crack Sealing

The table below identifies the cost savings, natural resource conservation, greenhouse gas emission reduction, and reduced energy usage benefits that can be realized by the implementation of the sustainable practices included in each of these specifications. A further description of the benefits to be derived from each of the specifications noted above follows, and the fully updated specifications can be found in Appendix F.

Specification	Cost Savings	Natural Resource Conservation	Greenhouse Gas Emission Reduction	Energy Usage Reduction
HMA – RAP	x	x	x	
HMA – WMA			x	x
HMA – QA	x	x	x	x
Reclaimed Pavement	x	x	x	x
Cold In Place Recycling	x	x	x	x
Preservation Treatments	x	x		

6.2 PAVING SPECIFICATIONS

6.2.1 HOT MIX ASPHALT

As in most cities, thousands of tons of hot mix asphalt (HMA) are placed each year in the City of Springfield, representing a huge opportunity to implement and realize the benefits of sustainable paving practices. Recent technological advances in paving materials and processes have been incorporated into the City of Springfield specifications to create benefits for the community, as described below.

Recycled Asphalt Material

The use of recycled asphalt pavement (RAP) in hot mix asphalt has been in practice since 1978. By weight, more hot mix asphalt is recycled in the United States than any other material. According to the National Asphalt Pavement Association, the increased use of RAP as a percentage of the total asphalt mix can significantly reduce greenhouse gas emissions by eliminating the significant fuel consumption required to acquire and process raw materials for conventional mixtures. The hot mix asphalt specification for the City of Springfield allows up to 15% of the hot mix asphalt to be comprised of RAP.

Warm Mix Asphalt

Warm mix asphalt (WMA) is composed of the same components as hot mix asphalt (Course aggregate, fine aggregate, RAP, and liquid asphalt binder) with the addition of either a chemical, wax, or steam additive formulated to allow the mixture to be mixed and compacted at lower temperatures than hot mix asphalt.
The lower mixing temperature means that less energy is required to heat the material in the asphalt plant. In addition, emissions are significantly reduced, as can be clearly seen in the photo to the left.

In addition to reduced energy usage and reduced emissions, the use of warm mix asphalt also allows greater percentages of RAP to be included in the mix, thereby realizing greater conservation of natural resources. Also, warm mix asphalt can be more successfully compacted in cooler weather than hot mix.

Quality Assurance

The City of Springfield pavement specifications include a requirement for the paving contractor to test the quality of the hot mix and the placement of the mix. In addition, the City may perform its own quality assurance tests to confirm the contractor's test results. Improved

quality in construction leads to longer lasting pavements. A study performed by VHB using data from various New England municipalities found that pavements constructed in communities that implemented quality assurance (QA) based specifications last 40% longer on average than pavements constructed in other communities. Over time, pavements that last longer cost less, consume fewer natural resources, produce fewer emissions, and require less energy – simply because the pavement will need to be resurfaced less often.

6.2.2 RECLAIMED PAVEMENT

Reclaimed pavement is one type of in place pavement recycling. Reclaimed pavement is different than the recycled asphalt pavement (RAP) that is incorporated into hot mix asphalt that is removed from the pavement, transported to an asphalt plant, and heated along with the other pavement mix materials. Reclaimed pavement is produced by grinding the existing pavement along with some of the underlying aggregate base materials in place using a large machine driven rotary grinding drum. By recycling the materials in place, the cost, energy used, and emissions generated from transporting and processing the materials are eliminated. In addition, all the aggregate base materials are conserved through the recycling process. The 2011 NPS study estimated a 30% cost savings, a 61% energy savings, and a 13% emissions reduction from the use of reclaimed pavement compared to the use of conventional aggregate base materials.

6.2.3 COLD IN PLACE RECYCLING

Cold in Place Recycling is another type of in place recycling. The specification for cold in place recycling developed for the City of Springfield is related to a process in which only the asphalt surfacing layers of pavement are recycled and does not recycle the underlying aggregate base material. This process can be expected to provide similar benefits to the use of reclaimed pavement.

6.2.4 PRESERVATION TREATMENTS

The Springfield pavement specifications include pavement treatments intended to preserve the condition of pavements that are in fair condition. The concept is to use a relatively low-cost treatment to prolong the need for more expensive resurfacing. By reducing the frequency of resurfacing projects, the overall cost and natural resources used are reduced.

The two preservation treatments for which specifications have been developed for the City of Springfield include Ultra-Thin Bonded Wearing Course and Crack Sealing. The Ultra-Thin Bonded Wearing Course is a nominal ¾" thick layer of specially formulated asphalt mix that is placed over the entire pavement surface. Crack sealing is performed by placing a liquid asphalt material that has been fortified with rubber or fibers into transverse or longitudinal cracks that typically form in pavements after a few years due to aging of the asphalt surface and the seasonal temperature changes experienced in the Northeast.

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IMAGE CREDITS

PG	DESCRIPTION
Civ	A vegetated stormwater facility can be planted with species which tolerate both flooding and drought. Image Credit: Flickr user Bart Everson
Cvi	A view over Memorial Bridge from West Springfield toward Springfield. Image Credit: Todd Zukowski
2	Native plant species provide a pleasing aesthetic at a raing garden installed by Wellnesscapes. Image Credit: Tom Benjamin, Wellnesscapes
3	CSO Outfall Number 3. Image Credit: Pioneer Valley Planning Commission
5	A girls rowing team enjoys active recreation in the Connecticut River. As a Category 5 Waters, the river can sometimes be unsafe for recreation. Image Credit: Ben Quick, Pioneer Valley Riverfront Club
7	Green Streets can increase neighborhood aesthetics, such as this residential example in the High Point neighborhood of Seattle, WA. Image Credit: Architectsea [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0) or GFDL (http://www.gnu.org/copyleft/fdl.html)], from Wikimedia Commons
9	*Top Left:* Established rain garden at the Renaissance School. Image Credit: Tom Benjamin, Wellnesscapes. *Top Right:* Installation of the rain garden at St. James' Commons. Image Credit: Corrin Meise-Munns. *Bottom Left:* Installation of the rain garden at Gardening the Community. Image Credit: Regenerative Design Group. *Bottom Right:* The rain garden at Springfield Museums, freshly planted and installed. Photo credit: Patty Gambarini
11	Municipal and community stakeholders patricipate in the May 2018 CRB. Image Credit: Pioneer Valley Planning Commission
15	Flooding on June 28, 2018 in the parking lot at 60 Congress St, Springfield. The City experienced 3.21" of rain within a few hours, causing flooding incedents throughout the City. Image Credit: Corrin Meise-Munns
16	On June 28, 2018, a 3.21" rainfall event in Springfield, which occured over the course of just a few hours, flooded many City roadways. On Congress Street, the water spilled over sidewalks on both sides of the road. Image Credit: Emily Slotnick
18-9	A view over Memorial Bridge from West Springfield toward Springfield. Image Credit: Todd Zukowski

23 The MA Department of Conservation and Recreation's Greening the Gateway Cities program plants trees in urban areas across Massachusetts. This tree was installed on Lucretia Avenue in Chicopee in 2018. Image Credit: MA DCR

24 The rain garden at the chapel at the Veteran Association in Northampton, MA filters and drains runoff during wet weather. Image Credit: Tom Benjamin, Wellnesscapes

26 Higher rates of impervious cover generate greater volume of stormwater runoff. Image credit: EPA.gov

27 A green wall in Mexico City filters runoff and cools the urban environment, all while making an artistic statement. Image Credit: Flickr user Mark Hogan

29 A bioretention planter in Portland, OR displays a textural planting of graminoids, blending in with the yards in the neighborhoods. Image Credit: Flickr user Steven Vance

33 This attractive example of permeable concrete pavers in Golden, CO won the 2012 Hardscape North America Hardscape Project Award. Image Credit: Flickr user Interlocking Concrete Pavement Institute

36 With its green roof, Holyoke Community College provides an example of how an institution can incorporate a green infrastructure demonstration project as part of its site design. Image Credit: Pioneer Valley Planning Commission

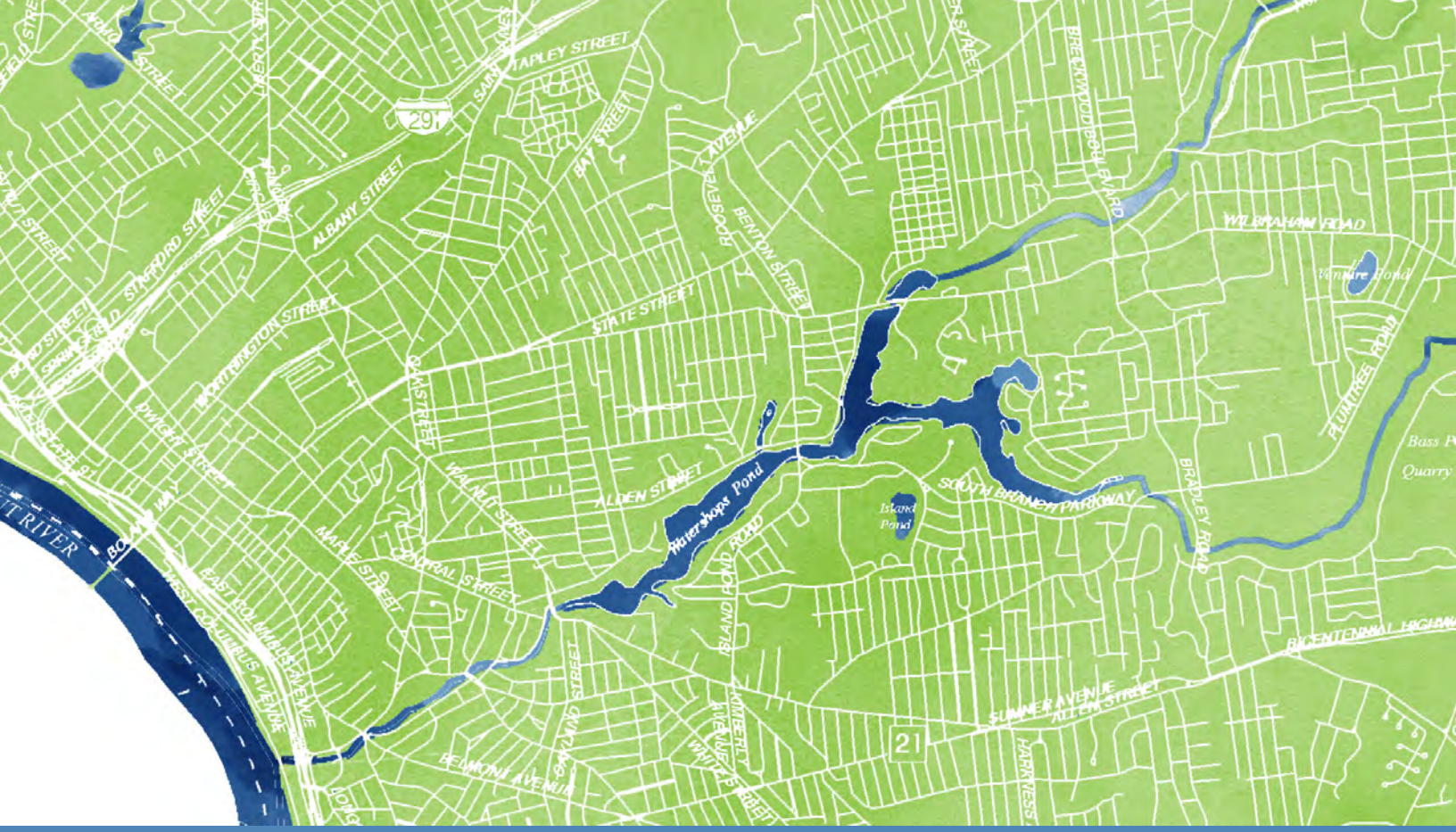
45 A filter strip of river stone is one part of a treatment train in this roadside Seattle system. Image Credit: Patty Gambarini

46 Signs along a bioswale in South Lake Union, Seattle, provides an opportunity for the City to educate its residents about stormwater issues. Image Credit: Patty Gambarini

48-9 Green infrastructure provides a double function as public art on Vine Street in Seattle, WA. Image Credit: Patty Gambarini

50 Court Square Historic District. Image Credit: John Phelan (https://commons.wikimedia.org/wiki/File:Court_Square,_Springfield_MA.jpg)

52 Tina Quagliato Sullivan, Director of Disaster Recovery & Compliance for the City of Springfield, was one of many municipal staff who participated in the May 2018 CRB. Image Credit: Pioneer Valley Planning Commission



Catalyst for Regional Progress

CITY OF SPRINGFIELD

GREEN INFRASTRUCTURE TECHNICAL GUIDELINES

A APPENDIX A: LIST OF GREEN INFRASTRUCTURE OPTIONS IN THE GI SELECTION TOOL

CITY OF SPRINGFIELD

GREEN INFRASTRUCTURE TECHNICAL GUIDELINES

B APPENDIX B: GI TYPICAL DETAIL DRAWINGS

PURPOSE:

PERMEABLE PAVEMENT (PAVEMENT) CONTROLS PEAK FLOWS AND VOLUMES OF STORMWATER RUNOFF VIA INFILTRATION THROUGH THE PAVEMENT SURFACE, STORAGE IN THE PAVEMENT SECTION, INFILTRATION INTO NATIVE SOIL, AND OVERFLOW THROUGH OPTIONAL SUBSURFACE OUTLETS. RUNOFF IS TREATED AS IT FILTERS THROUGH THE PAVEMENT SECTION, AND INFILTRATES INTO UNDERLYING NATIVE SOIL.

DESIGNER NOTES & GUIDELINES:

1. THE DESIGNER MUST ADAPT PLAN, SECTION DRAWINGS, AND CALCULATE DEPTH TO ADDRESS SITE-SPECIFIC CONDITIONS.
2. ALL PAVEMENT SYSTEMS MUST BE DESIGNED BY A LICENSED ENGINEER IN ACCORDANCE WITH THE AASHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURES BASED ON SITE-SPECIFIC CONDITIONS INCLUDING TRAFFIC LOADS AND SUBGRADE CONDITIONS. PAVEMENT SECTIONS SET FORTH IN THESE TYPICAL DETAILS ARE PROVIDED TO REPRESENT THE ANTICIPATED RANGE OF DESIGN REQUIREMENTS, BASED ON "GOOD" AND "POOR" SOIL CHARACTERIZATIONS NORMALLY ENCOUNTERED.
3. GEOTECHNICAL EVALUATION OF SUBGRADE SOILS TO VERIFY THEIR STRUCTURAL SUITABILITY FOR PERMEABLE PAVEMENT INSTALLATIONS IS REQUIRED. INFILTRATION TESTING REQUIREMENTS ARE SUBJECT TO DIFFERENT THRESHOLDS.
4. THE PERMEABLE PAVEMENT FACILITY MUST BE DESIGNED TO PROVIDE SUFFICIENT SUBSURFACE STORAGE IN THE PAVEMENT SECTION TO MEET PROJECT HYDROLOGIC PERFORMANCE GOALS. THE SECTION THICKNESS WILL BE A FUNCTION OF THE SUBGRADE INFILTRATION RATE (DRAINAGE COEFFICIENT), SUBGRADE SLOPE, AND THE HEIGHT AND SPACING OF SUBSURFACE CHECK DAMS, WHEN APPLICABLE. SEE **PC 2.1** AND **PC 2.2**.
5. ENTIRE PAVEMENT BASE SECTION MAY BE USED TO MEET SUBSURFACE STORAGE REQUIREMENTS.
6. SUBSURFACE STORAGE DRAWDOWN TIME (I.E. TIME FOR MAXIMUM SUBSURFACE STORAGE VOLUME TO INFILTRATE INTO SUBGRADE AFTER THE END OF A STORM) SHOULD NOT EXCEED 72 HOURS. DRAWDOWN TIME IS CALCULATED AS THE MAXIMUM SUBSURFACE PONDING DEPTH DIVIDED BY THE NATIVE SOIL INFILRATION RATE.
7. THE DESIGNER MUST EVALUATE CURRENT UTILITY SURVEYS FOR POTENTIAL UTILITY CROSSINGS OR CONFLICTS.

RELATED COMPONENTS

CHECK DAMS:	PC 2.1 - PC 2.2
LINERS:	GC 1.1, GC 1.2
OBSERVATION PORTS:	GC 4.1 - GC 4.3
CLEANOUTS:	GC 5.1

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

NOTES: PP 1.1, PP 1.2

SECTIONS: PP 2.1, PP 3.1, PP 4.1, PP 4.2

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION

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REVISED:

PERMEABLE PAVEMENT
DESIGNER NOTES (1 OF 2)

DWG NO. PP 1.1

LAYOUT REQUIREMENTS:

1. THE PREFERRED AND ALLOWED CATCHMENT AREA CONTRIBUTING RUN-ON TO A PERMEABLE PAVEMENT FACILITY IS PROVIDED IN THE FOLLOWING TABLE:

WEARING COURSE	PREFERRED RUN-ON RATIO	MAXIMUM RUN-ON RATIO** (AREA CONTRIBUTING RUN-ON: PERMEABLE PAVEMENT AREA)
PERVIOUS CONCRETE AND POROUS ASPHALT	MINIMAL	3:1
PERMEABLE PAVERS (≥ 1/2" GAPS) [PARCEL ONLY]*	0:1	3:1
PERMEABLE PAVERS (≥ 3/8" GAPS)*	0:1	2:1
PERMEABLE PAVERS (≥ 1/4" GAPS)	0:1	1:1
POROUS PAVERS	0:1	0:1 (NO RUN-ON)

*PAVERS WITH 3/8 INCH OR 1/2 INCH GAPS SHALL BE PERMEABLE INTERLOCKING CONCRETE PAVERS WITH INTEGRATED PRECAST INTERLOCKING SPACER.

**THE DESIGNER AND OWNER SHOULD CONSIDER THE INCREASED MAINTENANCE REQUIREMENTS (INCLUDING FREQUENT VACUUM SWEEPING) ASSOCIATED WITH HIGHER RUN-ON RATIOS WHEN DESIGNING THE FACILITY.

2. WHEN DESIGNED TO ACCEPT RUN-ON FROM OTHER CATCHMENT AREAS, PERMEABLE PAVEMENT AREAS MUST BE PROTECTED FROM SEDIMENTATION WHICH CAN CAUSE CLOGGING AND DIMINISHED FACILITY PERFORMANCE. THE FOLLOWING REQUIREMENTS APPLY FOR RUN-ON CONTRIBUTIONS:
   - RUN-ON FROM LAWN, LANDSCAPE OR OTHER ERODIBLE SURFACES IS DISCOURAGED. IF MINOR RUN-ON FROM LAWN OR LANDSCAPE AREAS IS UNAVOIDABLE, THOSE ERODIBLE AREAS MUST BE FULLY STABILIZED.
   - CONCENTRATED RUN-ON (E.G., DIRECT DISCHARGE FROM A DOWNSPOUT) SHOULD BE DISPERSED PRIOR TO DISCHARGE TO A PERMEABLE PAVEMENT FACILITY. ACCEPTABLE METHODS INCLUDE SHEET FLOW OR SUBSURFACE DELIVERY TO THE STORAGE RESERVOIR. IF SUBSURFACE DELIVERY IS USED, PRIMARY SETTLING IS REQUIRED (E.G., VIA SAND TRAP) FOLLOWED BY DISTRIBUTION TO STORAGE RESERVOIR (E.G., VIA PERFORATED PIPE).
4. FOR PEDESTRIAN APPLICATIONS, WEARING COURSE SHALL BE SET FLUSH (± 3/16 INCH) WITH ADJACENT WALKING SURFACES.
5. WEARING COURSE SHALL HAVE A MINIMUM SURFACE SLOPE OF 0.5% TO ALLOW FOR SURFACE OVERFLOW AND A MAXIMUM SURFACE SLOPE AS LISTED BELOW:
   a. POROUS ASPHALT SURFACE: = 5 PERCENT SLOPE
   b. PERVIOUS CONCRETE SURFACE: = 10 PERCENT SLOPE
   c. PERMEABLE PAVERS: = 12 PERCENT SLOPE (PER MANUFACTURER'S RECOMMENDATION)
6. WHILE THERE IS NO MAXIMUM SLOPE FOR THE SUBGRADE UNDER THE PERMEABLE PAVEMENT COURSES, THERE MAY BE ENGINEERING CHALLENGES ASSOCIATED WITH SUBSURFACE CHECK DAM REQUIREMENTS ON SUBGRADE SLOPES EXCEEDING 5%. SEE SUBSURFACE CHECK DAMS (**PC 2.1** AND **PC 2.2**).

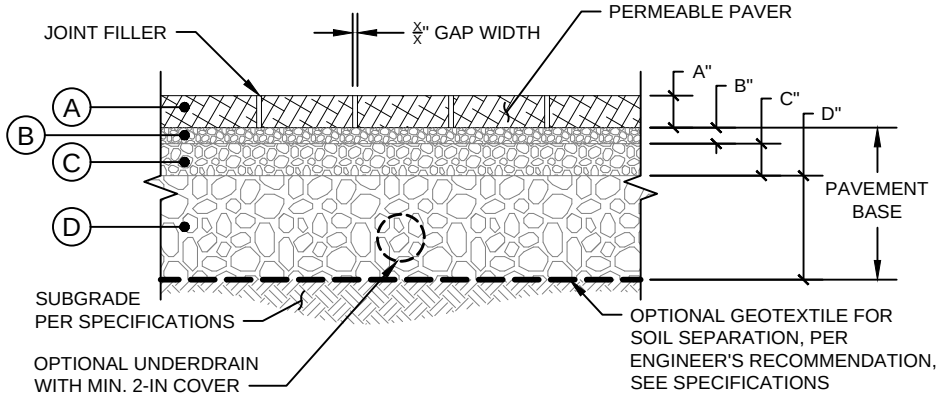
DESIGNER CHECKLIST (MUST SPECIFY, AS APPLICABLE):

- ☐ PERMEABLE PAVEMENT SPECIFICATIONS AND/OR PAVER TYPE AND GAP WIDTH
- ☐ PERMEABLE PAVEMENT WIDTH AND LENGTH
- ☐ ELEVATIONS AND CONTROL POINTS AT EVERY CORNER OR POINT OF TANGENCY
- ☐ THICKNESS OF EACH LAYER IN THE PAVEMENT SECTION
- ☐ JOINT SPACING AND TYPE
- ☐ SUBGRADE SLOPE
- ☐ SUBSURFACE CHECK DAM SPACING, HEIGHT, AND TYPE
- ☐ ELEVATIONS OF EACH PIPE INLET AND OUTLET INVERT
- ☐ TYPE AND DESIGN OF PERMEABLE PAVEMENT COMPONENTS (E.G., EDGE TREATMENTS, OUTLETS, UNDERDRAINS, etc.)

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

NOTES: PP 1.1 | PP 1.2

SECTIONS: PP 2.1 | PP 3.1 | PP 4.1 | PP 4.2



PERMEABLE PAVERS 1

MINIMUM MATERIAL THICKNESS (IN):

LAYER	MATERIAL TYPE*	VEHICULAR	PEDESTRIAN
A	PERMEABLE PAVERS	3	2
B	LEVELING COURSE AASHTO NO. 8	2	2
C	BASE COURSE AASHTO NO. 57	4	2
D	RESERVOIR COURSE AASHTO NO. 2, 3, OR 57	4 (8 WITH UNDERDRAIN)	4 (8 WITH UNDERDRAIN)

NOTES:

1. AGGREGATE MUST BE DOUBLE WASHED.
2. DESIGNER MUST SIZE RESERVOIR COURSE DEPTH TO MEET HYDROLOGIC AND PAVEMENT STRUCTURAL DESIGN REQUIREMENTS.

TYPICAL JOINT FILLER AGGREGATE SIZE:

GAP WIDTH (IN)	JOINT FILLER AGGREGATE*
3/8 OR 1/2	AASHTO NO. 8
1/4	AASHTO NO. 9 OR 89

* PROVIDED FOR REFERENCE ONLY, FOLLOW MANUFACTURER'S RECOMMENDATIONS

CONSTRUCTION NOTES:

1. SEE PERMEABLE/POROUS PAVER SPECIFICATIONS FOR WEARING COURSE, PAVEMENT BASE, SUBGRADE, AND OTHER REQUIREMENTS FOR PERMEABLE/POROUS PAVER FACILITIES.
2. MINIMUM UTILITY SETBACKS AND PROTECTION MEASURES MUST CONFORM TO DPW STANDARDS AND OTHER UTILITY PROVIDER REQUIREMENTS. COORDINATE WITH CITY ENGINEER IN THE EVENT OF UTILITY CROSSINGS AND UTILITY CONFLICTS.

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

NOTES		SECTIONS			
PP 1.1	PP 1.2	PP 2.1	PP 3.1	PP 4.1	PP 4.2

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION

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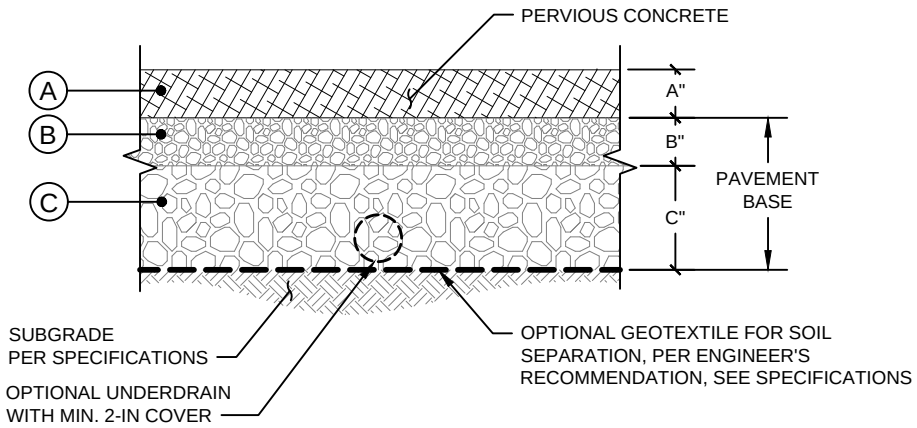
PERMEABLE PAVEMENT
MATERIAL SECTIONS
PERMEABLE PAVERS

DWG NO. PP 2.1



PERVIOUS CONCRETE 1

MINIMUM MATERIAL THICKNESS (IN):

LAYER	MATERIAL TYPE*	VEHICULAR	PEDESTRIAN
A	PERVIOUS CONCRETE	6	4
B	BASE COURSE AASHTO NO. 3 OR 57	4	4
C	RESERVOIR COURSE AASHTO NO. 2, 3, OR 57	4 (8 WITH UNDERDRAIN)	4 (8 WITH UNDERDRAIN)

NOTES:

1. AGGREGATE MUST BE DOUBLE WASHED.
2. DESIGNER MUST SIZE RESERVOIR COURSE DEPTH TO MEET STORMWATER MANAGEMENT AND PAVEMENT STRUCTURAL DESIGN REQUIREMENTS.

CONSTRUCTION NOTES:

1. SEE PERVIOUS CONCRETE SPECIFICATIONS FOR WEARING COURSE, PAVEMENT BASE, SUBGRADE, AND OTHER REQUIREMENTS FOR PERVIOUS CONCRETE FACILITIES.
2. MINIMUM UTILITY SETBACKS AND PROTECTION MEASURES MUST CONFORM TO DPW STANDARDS AND OTHER UTILITY PROVIDER REQUIREMENTS. COORDINATE WITH CITY ENGINEER IN THE EVENT OF UTILITY CROSSINGS AND UTILITY CONFLICTS.

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

NOTES: PP 1.1 | PP 1.2
SECTIONS: PP 2.1 | PP 3.1 | PP 4.1 | PP 4.2

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION

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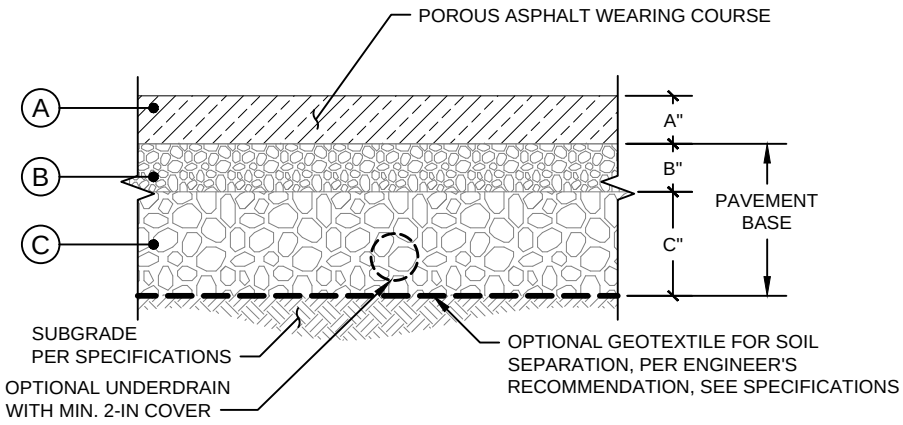
REVISED:

PERMEABLE PAVEMENT
MATERIAL SECTIONS
PERVIOUS CONCRETE

DWG NO. PP 3.1



POROUS ASPHALT 1

MINIMUM MATERIAL THICKNESS (IN):

LAYER	MATERIAL TYPE*	VEHICULAR	PEDESTRIAN
A	POROUS ASPHALT	4	3
B	BASE COURSE AASHTO NO. 57	4	4
C	RESERVOIR COURSE AASHTO NO. 2, 3, OR 57	4 (8 WITH UNDERDRAIN)	4 (8 WITH UNDERDRAIN)

NOTES:

1. AGGREGATE MUST BE DOUBLE WASHED.
2. DESIGNER MUST SIZE RESERVOIR COURSE DEPTH TO MEET STORMWATER MANAGEMENT AND PAVEMENT STRUCTURAL DESIGN REQUIREMENTS.

CONSTRUCTION NOTES:

1. SEE POROUS ASPHALT SPECIFICATIONS FOR WEARING COURSE, PAVEMENT BASE, SUBGRADE, AND OTHER REQUIREMENTS FOR POROUS ASPHALT FACILITIES.
2. MINIMUM UTILITY SETBACKS AND PROTECTION MEASURES MUST CONFORM TO DPW STANDARDS AND OTHER UTILITY PROVIDER REQUIREMENTS. COORDINATE WITH CITY ENGINEER IN THE EVENT OF UTILITY CROSSINGS AND UTILITY CONFLICTS.

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

NOTES		SECTIONS			
PP 1.1	PP 1.2	PP 2.1	PP 3.1	PP 4.1	PP 4.2

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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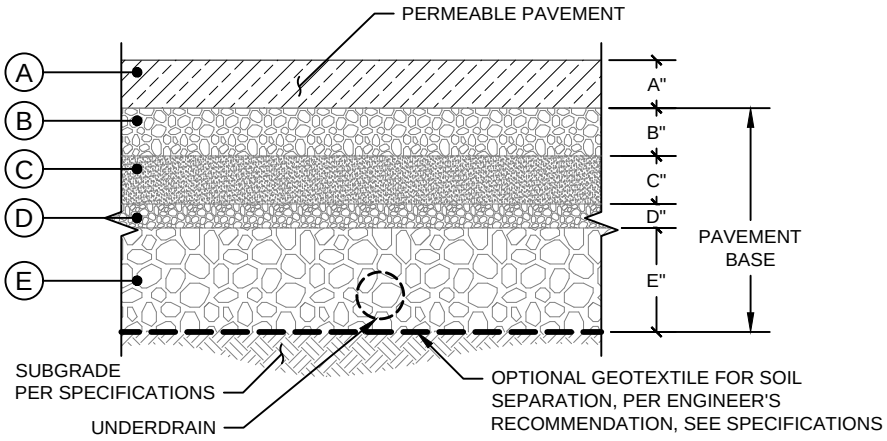
PERMEABLE PAVEMENT
MATERIAL SECTIONS
POROUS ASPHALT

DWG NO. PP 4.1



PERMEABLE PAVEMENT FOR PHOSPHORUS REMOVAL 1

MINIMUM MATERIAL THICKNESS (IN):

LAYER	MATERIAL TYPE*	VEHICULAR	PEDESTRIAN
A	PERMEABLE PAVEMENT	SEE PRECEDING TABLES	
B	BASE COURSE AASHTO NO. 57	SEE PRECEDING TABLES	
C	FILTER COURSE (CONCRETE SAND*)	8	8
D	CHOKER COURSE AASHTO NO.8	3	3
E	RESERVOIR COURSE AASHTO NO. 2, 3, OR 57	4 (8 WITH UNDERDRAIN)	4 (8 WITH UNDERDRAIN)

*SAND TO MEET MASSDOT M4.04.02 OR APPROVED EQUIVALENT

NOTES:

1. AGGREGATE MUST BE DOUBLE WASHED.
2. DESIGNER MUST SIZE RESERVOIR COURSE DEPTH TO MEET STORMWATER MANAGEMENT AND PAVEMENT STRUCTURAL DESIGN REQUIREMENTS.

NOTES: PP 1.1, PP 1.2

SECTIONS: PP 2.1, PP 3.1, PP 4.1, PP 4.2

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION

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PERMEABLE PAVEMENT
MATERIAL SECTIONS
PHOSPHORUS REMOVAL

DWG NO. PP 4.2

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

PURPOSE:

PERMEABLE PAVEMENT FACILITIES MUST BE DESIGNED TO PROVIDE SUBSURFACE STORAGE OF STORMWATER TO ALLOW TIME FOR THE WATER TO INFILTRATE INTO THE UNDERLYING SOIL. SLOPED FACILITIES ON POOR SOILS HAVE AN INCREASED POTENTIAL FOR LATERAL FLOWS THROUGH THE STORAGE RESERVOIR COURSE ALONG THE TOP OF THE RELATIVELY IMPERMEABLE SUBGRADE SOIL. THIS REDUCES THE STORAGE AND INFILTRATION CAPACITY OF THE PAVEMENT SYSTEM. SUBSURFACE DETENTION STRUCTURES, OR CHECK DAMS, CAN BE INCORPORATED INTO THE SUBGRADE AND ALIGNED PERPENDICULAR TO THE LONGITUDINAL SUBGRADE SLOPE TO CREATE PONDING IN THE AGGREGATE STORAGE RESERVOIR COURSE TO DETAIN SUBSURFACE FLOW, INCREASE INFILTRATION, AND REDUCE STRUCTURAL PROBLEMS ASSOCIATED WITH SUBGRADE EROSION ON SLOPES.

DESIGNER NOTES & GUIDELINES:

1. THE DESIGNER MUST ADAPT SECTION DRAWINGS TO ADDRESS SITE-SPECIFIC CONDITIONS.
2. THE DESIGNER MUST ESTABLISH THE HEIGHT AND SPACING OF THE CHECK DAMS BASED ON THE SUBGRADE SLOPE AND THE STORAGE DEPTH REQUIRED TO MEET PROJECT HYDROLOGIC PERFORMANCE GOALS. THE AVERAGE DEPTH OF SUBSURFACE STORAGE ACROSS THE FACILITY AREA MUST MEET THE REQUIRED STORAGE DEPTH. REFER TO CHECK DAM SPACING GUIDANCE ON THIS DRAWING FOR CHECK DAM SPACING CALCULATIONS.
3. MAXIMUM CHECK DAM HEIGHT IS GOVERNED BY 72 HOUR DRAWDOWN REQUIREMENT AND NATIVE SOIL INFILTRATION RATE. SEE **PP 1.1** FOR ADDITIONAL GUIDANCE.
4. THE AREA OF SUBBASE COVERED BY IMPERMEABLE CHECK DAM MATERIAL SHOULD BE EXCLUDED FROM HYDROLOGIC PERFORMANCE CALCULATIONS WHEN THE AREA IS SIGNIFICANT (GREATER THAN 10 PERCENT) RELATIVE TO THE PAVEMENT AREA.
5. THE DESIGNER MUST ENSURE THAT THE RESERVOIR COURSE DEPTH IS SUFFICIENT TO ACCOMMODATE THE HEIGHT OF THE CHECK DAMS WITH THE REQUIRED MINIMUM CLEARANCE.
6. CONVEYANCE CALCULATIONS ARE REQUIRED TO EVALUATE THE NEED FOR SUBSURFACE OUTLETS (E.G., PERFORATED OVERFLOW PIPES SET AT THE DESIGN SUBSURFACE PONDING DEPTH) AND DOWNSLOPE OVERFLOW SYSTEM.
7. LOCATE CHECK DAMS TO MINIMIZE IMPACT TO UTILITY ACCESS.
8. LOCATE PERVIOUS CONCRETE CONTROL JOINTS AT CHECK DAM LOCATIONS WHEN CHECK DAM EXTENDS INTO THE STRUCTURAL PAVEMENT SECTION.

DESIGNER CHECKLIST (MUST SPECIFY, AS APPLICABLE):

- ☐ CHECK DAM TYPE AND MATERIAL
- ☐ CHECK DAM ELEVATION, HEIGHT, AND WIDTH
- ☐ CHECK DAM SPACING
- ☐ CHECK DAM CLEARANCE (MEASURED FROM BOTTOM OF WEARING COURSE)

CHECK DAM SPACING GUIDANCE:

TYPICAL MAXIMUM SPACING, $L_{SPACING,\ MAX}$ (FEET) :

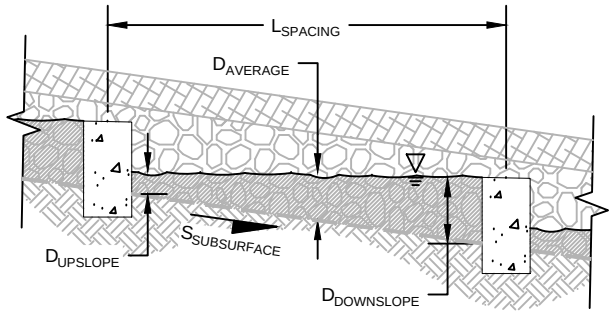
$$L_{SPACING,\ MAX} = D_{DOWNSLOPE} \div S_{SUBSURFACE}$$

$D_{DOWNSLOPE}$ = DOWNSLOPE STORAGE DEPTH (I.E. CHECK DAM HEIGHT) (FEET)
$S_{SUBSURFACE}$ = SUBSURFACE SLOPE (FT/FT)

SPACING, $L_{SPACING}$ (WHEN $L_{SPACING} \leq L_{SPACING,\ MAX}$) :

$$L_{SPACING} = \frac{2\ (D_{AVERAGE} - D_{DOWNSLOPE})}{- S_{SUBSURFACE}}$$

$D_{AVERAGE}$ = AVERAGE STORAGE DEPTH (FEET)



SUBSURFACE CHECK DAMS: NOTES PC 2.1; COMPONENTS PC 2.2
SUBSURFACE OUTLETS: COMPONENTS PC 3.4

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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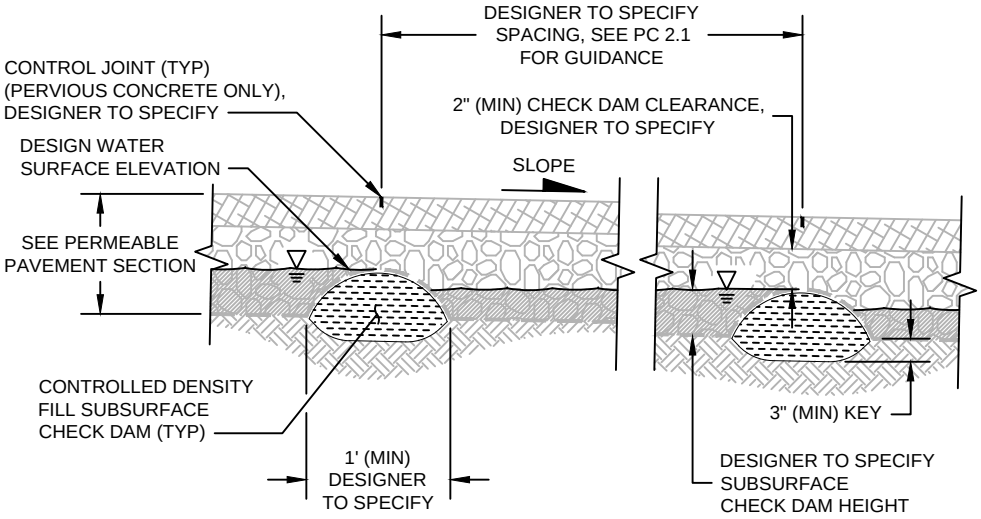
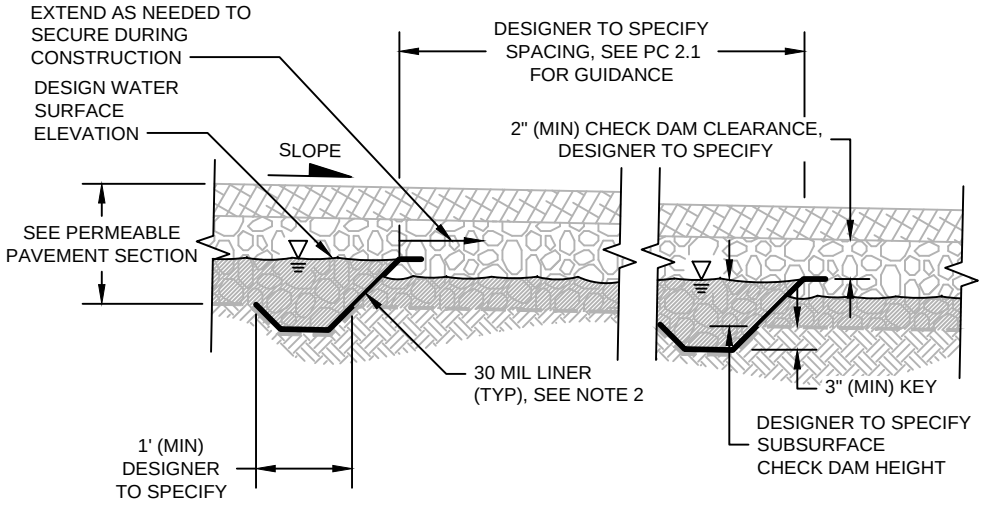
PAVEMENT COMPONENTS
SUBSURFACE CHECK DAMS
DESIGNER NOTES

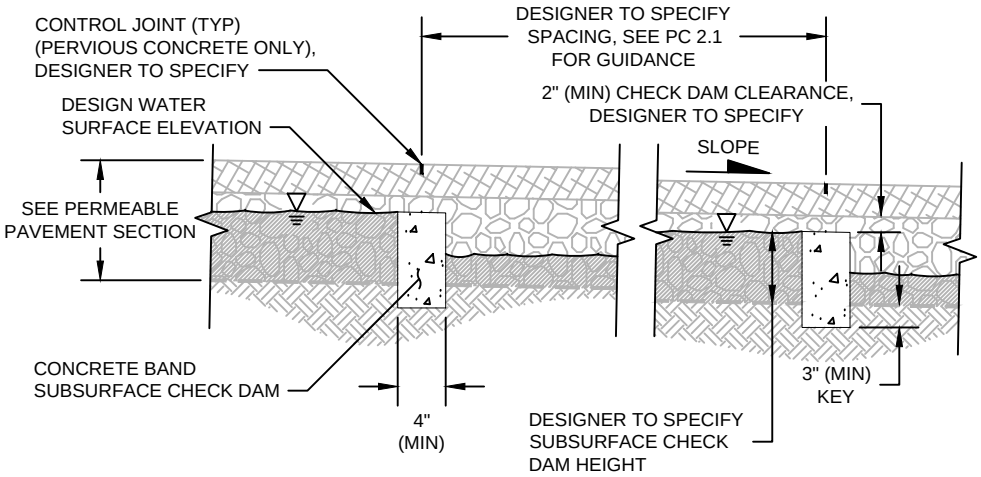
DWG NO. PC 2.1



CONTROLLED DENSITY FILL SUBSURFACE CHECK DAM 1



IMPERMEABLE LINER SUBSURFACE CHECK DAM 2



CONCRETE BAND SUBSURFACE CHECK DAM 3

CONSTRUCTION NOTES:

1. ALL MATERIAL AND WORKMANSHIP FOR CHECK DAMS SHALL CONFORM TO SPRINGFIELD STANDARD SPECIFICATIONS AND APPLICABLE CODES.
2. LINER SHALL BE HDPE CONFORMING TO GEOSYNTHETIC RESEARCH INSTITUTE (GRI) GM13 OR LLDPE CONFORMING TO GRI GM 17.

SUBSURFACE CHECK DAMS		SUBSURFACE OUTLETS
NOTES	COMPONENTS	COMPONENTS
PC 2.1	PC 2.2	PC 3.4

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

CITY OF SPRINGFIELD, MA

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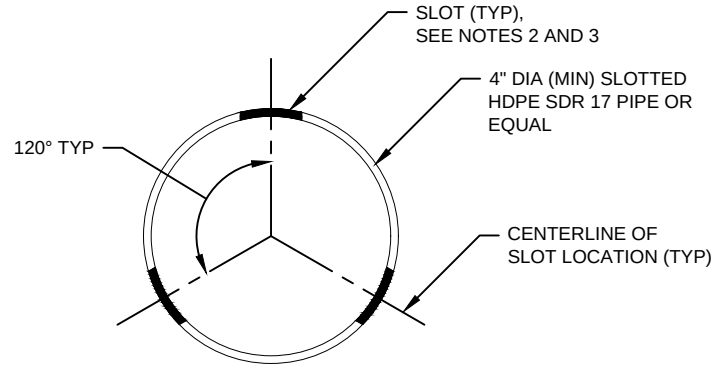
PAVEMENT COMPONENTS
SUBSURFACE CHECK DAMS

DWG NO. PC 2.2



SLOTTED UNDERDRAIN PIPE 2

CONSTRUCTION NOTES:

1. UNDERDRAIN PIPE SHALL BE SLOTTED HDPE SDR 17 OR ACCEPTABLE SUBSTITUTE MATERIAL PER ENGINEERS SPECIFICATION. SINGLE WALL AND DUAL WALL CORRUGATED HDPE PIPE (AASHTO M252 AND M294 TYPES C, S, AND D) ARE NOT ACCEPTABLE.
2. ALL PERFORATIONS SHALL BE SLOTTED TYPE, MEASURING 0.032 INCH WIDE (MAX), SPACED AT 0.25 INCH (MIN), AND PROVIDING A MINIMUM INLET AREA OF 5.0 SQUARE INCH PER LINEAR FOOT OF PIPE.
3. PERFORATIONS SHALL BE ORIENTED PERPENDICULAR TO LONG AXIS OF PIPE, AND EVENLY SPACED AROUND CIRCUMFERENCE AND LENGTH OF PIPE.

SUBSURFACE CHECK DAMS: NOTES PC 2.1; COMPONENTS PC 2.2
SUBSURFACE OUTLETS: COMPONENTS PC 3.4

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

CITY OF SPRINGFIELD, MA

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PAVEMENT COMPONENTS
UNDERDRAIN PIPE

DWG NO. PC 3.4

PURPOSE:

BIORETENTION PLANTERS CONTROL PEAK FLOWS AND VOLUMES OF STORMWATER RUNOFF BY PROVIDING SURFACE, SUBSURFACE STORAGE AND INFILTRATION INTO NATIVE SOIL. WATER IS ALSO TREATED AS IT FILTERS THROUGH THE BIORETENTION SOIL.

DESIGNER NOTES & GUIDELINES:

1. THE DESIGNER MUST ADAPT PLAN AND SECTION DRAWINGS TO ADDRESS SITE-SPECIFIC CONDITIONS.
2. PLANTER AREA, PONDING DEPTH, BIORETENTION SOIL DEPTH, AND AGGREGATE STORAGE DEPTH MUST BE SIZED TO MEET PROJECT HYDROLOGIC PERFORMANCE GOALS.
3. PONDING AND BIORETENTION SOIL DRAWDOWN TIME (I.E., TIME FOR MAXIMUM SURFACE PONDING TO DRAIN THROUGH THE BIORETENTION SOIL AFTER THE END OF A STORM) RECOMMENDATIONS:
   - 3 - 12 HOUR PONDING AND BIORETENTION SOIL DRAWDOWN (TYPICAL)
   - 24 HOUR MAXIMUM PONDING AND BIORETENTION SOIL DRAWDOWN
4. FACILITY DRAWDOWN TIME (i.e., TIME FOR SURFACE PONDING TO DRAIN THROUGH THE ENTIRE SECTION INCLUDING AGGREGATE STORAGE AFTER THE END OF A STORM) REQUIREMENTS:
   - 72 HOUR MAXIMUM FACILITY DRAWDOWN (i.e. ORIFICE CONTROLLED SYSTEM OR EXTENDED STORAGE DEPTH WITHIN INFILTRATION SYSTEM)
5. THE PLANTER WALL SLOPE IS TYPICALLY DESIGNED TO MATCH THE LONGITUDINAL SLOPE OF THE ADJACENT ROADWAY/SIDEWALK. THE FACILITY SUBGRADE, HOWEVER, SHOULD BE FLAT. CHECK DAMS MAY BE USED TO TERRACE FACILITIES TO PROVIDE SUFFICIENT PONDING FOR HIGHER-SLOPED INSTALLATIONS. DESIGNER MUST SPECIFY CHECK DAM HEIGHT AND SPACING. REFER TO **BC 6.1** AND **BC 6.2** FOR GUIDANCE ON CHECK DAM DESIGN.
6. DEPENDING ON THE HEIGHT OF THE PROPOSED PLANTER WALL, ADDITIONAL STRUCTURAL CONSIDERATIONS MAY BE REQUIRED TO ADDRESS WALL LOADING. REFER TO **BC 1.1** THROUGH **BC 1.7** FOR GUIDANCE ON EDGE TREATMENTS.
7. WHEN FACILITY CONSTRUCTION IMPACTS EXISTING SIDEWALK, ALL SAW CUTS MUST ADHERE TO DPW REQUIREMENTS. SAW CUTS SHOULD BE ALONG SCORE LINES AND ANY DISTURBED SIDEWALK FLAGS SHOULD BE REPLACED IN THEIR ENTIRETY.
8. PLANTERS IN PUBLIC RIGHT OF WAY SHALL BE DESIGNED WITH EMERGENCY OVERFLOW TO THE STREET IN THE EVENT THE PLANTER OUTLET IS OBSTRUCTED OR CLOGGED.
9. UP TO TWO PLANTERS MAY BE CONNECTED IN SERIES, IN LIEU OF MULTIPLE INLETS, PROVIDED THE CONNECTION IS A TRENCH DRAIN OR EQUAL SURFACE CONVEYANCE AND IS ADEQUATELY SIZED TO CONVEY FLOWS.
10. PLANTER VEGETATION MUST BE SPECIFIED BY DESIGN PROFESSIONAL PER DPW VEGETATION PALLET.
11. THE DESIGNER MUST EVALUATE UTILITY SURVEYS FOR POTENTIAL UTILITY CROSSINGS OR CONFLICTS.

LAYOUT REQUIREMENTS:

1. REFER TO THE DPW STANDARD DETAILS AND SPRINGFIELD COMPLETE STREETS GUIDE FOR COURTESY STRIP, THROUGHWAY, PARKING SPACE AND ACCESSIBLE PATH REQUIREMENTS.
2. LOCATE CURB CUTS AND GUTTER MODIFICATIONS TO AVOID CONFLICTS WITH ACCESSIBILITY REQUIREMENTS (E.G., LOCATE OUTSIDE OF CROSSWALKS).

RELATED COMPONENTS		
INLETS:	BC 2.1	BC 2.4
OUTLETS:	BC 3.1	BC 3.4
UNDERDRAINS:	BC 5.1	BC 5.2
CHECK DAMS:	BC 6.1	BC 6.2
LINERS:	GC 1.1	GC 1.2
OBSERVATION PORTS:	GC 4.1	GC 4.3
CLEANOUTS:		GC 5.1

DESIGNER CHECKLIST (MUST SPECIFY, AS APPLICABLE):

- ☐ PLANTER WIDTH AND LENGTH
- ☐ DEPTH OF PONDING
- ☐ DEPTH OF FREEBOARD
- ☐ DEPTH OF BIORETENTION SOIL
- ☐ DEPTH AND TYPE OF AGGREGATE STORAGE
- ☐ PLANTER SURFACE ELEVATION (TOP OF BIORETENTION SOIL) AT UPSLOPE AND DOWNSLOPE ENDS OF FACILITY
- ☐ CONTROL POINTS AT EVERY PLANTER WALL CORNER AND POINT OF TANGENCY
- ☐ DIMENSIONS AND DISTANCE TO EVERY INLET, OUTLET, CHECK DAM, SIDEWALK NOTCH, ETC.
- ☐ ELEVATIONS OF EVERY INLET, OUTLET, STRUCTURE RIM AND INVERT, CHECK DAM, PLANTER WALL CORNER, AND SIDEWALK NOTCH
- ☐ TYPE AND DESIGN OF PLANTER COMPONENTS (E.G., EDGE TREATMENTS, INLETS/GUTTER MODIFICATIONS, UTILITY CROSSINGS, LINER, AND PLANTING DETAILS)

NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS							
	PLAN	SECTIONS	PLAN	SECTIONS	ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	NOTES		PLAN	SECTIONS				
BP 1.1	BP 2.1	BP 2.2	BP 3.1	BP 3.2	BP 4.1	BP 4.2	BP 4.3	BP 4.4	BP 4.5	BP 4.6	BP 5.1	BP 5.2	BP 5.3	BP 5.4	BP 5.5	BP 5.6	BP 5.7

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

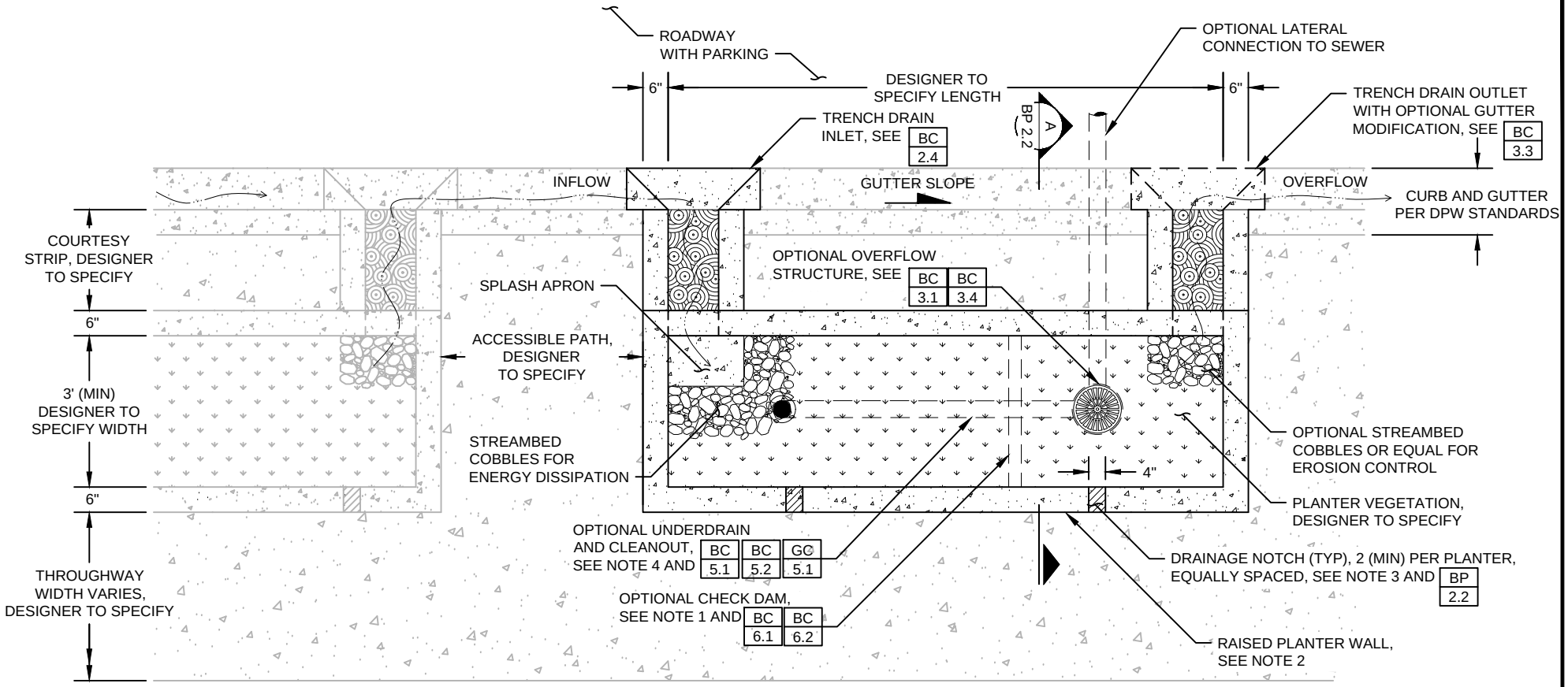
ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION

DATE: FEBRUARY 2019
VERSION: 1.0
REVISED:

BIORETENTION PLANTER
DESIGNER NOTES (1 OF 2)

DWG NO. BP 1.1

NOT FOR CONSTRUCTION - REFER TO USER GUIDE



CONSTRUCTION NOTES:

1. CHECK DAMS SHALL BE SPACED TO PROVIDE PONDING PER SITE SPECIFIC DESIGN.
2. SLOPE TOP OF PLANTER WALL TO MATCH LONGITUDINAL SLOPE OF ADJACENT SURFACE.
3. LAY OUT DRAINAGE NOTCHES TO PREVENT PONDING BEHIND PLANTER WALL WITH 5' MAXIMUM SPACING BETWEEN NOTCHES.
4. PROVIDE ONE CLEANOUT PER PLANTER (MIN) FOR FACILITIES WITH UNDERDRAINS.
5. COORDINATE WITH ENGINEER IN THE EVENT OF UTILITY CROSSING AND UTILITY CONFLICTS.

NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
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CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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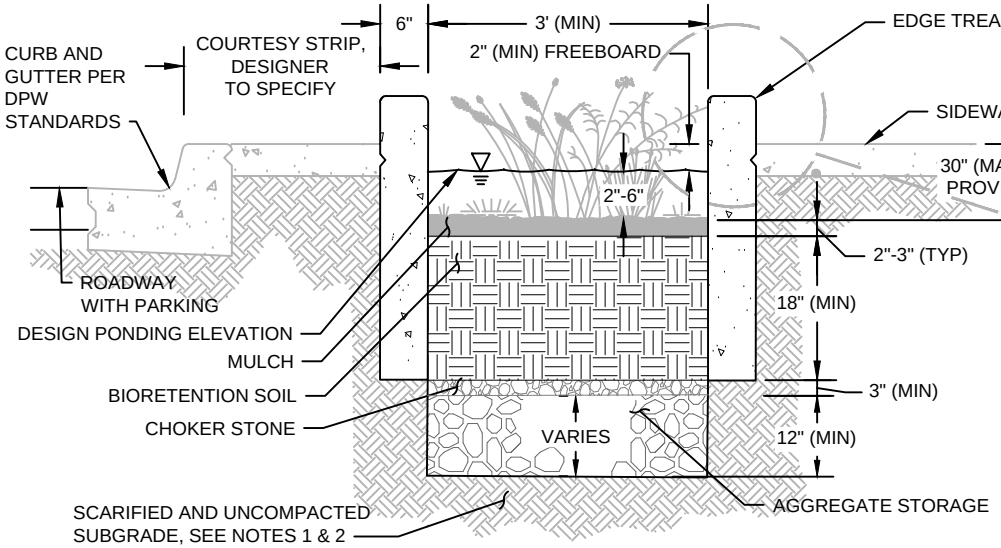
BIORETENTION PLANTER

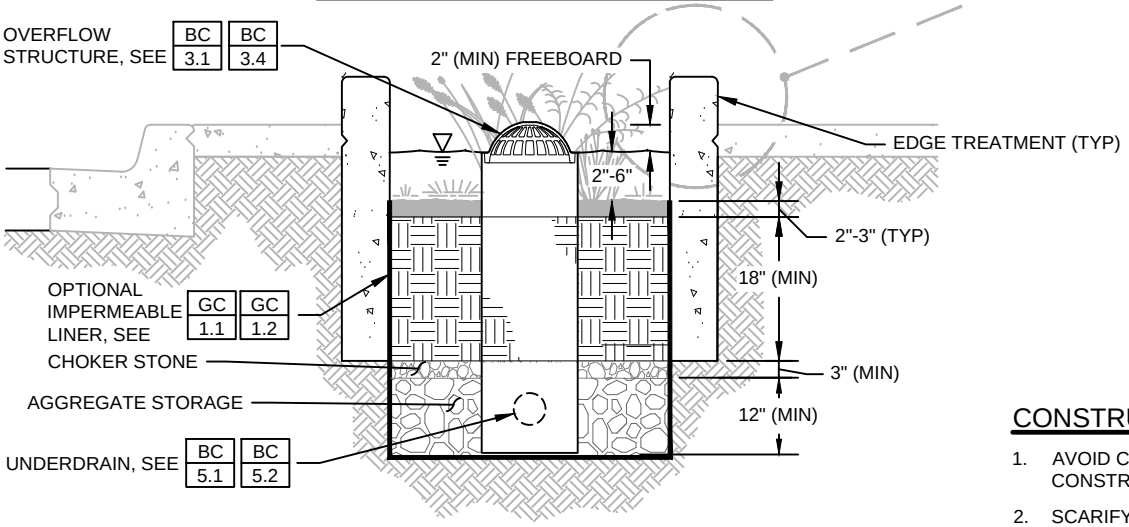
ROADSIDE PLANTER WITH PARKING PLAN

DWG NO. BP 2.1

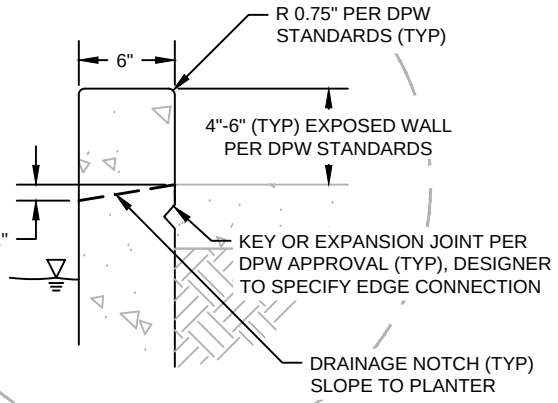
NOT FOR CONSTRUCTION - REFER TO USER GUIDE



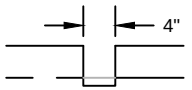
NO UNDERDRAIN - ALTERNATIVE 1



WITH UNDERDRAIN - ALTERNATIVE 2



SIDE VIEW



FRONT VIEW

TYPICAL DRAINAGE NOTCH DETAIL

BIORETENTION PLANTER WITH PARKING A

CONSTRUCTION NOTES:

1. AVOID COMPACTION OF EXISTING SUBGRADE BELOW PLANTER DURING CONSTRUCTION.
2. SCARIFY SUBGRADE TO A DEPTH OF 3 INCHES (MIN) IMMEDIATELY PRIOR TO PLACEMENT OF AGGREGATE STORAGE AND BIORETENTION SOIL MATERIAL.
3. MAXIMUM DROP FROM TOP OF CURB TO TOP OF BIORETENTION SOIL SHALL INCLUDE CONSIDERATIONS FOR BIORETENTION SOIL SETTLEMENT.

NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
	PLAN	SECTIONS	PLAN	SECTIONS	ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	NOTES		PLAN	SECTIONS			
BP 1.1	BP 2.1	BP 2.2	BP 3.1	BP 3.2	BP 4.1	BP 4.2	BP 4.3	BP 4.4	BP 4.5	BP 4.6	BP 5.1	BP 5.2	BP 5.3	BP 5.4	BP 5.5	BP 5.6	BP 5.7

CITY OF SPRINGFIELD, MA

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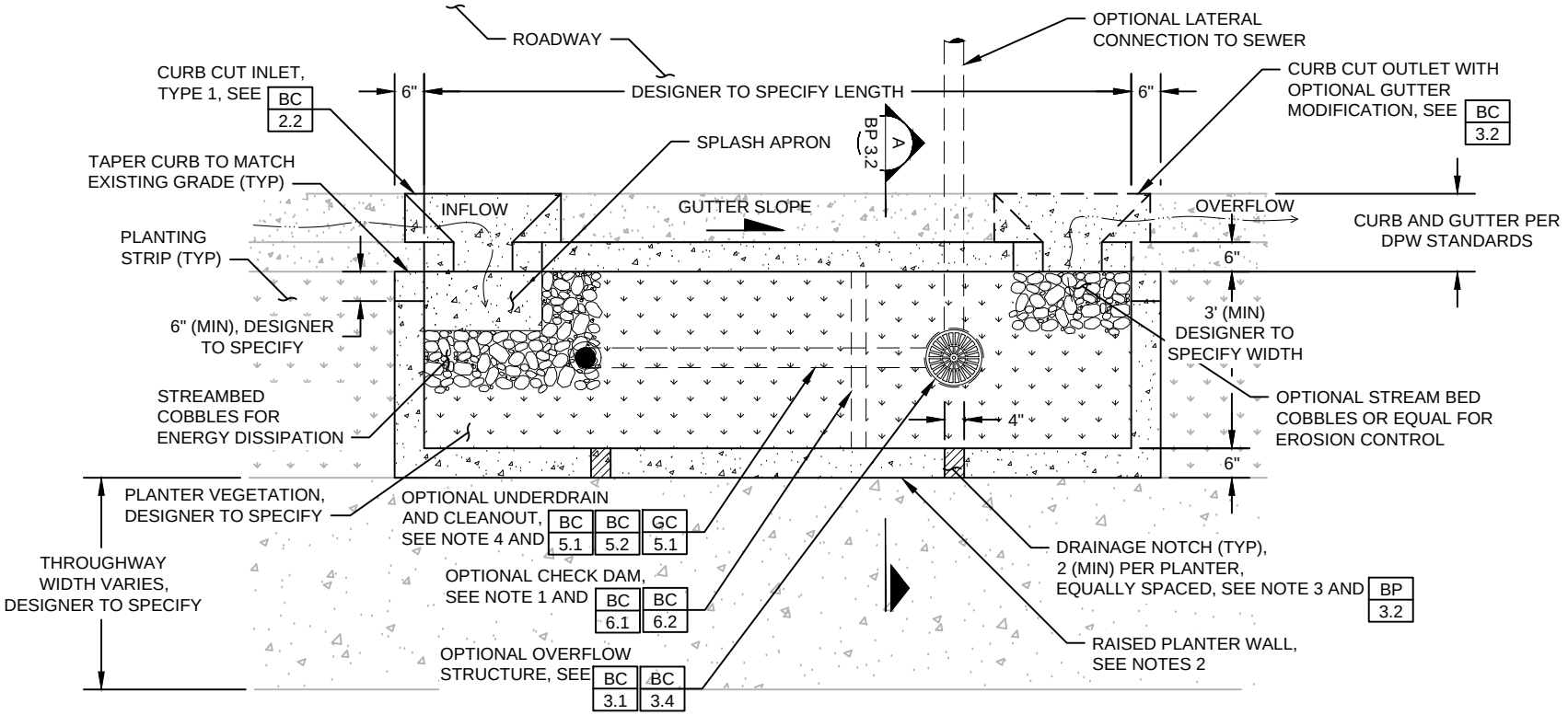
BIORETENTION PLANTER

ROADSIDE PLANTER WITH PARKING SECTIONS

DWG NO. BP 2.2

NOT FOR CONSTRUCTION - REFER TO USER GUIDE



CONSTRUCTION NOTES:

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2. SLOPE TOP OF PLANTER WALL TO MATCH LONGITUDINAL SLOPE OF ADJACENT SURFACE.
3. LAY OUT DRAINAGE NOTCHES TO PREVENT PONDING BEHIND PLANTER WALL WITH 5' MAXIMUM SPACING BETWEEN NOTCHES.
4. PROVIDE ONE CLEANOUT PER PLANTER (MIN) FOR FACILITIES WITH UNDERDRAINS.
5. COORDINATE WITH ENGINEER IN THE EVENT OF UTILITY CROSSING AND UTILITY CONFLICTS.

NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
	PLAN SECTIONS		PLAN SECTIONS		ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	NOTES		PLAN	SECTIONS			
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CITY OF SPRINGFIELD, MA

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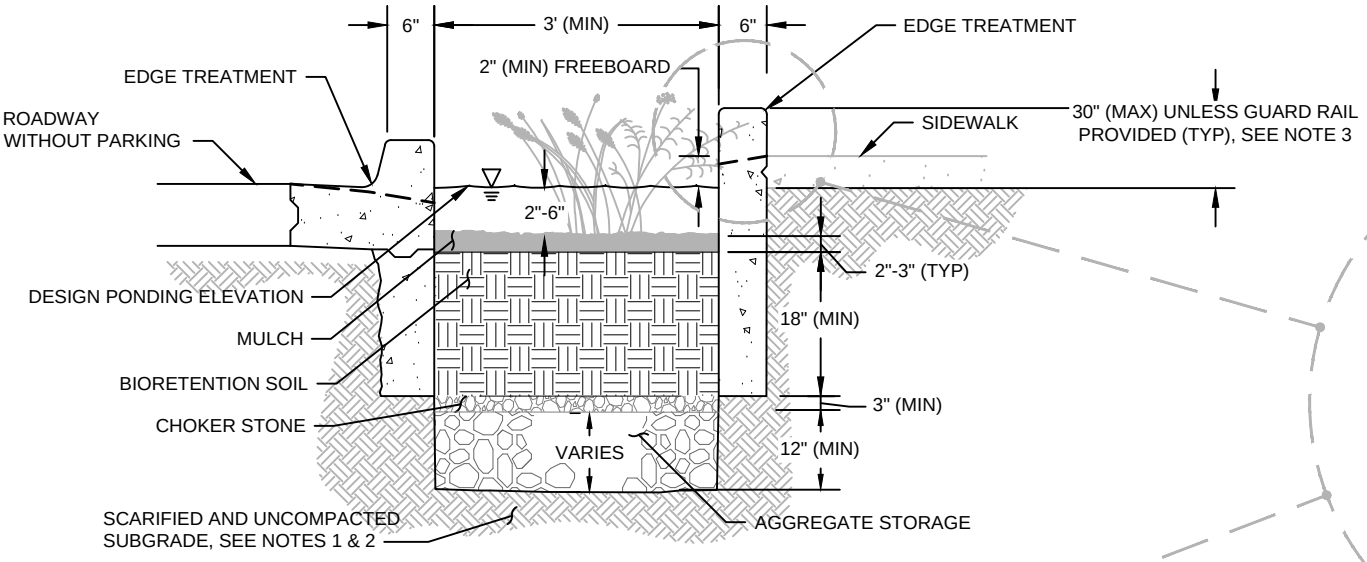
BIORETENTION PLANTER

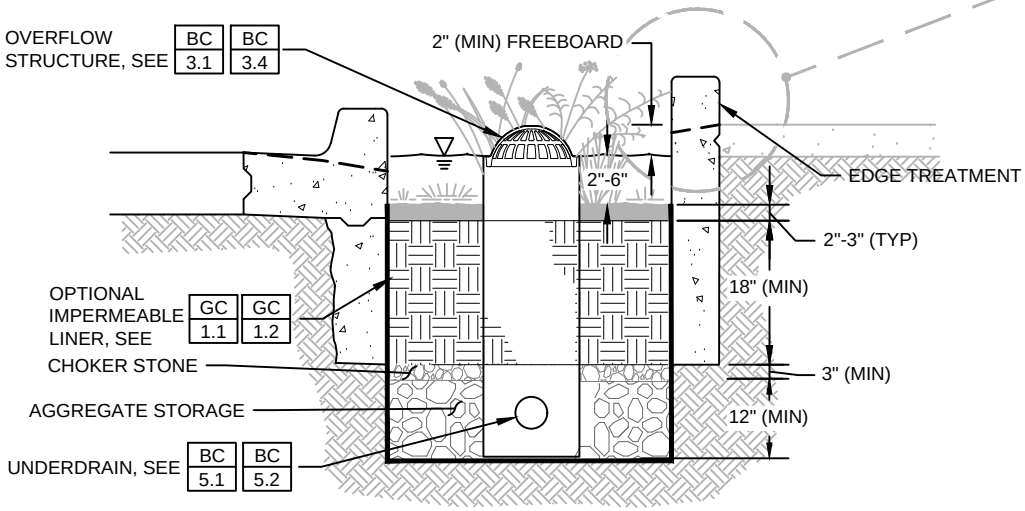
ROADSIDE PLANTER WITHOUT PARKING PLAN

DWG NO. BP 3.1

NOT FOR CONSTRUCTION - REFER TO USER GUIDE



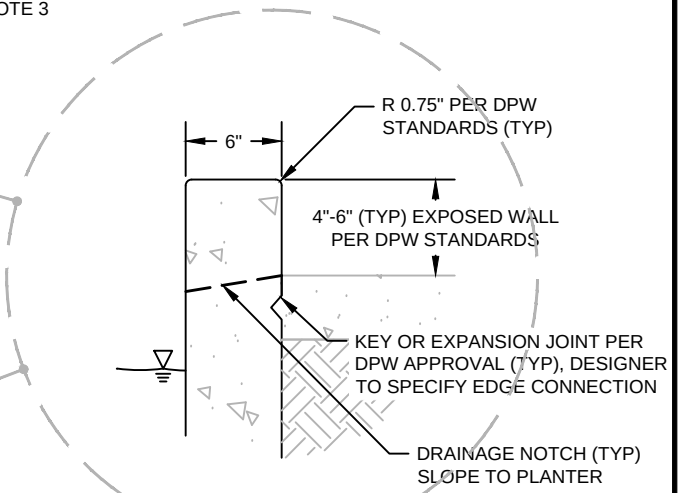
NO UNDERDRAIN - ALTERNATIVE 1



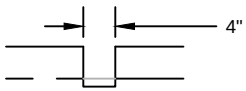
WITH UNDERDRAIN - ALTERNATIVE 2

BIORETENTION PLANTER WITHOUT PARKING

A



SIDE VIEW



FRONT VIEW

TYPICAL DRAINAGE NOTCH DETAIL

CONSTRUCTION NOTES:

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2. SCARIFY SUBGRADE TO A DEPTH OF 3 INCHES (MIN) IMMEDIATELY PRIOR TO PLACEMENT OF AGGREGATE STORAGE AND BIORETENTION SOIL MATERIAL.
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NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
	PLAN SECTIONS		PLAN SECTIONS		ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	NOTES		PLAN	SECTIONS			
BP 1.1	BP 2.1	BP 2.2	BP 3.1	BP 3.2	BP 4.1	BP 4.2	BP 4.3	BP 4.4	BP 4.5	BP 4.6	BP 5.1	BP 5.2	BP 5.3	BP 5.4	BP 5.5	BP 5.6	BP 5.7

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

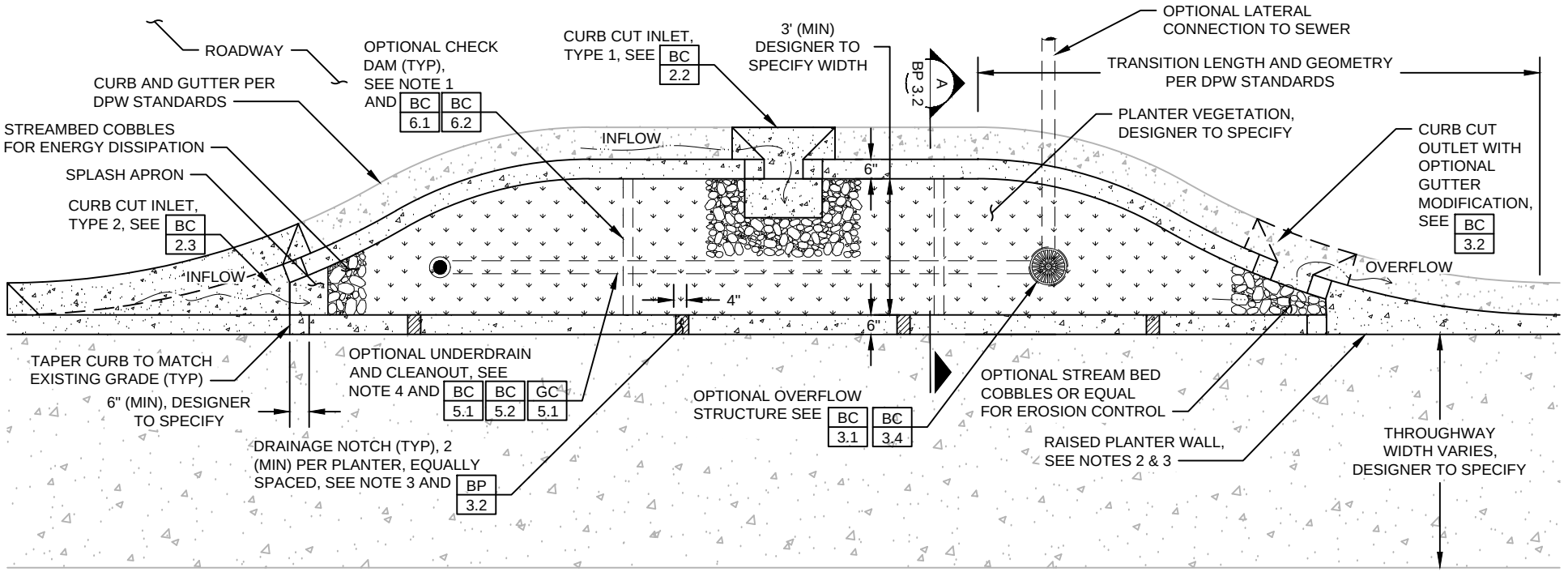
ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION

DATE: FEBRUARY 2019
VERSION: 1.0
REVISED:

BIORETENTION PLANTER

ROADSIDE PLANTER WITHOUT PARKING SECTIONS

DWG NO. BP 3.2



CONSTRUCTION NOTES:

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2. SLOPE TOP OF PLANTER WALL TO MATCH LONGITUDINAL SLOPE OF ADJACENT SURFACE.
3. LAY OUT DRAINAGE NOTCHES TO PREVENT PONDING BEHIND PLANTER WALL WITH 5' MAXIMUM SPACING BETWEEN NOTCHES.
4. PROVIDE ONE CLEANOUT PER PLANTER (MIN) FOR FACILITIES WITH UNDERDRAINS.
5. COORDINATE WITH ENGINEER IN THE EVENT OF UTILITY CROSSING AND UTILITY CONFLICTS.

NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
	PLAN SECTIONS		PLAN SECTIONS		ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	NOTES		PLAN	SECTIONS			
BP 1.1	BP 2.1	BP 2.2	BP 3.1	BP 3.2	BP 4.1	BP 4.2	BP 4.3	BP 4.4	BP 4.5	BP 4.6	BP 5.1	BP 5.2	BP 5.3	BP 5.4	BP 5.5	BP 5.6	BP 5.7

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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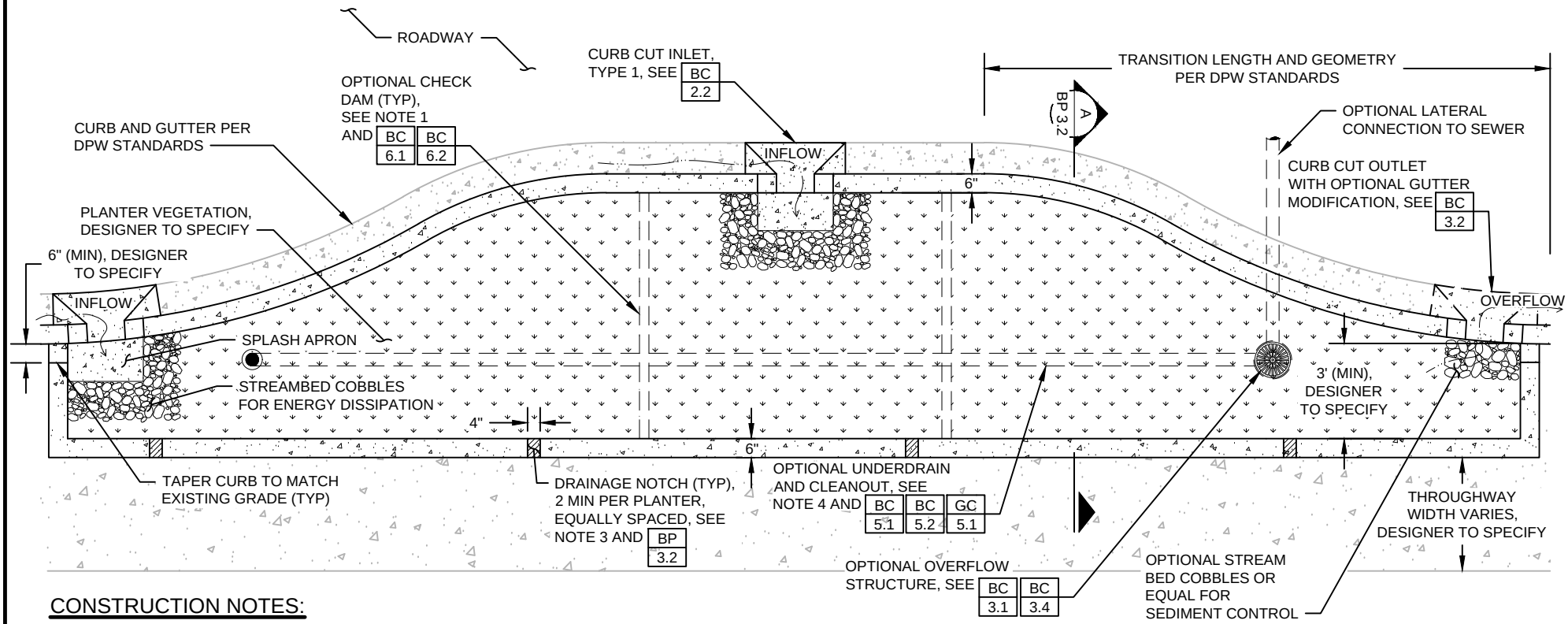
BIORETENTION PLANTER

ROADSIDE BULBOUT PLANTER ALTERNATIVE 1

DWG NO. **BP 4.1**

NOT FOR CONSTRUCTION - REFER TO USER GUIDE



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NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
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BP 1.1	BP 2.1	BP 2.2	BP 3.1	BP 3.2	BP 4.1	BP 4.2	BP 4.3	BP 4.4	BP 4.5	BP 4.6	BP 5.1	BP 5.2	BP 5.3	BP 5.4	BP 5.5	BP 5.6	BP 5.7

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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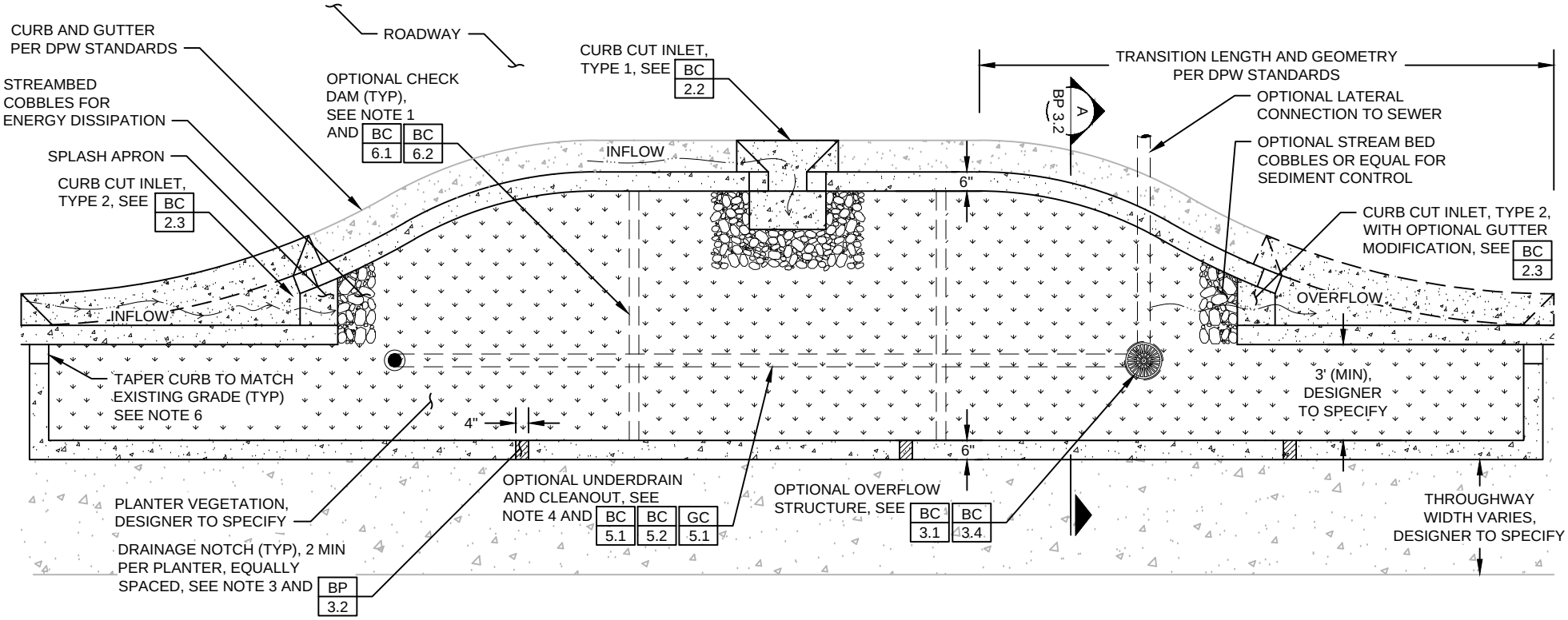
BIORETENTION PLANTER

ROADSIDE BULBOUT PLANTER ALTERNATIVE 2

DWG NO. BP 4.2

NOT FOR CONSTRUCTION - REFER TO USER GUIDE



CONSTRUCTION NOTES:

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5. COORDINATE WITH ENGINEER IN THE EVENT OF UTILITY CROSSING AND UTILITY CONFLICTS.
6. IF STREET PARKING IS ALLOWED IMMEDIATELY ADJACENT TO THE CURB CUT INLET/OUTLET, THE PLANTER WALL TAPER SHOULD BE LOCATED 18" BEHIND THE FACE OF CURB.

NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
	PLAN	SECTIONS	PLAN	SECTIONS	ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	NOTES		PLAN	SECTIONS			
BP 1.1	BP 2.1	BP 2.2	BP 3.1	BP 3.2	BP 4.1	BP 4.2	BP 4.3	BP 4.4	BP 4.5	BP 4.6	BP 5.1	BP 5.2	BP 5.3	BP 5.4	BP 5.5	BP 5.6	BP 5.7

CITY OF SPRINGFIELD, MA

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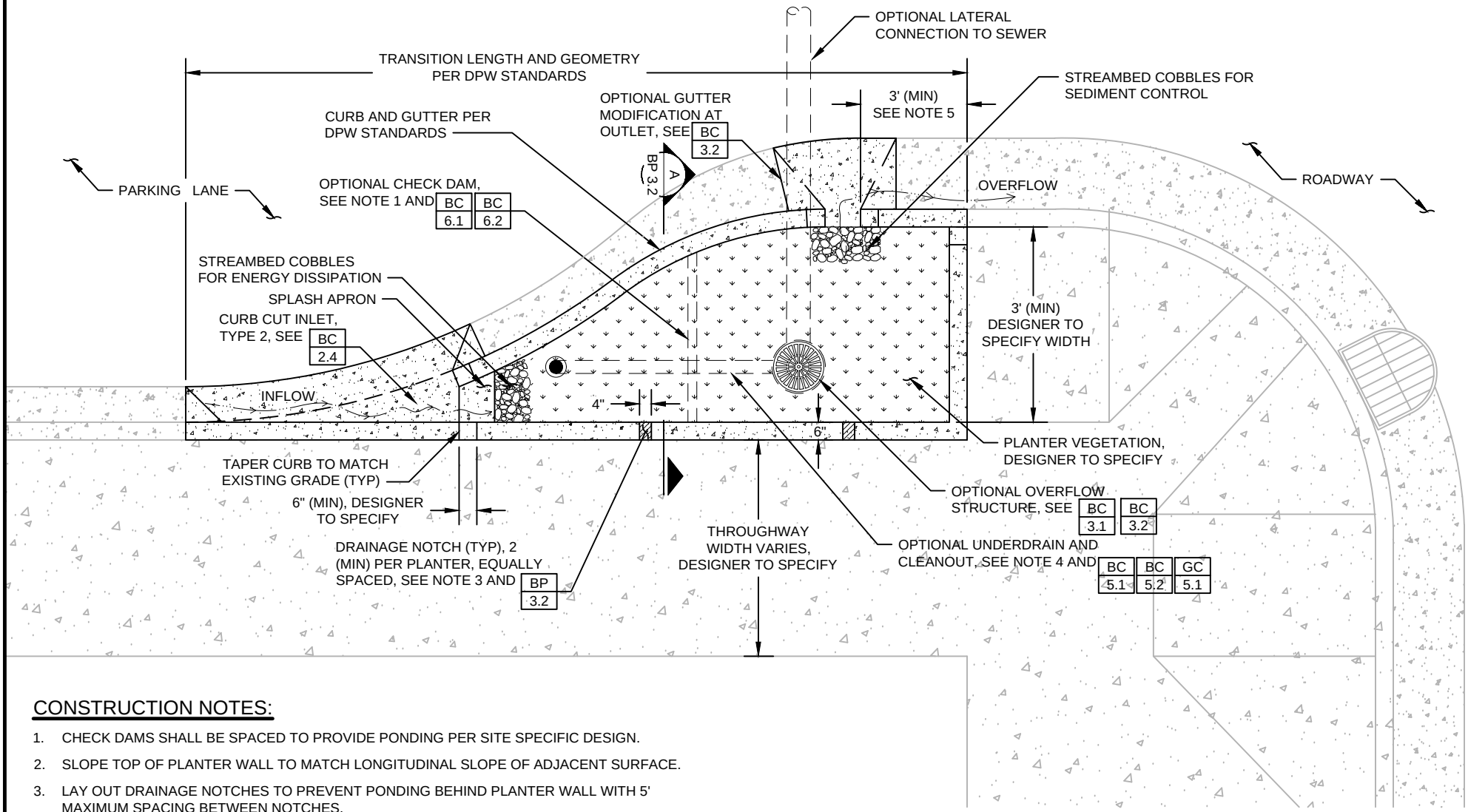
BIORETENTION PLANTER

ROADSIDE BULBOUT PLANTER ALTERNATIVE 3

DWG NO. **BP 4.3**

NOT FOR CONSTRUCTION - REFER TO USER GUIDE



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CITY OF SPRINGFIELD, MA

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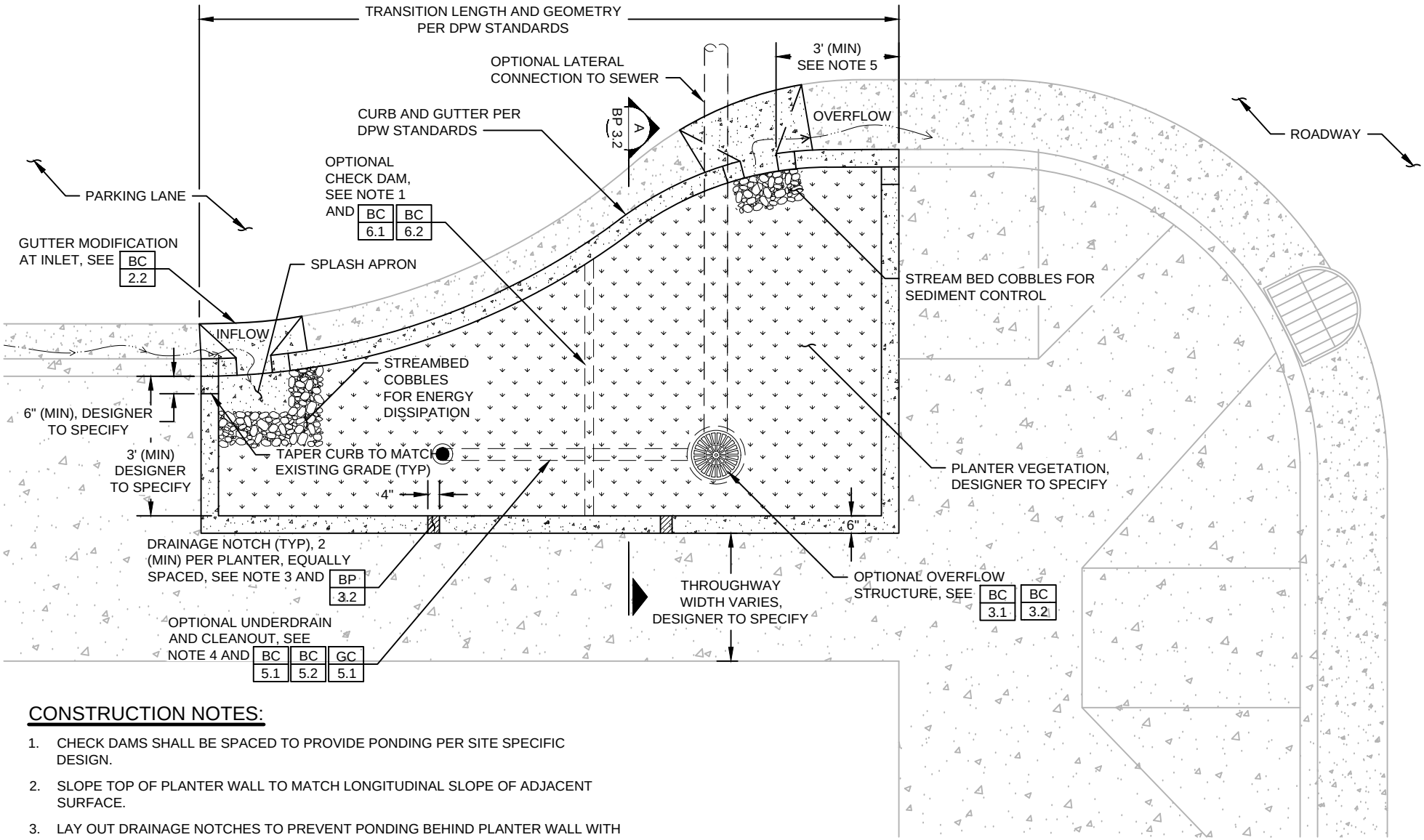
BIORETENTION PLANTER

ROADSIDE BULBOUT PLANTER ALTERNATIVE 4

DWG NO. **BP 4.4**

NOT FOR CONSTRUCTION - REFER TO USER GUIDE



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NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
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BP 1.1	BP 2.1	BP 2.2	BP 3.1	BP 3.2	BP 4.1	BP 4.2	BP 4.3	BP 4.4	BP 4.5	BP 4.6	BP 5.1	BP 5.2	BP 5.3	BP 5.4	BP 5.5	BP 5.6	BP 5.7

CITY OF SPRINGFIELD, MA

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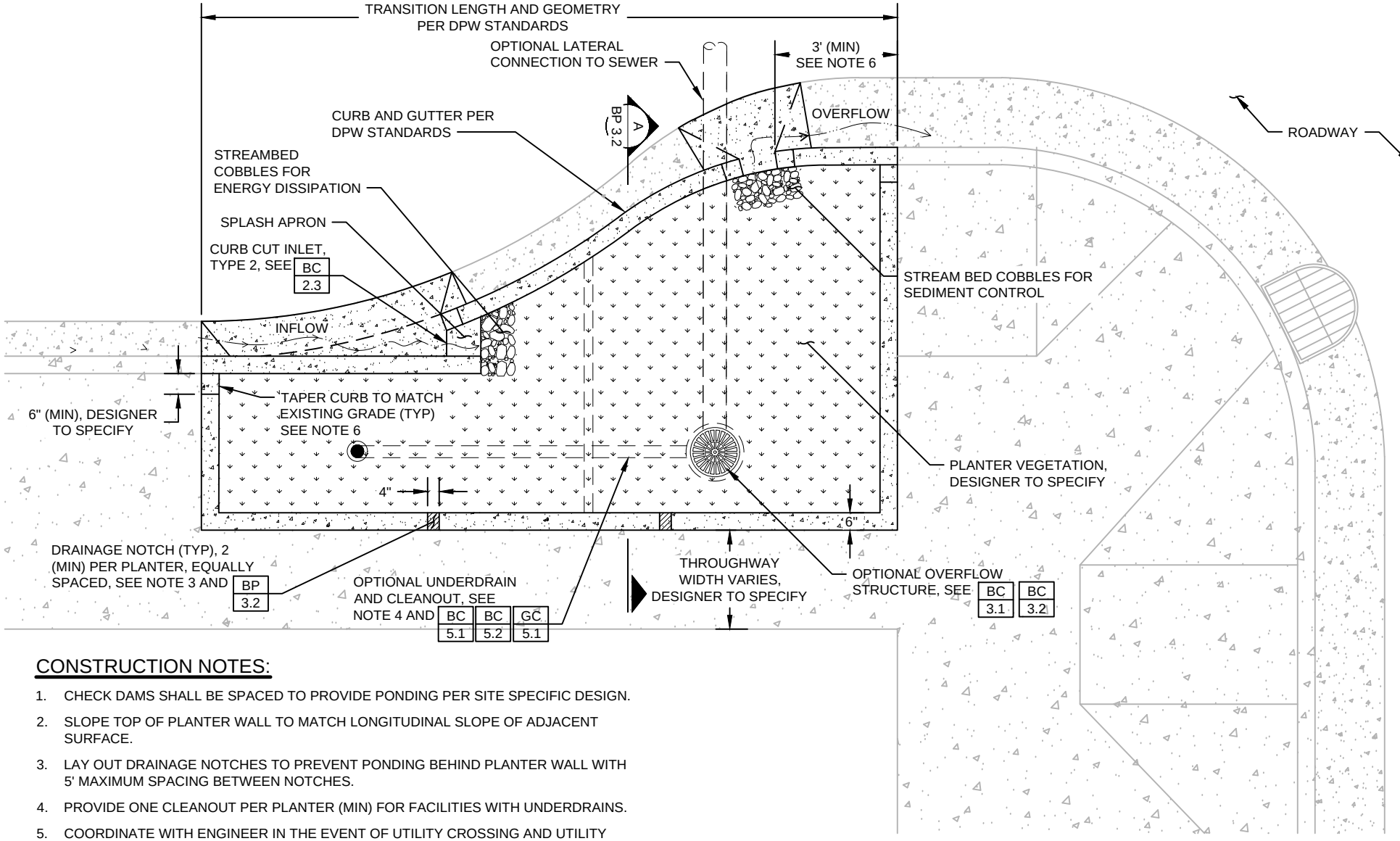
BIORETENTION PLANTER

ROADSIDE BULBOUT PLANTER ALTERNATIVE 5

DWG NO. **BP 4.5**

NOT FOR CONSTRUCTION - REFER TO USER GUIDE



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NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
	PLAN	SECTIONS	PLAN	SECTIONS	ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	NOTES		PLAN	SECTIONS			
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CITY OF SPRINGFIELD, MA

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BIORETENTION PLANTER

ROADSIDE BULBOUT PLANTER ALTERNATIVE 6

DWG NO. **BP 4.6**

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

PURPOSE:

PARCEL BIORETENTION PLANTERS CONTROL PEAK FLOWS AND VOLUMES OF STORMWATER RUNOFF BY PROVIDING SURFACE, SUBSURFACE STORAGE AND INFILTRATION INTO NATIVE SOIL. WATER IS TREATED AS IT FILTERS THROUGH THE BIORETENTION SOIL.

DESIGNER NOTES & GUIDELINES:

1. THE DESIGNER MUST ADAPT PLAN AND SECTION DRAWINGS TO ADDRESS BUILDING- AND SITE-SPECIFIC CONDITIONS.
2. THE DESIGNER MUST COMPLY WITH ALL APPLICABLE SITE AND BUILDING CODE REQUIREMENTS FOR ON-SITE ACCESSIBILITY AND SAFETY INCLUDING, BUT NOT LIMITED TO, CURBS, PEDESTRIAN SURFACING, AND GUARDRAILS/FALL HEIGHTS.
3. PLANTER AREA, PONDING DEPTH, BIORETENTION SOIL DEPTH, AND AGGREGATE STORAGE DEPTH MUST BE SIZED TO MEET PROJECT-SPECIFIC PERFORMANCE GOALS.
4. PONDING AND BIORETENTIONSOIL DRAWDOWN TIME (I.E., TIME FOR MAXIMUM SURFACE PONDING TO DRAIN THROUGH THE BIORETENTION SOIL AFTER THE END OF A STORM) RECOMMENDATIONS:
   - 3 - 12 HOUR PONDING AND BIORETENTION SOIL DRAWDOWN (TYPICAL)
   - 24 HOUR MAXIMUM PONDING AND BIORETENTION SOIL DRAWDOWN
5. FACILITY DRAWDOWN TIME (I.E., TIME FOR SURFACE PONDING TO DRAIN THROUGH THE ENTIRE SECTION INCLUDING AGGREGATE STORAGE AFTER THE END OF A STORM) REQUIREMENTS:
   - 72 HOUR MAXIMUM FACILITY DRAWDOWN (i.e.ORFICE CONTROLLED SYSTEM OR EXTENDED STORAGE DEPTH WITHIN INFILTRATION SYSTEM)
6. CHECK DAMS MAY BE USED TO TERRACE FACILITIES TO PROVIDE SUFFICIENT PONDING FOR HIGHER-SLOPED INSTALLATIONS. DESIGNER MUST SPECIFY CHECK DAM HEIGHT AND SPACING. REFER TO **BC 6.1** AND **BC 6.2** FOR GUIDANCE ON CHECK DAM DESIGN.
7. PLANTER OVERFLOW STRUCTURES SHALL BE DESIGNED TO CONVEY THE ANTICIPATED DESIGN FLOWS.
8. PLANTERS SHALL BE DESIGNED TO OVERFLOW TO THE STREET IN THE EVENT THE PLANTER OUTLET IS OBSTRUCTED OR CLOGGED.
9. MATERIALS FOR PLANTERS MAY VARY TO WORK WITH SITE AND ARCHITECTURAL PALETTE.
10. FACILITIES ADJACENT TO A BUILDING (WITHIN 10 FEET) SHOULD BE LINED TO AVOID NEGATIVE IMPACTS OF WATER AT FOUNDATION. LINER CAN BE OMITTED WITH LETTER FROM LICENSED DESIGN PROFESSIONAL(S) STATING THAT BUILDING WATERPROOFING, STRUCTURAL INTEGRITY, AND STORMWATER FUNCTION IS NOT IMPACTED.
11. FACILITIES MAY BE EXTENDED ABOVE GRADE FOR SEATWALL OR RAISED PLANTER CONFIGURATIONS, IF APPROPRIATE CONVEYANCE MEASURES ARE PROVIDED TO MEET DESIGN REQUIREMENTS.
12. CONVEYANCE CONNECTIONS MAY BE CONFIGURED TO ACCEPT RUNOFF VIA OVERHEAD CONVEYANCE (DOWNSPOUTS, OVERHEAD RUNNELS), SURFACE FLOW (CHANNELS), OR SUBSURFACE CONVEYANCE (PIPES, TRENCH DRAINS).
13. CONVEYANCE CONNECTIONS (E.G. SCUPPER, CHANNEL, PIPE) SHALL BE SIZED TO ACCOMMODATE DRAINAGE FROM ROOF AREA WITH ADEQUATE FREEBOARD TO AVOID OVERFLOWING.
14. UNDERDRAINS REQUIRED ON STRUCTURE TO DRAIN PLANTER AND AVOID ACCUMULATION OF WATER ON STRUCTURE WATERPROOFING SYSTEM.
15. OVERFLOW STRUCTURE (MATERIAL AND WORKMANSHIP) SHALL CONFORM TO APPLICABLE PUBLIC WORKS CODES AND REQUIREMENTS. SIZE AND MODEL OF ATRIUM GRATE AT OVERFLOW TO BE DETERMINED BY ENGINEER TO ENSURE CONVEYANCE OF PEAK FLOW.
16. THE DESIGNER MUST EVALUATE UTILITY SURVEYS FOR POTENTIAL UTILITY CROSSINGS OR CONFLICTS.

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

NOTES	W/ PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS							
	PLAN	SECTIONS	PLAN	SECTIONS	ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	NOTES		PLAN	SECTIONS				
BP 1.1	BP 2.1	BP 2.2	BP 3.1	BP 3.2	BP 4.1	BP 4.2	BP 4.3	BP 4.4	BP 4.5	BP 4.6	BP 5.1	BP 5.2	BP 5.3	BP 5.4	BP 5.5	BP 5.6	BP 5.7

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION

DATE: FEBRUARY 2019
VERSION: 1.0
REVISED:

BIORETENTION PLANTER

PARCEL PLANTER DESIGNER NOTES (1 OF 2)

DWG NO. BP 5.1

LAYOUT REQUIREMENTS:

THE DESIGNER MUST COMPLY WITH ALL STORMWATER, LAND USE, AND BUILDING CODE REQUIREMENTS:

1. ADHERE TO ALL CODES FOR ACCESSIBILITY REQUIRED FOR PARCEL LEVEL DEVELOPMENT
2. PARCEL PLANTERS SHOULD NOT INTERFERE WITH OTHER LAND USE REQUIREMENTS SUCH AS BUFFERING AND SCREENING, SETBACKS, SIGHT DISTANCE, AND MINIMUM SITE COVERAGE.
3. DESIGNER MUST COMPLY WITH ALL CURRENT LOCAL CODES.

DESIGNER CHECKLIST (MUST SPECIFY, AS APPLICABLE):

- ☐ PLANTER WIDTH AND LENGTH
- ☐ DEPTH OF PONDING
- ☐ DEPTH OF FREEBOARD
- ☐ DEPTH OF BIORETENTION SOIL
- ☐ DEPTH AND TYPE OF GRAVEL STORAGE, IF ANY
- ☐ PLANTER SURFACE ELEVATION (TOP OF BIORETENTION SOIL) AT UPSLOPE AND DOWNSLOPE ENDS OF FACILITY
- ☐ CONTROL POINTS AT EVERY PLANTER WALL CORNER OR POINT OF TANGENCY
- ☐ DIMENSIONS AND DISTANCE TO EVERY INLET, OUTLET, CHECK DAM, SIDEWALK NOTCH, ETC.
- ☐ ELEVATIONS OF EVERY INLET, OUTLET, STRUCTURE RIM AND INVERT, CLEAN OUT, PLANTER WALL CORNER, AND SIDEWALK NOTCH
- ☐ TYPE AND DESIGN OF PLANTER COMPONENTS (E.G., EDGE TREATMENTS, INLETS/GUTTER MODIFICATIONS, UTILITY CROSSINGS, LINER, AND PLANTING DETAILS).
- ☐ OVERFLOW STRUCTURE AND ATRIUM GRATE SIZE AND MODEL NUMBER

RELATED COMPONENTS

INLETS:	BC 2.1 - BC 2.4
OUTLETS:	BC 3.1 - BC 3.4
UNDERDRAINS:	BC 5.1 - BC 5.2
CHECK DAMS:	BC 6.1 - BC 6.2
LINERS:	GC 1.1, GC 1.2
OBSERVATION PORTS:	GC 3.1, GC 3.3
CLEANOUTS:	GC 5.2

NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
	PLAN	SECTIONS	PLAN	SECTIONS	ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	NOTES		PLAN	SECTIONS			
BP 1.1	BP 2.1	BP 2.2	BP 3.1	BP 3.2	BP 4.1	BP 4.2	BP 4.3	BP 4.4	BP 4.5	BP 4.6	BP 5.1	BP 5.2	BP 5.3	BP 5.4	BP 5.5	BP 5.6	BP 5.7

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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BIORETENTION PLANTER

PARCEL PLANTER

DESIGNER NOTES (2 OF 2)

DWG NO. BP 5.2

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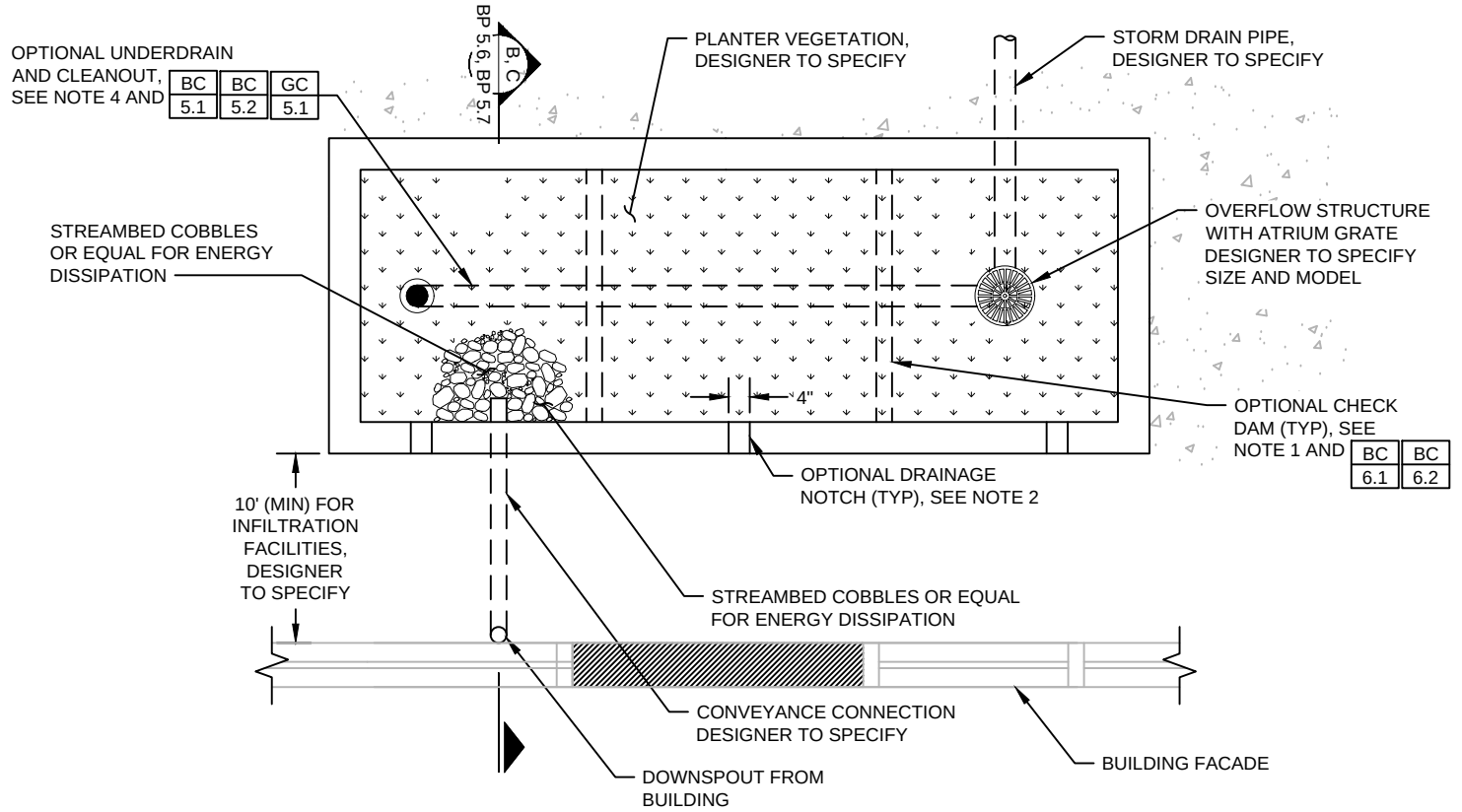

PLAN - ALTERNATIVE 1 (1)

CONSTRUCTION NOTES:

1. CHECK DAMS SHALL BE SPACED TO PROVIDE PONDING PER SITE SPECIFIC DESIGN.
2. LAY OUT DRAINAGE NOTCHES TO PREVENT PONDING BEHIND PLANTER WALL WITH 5' MAXIMUM SPACING BETWEEN NOTCHES .
3. COORDINATE WATERPROOFING AT BUILDINGS WITH ARCHITECT AND ENGINEER, AS APPLICABLE.
4. COORDINATE WITH ENGINEER IN THE EVENT OF UTILITY CROSSING AND UTILITY CONFLICTS.

NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
	PLAN	SECTIONS	PLAN	SECTIONS	ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	NOTES		PLAN	SECTIONS			
BP 1.1	BP 2.1	BP 2.2	BP 3.1	BP 3.2	BP 4.1	BP 4.2	BP 4.3	BP 4.4	BP 4.5	BP 4.6	BP 5.1	BP 5.2	BP 5.3	BP 5.4	BP 5.5	BP 5.6	BP 5.7

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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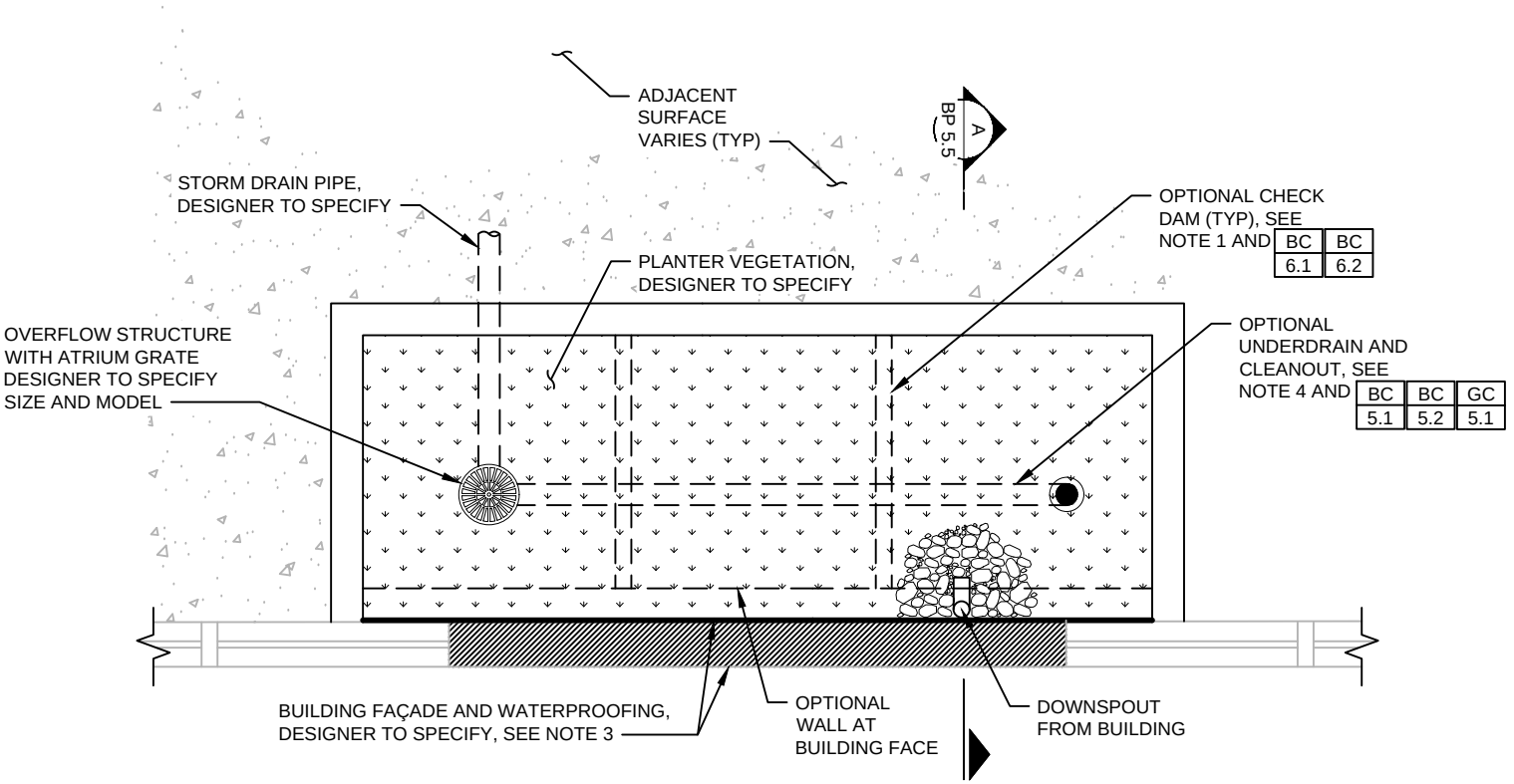
BIORETENTION PLANTER

PARCEL PLANTER PLAN ALTERNATIVE 1

DWG NO. BP 5.3

NOT FOR CONSTRUCTION - REFER TO USER GUIDE



PLAN - ALTERNATIVE 2 (1)

CONSTRUCTION NOTES:

1. CHECK DAMS SHALL BE SPACED TO PROVIDE PONDING PER SITE SPECIFIC DESIGN.
2. LAY OUT DRAINAGE NOTCHES TO PREVENT PONDING BEHIND PLANTER WALL WITH 5' MAXIMUM SPACING BETWEEN NOTCHES .
3. COORDINATE WATERPROOFING AT BUILDINGS WITH ARCHITECT AND ENGINEER, AS APPLICABLE.
4. PROVIDE ONE CLEANOUT PER PLANTER (MIN) FOR FACILITIES WITH UNDERDRAINS.
5. COORDINATE WITH ENGINEER IN THE EVENT OF UTILITY CROSSING AND UTILITY CONFLICTS.

NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
	PLAN	SECTIONS	PLAN	SECTIONS	ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	NOTES		PLAN	SECTIONS			
BP 1.1	BP 2.1	BP 2.2	BP 3.1	BP 3.2	BP 4.1	BP 4.2	BP 4.3	BP 4.4	BP 4.5	BP 4.6	BP 5.1	BP 5.2	BP 5.3	BP 5.4	BP 5.5	BP 5.6	BP 5.7

CITY OF SPRINGFIELD, MA

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BIORETENTION PLANTER

PARCEL PLANTER PLAN ALTERNATIVE 2

DWG NO. BP 5.4

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

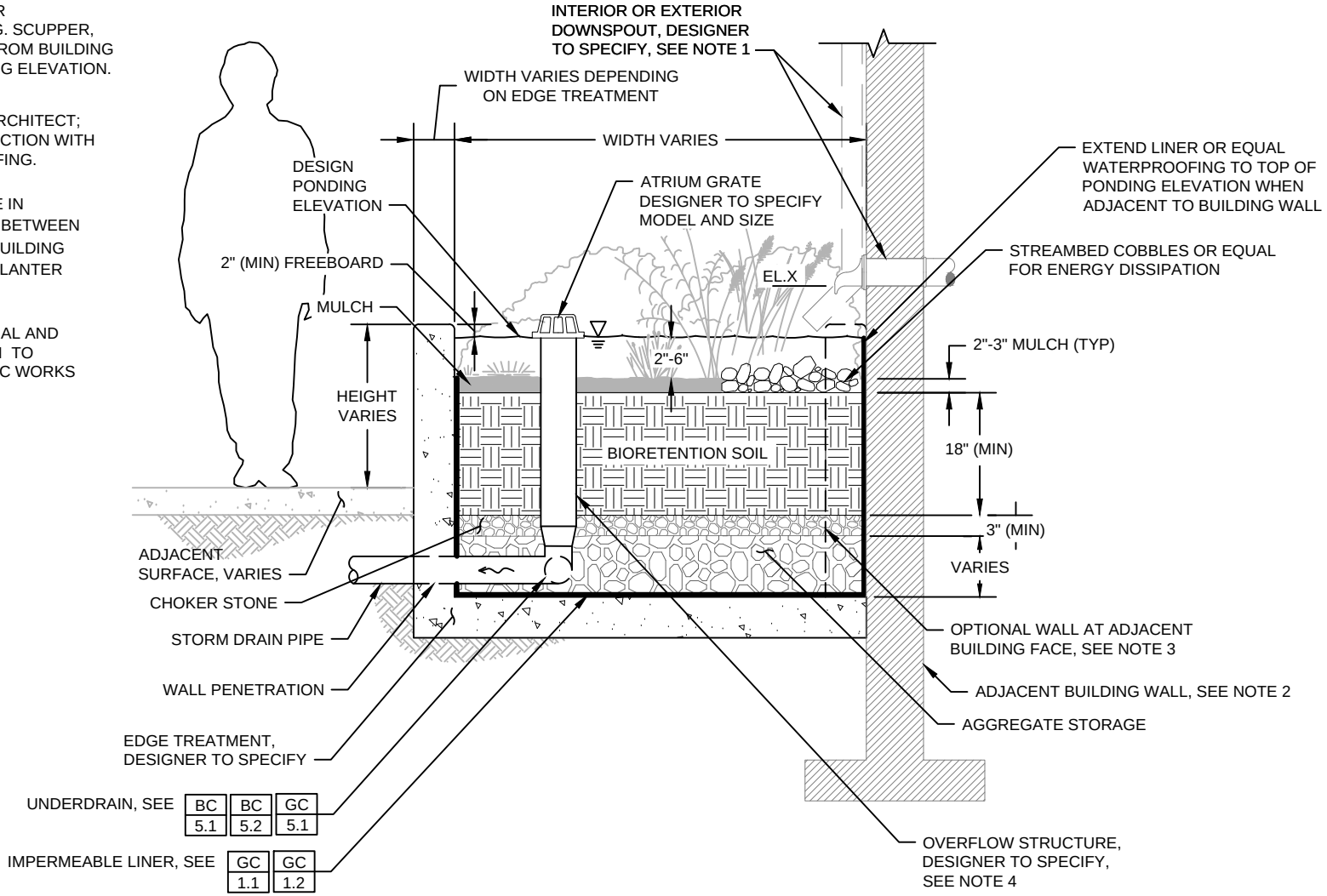
CONSTRUCTION NOTES:

1. INSTALL DOWNSPOUTS OR OTHER CONVEYANCE CONNECTIONS (E.G. SCUPPER, CHANNEL, OVERHEAD RUNNEL) FROM BUILDING TO DRAIN ABOVE DESIGN PONDING ELEVATION.

2. BUILDING WATERPROOFING BY ARCHITECT; COORDINATE PLANTER CONSTRUCTION WITH BUILDING FAÇADE / WATERPROOFING.

3. PROVIDE WALL AT BUILDING FACE IN CASES WHERE GAP IS REQUIRED BETWEEN WALL AND PLANTER OR WHERE BUILDING FAÇADE IS INCOMPATIBLE WITH PLANTER CONFIGURATION.

4. OVERFLOW STRUCTURE (MATERIAL AND WORKMANSHIP) SHALL CONFORM TO APPLICABLE BUILDING AND PUBLIC WORKS CODES AND REQUIREMENTS.



SECTION - RAISED BIORETENTION PLANTER (A)

NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
	PLAN	SECTIONS	PLAN	SECTIONS	ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	NOTES		PLAN	SECTIONS			
BP 1.1	BP 2.1	BP 2.2	BP 3.1	BP 3.2	BP 4.1	BP 4.2	BP 4.3	BP 4.4	BP 4.5	BP 4.6	BP 5.1	BP 5.2	BP 5.3	BP 5.4	BP 5.5	BP 5.6	BP 5.7

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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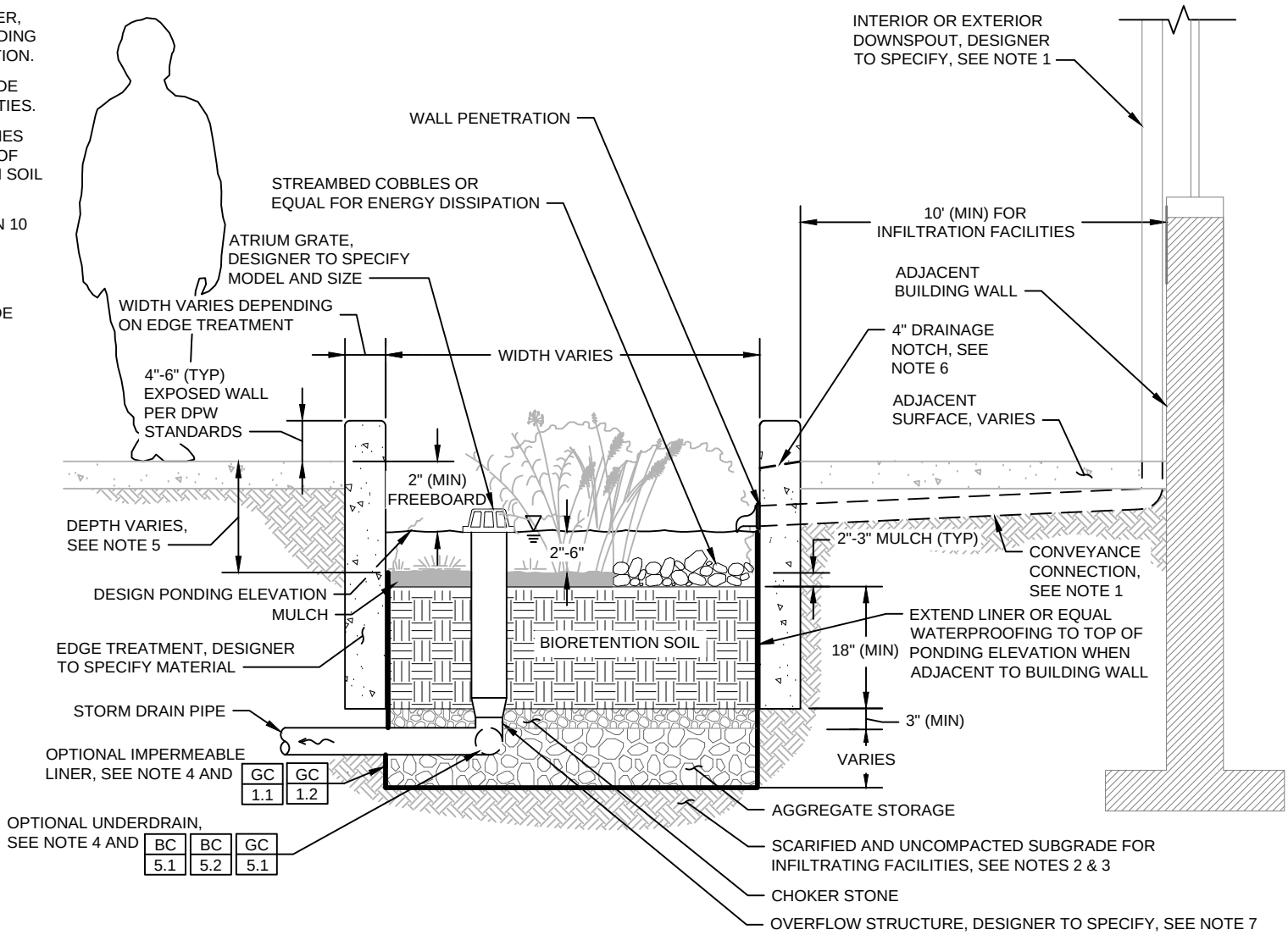
BIORETENTION PLANTER
PARCEL PLANTER
RAISED PLANTER SECTION

DWG NO. BP 5.5

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

CONSTRUCTION NOTES:

1. INSTALL DOWNSPOUTS AND OTHER CONVEYANCE CONNECTIONS (E.G. SCUPPER, CHANNEL, OVERHEAD RUNNEL) FROM BUILDING TO DRAIN ABOVE DESIGN PONDING ELEVATION.
2. AVOID COMPACTION OF EXISTING SUBGRADE BELOW PLANTER FOR INFILTRATION FACILITIES.
3. SCARIFY SUBGRADE TO A DEPTH OF 3 INCHES (MIN) IMMEDIATELY PRIOR TO PLACEMENT OF AGGREGATE STORAGE AND BIORETENTION SOIL MATERIALS.
4. UNDERDRAIN AND LINER REQUIRED WITHIN 10 FEET OF BUILDING ENVELOPE UNLESS APPROVED PER DESIGNER.
5. MAXIMUM DROP FROM TOP OF WALKING SURFACE TO TOP OF MULCH SHALL INCLUDE CONSIDERATIONS FOR SOIL SETTLEMENT.
6. LAY OUT DRAINAGE NOTCHES TO PREVENT PONDING BEHIND PLANTER WALL. SLOPE NOTCHES TO DRAIN TO PLANTER.
7. OVERFLOW STRUCTURE (MATERIAL AND WORKMANSHIP) SHALL CONFORM TO APPLICABLE BUILDING AND PUBLIC WORKS CODES AND REQUIREMENTS.



SECTION - SURFACE BIORETENTION PLANTER (B)

NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
	PLAN	SECTIONS	PLAN	SECTIONS	ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	NOTES		PLAN	SECTIONS			
BP 1.1	BP 2.1	BP 2.2	BP 3.1	BP 3.2	BP 4.1	BP 4.2	BP 4.3	BP 4.4	BP 4.5	BP 4.6	BP 5.1	BP 5.2	BP 5.3	BP 5.4	BP 5.5	BP 5.6	BP 5.7

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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BIORETENTION PLANTER

PARCEL PLANTER

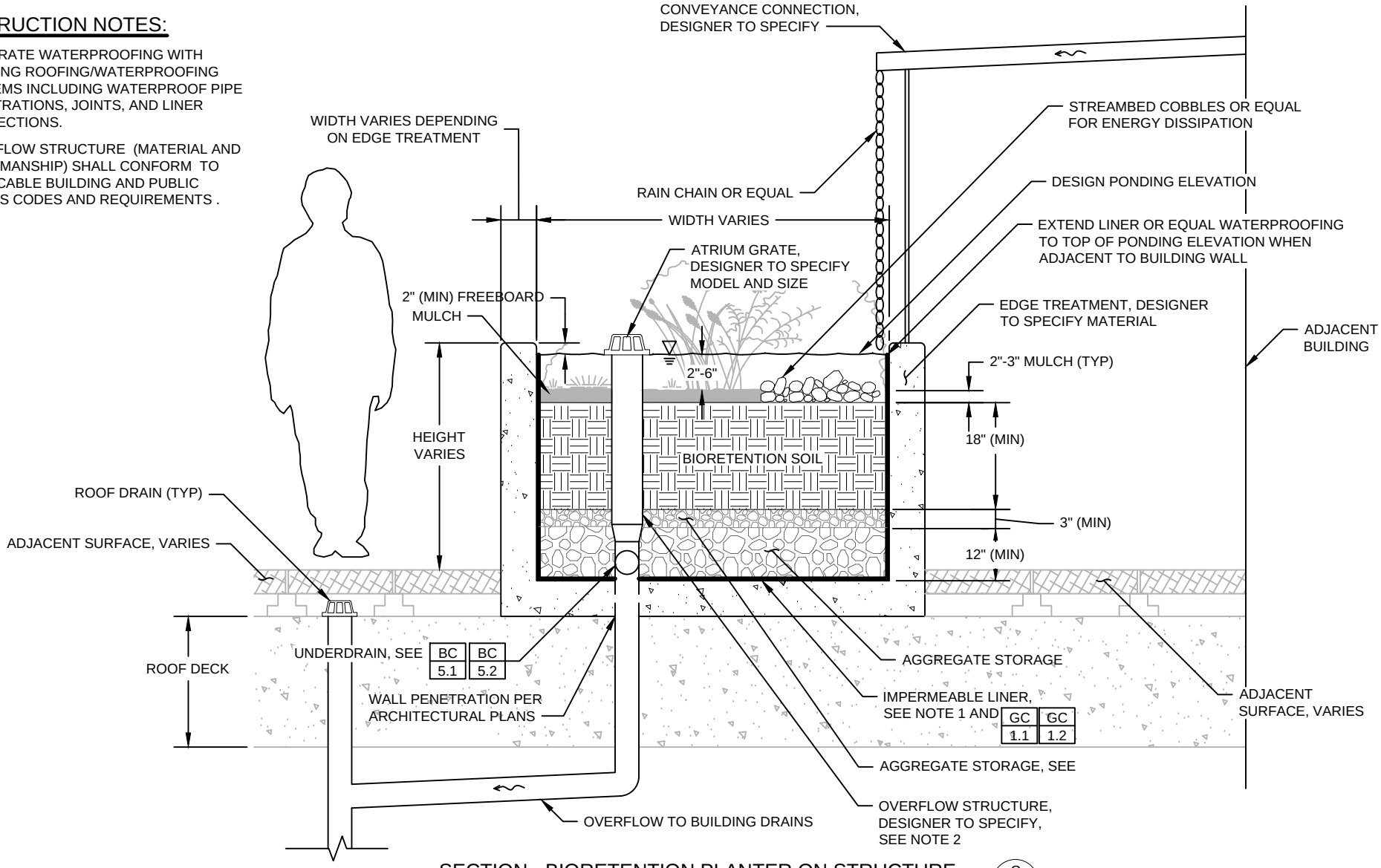
AT-GRADE PLANTER SECTION

DWG NO. **BP 5.6**

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

CONSTRUCTION NOTES:

1. INTEGRATE WATERPROOFING WITH BUILDING ROOFING/WATERPROOFING SYSTEMS INCLUDING WATERPROOF PIPE PENETRATIONS, JOINTS, AND LINER CONNECTIONS.
2. OVERFLOW STRUCTURE (MATERIAL AND WORKMANSHIP) SHALL CONFORM TO APPLICABLE BUILDING AND PUBLIC WORKS CODES AND REQUIREMENTS .



SECTION - BIORETENTION PLANTER ON STRUCTURE C

NOTES	W/PARKING		W/O PARKING		BULBOUT						PARCEL APPLICATIONS						
	PLAN	SECTIONS	PLAN	SECTIONS	ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	NOTES		PLAN	SECTIONS			
BP 1.1	BP 2.1	BP 2.2	BP 3.1	BP 3.2	BP 4.1	BP 4.2	BP 4.3	BP 4.4	BP 4.5	BP 4.6	BP 5.1	BP 5.2	BP 5.3	BP 5.4	BP 5.5	BP 5.6	BP 5.7

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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BIORETENTION PLANTER

PARCEL PLANTER

PLANTER ON STRUCTURE SECTION

DWG NO. **BP 5.7**

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

PURPOSE:

BIORETENTION BASINS CONTROL PEAK FLOWS AND VOLUMES OF STORMWATER RUNOFF BY PROVIDING SURFACE, SUBSURFACE STORAGE AND INFILTRATION INTO NATIVE SOIL. WATER IS ALSO TREATED AS IT FILTERS THROUGH THE BIORETENTION SOIL.

RELATED SPECIFICATIONS	CSI NO.
BIORETENTION: - BIORETENTION SOIL MIX - AGGREGATE STORAGE - MULCH - STREAMBED COBBLES	33 47 27

RELATED COMPONENTS	
INLETS:	BC 2.1 - BC 2.4
OUTLETS:	BC 3.1 - BC 3.4
UNDERDRAINS:	BC 5.1 - BC 5.2
CHECK DAMS:	BC 6.1 - BC 6.2
LINERS:	GC 1.1 - GC 1.2
OBSERVATION PORTS:	GC 4.1 - GC 4.3
CLEANOUTS:	GC 5.1

DESIGNER NOTES & GUIDELINES:

1. THE DESIGNER MUST ADAPT PLAN AND SECTION DRAWINGS TO ADDRESS SITE-SPECIFIC CONDITIONS.
2. FACILITY AREA, PONDING DEPTH, BIORETENTION SOIL DEPTH, AND AGGREGATE STORAGE DEPTH MUST BE SIZED TO MEET PROJECT HYDROLOGIC PERFORMANCE GOALS.
3. PONDING AND BIORETENTIONSOIL DRAWDOWN TIME (I.E., TIME FOR MAXIMUM SURFACE PONDING TO DRAIN THROUGH THE BIORETENTION SOIL AFTER THE END OF A STORM) RECOMMENDATIONS:
   - 3 - 12 HOUR PONDING AND BIORETENTION SOIL DRAWDOWN (TYPICAL)
   - 24 HOUR MAXIMUM PONDING AND BIORETENTION SOIL DRAWDOWN
4. FACILITY DRAWDOWN TIME (I.E., TIME FOR SURFACE PONDING TO DRAIN THROUGH THE ENTIRE SECTION INCLUDING AGGREGATE STORAGE AFTER THE END OF A STORM) REQUIREMENTS:
   - 72 HOUR MAXIMUM FACILITY DRAWDOWN (i.e.ORFICE CONTROLLED SYSTEM OR EXTENDED STORAGE DEPTH WITHIN INFILTRATION SYSTEM).
5. AN AGGREGATE COURSE IS REQUIRED UNDER THE BIORETENTION SOIL FOR BIORETENTION IN SEPARATE SEWER SYSTEM AREAS TO PROVIDE ADDITIONAL TREATMENT. THIS AGGREGATE COURSE IS OPTIONAL FOR FACILITIES IN COMBINED SEWER SYSTEM AREAS. SEE GUIDANCE ON **BC 4.1**.
6. CHECK DAMS MAY BE USED TO TERRACE FACILITIES TO PROVIDE SUFFICIENT PONDING FOR HIGHER-SLOPED INSTALLATIONS. DESIGNER MUST SPECIFY CHECK DAM HEIGHT AND SPACING. REFER TO **BC 6.1** AND **BC 6.2** FOR GUIDANCE ON CHECK DAM DESIGN.
7. THE FOLLOWING GUIDELINES APPLY TO RIGHT-OF-WAY APPLICATIONS:
   - BULBOUT CURB TRANSITIONS SHALL CONFORM TO DPW STANDARDS.
   - WHEN FACILITY CONSTRUCTION IMPACTS EXISTING SIDEWALK, ALL SAW CUTS MUST ADHERE TO DPW REQUIREMENTS. SAW CUTS SHOULD BE ALONG SCORE LINES AND ANY DISTURBED SIDEWALK FLAGS SHOULD BE REPLACED IN THEIR ENTIRETY.
   - DESIGNER TO SPECIFY TRANSITION OF PLANTER TO TOP OF CURB ELEVATION BETWEEN CURB CUTS OR CONTINUOUS 6 INCH REVEAL AT CURB EDGE.
8. UP TO TWO PLANTERS MAY BE CONNECTED IN SERIES, IN LIEU OF MULTIPLE INLETS, PROVIDED THE CONNECTION IS A TRENCH DRAIN OR EQUAL SURFACE CONVEYANCE AND IS ADEQUATELY SIZED TO CONVEY FLOWS.

DESIGNER CHECKLIST (MUST SPECIFY, AS APPLICABLE):

- ☐ FACILITY WIDTH, LENGTH, SLOPES (INCLUDING SIDE, CROSS, AND LONGITUDINAL), AND SHAPE
- ☐ DEPTH OF BIORETENTION SOIL
- ☐ DEPTH AND TYPE OF GRAVEL STORAGE, IF ANY
- ☐ PLANTER SURFACE ELEVATION (TOP OF BIORETENTION SOIL) AT UPSLOPE AND DOWNSLOPE ENDS OF FACILITY
- ☐ CONTROL POINTS AT EVERY CORNER OF FACILITY AND POINT OF TANGENCY
- ☐ DIMENSIONS AND DISTANCE TO EVERY INLET, OUTLET, CHECK DAM, SIDEWALK NOTCH, ETC.
- ☐ ELEVATIONS OF EVERY INLET, OUTLET, STRUCTURE RIM AND INVERT, CHECK DAM, AND SIDEWALK NOTCH
- ☐ TYPE AND DESIGN OF FACILITY COMPONENTS (E.G., EDGE TREATMENTS, INLETS/GUTTER MODIFICATIONS, UTILITY CROSSINGS, LINER, AND PLANTING DETAILS)

LAYOUT REQUIREMENTS:

1. FOR RIGHT-OF-WAY APPLICATIONS, REFER TO THE DPW DETAILS AND SPRINGFIELD COMPLETE STREETS GUIDE FOR CONSTRUCTION FOR COURTESY STRIP, THROUGHWAY, PARKING SPACE AND ACCESSIBLE PATH REQUIREMENTS.
2. LOCATE CURB CUTS AND GUTTER MODIFICATIONS TO AVOID CONFLICTS WITH ACCESSIBILITY REQUIREMENTS (E.G., LOCATE OUTSIDE OF CROSSWALKS).

NOTES: BB 1.1

SECTIONS: BB 2.1, BB 2.2

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION

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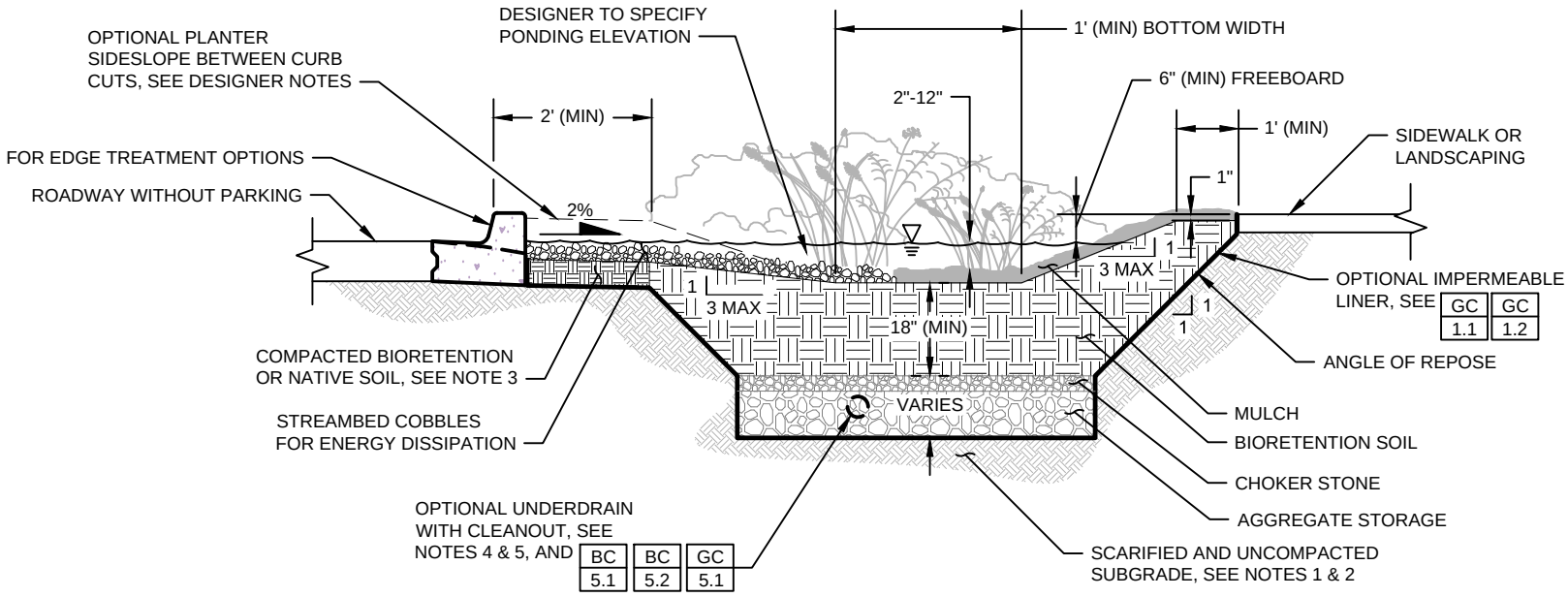
BIORETENTION BASIN
DESIGNER NOTES

DWG NO. BB 1.1



CONSTRUCTION NOTES:

1. AVOID COMPACTION OF EXISTING SUBGRADE BELOW BASIN FOR INFILTRATION BASINS.
2. SCARIFY SUBGRADE TO A DEPTH OF 3 INCHES (MIN) IMMEDIATELY PRIOR TO PLACEMENT OF AGGREGATE STORAGE AND BIORETENTION SOIL MATERIALS.
3. COMPACT BIORETENTION SOIL IMMEDIATELY BEHIND CURB TO 90% OF MAXIMUM DENSITY PER STANDARD PROCTOR TEST (ASTM D698).
4. UNDERDRAIN REQUIRED FOR ALL FACILITIES WITH IMPERMEABLE LINER.
5. PROVIDE ONE CLEANOUT PER PLANTER (MIN) FOR FACILITIES WITH UNDERDRAINS.
6. COORDINATE WITH ENGINEER IN THE EVENT OF UTILITY CROSSING AND UTILITY CONFLICTS.

NOTES	SECTIONS	
BB 1.1	BB 2.1	BB 2.2

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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BIORETENTION BASIN
ROADSIDE SECTION

DWG NO. BB 2.1

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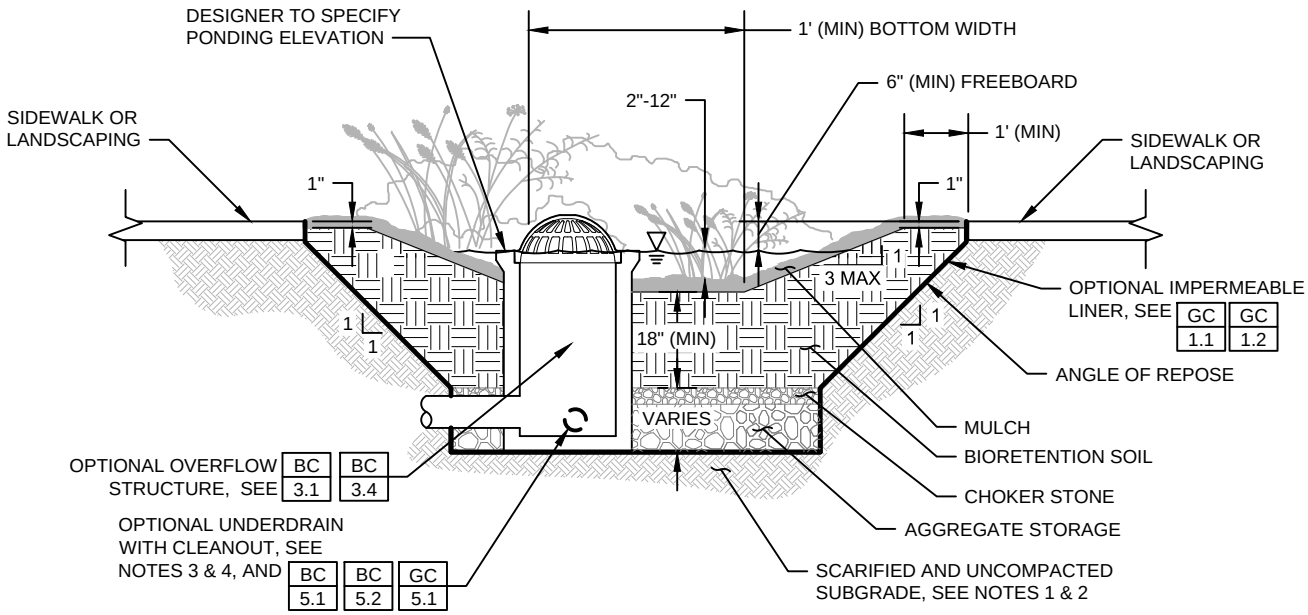

CONSTRUCTION NOTES:

1. AVOID COMPACTION OF EXISTING SUBGRADE BELOW BASIN FOR INFILTRATION BASINS.
2. SCARIFY SUBGRADE TO A DEPTH OF 3 INCHES (MIN) IMMEDIATELY PRIOR TO PLACEMENT OF AGGREGATE STORAGE AND BIORETENTION SOIL MATERIALS.
3. UNDERDRAIN REQUIRED FOR ALL FACILITIES WITH IMPERMEABLE LINER.
4. PROVIDE ONE CLEANOUT PER PLANTER (MIN) FOR FACILITIES WITH UNDERDRAINS.
5. COORDINATE WITH ENGINEER IN THE EVENT OF UTILITY CROSSING AND UTILITY CONFLICTS.

NOTES: BB 1.1

SECTIONS: BB 2.1, BB 2.2

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CITY OF SPRINGFIELD, MA

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BIORETENTION BASIN

PARCEL SECTION

DWG NO. BB 2.2

PURPOSE:

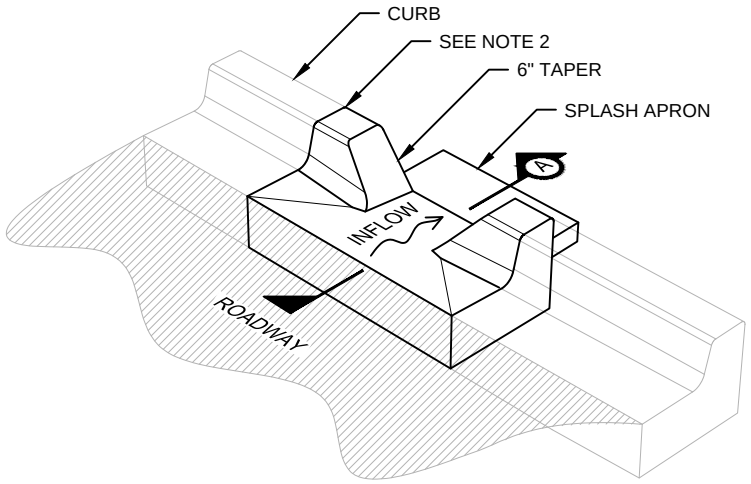
CURB CUTS AND TRENCH DRAINS SERVE AS INLETS TO CONVEY STORMWATER RUNOFF TO A BIORETENTION FACILITY. CURB CUTS ARE TYPICALLY USED IN PLANTER APPLICATIONS WHEN THE FACILITY IS IMMEDIATELY ADJACENT TO THE ROADWAY (I.E. NO COURTESY STRIP), PROVIDING AN OPENING TO INTERCEPT AND CONVEY STORMWATER FROM THE GUTTER TO THE PLANTER. TRENCH DRAIN SYSTEMS ARE MOST COMMONLY USED TO CONVEY STORMWATER FROM A GUTTER THROUGH THE COURTESY STRIP TO A BIORETENTION PLANTER; PROVIDING A CONTINUOUS SURFACE FOR PEDESTRIAN ACCESS WHILE MINIMIZING ELEVATION LOSSES AT THE FACILITY INFLOW LOCATIONS. CURB CUT AND TRENCH DRAIN INLETS INCLUDE MODIFICATIONS TO THE GUTTER TO HELP DIRECT FLOW INTO THE FACILITY.

DESIGNER NOTES & GUIDELINES:

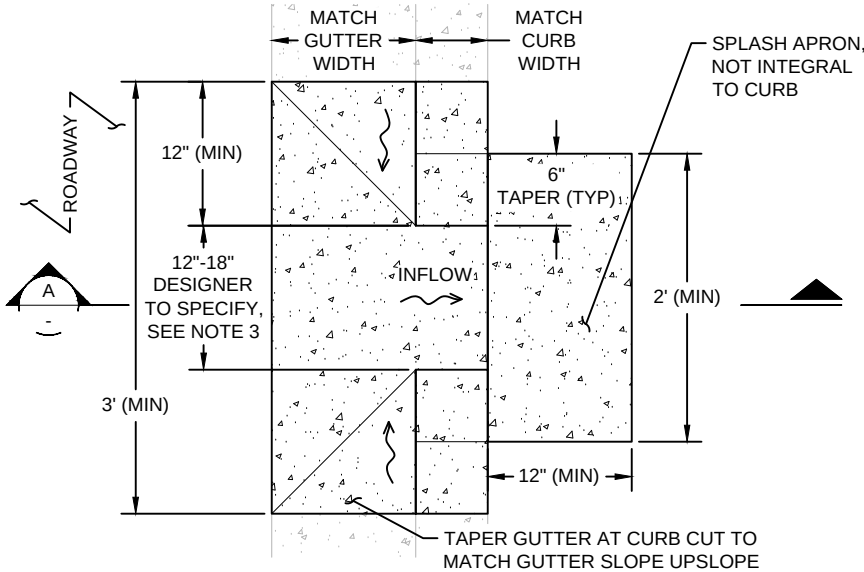
1. THE DESIGNER MUST ADAPT DRAWINGS TO ADDRESS SITE-SPECIFIC CONDITIONS.
2. THE DESIGNER MUST ENSURE THAT CURB CUTS AND TRENCH DRAIN INLETS ARE ADEQUATELY SIZED, SPACED, AND SLOPED TO SATISFY HYDRAULIC REQUIREMENTS. THE CURB CUT OPENING WIDTH MUST BE SIZED BASED ON THE CATCHMENT AREA, LONGITUDINAL SLOPE ALONG THE CURB, AND THE CROSS SLOPE OF THE GUTTER OR ADJACENT PAVEMENT AT THE INLET. SEE SIZING EQUATIONS AND NOMOGRAPHS FOR CURB OPENING INLETS IN THE U.S. DEPARTMENT OF TRANSPORTATION HYDRAULIC ENGINEERING CIRCULAR NO. 27.
3. TRENCH DRAIN GRATES AND ASSEMBLIES MUST COMPLY WITH DPW STANDARDS.

DESIGNER CHECKLIST (MUST SPECIFY, AS APPLICABLE):

- ☐ CURB CUT DIMENSIONS
- ☐ FRAME AND GRATE TYPE/MATERIAL AND DIMENSIONS
- ☐ CHANNEL DIMENSIONS
- ☐ CONTROL ELEVATIONS FOR OPENINGS AT GUTTER AND PLANTER WALL



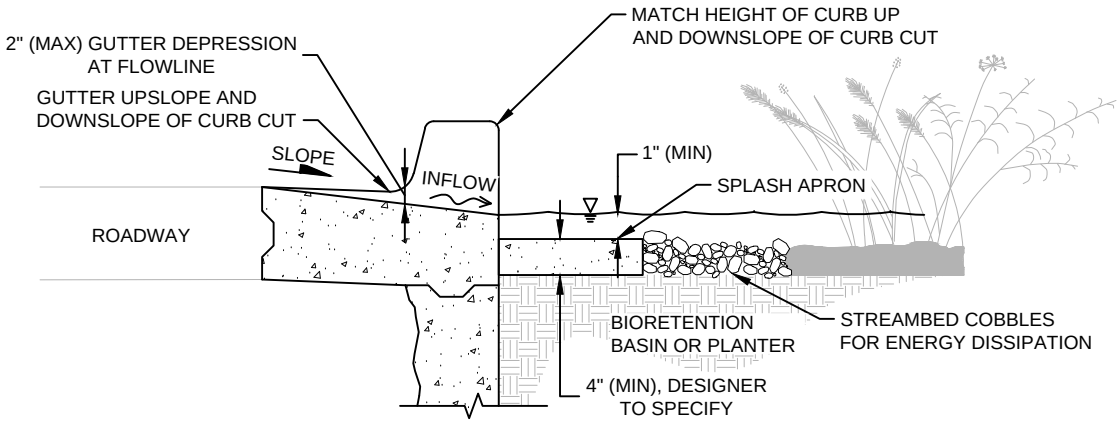
ISOMETRIC



PLAN

CONSTRUCTION NOTES:

1. ALL MATERIAL AND WORKMANSHIP FOR CURB CUTS SHALL CONFORM TO STANDARD SPECIFICATIONS AND APPLICABLE CODES.
2. BOND NEW CURB AND GUTTER TO EXISTING CURB AND GUTTER WITH EPOXY AND DOWEL CONNECTION.
3. INLET CURB CUT WIDTH SHALL BE 18" ON GUTTER SLOPES ≥ 5%



SECTION A

INLET - CURB CUT TYPE 1 (1)

INLETS				OUTLETS				UNDERDRAINS		CHECK DAM	
NOTES	COMPONENTS			NOTES	COMPONENTS			NOTES	COMPONENTS	NOTES	COMPONENTS
BC 2.1	BC 2.2	BC 2.3	BC 2.4	BC 3.1	BC 3.2	BC 3.3	BC 3.4	BC 5.1	BC 5.2	BC 6.1	BC 6.2

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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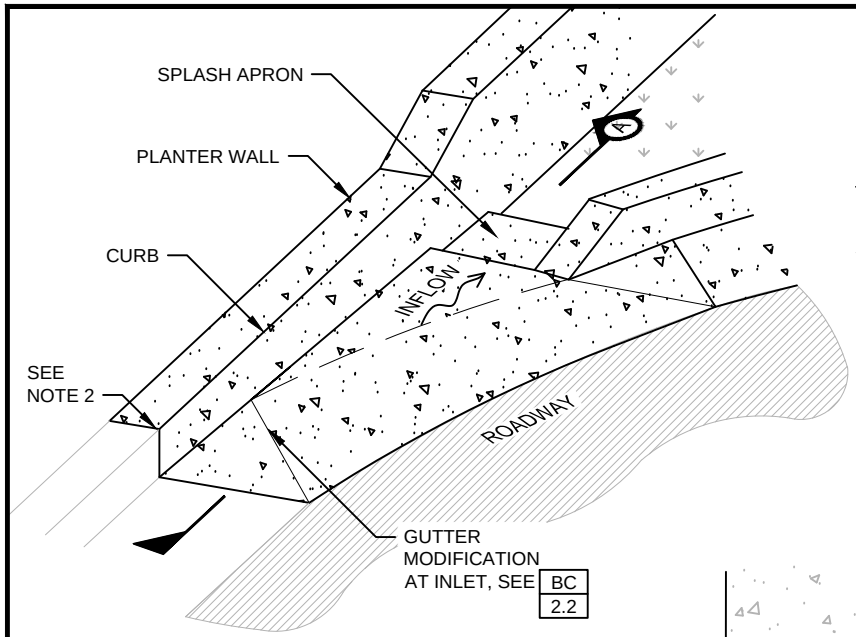
REVISED:

BIORETENTION COMPONENTS
INLETS
CURB CUT WITH GUTTER MODIFICATION

DWG NO. BC 2.2



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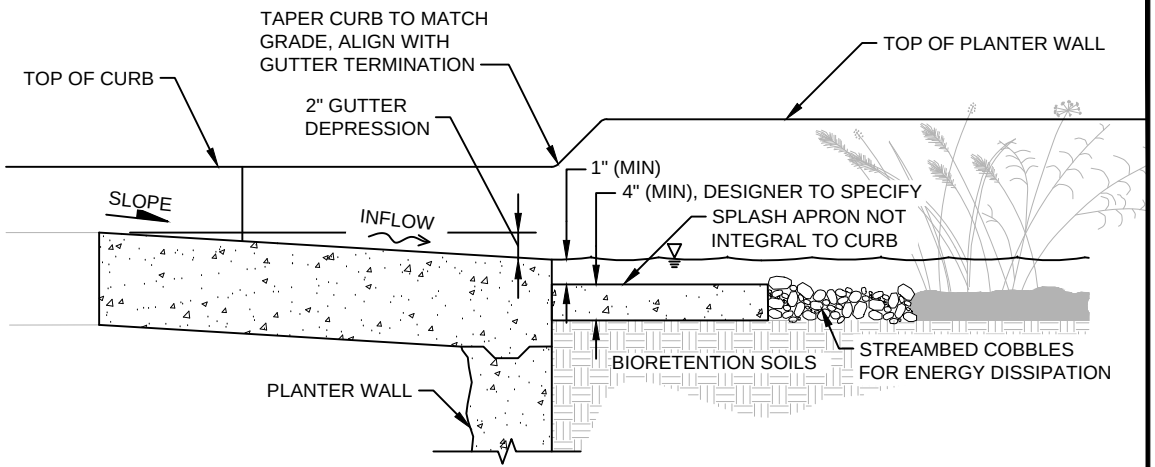
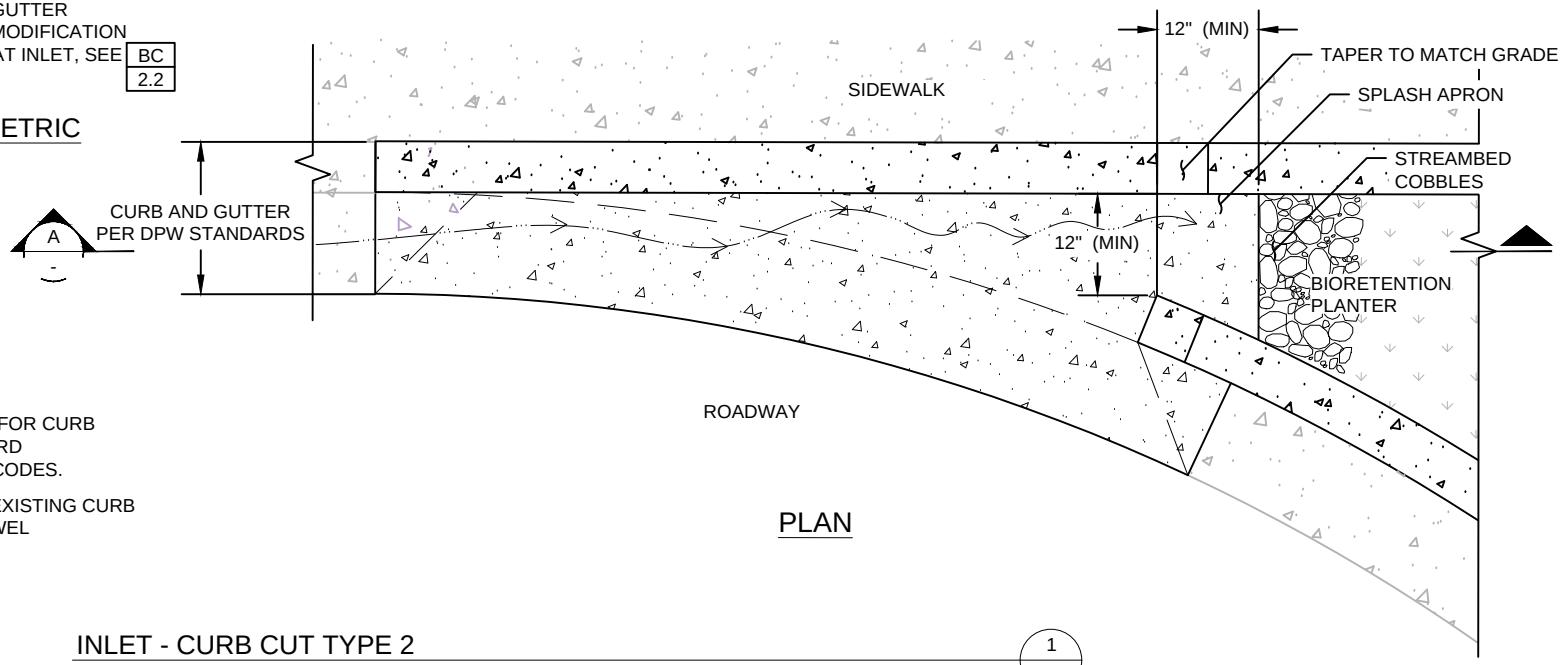


SECTION A



PLAN

CONSTRUCTION NOTES:

1. ALL MATERIAL AND WORKMANSHIP FOR CURB CUTS SHALL CONFORM TO STANDARD SPECIFICATIONS AND APPLICABLE CODES.
2. BOND NEW CURB AND GUTTER TO EXISTING CURB AND GUTTER WITH EPOXY AND DOWEL CONNECTION.

INLET - CURB CUT TYPE 2 (1)

INLETS				OUTLETS				UNDERDRAINS		CHECK DAM	
NOTES	COMPONENTS			NOTES	COMPONENTS			NOTES	COMPONENTS	NOTES	COMPONENTS
BC 2.1	BC 2.2	BC 2.3	BC 2.4	BC 3.1	BC 3.2	BC 3.3	BC 3.4	BC 5.1	BC 5.2	BC 6.1	BC 6.2

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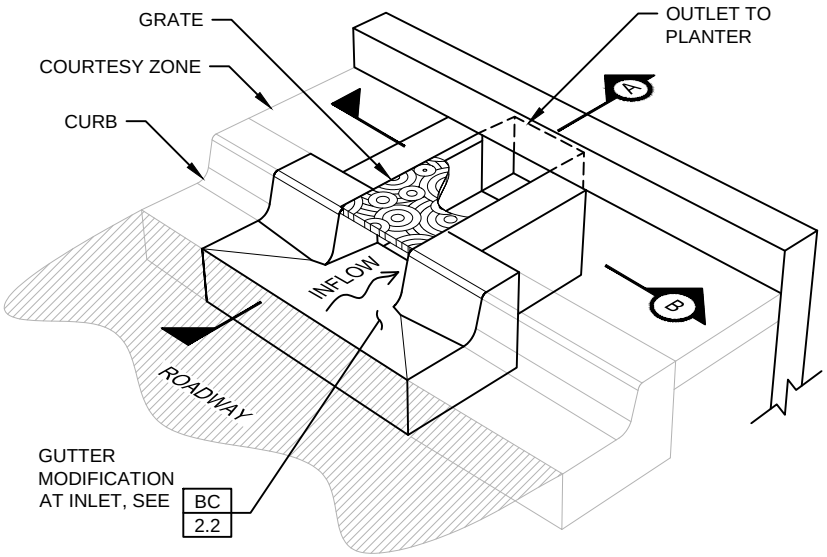
BIORETENTION COMPONENTS

INLETS

CURB CUT AT BULB OUT

DWG NO. BC 2.3

NOT FOR CONSTRUCTION - REFER TO USER GUIDE



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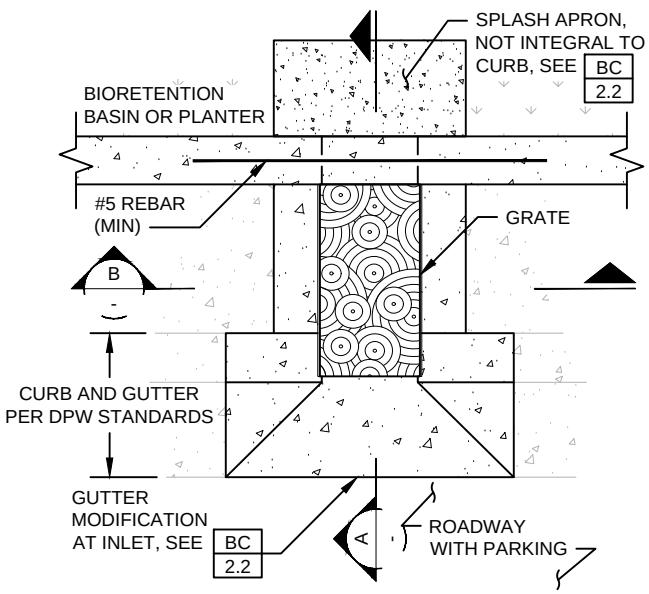
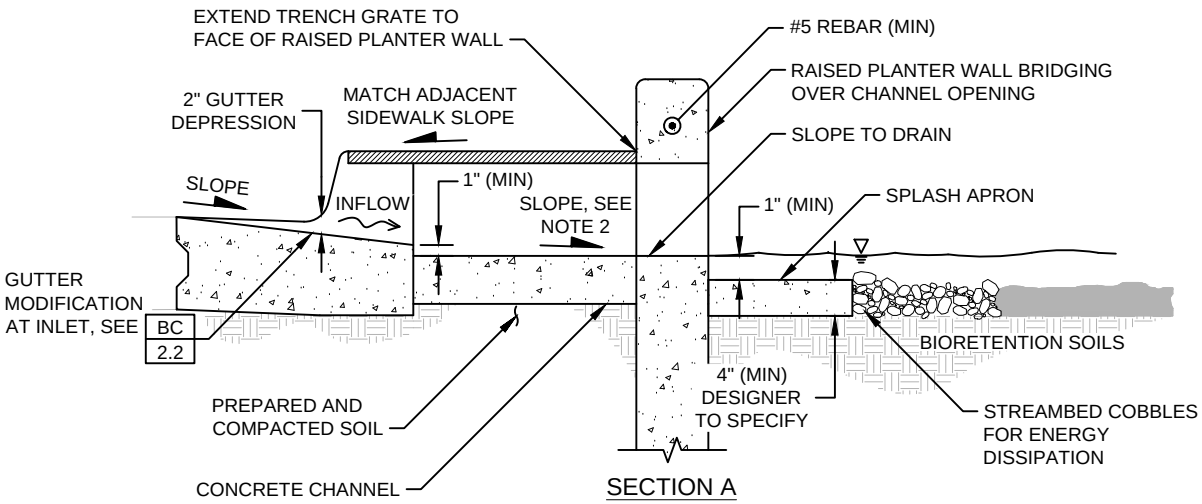


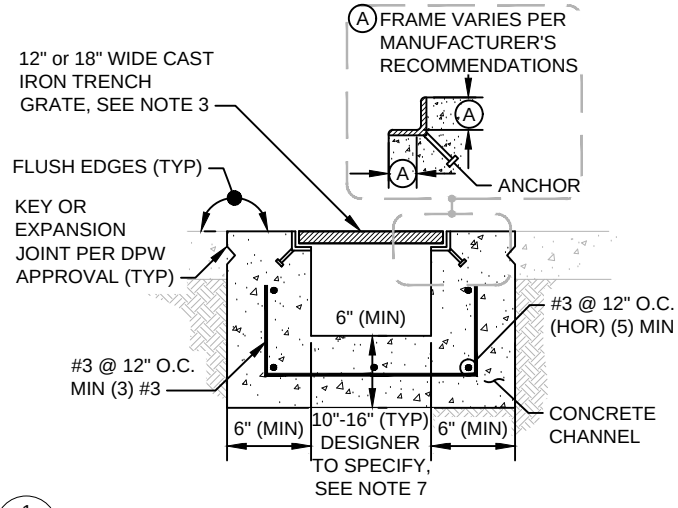
PLAN

CONSTRUCTION NOTES:

1. ALL MATERIAL AND WORKMANSHIP FOR TRENCH DRAIN ASSEMBLY SHALL CONFORM TO SPRINGFIELD STANDARD SPECIFICATIONS AND APPLICABLE CODES.
2. SLOPE TO PROVIDE AT LEAST 1 INCH DROP OVER LENGTH OF CHANNEL OR A MINIMUM OF 2 PERCENT, WHICHEVER IS LARGER.
3. ALL TRENCH GRATES SHALL BE REMOVABLE, RATED PER THE ANTICIPATED LOADING, AND BOLTED IN PLACE OR OUTFITTED WITH APPROVED TAMPER-RESISTANT LOCKING MECHANISM, FLUSH OR RECESSED IN GRATE.
4. BOND NEW CURB AND GUTTER TO EXISTING CURB AND GUTTER WITH EPOXY AND DOWEL CONNECTION.
5. HORIZONTAL CONTROL JOINTS SHALL BE PROVIDED EVERY 10 LINEAR FEET, OR PER MANUFACTURER'S RECOMMENDATIONS.
6. APPLY EPOXY BONDING AGENT AT ALL TRENCH DRAIN CONSTRUCTION COLD JOINTS.
7. INLET CURB CUT AND CONCRETE CHANNEL WIDTH SHALL BE 16" (MIN) ON GUTTER SLOPES ≥ 5%.



SECTION A



SECTION B

INLET - TRENCH DRAIN 1

INLETS				OUTLETS				UNDERDRAINS		CHECK DAM	
NOTES	COMPONENTS			NOTES	COMPONENTS			NOTES	COMPONENTS	NOTES	COMPONENTS
BC 2.1	BC 2.2	BC 2.3	BC 2.4	BC 3.1	BC 3.2	BC 3.3	BC 3.4	BC 5.1	BC 5.2	BC 6.1	BC 6.2

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BIORETENTION COMPONENTS

INLETS

CURB CUT WITH TRENCH DRAINS

DWG NO. BC 2.4

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

PURPOSE:

BIORETENTION OUTLET STRUCTURES CONVEY SURFACE AND/OR SUBSURFACE OUTFLOWS FROM A BIORETENTION FACILITY TO AN APPROVED DISCHARGE LOCATION.

DESIGNER NOTES & GUIDELINES:

1. THE DESIGNER MUST ADAPT DRAWINGS TO ADDRESS SITE-SPECIFIC CONDITIONS.
2. THE DESIGNER MUST SIZE CURB CUT, GRATE, AND OTHER OVERFLOW STRUCTURE FEATURES TO SATISFY HYDRAULIC REQUIREMENTS.
3. AN OUTLET STRUCTURE OR CLEANOUT(S) THAT ALLOWS MAINTENANCE ACCESS TO ALL PIPES IS REQUIRED FOR FACILITIES WITH UNDERDRAINS.
4. IF SITE CONSTRAINTS NECESSITATE STORM DRAIN PIPE IN AN AREA SUBJECT TO VEHICULAR TRAFFIC OR OTHER LOADING, APPROPRIATE COVER DEPTH AND PIPE MATERIAL MUST BE SPECIFIED.
5. OUTLET PIPES MUST BE EQUIPPED WITH CLEANOUTS, SEE CLEANOUT DETAILS (**GC 5.2**).
6. SUMP REQUIREMENTS (12 INCH SUMP AND CAST IRON HOOD/TRAP) MAY BE ELIMINATED WHEN OVERFLOW DIRECTLY DISCHARGES TO DOWNSTREAM (PUBLIC WORKS) DEEP SUMP CATCH BASIN.
7. LOCATE ALL OVERFLOW PIPES AT AN ELEVATION HIGHER THAN THE SEWER HYDRAULIC GRADE LINE TO PREVENT BACKFLOW INTO THE BIORETENTION FACILITY.

DESIGNER CHECKLIST (MUST SPECIFY, AS APPLICABLE):

- ☐ OUTLET STRUCTURE TYPE/MATERIAL, DIAMETER, AND DEPTH
- ☐ ATRIUM GRATE MANUFATURER, MODEL NO., AND SIZE
- ☐ SAND TRAP COMPONENTS AND DIMENSIONS
- ☐ FRAME AND GRATE TYPE, MODEL NO., AND SIZE
- ☐ CONTROL ELEVATIONS FOR OUTLET STRUCTURE RIMS
- ☐ MATERIAL AND DIAMETER FOR ALL PIPES
- ☐ WATER TIGHT CONNECTOR TYPE FOR ALL WALL PENETRATIONS (E.G., GROUTED, COMPRESSION, BOOT), SEE GC 2.9 AND GC 2.10

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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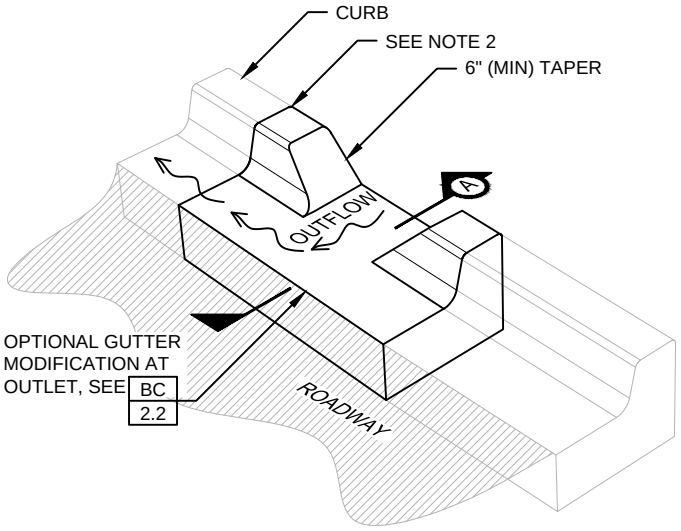
REVISED:

BIORETENTION COMPONENTS
OUTLETS
DESIGNER NOTES

DWG NO. BC 3.1

NOT FOR CONSTRUCTION - REFER TO USER GUIDE



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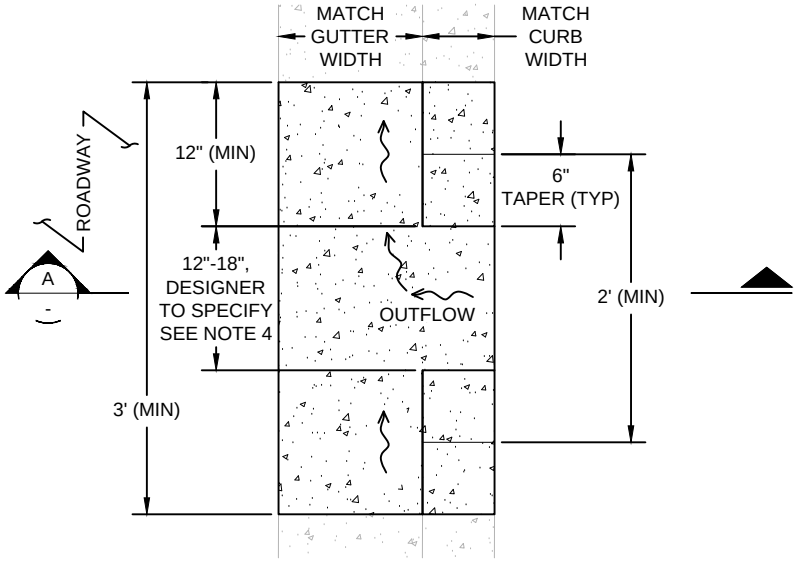
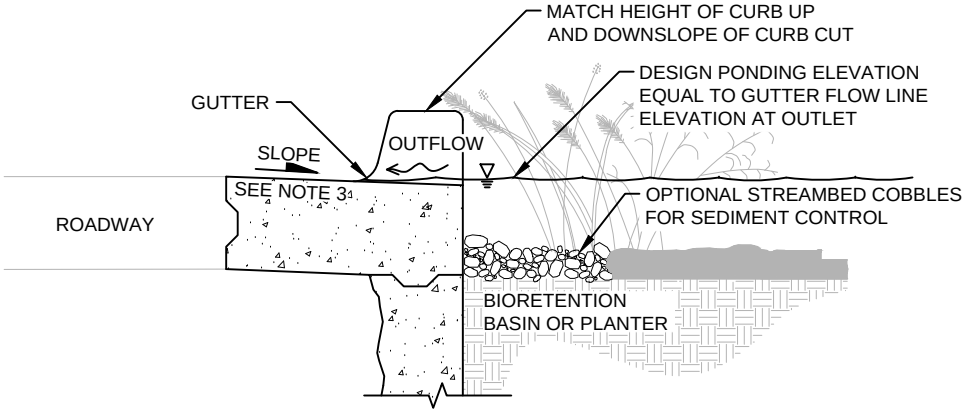


PLAN

CONSTRUCTION NOTES:

1. ALL MATERIAL AND WORKMANSHIP FOR CURB CUTS SHALL CONFORM TO SPRINGFIELD STANDARD SPECIFICATIONS AND APPLICABLE CODES.
2. BOND NEW CURB AND GUTTER TO EXISTING CURB AND GUTTER WITH EPOXY AND DOWEL CONNECTION.
3. MATCH GUTTER SLOPE UP AND DOWNSLOPE OF CURB CUT SLOPE SIMILAR TO INLET DETAIL UNLESS MODIFYING GUTTER
4. OUTLET CURB CUT WIDTH SHALL BE18" ON GUTTER SLOPES ≥ 5%



SECTION A

OUTLET - CURB CUT 1

INLETS				OUTLETS				UNDERDRAINS		CHECK DAM	
NOTES	COMPONENTS			NOTES	COMPONENTS			NOTES	COMPONENTS	NOTES	COMPONENTS
BC 2.1	BC 2.2	BC 2.3	BC 2.4	BC 3.1	BC 3.2	BC 3.3	BC 3.4	BC 5.1	BC 5.2	BC 6.1	BC 6.2

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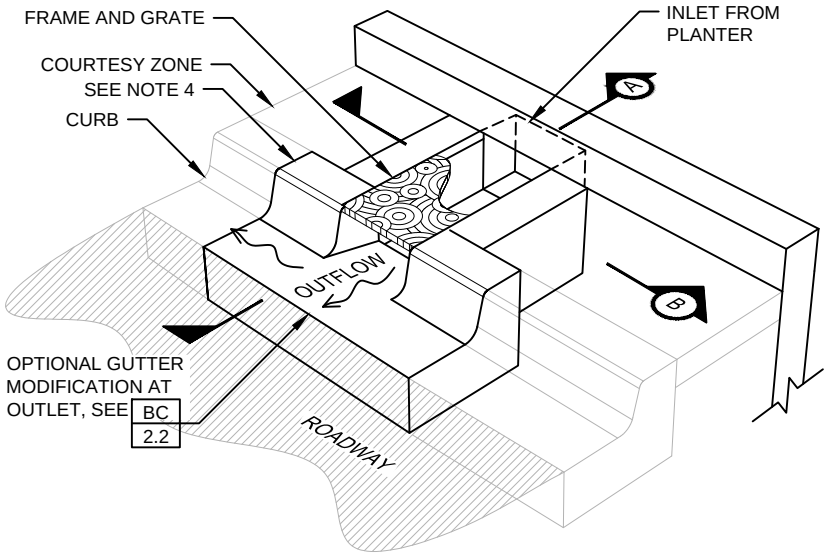
BIORETENTION COMPONENTS

OUTLETS
CURB CUT

DWG NO. BC 3.2

NOT FOR CONSTRUCTION - REFER TO USER GUIDE



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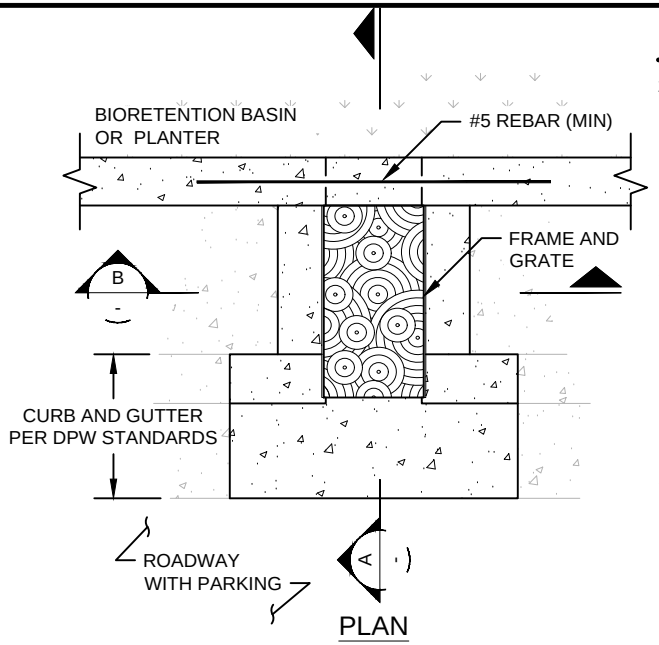
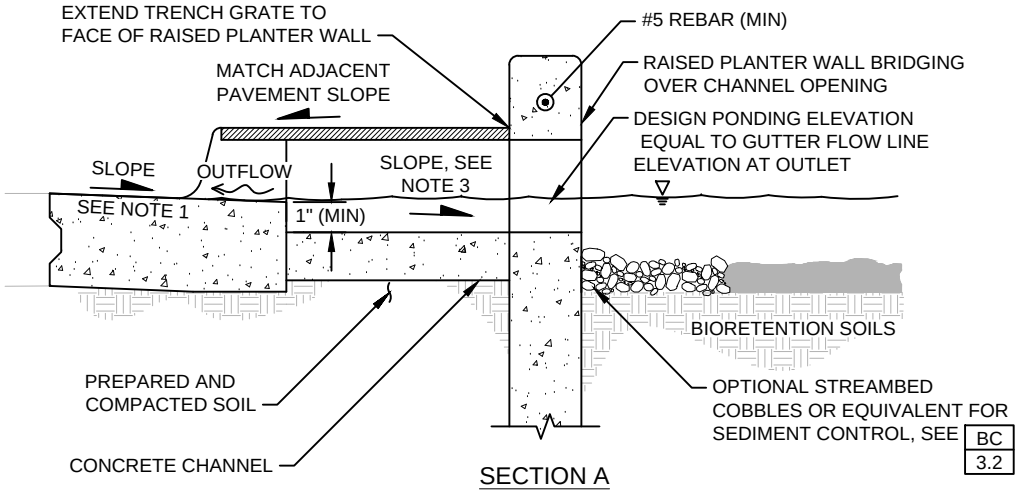


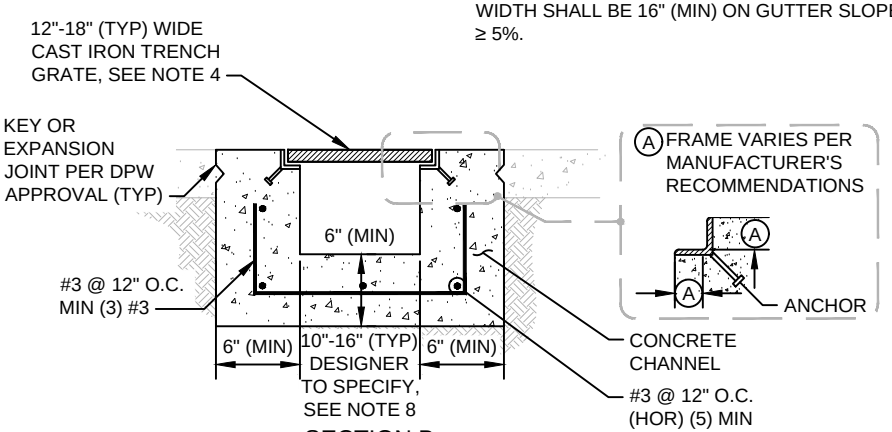
PLAN

CONSTRUCTION NOTES:

1. ALL MATERIAL AND WORKMANSHIP FOR TRENCH DRAIN ASSEMBLY SHALL CONFORM TO SPRINGFIELD STANDARD SPECIFICATIONS AND APPLICABLE CODES.
2. MATCH GUTTER SLOPE UP AND DOWNSLOPE (UNLESS MODIFYING GUTTER SLOPE INLET DETAIL).
3. SLOPE TO PROVIDE AT LEAST 1 INCH DROP OVER LENGTH OF CHANNEL OR A MINIMUM OF 2 PERCENT, WHICHEVER IS LARGER.
4. ALL TRENCH GRATES SHALL BE REMOVABLE, RATED PER THE ANTICIPATED LOADING, AND BOLTED IN PLACE OR OUTFITTED WITH APPROVED TAMPER-RESISTANT LOCKING MECHANISM, FLUSH OR RECESSED IN GRATE.
5. HORIZONTAL CONTROL JOINTS SHALL BE PROVIDED EVERY 10 LINEAR FEET, OR PER MANUFACTURER'S RECOMMENDATIONS.
6. BOND NEW CURB AND GUTTER TO EXISTING CURB AND GUTTER WITH EPOXY AND DOWEL CONNECTION.
7. APPLY EPOXY BONDING AGENT AT ALL TRENCH DRAIN CONSTRUCTION COLD JOINTS.
8. INLET CURB CUT AND CONCRETE CHANNEL WIDTH SHALL BE 16" (MIN) ON GUTTER SLOPES ≥ 5%.



SECTION A



SECTION B

OUTLET - TRENCH DRAIN 1

INLETS				OUTLETS				UNDERDRAINS		CHECK DAM	
NOTES	COMPONENTS			NOTES	COMPONENTS			NOTES	COMPONENTS	NOTES	COMPONENTS
BC 2.1	BC 2.2	BC 2.3	BC 2.4	BC 3.1	BC 3.2	BC 3.3	BC 3.4	BC 5.1	BC 5.2	BC 6.1	BC 6.2

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REVISED:

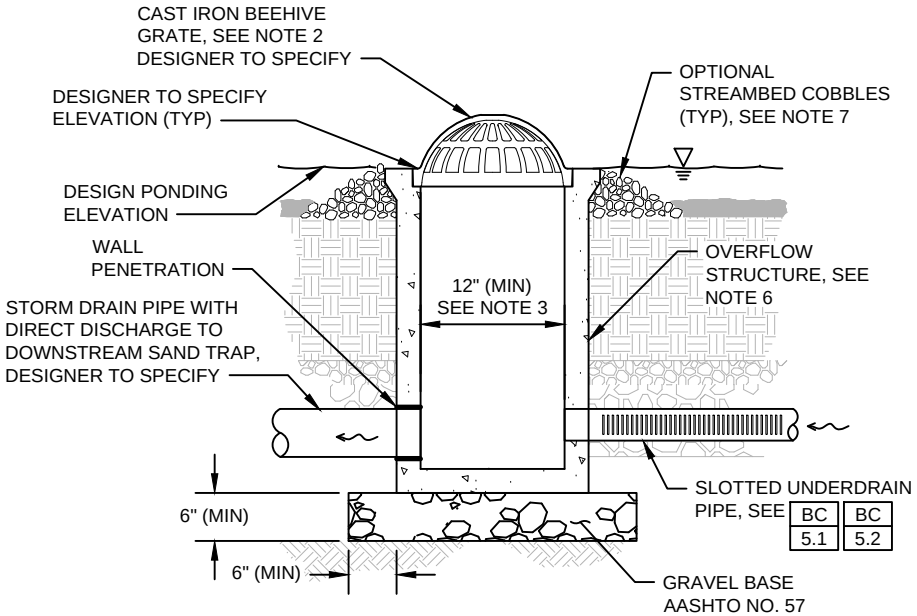
BIORETENTION COMPONENTS

OUTLETS

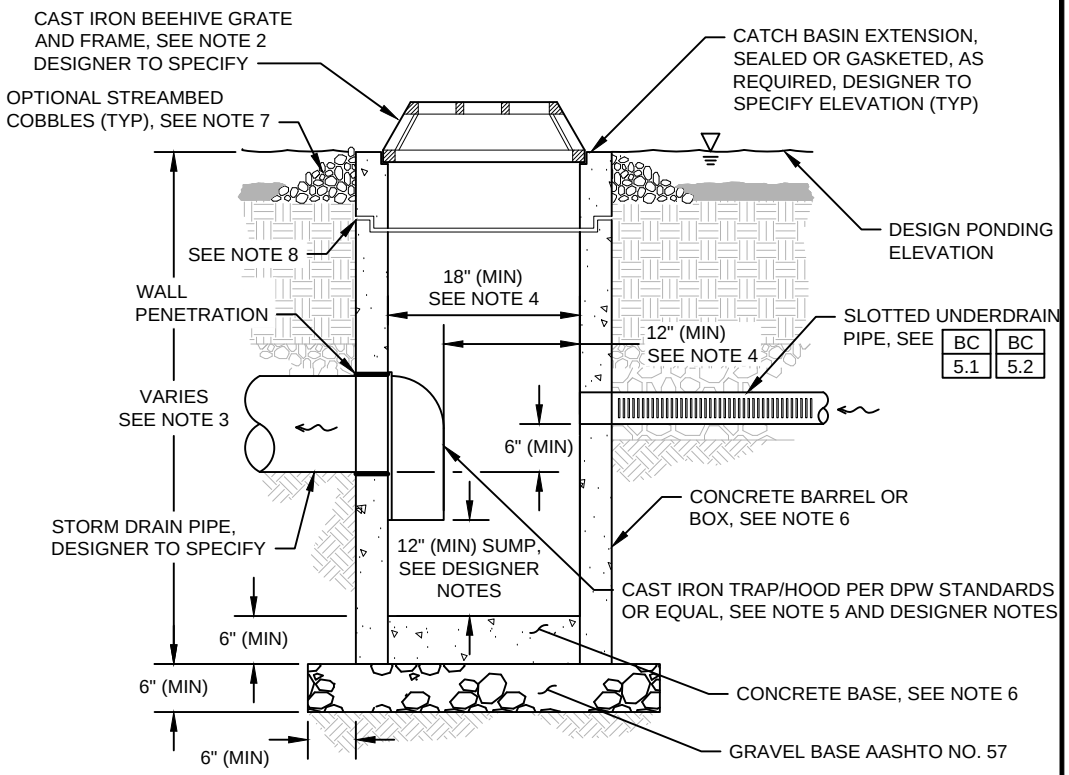
CURB CUT WITH TRENCH DRAIN

DWG NO. BC 3.3

NOT FOR CONSTRUCTION - REFER TO USER GUIDE



OVERFLOW STRUCTURE AREA DRAIN 1



OVERFLOW STUCTURE WITH INTERGAL SAND TRAP 2

CONSTRUCTION NOTES:

1. ALL MATERIAL AND WORKMANSHIP FOR OVERFLOW STRUCTURES SHALL CONFORM TO SPRINGFIELD STANDARD SPECIFICATIONS AND APPLICABLE CODES.
2. SIZE OF ATRIUM GRATE SHALL MATCH SIZE OF RISER SPECIFIED IN PLANS, SHALL BE REMOVABLE TO PROVIDE MAINTENANCE ACCESS, AND SHALL BE BOLTED IN PLACE OR OUTFITTED WITH APPROVED TAMPER-RESISTANT LOCKING MECHANISM. MAXIMUM GRATE OPENING SHALL BE 4 INCHES.
3. IF INTERIOR DEPTH OF OVERFLOW STRUCTURE EXCEEDS 5 FEET, A PERMANENT BOLTED LADDER AND MINIMUM CLEAR SPACE OF 30 INCH BY 30 INCH IN SHALL BE PROVIDED FOR MAINTENANCE ACCESS.
4. 12 INCH (MIN) CLEARANCE WITHIN OVERFLOW STRUCTURE SHALL BE PROVIDED FOR MAINTENANCE ACCESS.
5. INSTALL CAST IRON TRAP/HOOD PER MANUFACTURER'S RECOMMENDATIONS.
6. BARREL/BOX AND BASE OF CATCH BASIN MAY BE PRE-CAST WITH REINFORCING STEEL PER MANUFACTURER'S RECOMMENDATIONS, POURED IN PLACE CONCRETE WITHOUT STEEL PER SPRINGFIELD STANDARD PLANS AND SPECIFICATIONS, OR NYLOPLAST DRAIN BASIN (2812AG OR EQUAL). ENGINEER TO SPECIFY.
7. MINIMUM STREAMBED COBBLE DIAMETER SHALL BE LARGER THAN MAXIMUM GRATE OPENING.
8. GROUT ALL PENETRATIONS, CRACKS, SEAMS, AND JOINTS WITH CLASS "C" MORTAR.

INLETS				OUTLETS				UNDERDRAINS		CHECK DAM	
NOTES	COMPONENTS			NOTES	COMPONENTS			NOTES	COMPONENTS	NOTES	COMPONENTS
BC 2.1	BC 2.2	BC 2.3	BC 2.4	BC 3.1	BC 3.2	BC 3.3	BC 3.4	BC 5.1	BC 5.2	BC 6.1	BC 6.2

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BIORETENTION COMPONENTS

OUTLETS
OVERFLOW STRUCTURES

DWG NO. BC 3.4

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

PURPOSE:

UNDERDRAINS ARE USED TO COLLECT STORMWATER THAT HAS BEEN FILTERED THROUGH BIORETENTION SOIL AND CONVEY THAT TREATED STORMWATER TO A DESIGNATED OUTLET (E.G., PLANTER OVERFLOW STRUCTURE).

DESIGNER NOTES & GUIDELINES:

1. THE DESIGNER SHOULD INCLUDE UNDERDRAINS IN FACILITY DESIGN IN THE FOLLOWING SCENARIOS:
   - INFILTRATION IS PROHIBITED OR IMPRUDENT (E.G., FACILITY NEAR SENSITIVE INFRASTRUCTURE OR STEEP SLOPES, RISK OF CONTAMINATION IS HIGH OR SITE GROUNDWATER/SOILS ARE CONTAMINATED, THERE IS POOR INFILTRATION CAPACITY DUE TO SOILS OR HIGH GROUNDWATER).
   - SUBGRADE MEASURED (I.E., UNCORRECTED) INFILTRATION RATE IS LESS THAN 0.17 INCHES PER HOUR.
   - FULL CAPACITY DRAWDOWN PERIOD OF 72 HOURS CANNOT BE ACHIEVED.
3. AN OUTLET STRUCTURE AND/OR CLEANOUT(S) TO ALLOW MAINTENANCE ACCESS TO ALL PIPES IS REQUIRED FOR FACILITIES WITH UNDERDRAINS.
4. UNDERDRAIN PIPE SHALL HAVE A SMOOTH INTERIOR WALL TO FACILITATE MAINTENANCE WITH PRESSURIZED WATER OR ROOT CUTTING EQUIPMENT.
5. DESIGNER SHOULD CONSIDER THE INSTALLED ELEVATION OF THE UNDERDRAIN PIPE WITHIN THE BIORETENTION FACILITIES AGGREGATE STORAGE LAYER TO PROMOTE INFILTRATION, BELOW THE UNDERDRAIN, WHEN FEASIBLE. DESIGNER SHOULD ALSO CONSIDER THE USE OF ORIFICES OR OTHER CONTROL STRUCTURES TO PROVIDE ADDITIONAL INFILTRATION AND FLOW CONTROL BENEFITS WHERE APPLICABLE.

DESIGNER CHECKLIST (MUST SPECIFY, AS APPLICABLE):

- ☐ UNDERDRAIN MATERIAL TYPE AND SIZE
- ☐ UNDERDRAIN ELEVATION, SLOPE, AND LOCATION WITHIN BASIN OR PLANTER
- ☐ PIPE BEDDING MATERIAL SPECIFICATION (i.e. AGGREGATE STORAGE LAYER)
- ☐ DISCHARGE LOCATION TO OVERFLOW STRUCTURE
- ☐ CLEANOUT LOCATIONS AND MAINTENANCE ACCESS
- ☐ ORIFICE FLOW CONTROL STRUCTURE(S), AS APPLICABLE

INLETS				OUTLETS				UNDERDRAINS		CHECK DAM	
NOTES	COMPONENTS			NOTES	COMPONENTS			NOTES	COMPONENTS	NOTES	COMPONENTS
BC 2.1	BC 2.2	BC 2.3	BC 2.4	BC 3.1	BC 3.2	BC 3.3	BC 3.4	BC 5.1	BC 5.2	BC 6.1	BC 6.2

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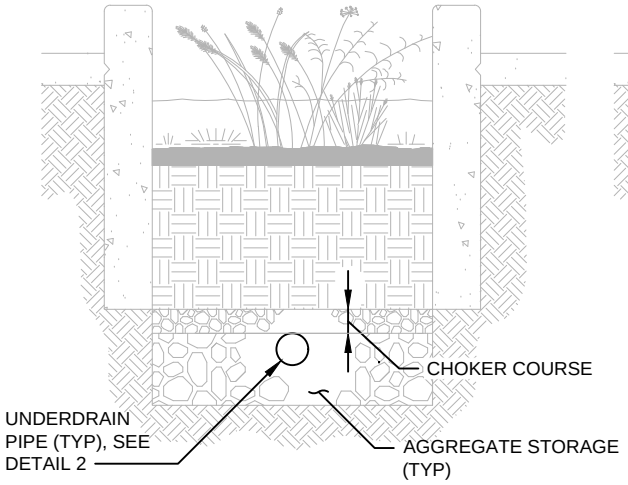
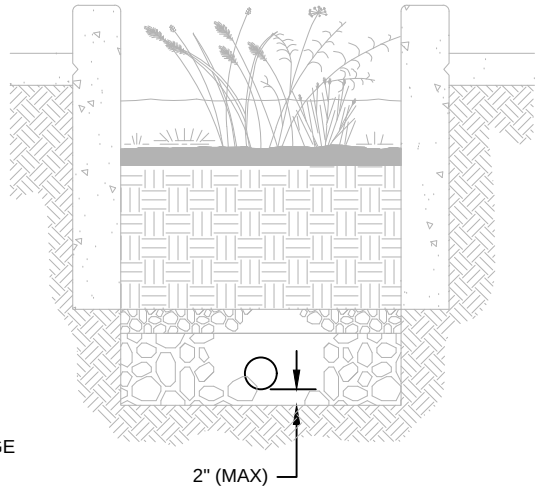
BIORETENTION COMPONENTS
UNDERDRAINS
DESIGNER NOTES

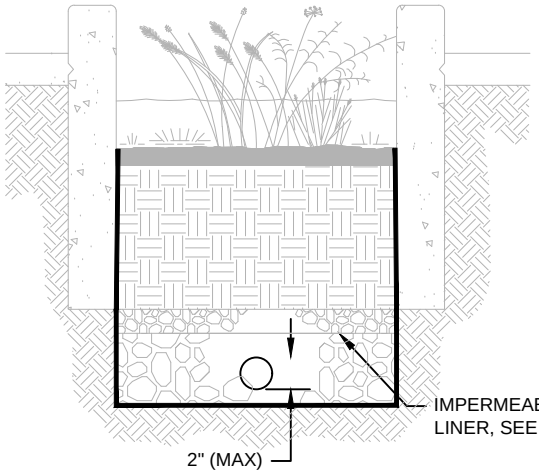
DWG NO. BC 5.1



ELEVATED UNDERDRAIN
TYPE B/C SOILS (WHEN REQUIRED)



BOTTOM UNDERDRAIN
TYPE D SOILS

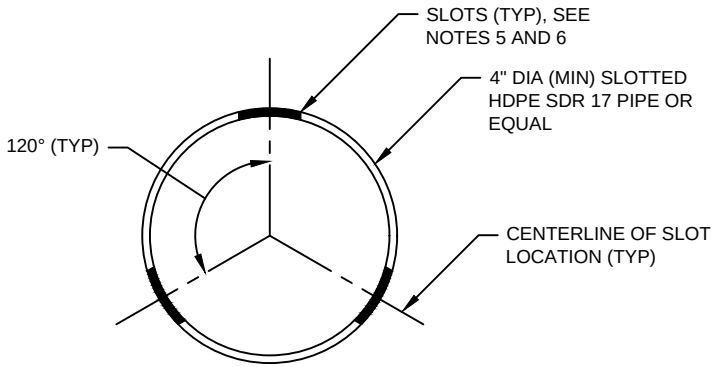


UNDERDRAIN WITH LINER
WHERE INFILTRATION PROHIBITED

UNDERDRAIN PLACEMENT ALTERNATIVES

CONSTRUCTION NOTES:

1. ALL MATERIAL AND WORKMANSHIP FOR UNDERDRAINS SHALL CONFORM TO SPRINGIFELD STANDARD SPECIFICATIONS AND APPLICABLE CODES.
2. SET CROWN OF UNDERDRAIN PIPE AT OR BELOW BOTTOM OF CHOKER COURSE. SEE DESIGNER NOTES FOR ADDITIONAL GUIDANCE ON LOCATING UNDERDRAIN PIPE IN GRAVEL STORAGE.
3. LONGITUDINAL SLOPE OF UNDERDRAIN PIPE SHALL BE 0.5% MINIMUM.
4. UNDERDRAIN PIPE SHALL BE SLOTTED HDPE SDR 17 OR ACCEPTABLE SUBSTITUTE MATERIAL PER ENGINEERS SPECIFICATION. SINGLE WALL AND DUAL WALL CORRUGATED HDPE PIPE (AASHTO M252 AND M294 TYPES C, S, AND D) ARE NOT ACCEPTABLE.
5. UNDERDRAIN PIPE SHALL BE SLOTTED TYPE, MEASURING 0.032 INCH WIDE (MAX), SPACED AT 0.25 INCH (MIN), AND PROVIDING A MINIMUM INLET AREA OF 5.0 SQUARE INCH PER LINEAR FOOT OF PIPE.
6. SLOTS SHALL BE ORIENTED PERPENDICULAR TO LONG AXIS OF PIPE, AND EVENLY SPACED AROUND CIRCUMFERENCE AND LENGTH OF PIPE.



SLOTTED UNDERDRAIN PIPE 2

INLETS				OUTLETS				UNDERDRAINS		CHECK DAM	
NOTES	COMPONENTS			NOTES	COMPONENTS			NOTES	COMPONENTS	NOTES	COMPONENTS
BC 2.1	BC 2.2	BC 2.3	BC 2.4	BC 3.1	BC 3.2	BC 3.3	BC 3.4	BC 5.1	BC 5.2	BC 6.1	BC 6.2

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BIORETENTION COMPONENTS
UNDERDRAINS

DWG NO. BC 5.2

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

PURPOSE:

CHECK DAMS ARE OFTEN USED IN BIORETENTION FACILITIES AT SLOPED LOCATIONS (ALIGNED PERPENDICULAR TO THE LONGITUDINAL SLOPE OF THE FACILITY) TO REDUCE FLOW VELOCITIES (AND EROSION) THROUGH THE FACILITY AND TO PROMOTE SURFACE PONDING, SUBSURFACE STORAGE, AND INFILTRATION OF STORMWATER. CHECK DAMS CAN BE CONSTRUCTED OF A VARIETY OF MATERIALS INCLUDING CONCRETE, WOOD, METAL, ROCK, OR COMPACTED SOIL.

DESIGNER NOTES & GUIDELINES:

1. THE DESIGNER MUST ADAPT SECTION DRAWINGS TO ADDRESS SITE-SPECIFIC CONDITIONS.
2. THE DESIGNER MUST ESTABLISH THE HEIGHT AND SPACING OF CHECK DAMS BASED ON THE PONDING DEPTH REQUIRED TO MEET PROJECT HYDROLOGIC PERFORMANCE GOALS AND THE MAXIMUM DESIRED DROP FROM THE SURROUNDING GRADE TO THE FACILITY BOTTOM. REFER TO CHECK DAM SPACING GUIDANCE PROVIDED ON THIS DRAWING FOR FURTHER GUIDANCE.
3. FOR BIORETENTION SWALES (SLOPED BOTTOM), THE AVERAGE DEPTH OF PONDING ACROSS THE FACILITY AREA MUST MEET THE REQUIRED STORAGE DEPTH.

THE DESIGNER SHALL SPECIFY THE FOLLOWING, AS APPLICABLE:

- ☐ CHECK DAM TYPE AND MATERIAL
- ☐ CHECK DAM HEIGHT, WIDTH, AND ELEVATION
- ☐ CHECK DAM SPACING

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

INLETS				OUTLETS				UNDERDRAINS		CHECK DAM	
NOTES	COMPONENTS			NOTES	COMPONENTS			NOTES	COMPONENTS	NOTES	COMPONENTS
BC 2.1	BC 2.2	BC 2.3	BC 2.4	BC 3.1	BC 3.2	BC 3.3	BC 3.4	BC 5.1	BC 5.2	BC 6.1	BC 6.2

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

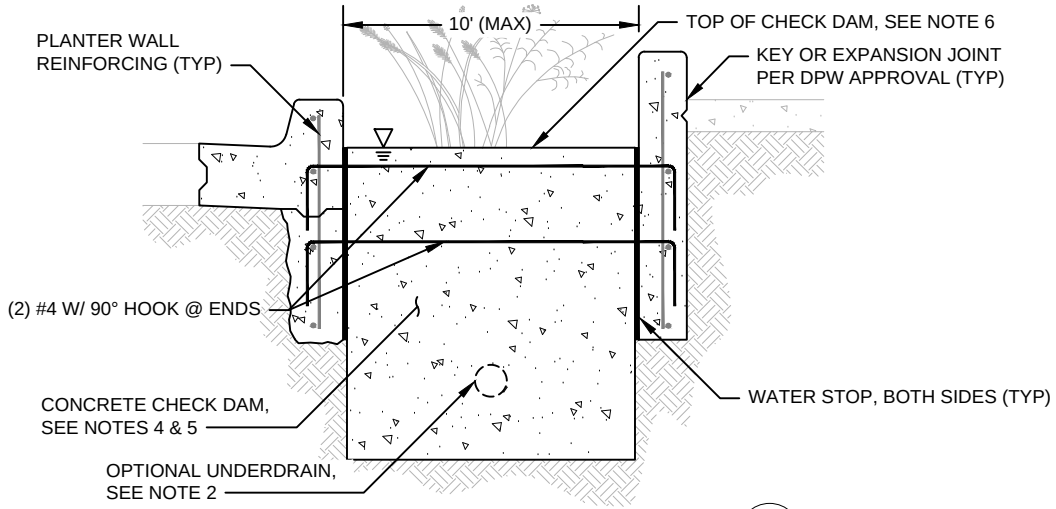
ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION

DATE: FEBRUARY 2019
VERSION: 1.0
REVISED:

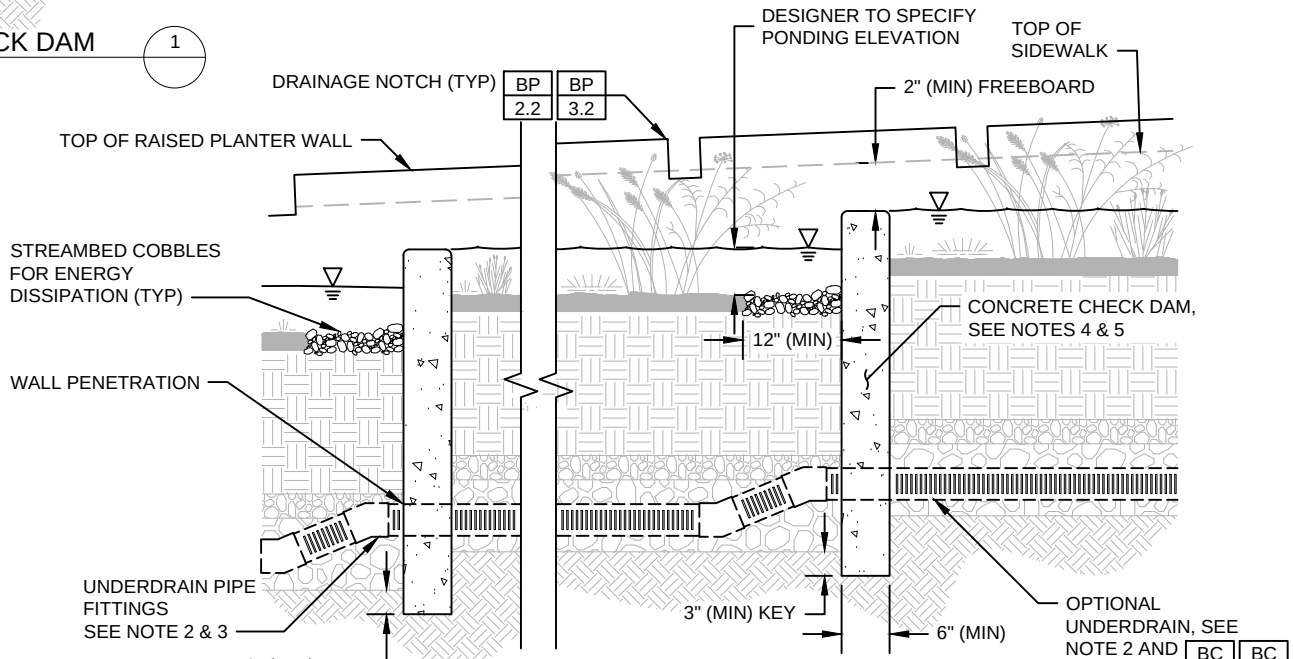
BIORETENTION COMPONENTS

CHECK DAMS
DESIGNER NOTES

DWG NO. BC 6.1



SECTION - CONCRETE CHECK DAM 1



PROFILE - CONCRETE CHECK DAM 2

CONSTRUCTION NOTES:

1. ALL MATERIAL AND WORKMANSHIP FOR CHECK DAM ASSEMBLY SHALL CONFORM TO SPRINGFIELD STANDARD SPECIFICATIONS AND APPLICABLE CODES.
2. UNDERDRAIN TO PASS THROUGH CHECK DAM IN NON-PERFORATED HDPE SDR 17 PIPE.
3. PIPE FITTINGS SHALL BE USED TO ACCOMMODATE CHANGES IN GRADE, AS NEEDED.
4. CONCRETE CHECK DAM SHALL BE CONTINUOUS (NO JOINTS) AND REINFORCED WITH #4 BAR, PLACED AT 18 INCHES ON CENTER, EACH WAY.
5. TOP OF CHECK DAM TO BE LEVEL WITH CREST ELEVATION MATCHING PONDING ELEVATION UNLESS NOTCH SIZED TO CONVEY DESIGN FLOWS PROVIDED.

INLETS				OUTLETS				UNDERDRAINS		CHECK DAM	
NOTES	COMPONENTS			NOTES	COMPONENTS			NOTES	COMPONENTS	NOTES	COMPONENTS
BC 2.1	BC 2.2	BC 2.3	BC 2.4	BC 3.1	BC 3.2	BC 3.3	BC 3.4	BC 5.1	BC 5.2	BC 6.1	BC 6.2

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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BIORETENTION COMPONENTS
CHECK DAMS

DWG NO. BC 6.2

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

PURPOSE:

SUBSURFACE INFILTRATION SYSTEMS, ALSO KNOWN AS DRY WELLS, STORMWATER DRAINAGE WELLS, INFILTRATION GALLERIES, AND SEEPAGE PITS, CONTROL PEAK FLOWS AND VOLUMES OF STORMWATER RUNOFF THROUGH SUBSURFACE STORAGE AND INFILTRATION INTO NATIVE SOIL. WATER IS ALSO TREATED AS IT FILTERS THROUGH THE GRAVEL, SAND (IF PROVIDED), AND NATIVE SOIL.

RELATED COMPONENTS	
OBSERVATION PORTS:	GC 4.1 - GC 4.3
CLEANOUTS:	GC 5.1

DESIGNER NOTES & GUIDELINES:

1. THE DESIGNER MUST ADAPT PLAN AND SECTION DRAWINGS TO ADDRESS SITE-SPECIFIC CONDITIONS.
2. FIELD-TESTED INFILTRATION RATES OF NATIVE SOILS MUST BE BETWEEN 0.17 (INCHES PER HOUR) AND 2.4 (INCHES PER HOUR). FOR SITES WITH INFILTRATION RATES GREATER THAN 2.4 IN/HR, SUBSURFACE INFILTRATION SYSTEMS MAY STILL BE ALLOWED PROVIDED THAT THE RUNOFF IS FULLY TREATED USING UPSTREAM BMPS OR PRETREATMENT PER MASSDEP STORMWATER HANDBOOK.
3. SUBSURFACE STORAGE DRAWDOWN TIME (I.E. TIME FOR MAXIMUM SUBSURFACE STORAGE VOLUME TO INFILTRATE INTO SUBGRADE AFTER THE END OF A STORM) SHOULD NOT EXCEED 72 HOURS. DRAWDOWN TIME IS CALCULATED AS THE MAXIMUM SUBSURFACE STORAGE DEPTH DIVIDED BY THE NATIVE SOIL INFILTRATION RATE.
4. SUBSURFACE INFILTRATION SYSTEM SUBGRADES SHOULD BE LEVEL, REGARDLESS OF ANY LONGITUDINAL SLOPE OF THE SITE, TO PROMOTE EQUAL SUBSURFACE DISTRIBUTION OF RUNOFF.
5. DEPENDING ON THE HEIGHT AND AREA OF THE PROPOSED SUBSURFACE INFILTRATION SYSTEM, ADDITIONAL STRUCTURAL CONSIDERATIONS MAY BE REQUIRED TO ADDRESS EARTH PRESSURE AND/OR SURFACE LOADING.
6. SUBSURFACE INFILTRATION SYSTEMS ARE MOST COMMONLY USED TO MANAGE STORMWATER RUNOFF FROM ROOFS AND PARKING LOTS, BUT CAN BE USED IN OTHER APPLICATIONS. IN AREAS WITH HIGH SEDIMENT LOADS, RUNOFF SHOULD PASS THROUGH STORMWATER PRE-TREATMENT MEASURES TO REMOVE COARSE SEDIMENT THAT CAN CLOG PORE SPACES.
7. REFER TO MASSDEP STORMWATER HANDBOOK FOR REQUIRED PRETREATMENT OF RUNOFF FROM AREAS OF HIGHER POTENTIAL POLLUTANT LOADS.
8. SMALL SYSTEMS (TYPICALLY A FEW FEET IN WIDTH) ARE KNOWN AS DRY WELLS AND ARE RECOMMENDED FOR SMALL DRAINAGE AREAS WITH LOW POLLUTANT LOADINGS, SUCH AS ROOFTOPS LESS THAN 0.25 ACRES IN SIZE. LARGER SYSTEMS (TYPICALLY 10 TO 100 FEET IN WIDTH) ARE KNOWN AS INFILTRATION GALLERIES AND CAN BE USED TO RECEIVE RUNOFF FROM DRAINAGE AREAS TYPICALLY UP TO 5 ACRES IN SIZE.
9. THE DRAWINGS PROVIDED DO NOT COVER DESIGNS THAT UTILIZE PROPRIETARY STORAGE, DISTRIBUTION, AND/OR STRUCTURAL SYSTEMS OTHER THAN PREFABRICATED DRY WELL STRUCTURES, WHICH HAVE BEEN SHOWN IN A GENERIC WAY. REFER TO THE MANUFACTURER'S RECOMMENDATIONS FOR ALL PROPRIETARY SYSTEMS.

GENERAL UTILITY NOTES:

1. PROVIDE UTILITY TRENCH DAM, ANTI-SEEP COLLAR, OR EQUIVALENT TO PREVENT PREFERENTIAL FLOW OF WATER FROM INFILTRATIVE FACILITY INTO UTILITY TRENCH FROM CAUSING DAMAGE DOWNSTREAM. ENGINEER TO EVALUATE SITE CONDITIONS AND NEED FOR TRENCH DAM.
2. PROPOSED UTILITY LINES TO BE LOCATED OUTSIDE OF FACILITY.

LAYOUT REQUIREMENTS:

1. PROVIDE 10-FOOT SETBACK FROM BUILDING TO EDGE OF INFILTRATION FACILITY. REFER TO MASSDEP STORMWATER HANDBOOK FOR ADDITIONAL SETBACK REQUIREMENTS.
2. MINIMUM 2-FOOT VERTICAL SEPARATION FROM BASE OF SUBSURFACE INFILTRATION SYSTEM TO SEASONAL HIGH WATER TABLE, BEDROCK, AND/OR IMPERMEABLE LAYER IS REQUIRED.

DESIGNER CHECKLIST (MUST SPECIFY, AS APPLICABLE):

- ☐ SUBSURFACE INFILTRATION SYSTEM WIDTH AND LENGTH
- ☐ DEPTH AND TYPE OF AGGREGATE STORAGE LAYER
- ☐ DEPTH AND TYPE OF FILTER SAND, IF REQUIRED
- ☐ ELEVATIONS AND CONTROL POINTS AT EVERY CORNER
- ☐ AGGREGATE STORAGE SPECIFICATIONS AND/OR DRY WELL TYPE AND DIMENSIONS
- ☐ ELEVATIONS OF EACH PIPE INLET AND OVERFLOW INVERT
- ☐ TYPE AND DESIGN OF SUBSURFACE INFILTRATION COMPONENTS (E.G. INLETS, OVERFLOWS, OBSERVATION WELLS)
- ☐ SETBACK DIMENSIONS TO BEDROCK, HIGH GROUNDWATER TABLE, PROPERTY LINES, FOUNDATIONS, WATER SUPPLY WELLS, SEWER MAINS, AND GROUND SLOPES OF 15% OR GREATER, AS APPLICABLE. SEE SFPUC ASSET PROTECTION STANDARDS.
- ☐ TYPE AND SIZE OF PRETREATMENT MEASURE, AS NESSESARY

NOTES	LARGE SYSTEMS		SMALL SYSTEMS	
	PLAN SECTIONS		PLAN SECTIONS	
SI 1.1	SI 2.1	SI 2.2	SI 3.1	SI 3.2

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION

DATE: FEBRUARY 2019
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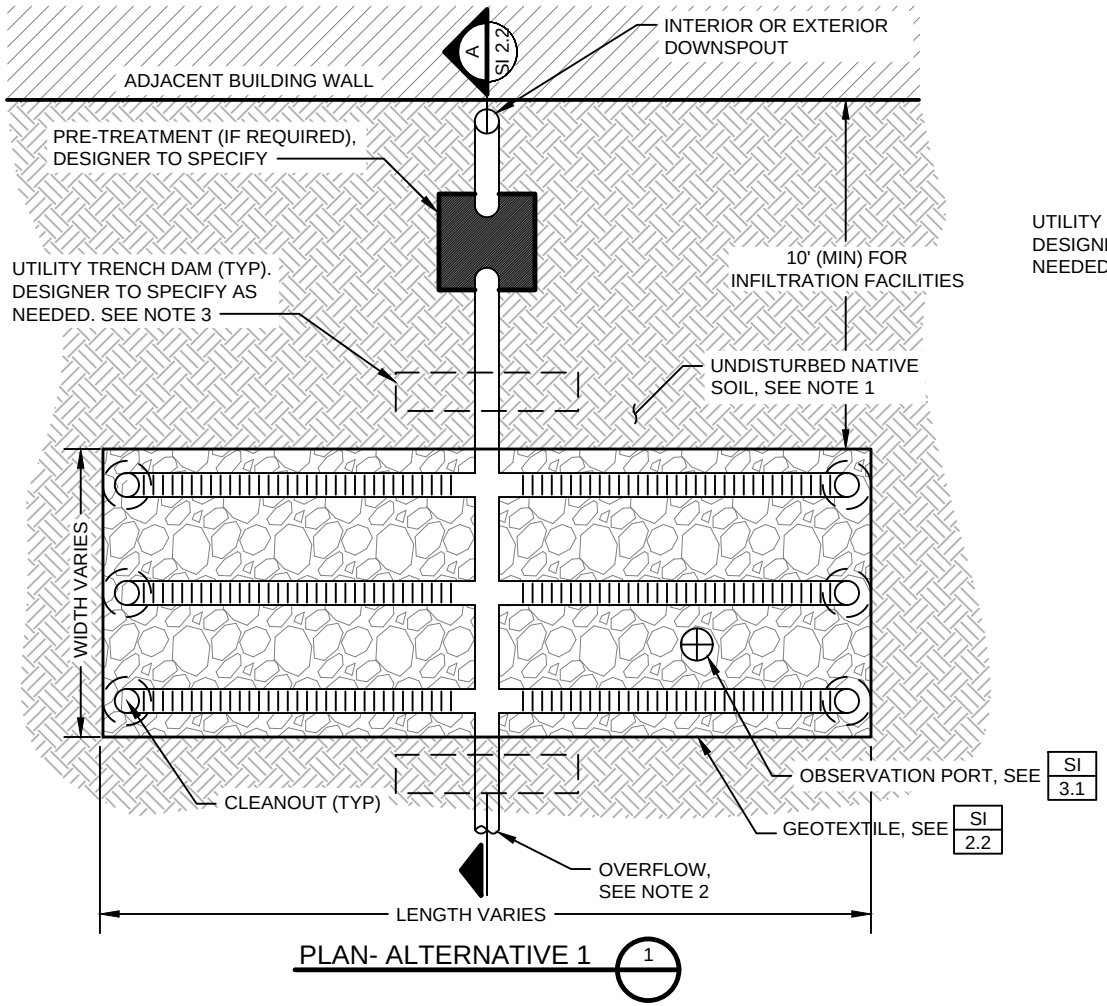
REVISED:

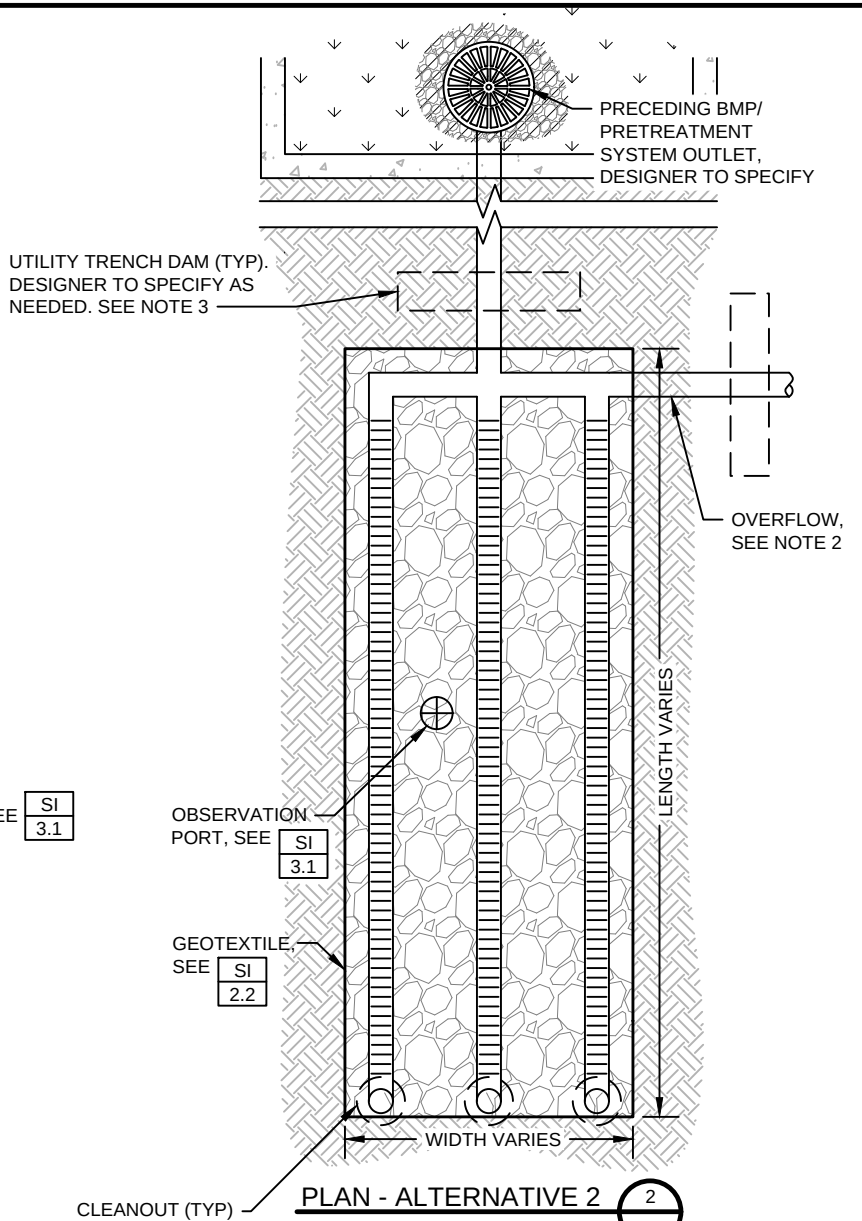
SUBSURFACE INFILTRATION SYSTEMS

DESIGNER NOTES (1 OF 2)

DWG NO. SI 1.1



PLAN- ALTERNATIVE 1 (1)



PLAN - ALTERNATIVE 2 (2)

CONSTRUCTION NOTES:

1. AVOID COMPACTION AND DISTURBANCE OF EXISTING SOIL WITHIN 5 FEET ADJACENT TO AND BELOW INFILTRATION FACILITIES DURING CONSTRUCTION.
2. ROUTE OVERFLOW PIPE TO THE STORM SEWER OR TO ANOTHER BMP FOR FURTHER TREATMENT AS SHOWN ON THE DESIGN PLANS.
3. PROVIDE UTILITY TRENCH DAM OR EQUIVALENT MEASURE OUTSIDE OF THE INFILTRATION FACILITY AT PIPE PENETRATIONS TO PREVENT PREFERENTIAL FLOW FROM INFILTRATION GALLERY INTO UTILITY TRENCHES. COORDINATE WITH ENGINEER.

NOTES	LARGE SYSTEMS		SMALL SYSTEMS	
	PLAN SECTIONS		PLAN SECTIONS	
SI 1.1	SI 2.1	SI 2.2	SI 3.1	SI 3.2

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CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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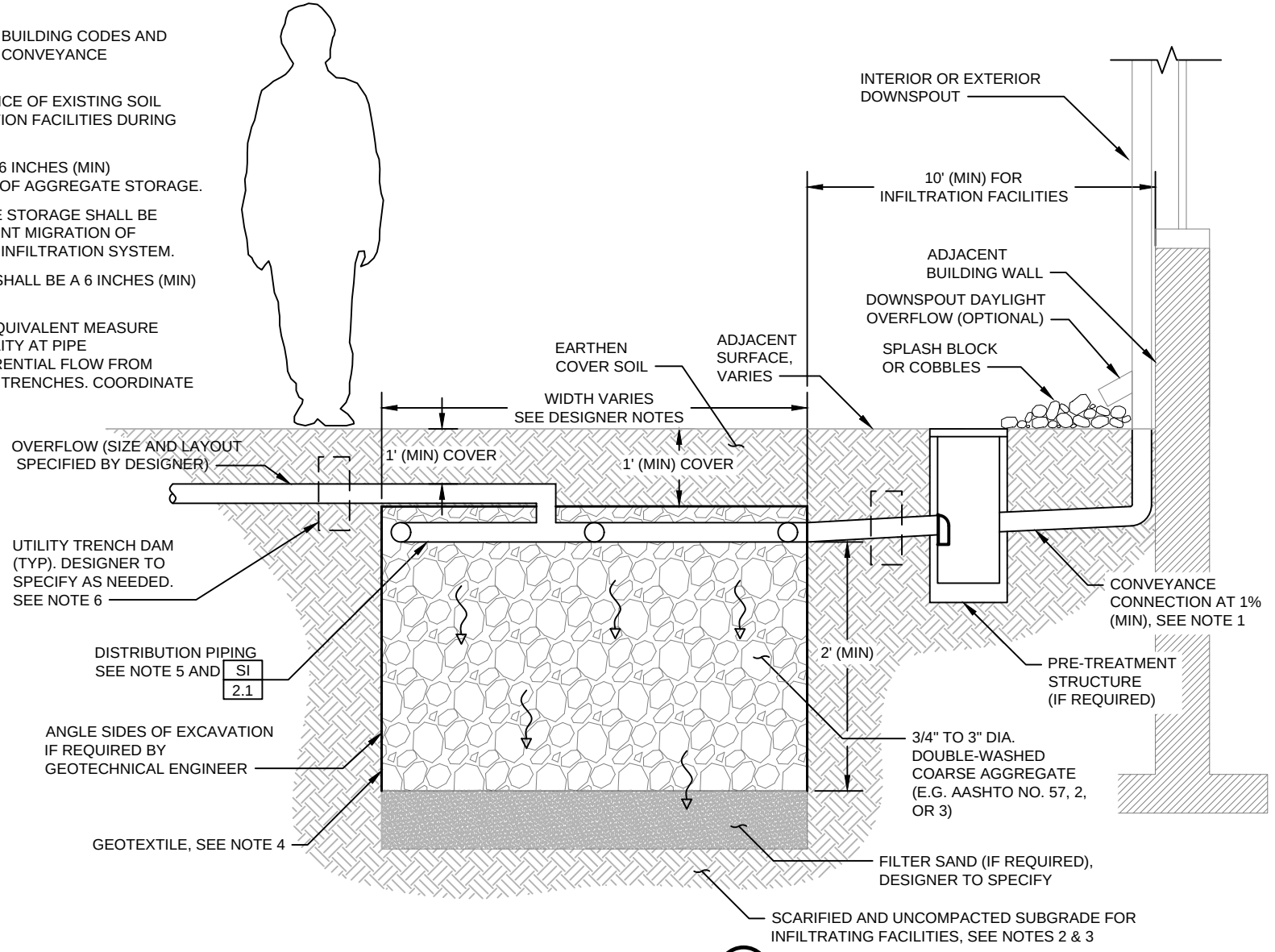
SUBSURFACE INFILTRATION SYSTEM

INFILTRATION GALLERY
LARGE SYSTEM - PLAN

DWG NO. SI 2.1

CONSTRUCTION NOTES:

1. REFER TO APPLICABLE SPRINGFIELD BUILDING CODES AND PUBLIC WORKS REQUIREMENTS FOR CONVEYANCE CONNECTION REQUIREMENTS.
2. AVOID COMPACTION AND DISTURBANCE OF EXISTING SOIL ADJACENT TO AND BELOW INFILTRATION FACILITIES DURING CONSTRUCTION.
3. SCARIFY SUBGRADE TO A DEPTH OF 6 INCHES (MIN) IMMEDIATELY PRIOR TO PLACEMENT OF AGGREGATE STORAGE.
4. SIDEWALLS AND TOP OF AGGREGATE STORAGE SHALL BE LINED WITH A GEOTEXTILE TO PREVENT MIGRATION OF ADJACENT SOILS INTO SUBSURFACE INFILTRATION SYSTEM.
5. SUBSURFACE DISTRIBUTION PIPING SHALL BE A 6 INCHES (MIN) IN DIAMETER.
6. PROVIDE UTILITY TRENCH DAM OR EQUIVALENT MEASURE OUTSIDE OF THE INFILTRATION FACILITY AT PIPE PENETRATIONS TO PREVENT PREFERENTIAL FLOW FROM INFILTRATION GALLERY INTO UTILITY TRENCHES. COORDINATE WITH ENGINEER.



SECTION - ALTERNATIVE 1 (A)

NOTES	LARGE SYSTEMS		SMALL SYSTEMS	
	PLAN SECTIONS		PLAN SECTIONS	
SI 1.1	SI 2.1	SI 2.2	SI 3.1	SI 3.2

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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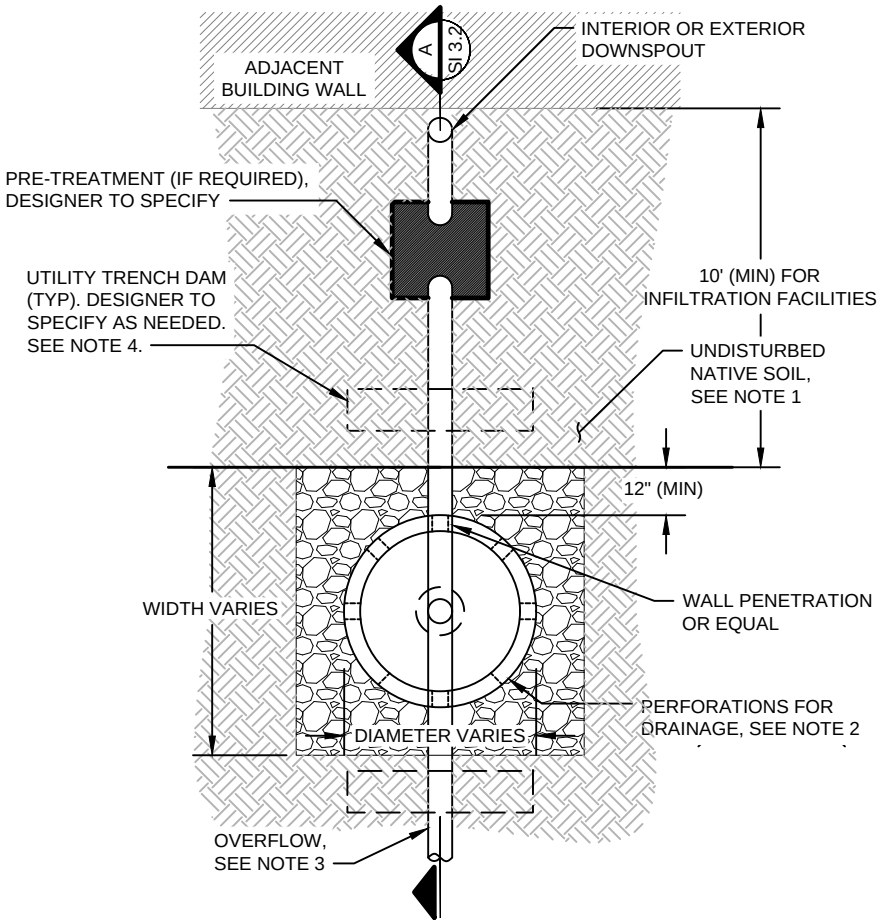
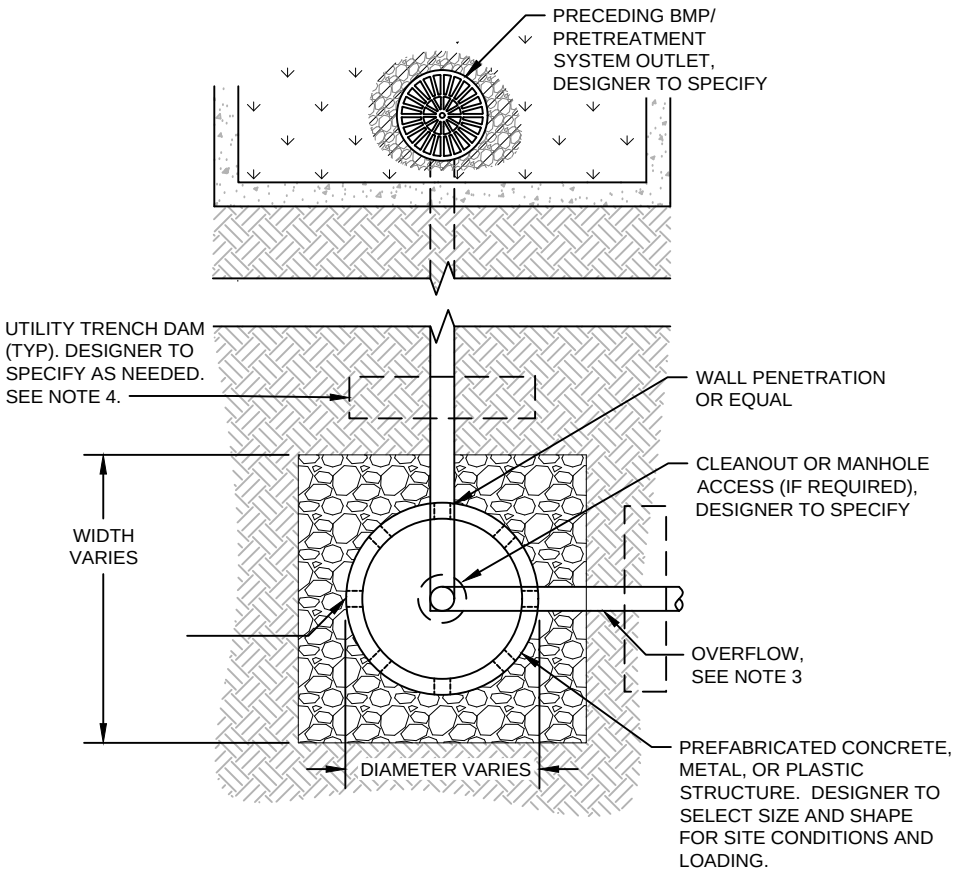
SUBSURFACE INFILTRATION SYSTEM

INFILTRATION GALLERY
LARGE SYSTEM - SECTION

DWG NO. SI 2.2



PLAN- ALTERNATIVE 1 (1)



PLAN - ALTERNATIVE 2 (2)

CONSTRUCTION NOTES:

1. AVOID COMPACTION AND DISTURBANCE OF EXISTING SOIL WITHIN 5 FEET ADJACENT TO AND BELOW INFILTRATION FACILITIES DURING CONSTRUCTION.
2. PREFABRICATED DRY WELLS SHALL HAVE SMALL DIAMETER PERFORATIONS TO PREVENT LATERAL MOVEMENT OF AGGREGATE INTO WELL AND SHALL BE SUFFICIENT IN NUMBER TO ALLOW FOR THE DRAINAGE OF THE STRUCTURE WITHIN 72 HOURS.
3. ROUTE OVERFLOW PIPE TO THE STORM SEWER OR TO ANOTHER BMP FOR FURTHER TREATMENT AS SHOWN ON THE DESIGN PLANS.
4. PROVIDE UTILITY TRENCH DAM OR EQUIVALENT MEASURE OUTSIDE OF THE INFILTRATION FACILITY AT PIPE PENETRATIONS TO PREVENT PREFERENTIAL FLOW FROM INFILTRATION GALLERY INTO UTILITY TRENCHES. COORDINATE WITH ENGINEER.

NOTES	LARGE SYSTEMS		SMALL SYSTEMS	
	PLAN SECTIONS		PLAN SECTIONS	
SI 1.1	SI 2.1	SI 2.2	SI 3.1	SI 3.2

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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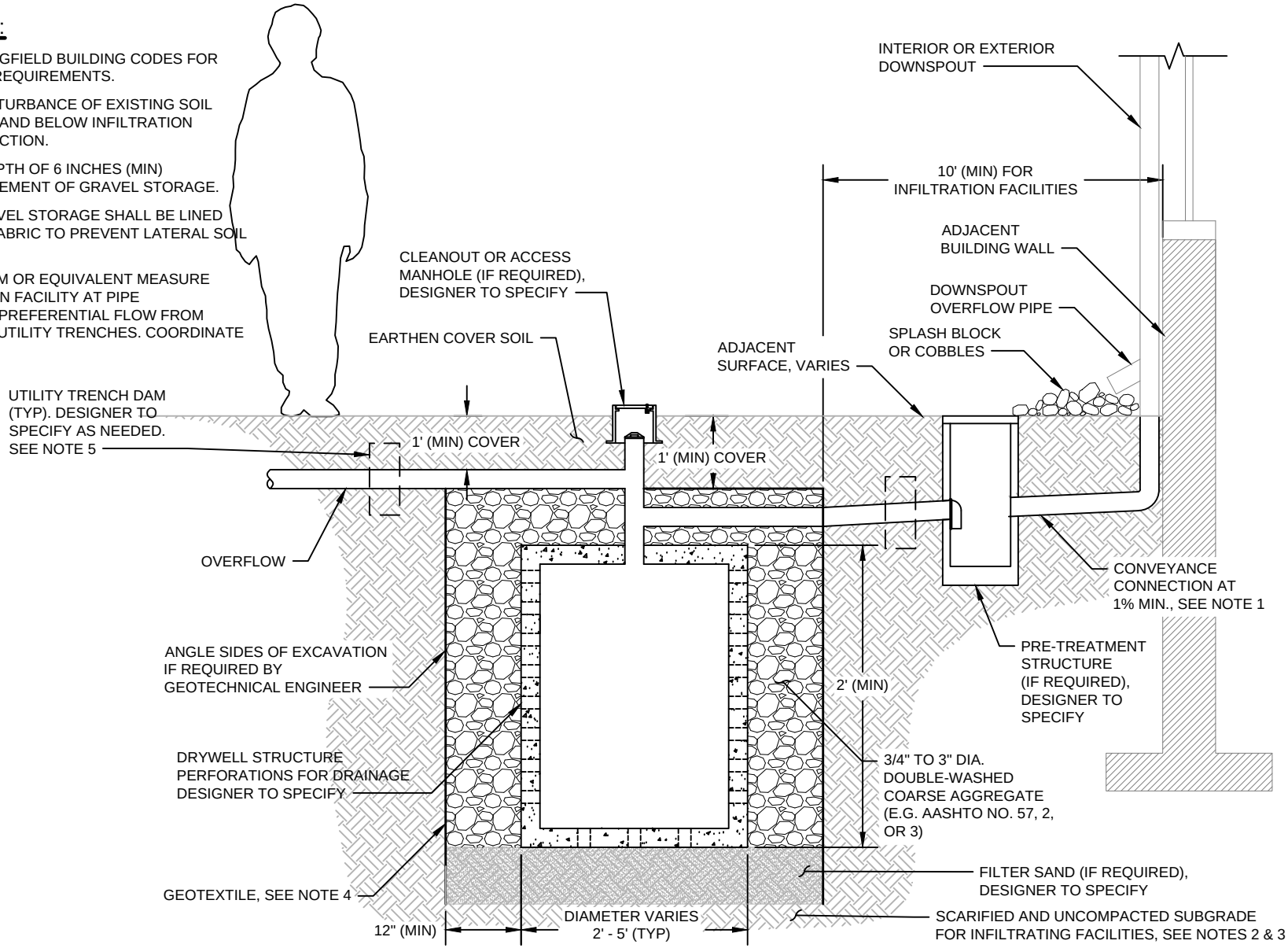
SUBSURFACE INFILTRATION SYSTEM

DRY WELL
SMALL SYSTEM - PLAN

DWG NO. SI 3.1

CONSTRUCTION NOTES:

1. REFER TO APPLICABLE SPRINGFIELD BUILDING CODES FOR CONVEYANCE CONNECTION REQUIREMENTS.
2. AVOID COMPACTION AND DISTURBANCE OF EXISTING SOIL WITHIN 5 FEET ADJACENT TO AND BELOW INFILTRATION FACILITIES DURING CONSTRUCTION.
3. SCARIFY SUBGRADE TO A DEPTH OF 6 INCHES (MIN) IMMEDIATELY PRIOR TO PLACEMENT OF GRAVEL STORAGE.
4. SIDEWALLS AND TOP OF GRAVEL STORAGE SHALL BE LINED WITH A PERMEABLE FILTER FABRIC TO PREVENT LATERAL SOIL MOVEMENT.
5. PROVIDE UTILITY TRENCH DAM OR EQUIVALENT MEASURE OUTSIDE OF THE INFILTRATION FACILITY AT PIPE PENETRATIONS TO PREVENT PREFERENTIAL FLOW FROM INFILTRATION GALLERY INTO UTILITY TRENCHES. COORDINATE WITH ENGINEER.



SECTION - ALTERNATIVE 1 (A)

NOTES	LARGE SYSTEMS		SMALL SYSTEMS	
	PLAN SECTIONS		PLAN SECTIONS	
SI 1.1	SI 2.1	SI 2.2	SI 3.1	SI 3.2

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

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REVISED:

SUBSURFACE INFILTRATION SYSTEMS

DRY WELL
SMALL SYSTEM - SECTION

DWG NO. SI 3.2

PURPOSE:

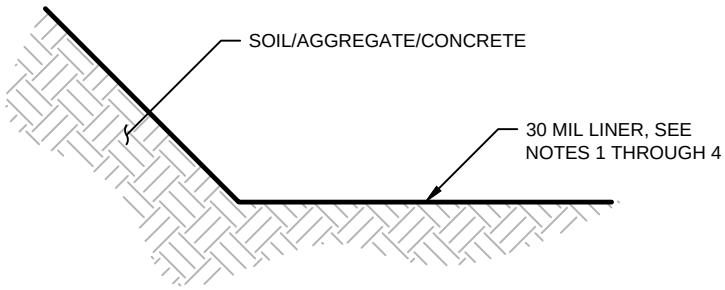
IMPERMEABLE LINERS IN GREEN INFRASTRUCTURE CAN BE USED TO RESTRICT MOVEMENT OF WATER INTO UNDERLYING AND/OR ADJACENT SOILS AND/OR AGGREGATES TO PROTECT SENSITIVE INFRASTRUCTURE (E.G., IMPERMEABLE ROADWAY BASE, FOUNDATIONS, UTILITIES), MITIGATE RISK OF GEOLOGIC HAZARDS (E.G., STEEP SLOPES, CONTAMINATED SOILS), OR OTHER SITE-SPECIFIC CONDITIONS)

DESIGNER NOTES & GUIDELINES:

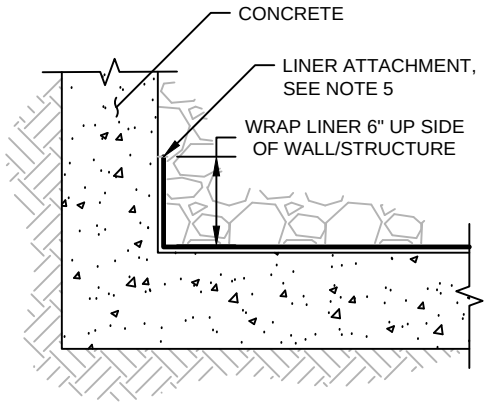
1. THE DESIGNER MUST ADAPT DRAWINGS TO ADDRESS SITE-SPECIFIC CONDITIONS.
2. THE DESIGNER AND/OR GEOTECHNICAL ENGINEER SHOULD ASSESS THE RISK OF WATER LEAKAGE FROM THE PLANTER AND DETERMINE THE LINER EXTENTS AND LINER CONNECTION REQUIREMENTS (E.G., WATER TIGHT, SOIL TIGHT), DEPENDING ON DEGREE OF PROTECTION NECESSARY TO PROTECT ADJACENT INFRASTRUCTURE.
6. CONSIDER PLACING GEOTEXTILE ON PREPARED SUBGRADE PRIOR TO PLACEMENT OF LINER TO PROTECT LINER FROM DAMAGE DURING INSTALLATION.
7. DEPENDING ON ANTICIPATED FACILITY MAINTENANCE, IT MAY BE PRUDENT TO INCLUDE A GEOTEXTILE OVER THE LINER TO PROVIDE AN ADDITIONAL BARRIER BETWEEN LINER AND MAINTENANCE EQUIPMENT OR TO PROTECT AGAINST AGGRESSIVE PUNCTURES DURING PLACEMENT AND COMPACTION.

DESIGNER CHECKLIST (MUST SPECIFY, AS APPLICABLE):

- ☐ LINER TYPE AND EXTENTS (E.G., FULL LINER, PARTIAL LINER)
- ☐ LINER ANCHOR TYPE (E.G., WATER TIGHT, SOIL TIGHT)
- ☐ LINER JOINT WELDING/SEALING REQUIREMENTS
- ☐ OTHER CRITICAL PROJECT-SPECIFIC PLACEMENT REQUIREMENTS



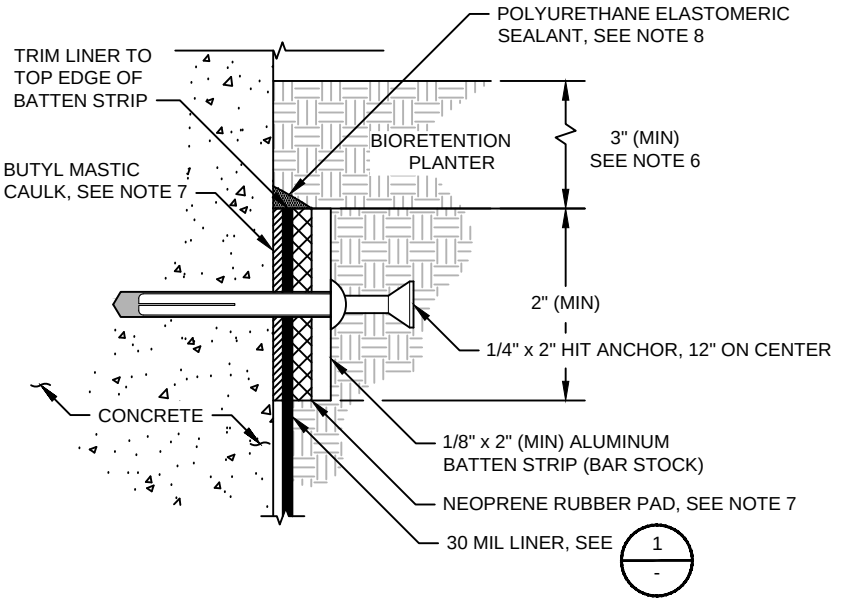
IMPERMEABLE LINER 1



SOIL TIGHT LINER ATTACHMENT AT WALL/STRUCTURE 2

CONSTRUCTION NOTES:

1. LINER SHALL BE HDPE CONFORMING TO GEOSYNTHETIC RESEARCH INSTITUTE (GRI) GM13 OR LLDPE CONFORMING TO GRI GM17.
2. LINER SHALL LAY FLUSH WITH GROUND WITH NO AIR VOIDS BELOW THE LINER PRIOR TO BACKFILLING MATERIAL ABOVE THE LINER. CONTOUR THE SUBGRADE AS NEEDED TO ENSURE LINER LAYS FLUSH WITH GROUND.
3. OVERLAP LINER PER MANUFACTURER'S RECOMMENDATIONS.
4. ALL SEAMS SHALL BE WELDED PER MANUFACTURER'S RECOMMENDATIONS UNLESS OTHERWISE SPECIFIED.
5. SECURE LINER CONTINUOUSLY WITH DOUBLE-SIDED TAPE ALONG LINER EDGE AND SINGLE SIDED TAPE ALONG THE TOP EDGE OF LINER TO HOLD LINER IN PLACE DURING BACKFILLING.
6. TOP OF LINER TO BE AT LEAST 3" BELOW FINISH GRADE OF BIORETENTION SOIL EXCEPT WHEN ADJACENT TO BUILDING WALL. WHEN ADJACENT TO BUILDING WALL, LINER OR EQUAL WATERPROOFING SHALL EXTEND TO TOP OF FREEBOARD ELEVATION.
7. APPLY BUTYL MASTIC CAULK, BATTEN STRIP, AND NEOPRENE RUBBER PAD CONTINUOUSLY ALONG TOP EDGE OF LINER.
8. APPLY BEAD OF POLYURETHANE ELASTOMERIC SEALANT CONTINUOUSLY ALONG TOP EDGE OF BATTEN STRIP ASSEMBLY.



WATER TIGHT LINER ATTACHMENT AT WALL/STRUCTURE 3

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

NOTES	COMPONENTS	NOTES	COMPONENTS		COMPONENTS
GC 1.1	GC 1.2	GC 4.1	GC 4.2	GC 4.3	GC 5.1

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION

DATE: FEBRUARY 2019
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REVISED:

GENERAL COMPONENTS
LINERS
LINERS AND ATTACHMENTS

DWG NO. GC 1.2

PURPOSE:

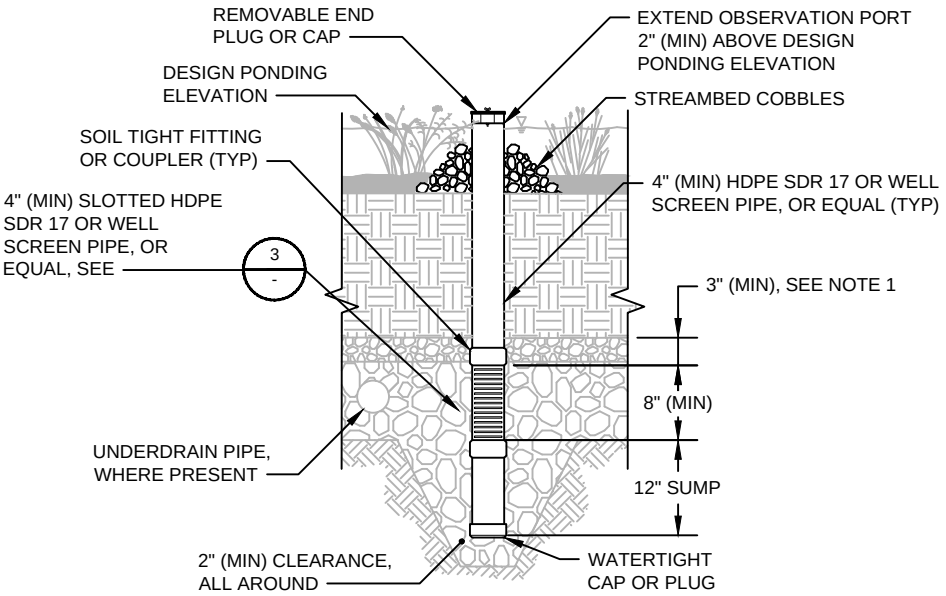
OBSERVATION PORTS ALLOW FOR MEASUREMENT OF DRAWDOWN THROUGH A FACILITY (WHEN WATER LEVEL MEASUREMENTS ARE NOT OBSERVABLE AT THE SURFACE). THESE PORTS CAN ALSO BE USED FOR LONG-TERM MONITORING WITH A PRESSURE TRANSDUCER. FOR SYSTEMS INCLUDING UNDERDRAINS, CLEANOUTS MAY SERVE AS THE FACILITY OBSERVATION PORT PROVIDED LONG-TERM MONITORING IS NOT REQUIRED FOR THE FACILITY.

DESIGNER NOTES & GUIDELINES:

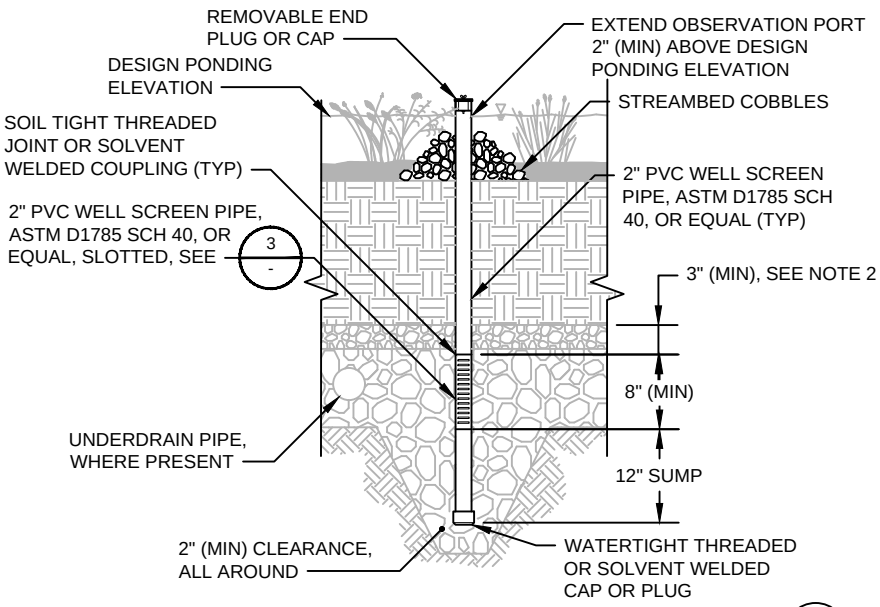
1. THE DESIGNER MUST ADAPT DRAWINGS TO ADDRESS SITE-SPECIFIC CONDITIONS.
2. OBSERVATION PORTS WITHIN A BIORETENTION FACILITY ARE NOT REQUIRED TO INCLUDE A SEPARATE LOCKING COVER ASSEMBLY. HOWEVER, DESIGNERS SHOULD CONSIDER REQUIRING A LOCKING OBSERVATION PORT CAP OR PLUG IF THE RISK OF TAMPERING IS CONSIDERED TO BE HIGH.
3. WHENEVER FEASIBLE, OBSERVATION PORTS SHOULD BE LOCATED OUTSIDE OF THE TRAVELED WAY. IF SITE CONSTRAINTS NECESSITATE INSTALLATION OF OBSERVATION PORTS IN AN AREA SUBJECT TO VEHICULAR TRAFFIC OR OTHER LOADING, OBSERVATION PORT COVER ASSEMBLIES AND MANHOLES MUST BE DESIGNED TO WITHSTAND ANTICIPATED LOADING (E.G., H-20).
4. OBSERVATION PORTS SHOULD INCLUDE A 12 INCH WATERTIGHT SUMP TO ACCOMMODATE CONTINUOUS WATER LEVEL MEASUREMENT WITH A PRESSURE TRANSDUCER.

DESIGNER CHECKLIST (MUST SPECIFY, AS APPLICABLE):

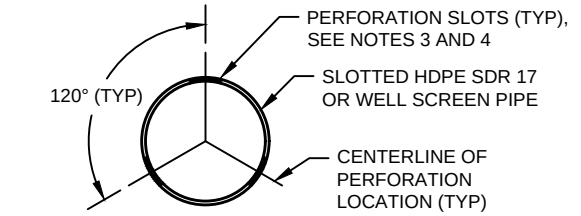
- ☐ OBSERVATION PORT MATERIAL, DIAMETER, AND DEPTH
- ☐ OBSERVATION PORT COVER ASSEMBLY/MANHOLE TYPE AND SIZE (IF APPLICABLE)
- ☐ CONTROL ELEVATIONS FOR OBSERVATION PORT RIMS
- ☐ TYPE OF MONITORING EQUIPMENT TO BE INSTALLED (IF APPLICABLE)



HDPE OBSERVATION PORT 1



PVC WELL CASING/SCREEN OBSERVATION PORT 2



PIPE SLOT DETAIL 3

CONSTRUCTION NOTES:

1. ALL MATERIAL AND WORKMANSHIP FOR OBSERVATION PORTS SHALL CONFORM TO SPRINGFIELD STANDARD SPECIFICATIONS AND APPLICABLE CODES.
2. PROVIDE 3 INCH MINIMUM COVER FROM BOTTOM OF BIORETENTION SOIL TO BEGINNING OF OBSERVATION PORT PERFORATIONS.
3. ALL PERFORATIONS SHALL BE SLOTTED TYPE, MEASURING 0.032 INCH WIDE (MAX), SPACED AT 0.25 INCH (MIN), AND PROVIDING A MINIMUM INLET AREA OF 5.0 SQUARE INCH PER LINEAR FOOT OF PIPE FOR PIPES 4 INCH IN DIAMETER AND LARGER AND 2.0 SQUARE INCHES PER LINEAR FOOT OF PIPE FOR PIPES SMALLER THAN 4 INCHES IN DIAMETER.
4. PERFORATIONS SHALL BE ORIENTED PERPENDICULAR TO LONG AXIS OF PIPE, AND EVENLY SPACED AROUND CIRCUMFERENCE AND LENGTH OF PIPE.
5. ALL FITTINGS SHALL BE SOIL TIGHT, UNLESS NOTED OTHERWISE.

NOTES	COMPONENTS	NOTES	COMPONENTS		COMPONENTS
GC 1.1	GC 1.2	GC 4.1	GC 4.2	GC 4.3	GC 5.1

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

CITY OF SPRINGFIELD, MA

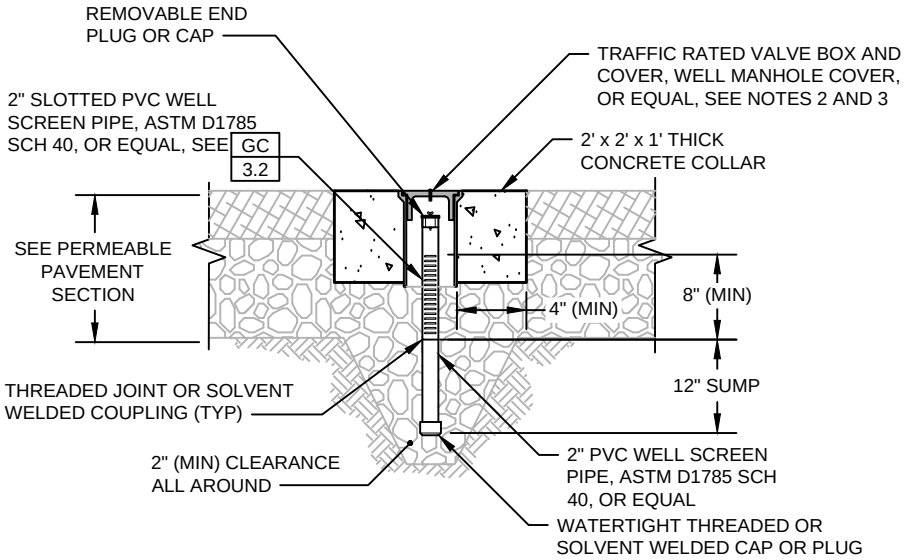
GREEN INFRASTRUCTURE TYPICAL DETAILS

ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION

DATE: FEBRUARY 2019
VERSION: 1.0
REVISED:

GENERAL COMPONENTS
OBSERVATION PORT
BIORETENTION

DWG NO. GC 4.2



PVC WELL SCREEN OBSERVATION PORT 1

CONSTRUCTION NOTES:

1. ALL MATERIAL AND WORKMANSHIP FOR OBSERVATION PORTS SHALL CONFORM TO SPRINGFIELD STANDARD SPECIFICATIONS AND APPLICABLE CODES.
2. COVER SHALL BE TRAFFIC RATED WITH TAMPER RESISTANT LOCKING MECHANISM. COVER SHALL INCLUDE CASTING OF STANDARD TRIANGLE SYMBOL, "TEST WELL", "MONITORING WELL", OR EQUAL.
3. OBSERVATION PORT COVERS AND LIDS MUST COMPLY WITH DPW STANDARD ACCESSIBILITY REQUIREMENTS.
4. WELL SCREEN SLOTS SHALL BE 0.032 INCHES WIDE (MAX), SPACED AT 0.25 INCH (MIN), AND PROVIDE A MINIMUM INLET AREA OF 2.0 SQUARE INCH PER LINEAR FOOT OF PIPE.
5. ALL FITTINGS SHALL BE SOIL TIGHT, UNLESS NOTED OTHERWISE.

NOTES	COMPONENTS	NOTES	COMPONENTS		COMPONENTS
GC 1.1	GC 1.2	GC 4.1	GC 4.2	GC 4.3	GC 5.1

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

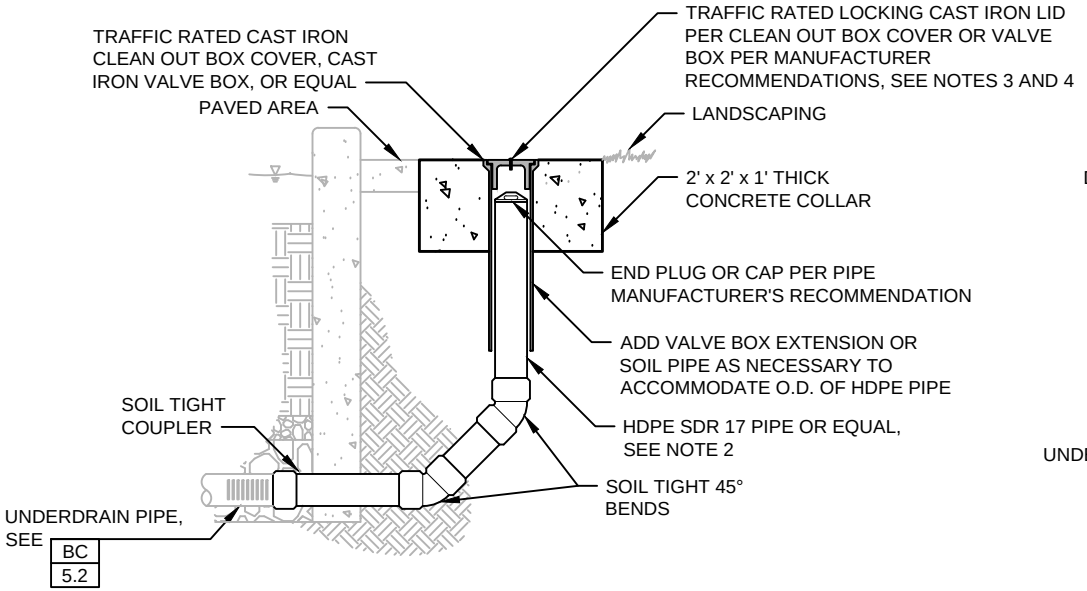
ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION

DATE: FEBRUARY 2019
VERSION: 1.0
REVISED:

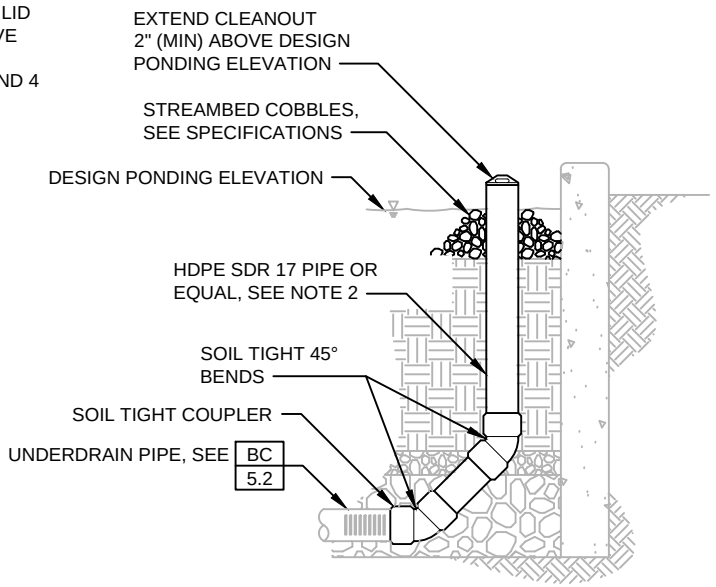
GENERAL COMPONENTS
OBSERVATION PORT
PERMEABLE PAVEMENT

DWG NO. GC 4.3

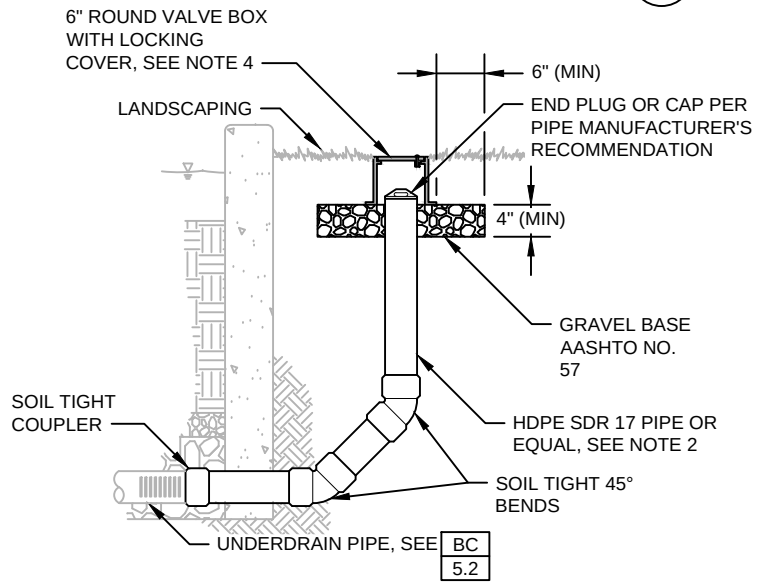
NOT FOR CONSTRUCTION - REFER TO USER GUIDE



CLEANOUT - ALTERNATIVE 1 (1)



CLEANOUT - ALTERNATIVE 2 (2)



CLEANOUT - ALTERNATIVE 3 (PARCEL ONLY) (3)

CONSTRUCTION NOTES:

1. ALL MATERIAL AND WORKMANSHIP FOR CLEANOUTS SHALL CONFORM TO SPRINGFIELD STANDARD SPECIFICATIONS AND APPLICABLE CODES.
2. CLEANOUT PIPE AND FITTINGS SHALL BE SAME SIZE AND MATERIAL AS SLOTTED UNDERDRAIN PIPE.
3. COVER SHALL BE TRAFFIC RATED WITH TAMPER RESISTANT LOCKING MECHANISM. COVER SHALL INCLUDE CASTING OF "CO" OR EQUAL.
4. CLEANOUT COVERS AND LIDS MUST COMPLY WITH PUBLIC WORKS STANDARD ACCESSIBILITY REQUIREMENTS.
5. CLEANOUT SHALL BE INSTALLED TO ALLOW FOR MAINTENANCE ACCESS TO ALL PIPES.
6. ALL FITTINGS SHALL BE SOIL TIGHT.

NOTES	COMPONENTS	NOTES	COMPONENTS		COMPONENTS
GC 1.1	GC 1.2	GC 4.1	GC 4.2	GC 4.3	GC 5.1

NOT FOR CONSTRUCTION - REFER TO USER GUIDE

CITY OF SPRINGFIELD, MA

GREEN INFRASTRUCTURE TYPICAL DETAILS

ADAPTED FROM SAN FRANCISCO PUBLIC UTILITIES COMMISSION

DATE: FEBRUARY 2019
VERSION: 1.0
REVISED:

GENERAL COMPONENTS
CLEANOUTS

DWG NO. GC 5.1

CITY OF SPRINGFIELD

GREEN INFRASTRUCTURE TECHNICAL GUIDELINES

C APPENDIX C: METHOD FOR USING THE GI SELECTION TOOL

DIRECTIONS

The Green Infrastructure Selection Tool is designed to be used by addressing the "Application" first and then working from left to right through the site condition parameters in the database to further refine the search. If, however, there is a specific parameter criterion that is critical to the search, then that parameter should be considered first.

The Selection Tool is operated through the filter function of Microsoft Excel. When a parameter applies to a GI option an "X" is placed in the intersecting cell, when it applies with conditions an asterisk is used followed by an acronym identifying the consideration, and when it does not apply then the cell is left blank.

EXAMPLE

The following example provides step-by-step instructions to use the GI Selection Tool to identify a palette of GI options based on known site characteristics and required tolerances. In this example, the site has the following characteristics:

- Type of Project: Private Parcel
- Application: Private Parking Lot
- Soil Permeability: SP-1 (<0.17 in/hr)
- Topography: TG-1 (0-5%)
- Depth to Water Table: WT-2 (3-5 ft)
- Depth to Bedrock: BE-3 (>5 ft)
- Known Soil Contamination: No
- Storm Sewer: Combined
- Urban Forest: Low
- Operations and Maintenance: Snow Removal, Sand Application

Green Infrastructure Options	SITE CONDITIONS								STORM SEWER		URBAN FOREST		OPERATIONS AND MAINTENANCE					Considerations
	Depth to Water Table			Depth to Bedrock			Known Soil Contamination		Separated		General Area Canopy Cover		Garbage/Solid Waste		Winter Maintenance Protocol			
	WT-1 (< 3 ft)	WT-2 (3-5 ft)	WT-3 (> 5 ft)	BE-1 (< 3 ft)	BE-2 (3-5 ft)	BE-3 (> 5 ft)	Yes	No	Separate (MS4)	Combined	High	Low	Curbside Waste Removal	Other	Snow Removal	Salt Application	Sand Application	
Trees with Sand-Based Structural Soil		x	x			x		x	x	x	x	xP	x	x	x	*SPS	x	*SPS
Trees in Soil Cell		x	x			x		x		x	x	xP	x	x	x	*SPS	x	*SPS
Tree in Open Planter		x	x			x		x		x	x	xP	x	x	x	*SPS	x	*SPS
Stormwater Planter with Underdrain		x	x		x	x		x	x	x	x	x	x	x	x	*SPS		*UU
Stormwater Planter with Pre-treatment & Underdrain		x	x		x	x		x	x	x	x	x	x	x	x	*SPS	x	*UU /*SPS
Stormwater Biofilter (Filtration Only Bioretention) - Impervious Bottom	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	*SPS	x	*UU /*SPS
Filter Strip / Buffer Strip with Underdrain		x	x		x	x		x	x	x	x	x	x	x	x	*SPS		*SPS

Step 1

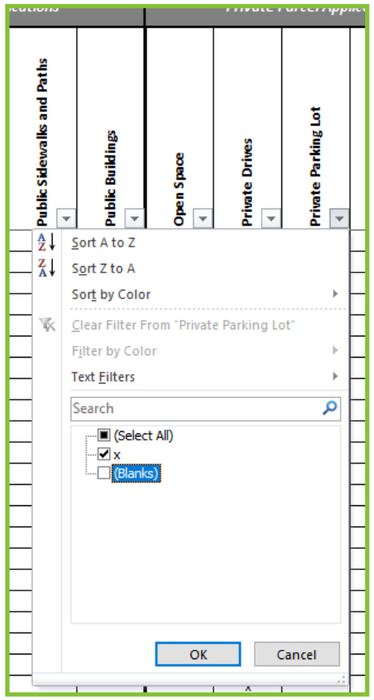
Select Tab 3.0 to begin screening for a "Private Parcel" construction project.

Step 2

The project involves redeveloping a Private Parking Lot, so deselect "blank" and click OK. This will remove any options that will not apply to that application specifically.

Step 3

Deselect the "blank" option in the drop-down for SP-1 (<0.17 in/hr). This will remove options that are only suitable in highly permeable soils.



Step 4

There are no "blanks"in the drop-down for TG-1 (0-5%). Therefore there are no changes to be made to the drop-down menu.

Step 5

There are no "blanks"in the drop-down for WT-2 (3-5 ft). Therefore there are no changes to be made to the drop-down menu.

Step 6

There are no "blanks" in the drop-down for BE-3 (>5 ft). Therefore there are no changes to be made to the drop-down menu.

Step 7

There are no "blanks"in the drop-down for No Known Soil Contamination. Therefore there are no changes to be made to the drop-down menu.

Step 8

There are no "blanks"in the drop-down for Combined Storm Sewer. Therefore there are no changes to be made to the drop-down menu.

Step 9

There are no "blanks"in the drop-down for Low Urban Forest Canopy. Therefore there are no changes to be made to the drop-down menu.

Step 10

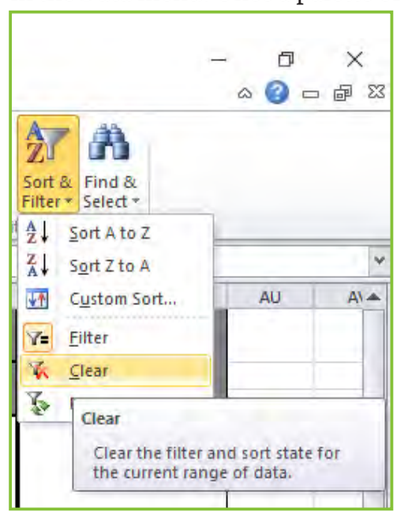
In this scenario, the developer only wishes to consider those options which would allow for flexible space for snow storage and would be unhampered by the application of sand during winter maintenance. Deselect the "*L" option in the drop-down menus for "Snow Removal" and the "*PS" option in "Sand Application". This will restrict options to those suitable given these maintenance and operation parameters. Because there is no Waste Removal or Salt Applications to contend with in this scenario, there are no changes required in this section.

Results

The resulting list above provides a palette of GI options that are viable within the right-of-way of this sample Private Parcel application.

RESET THE SELECTION TOOL

To reset the Tool click "clear" under "Sort & Filter" in the Data menu. Once a palette of options are identified, then the GI selection, design, and implement processes can begin.

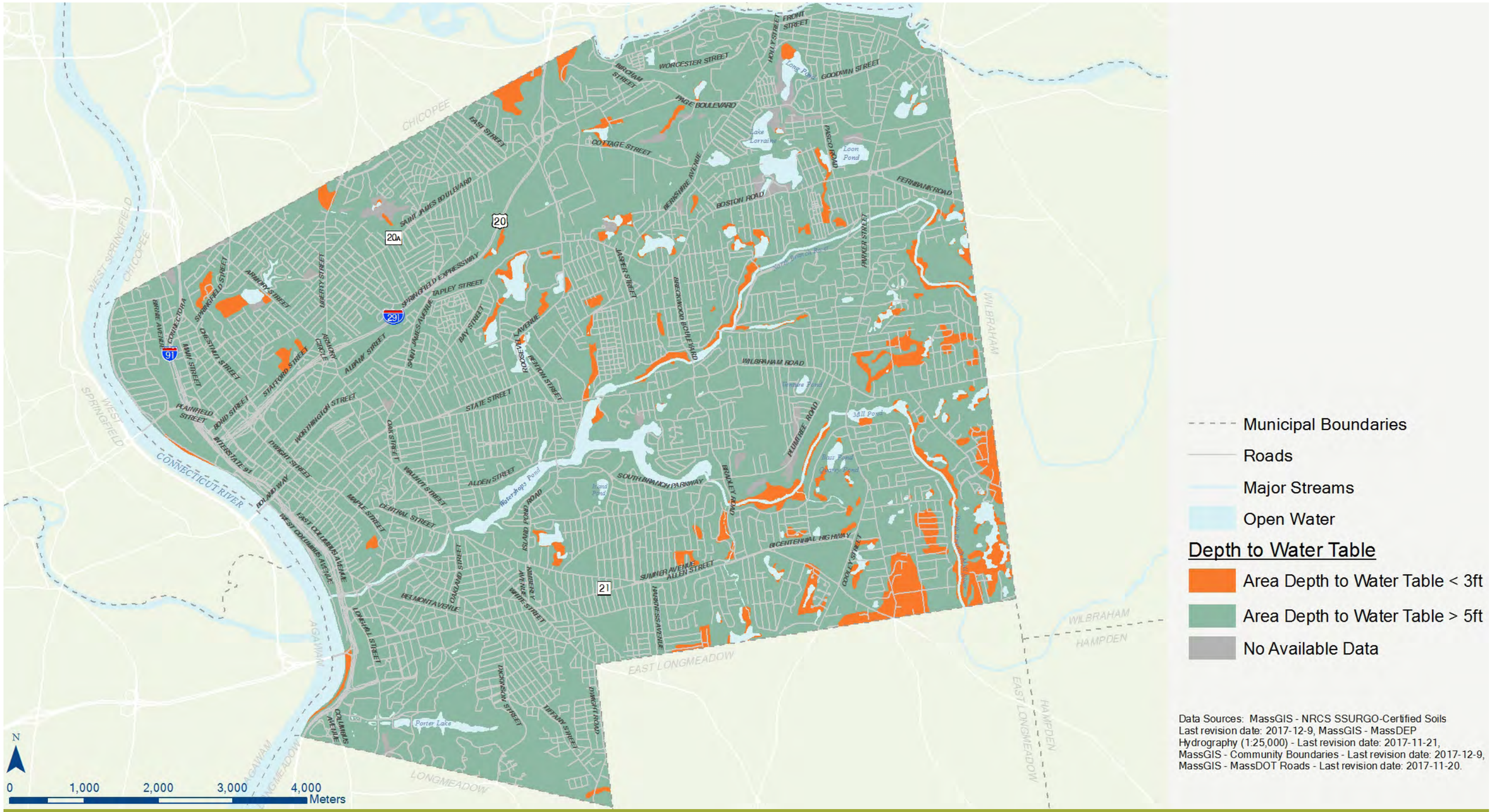


CITY OF SPRINGFIELD

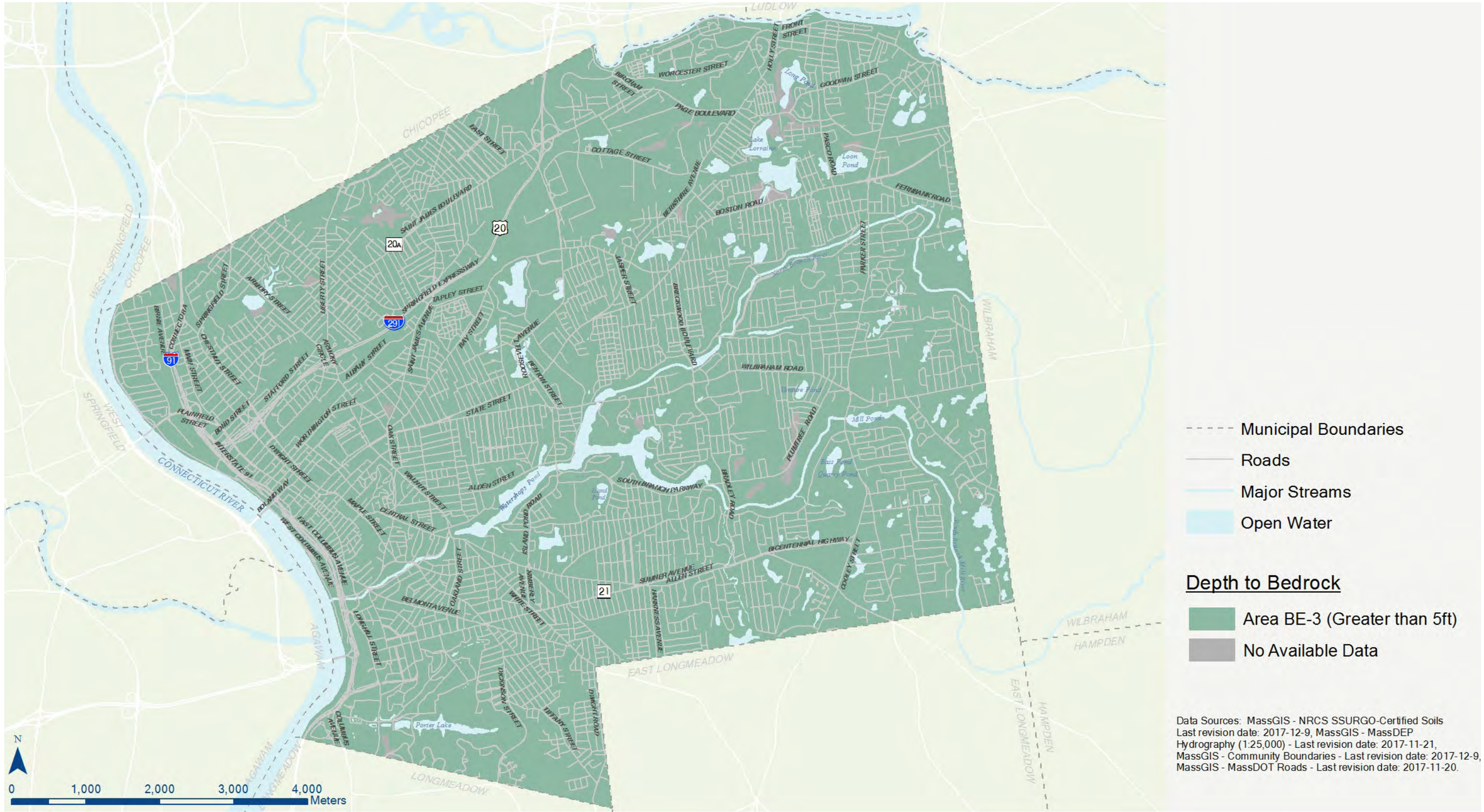
GREEN INFRASTRUCTURE TECHNICAL GUIDELINES

D APPENDIX D: CITY-WIDE REFERENCE MAPS

MAP 1 TOPOGRAPHIC GRADIENTS



MAP 2 DEPTH TO WATER TABLE



Municipal Boundaries

Roads

Major Streams

Open Water

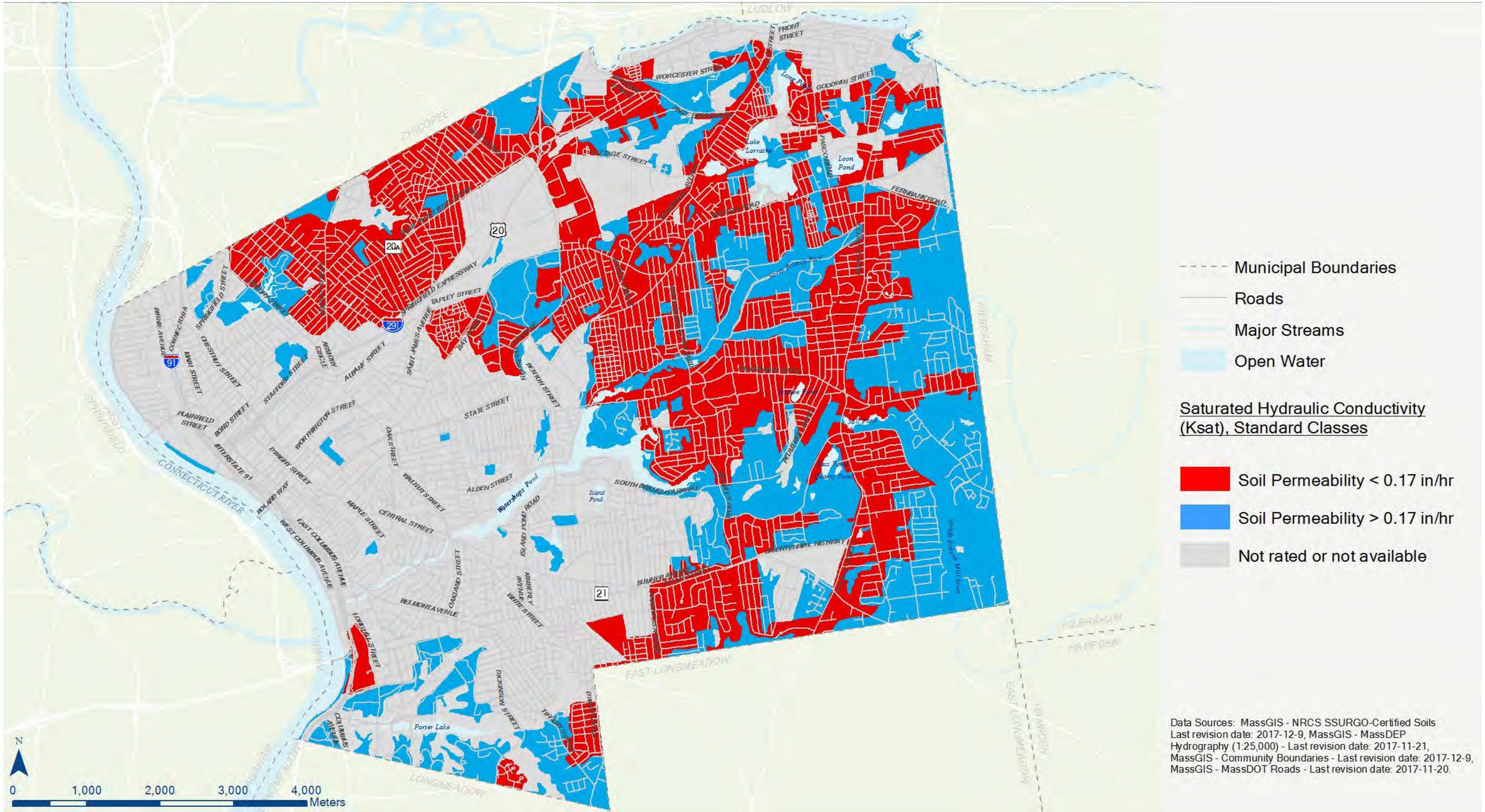
Depth to Bedrock

Area BE-3 (Greater than 5ft)

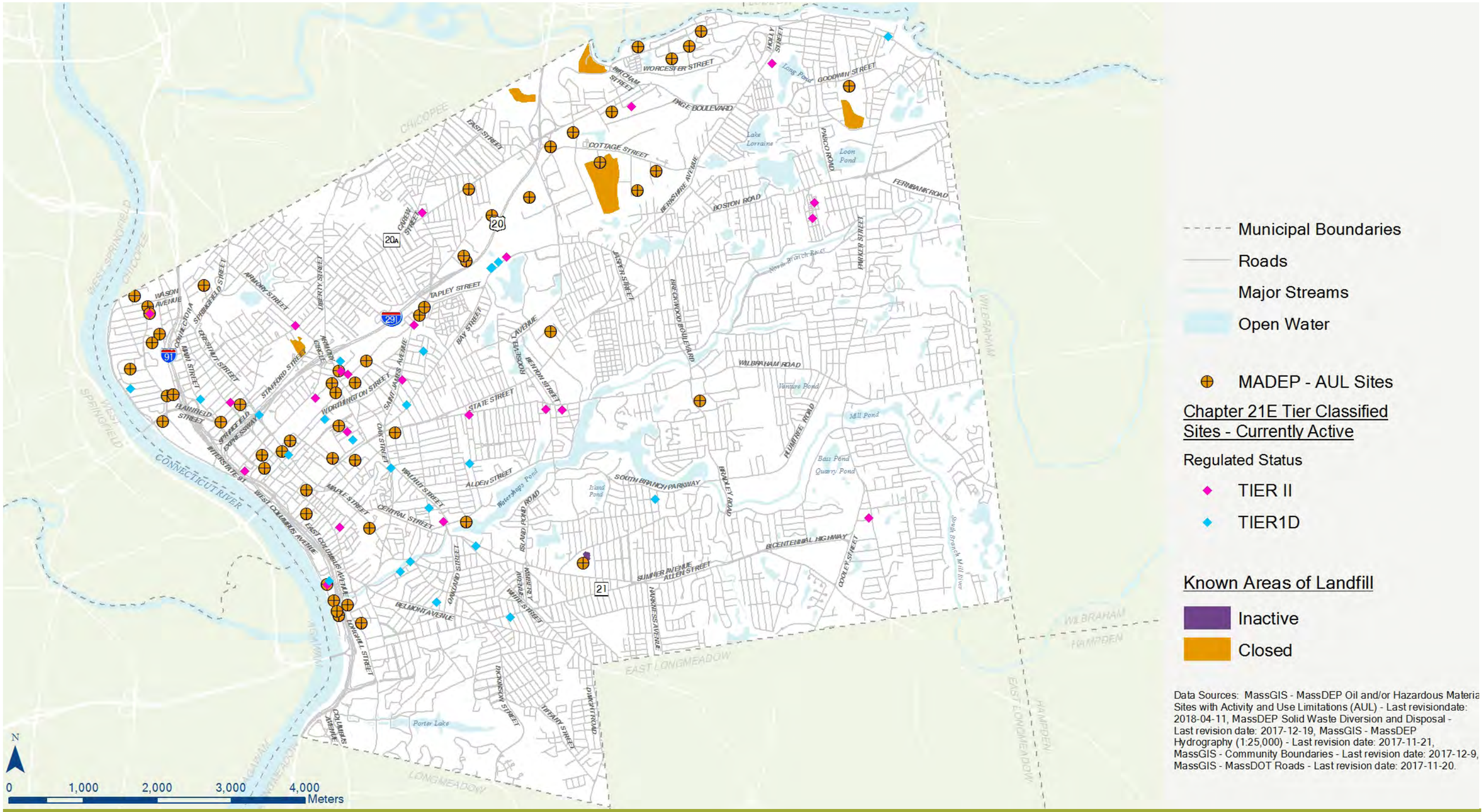
No Available Data

Data Sources: MassGIS - NRCS SSURGO-Certified Soils Last revision date: 2017-12-9, MassGIS - MassDEP Hydrography (1:25,000) - Last revision date: 2017-11-21, MassGIS - Community Boundaries - Last revision date: 2017-12-9, MassGIS - MassDOT Roads - Last revision date: 2017-11-20.

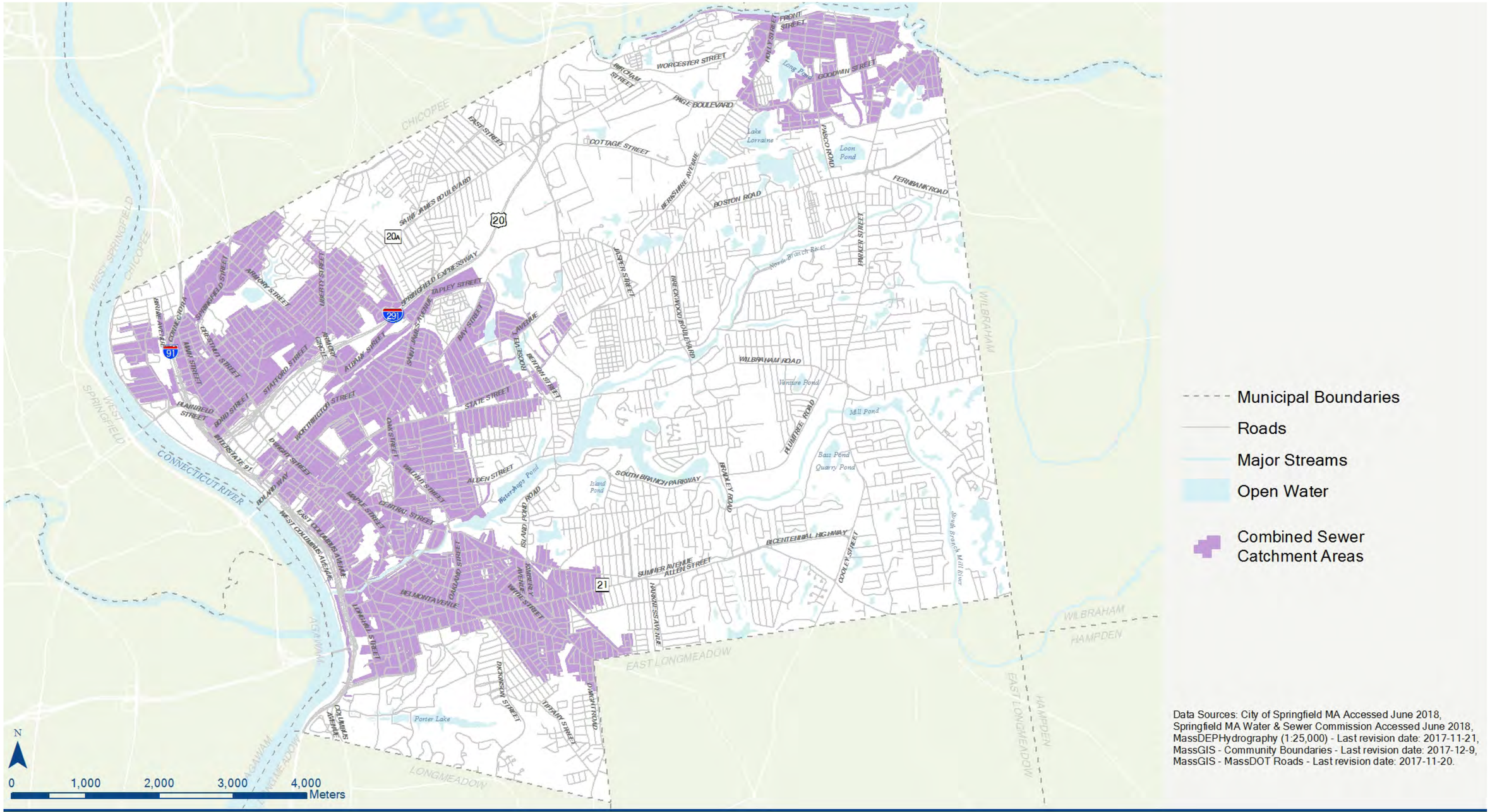
MAP 3 DEPTH TO BEDROCK



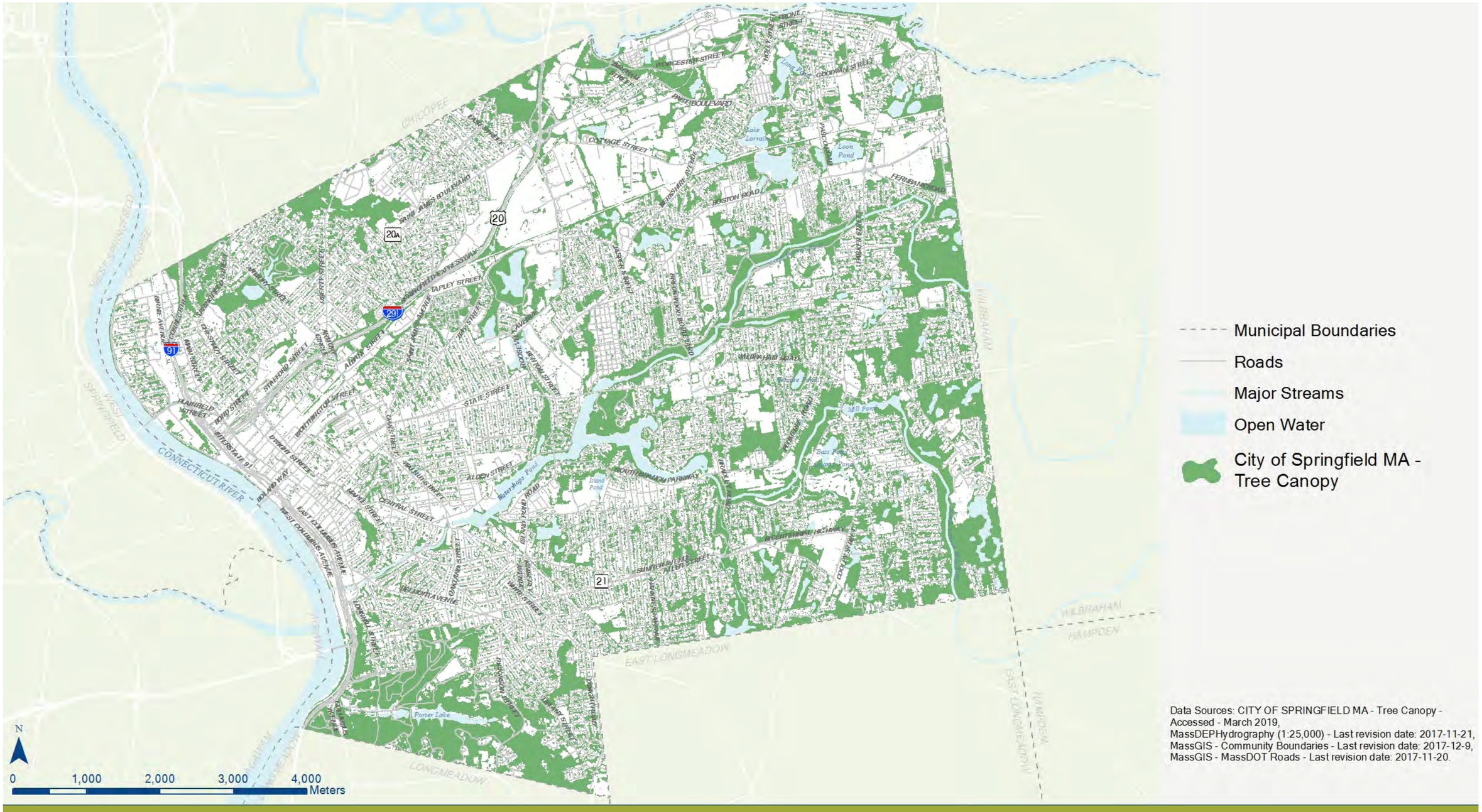
MAP 4 SOIL PERMEABILITY



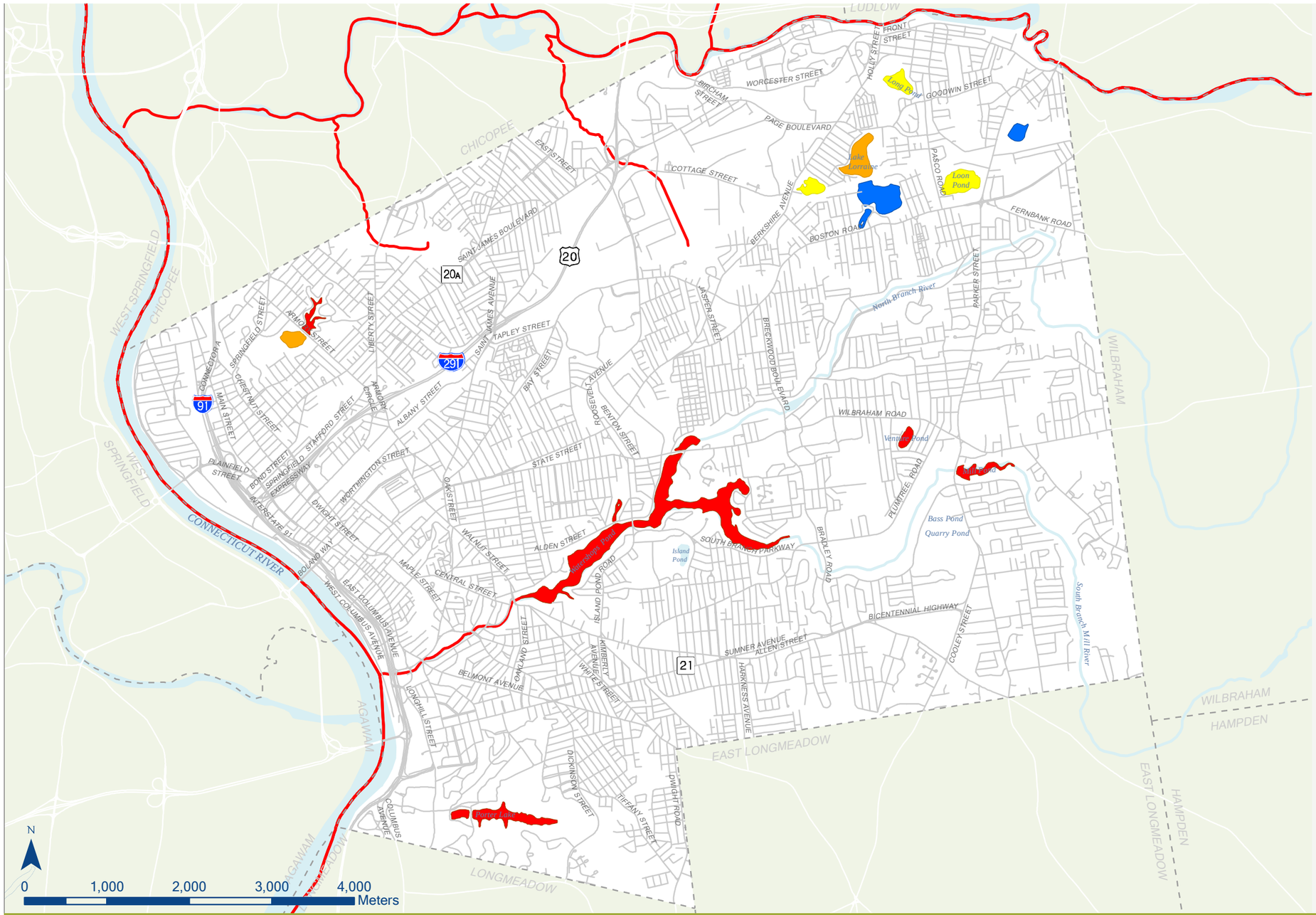
MAP 5 AREAS OF KNOWN SOIL CONTAMINATION



MAP 6 COMBINED STORM SEWER CATCHMENT AREAS



MAP 7 URBAN FOREST CANOPY COVER



Municipal Boundaries

Roads

Major Streams

Open Water

MassDEP Integrated List of Waters (305(b)/306(d))

Water Body Segments - Rivers (arcs)

5 - Impaired - TMDL required

Water Body Segments - Lakes, Estuaries (polygons)

3 - No uses assessed

4A -Impaired - TMDL is completed

4C - Impairment not caused by a pollutant

5 - Impaired - TMDL required

Data Sources: MassGIS - MassDEP 2014 Integrated list of Waters - Last revision date: 2018-01-02, MassDEPHydrography (1:25,000) - Last revision date: 2017-11-21, MassGIS - Community Boundaries - Last revision date: 2017-12-9, MassGIS - MassDOT Roads - Last revision date: 2017-11-20.

MAP 8 WATER BODY IMPAIRMENTS

CITY OF SPRINGFIELD

GREEN INFRASTRUCTURE TECHNICAL GUIDELINES

E APPENDIX E: OPERATIONS AND MAINTENANCE PROTOCOLS

VEGETATED SYSTEMS

GI/LID OPTION	OPERATIONS & MAINTENANCE PROTOCOLS (OMP)	INSPECTIONS/MONITORING	REPAIRS/REPLACEMENT
Urban Forest Canopy & Street Trees	**UFC_OMP1** Description: Removal of garbage and natural debris on or around tree base Frequency: Once in spring and after major wind storm events as required Equipment: Handwork Personnel: One individual Hours: Area dependent **UFC_OMP2** Description: Watering Frequency: New trees weekly; mature trees as required Equipment: Irrigation system (if available) / water truck Personnel: One individual Hours: Area dependent **UFC_OMP3** Description: Weeding & pest control Frequency: Weeding & pest control as necessary Equipment: Handwork Personnel: One individual Hours: Area dependent **UFC_OMP4** Description: Pruning Frequency: annually, by certified arborist Equipment: Handwork Personnel: One individual Hours: Area dependent **UFC_OMP5** Description: Mulch placement over root system Frequency: As required to maintain 2-4" layer. Mulching material shall be pulled back no less than 3" and no more than 6" from the trunk. Equipment: Handwork; mulch Personnel: One individual Hours: Area dependent	**KEY AREAS OF CONCERN / INSPECTION FREQUENCY:** • Structural integrity inspection (annually) • Tree health inspection (bi-annually) • Girdling at tree grate (bi-annually) • Pest and disease inspection (bi-annually) • Inspection and maintenance log **SPECIALIZED TRAINING:** • Irrigation systems training • Arborist certification for tree pruning/care	**TRUNK AND CROWN INJURY** • Pruning • Cabling/bracing • Remove bark **ROOTZONE AERATION** • Vertical mulching or radial aeration **NOTES** • Irrigation to occur at n ight or in early morning

VEGETATED SYSTEMS

GI/LID OPTION	OPERATIONS & MAINTENANCE PROTOCOLS (OMP)	INSPECTIONS/MONITORING	REPAIRS/REPLACEMENT

Trees with Sand-Based Structural Soil
Stormwater Infiltration Tree Trenches
Trees in Soil Cell
Tree in Open Planter
Stormwater Tree Pits
	TP_OMP1
	Description: Removal of garbage and natural debris on or around tree base
	Frequency: Bi-annually or as required
	Equipment: Handwork
	Personnel: One individual
	Hours: Area dependent
		KEY AREAS OF CONCERN / INSPECTION FREQUENCY:
		• Structural integrity of surface treatment (annually)
		• Tree opening - soil settlement (annually)
		• Tree opening - clogging (Spring and fall or after every rain event over 2")
		• Sediment accumulation inspection of inlet, pretreatment, mulch, as necessary (bi-annually)
		• Standing water (monthly or after every rain event over 2")
		• Sediment accumulation testing (bi-annually)
		• Filter bed erosion/sediment accumulation/surface sinking (monthly through warranty period/bi-annually)
		• Inlet structural integrity/obstruction/erosion (annually)
		• Contributing drainage area condition (bi-annually)
		• Garbage (weekly)
		• Tree
		  • Safety (spring or after every storm event)
		  • Healthy (spring/fall)
		  • Root girdling (every 4-5 years)
		  • Mulch on root collar (annually)
		  • Damage from pests and animals (bi-annually)
			STRUCTURAL SOIL CLOGGING
			• Remove and replace top 6" of soil to alleviate fine texture clogging; as necessary
			
			POOR PLANT GROWTH
			• Replace top 2" of soil with compost; as necessary
			• Amend soil with limestone or compost/sulphur to raise or lower pH of soil as required.
			• Replace dead/diseased trees: as required.
			
			ACCESS TO UTILITIES
			• Remove and reuse panels or remove and replace as necessary in accordance with manufacturers' recommendations
			
			MULCH REPLACEMENT
			• Add mulch (maintain 2-4" layer, puled back not less than 3" and no more than 6" from the trunk)
			
			SURFACE PONDING
			• Remove accumulated sediment. Till filter media to 8" or remove and replace top 6" of filter media necessary
			
			FILTER MEDIA CLOGGING
			• Remove mulch and plantings. Core aerate to 8" and replace with non-compacted filter media as necessary.
			
			SALT ACCUMULATION
			• Flush with fresh water to alleviate excess salt in the soil as necessary
			
			SEDIMENT ACCUMULATION
			• Remove accumulated with vacuum truck. In extreme cases remove plant material and top 2" of contaminated filter media. Replace with 2" of new filter media and plant material, if necessary.

	TP_OMP2 Description: Sediment removal from tree opening (if required) Frequency: As necessary Equipment: Handwork Personnel: One individual Hours: ~ 0.25 hrs/tree		
	TP_OMP3 Description: Pruning Frequency: Annually, by certified arborist Equipment: Handwork/chainsaw Personnel: One individual Hours: ~ 0.25 hrs/tree		
	TP_OMP4 Description: Watering Frequency: Under 2 yrs, weekly; Over 2 yrs, as required Equipment: Gatorbags/Water truck Personnel: One individual Hours: ~ 0.25 hrs/tree	SOIL CELLS • Soil cell structure (only required if facility shows sign of damage due to excessive load) • Air / water inlet: clogging / proper operation (anually / after major storms) • Energy dissipation component: proper operation (annually/after major storms) • Flow restrictor: proper operation (annually/after major storms) • Distribution pipe: proper operation (annually) • Underdrain pipe: proper operation (annually) • Inspection and maintenance log **SPECIALIZED TRAINING:** • Inspection and cleanout procedures • Sediment removal procedure • Sub-drain flushing procedure • Indentification of monuments and extent of facility • Soil cell repair training • Arborist training for tree pruning and care	
	TP_OMP5 Description: Flush sub-drain (if applicable) Frequency: Annually Equipment: Water truck Personnel: One individual Hours: System dependent		
	TP_OMP6 Description: Pest management Frequency: As required Equipment: Case dependent Personnel: Case dependent Hours: Case dependent		
	TP_OMP7 Description: Mulch placement over root system (if applicable) Frequency: As required to maintain 2-4" layer. Mulching material shall be pulled back no less than 3" and no more than 6" from the trunk. Equipment: Handwork; mulch Personnel: One individual Hours: Area dependent		

VEGETATED SYSTEMS

GI/LID OPTION	OPERATIONS & MAINTENANCE PROTOCOLS (OMP)	INSPECTIONS/MONITORING	REPAIRS/REPLACEMENT
Trees with Sand-Based Structural Soil Stormwater Infiltration Tree Trenches Trees in Soil Cell Tree in Open Planter Stormwater Tree Pits	**TP_OMP8** Description: Sweep contributing areas and remove sediment from pretreatment (if applicable) Frequency: Bi-annually to annually Equipment: Mechanical sweeper/handwork Personnel: One individual Hours: Area dependent		
	TP_OMP9 Description: Cultivate surface and weed planting bed Frequency: Once in spring Equipment: Handwork Personnel: One individual Hours: Area dependent		
	TP_OMP10 Description: Inspect and clean inlets Frequency: Bi-annually (spring/late fall) Equipment: Handwork Personnel: One individual Hours: 0.25 hrs/inlet		
Rain Garden Bioretention Planter w/o Pre-treatment or Underdrain Bioretention Planter with Pre-treatment w/o Underdrain Bioretention Planter with Underdrain Bioretention Planter with Pre-treatment & Underdrain Biofilter Planter (Filtration Only Bioretention) - Impervious Bottom Stormwater Planter w/o Pre-treatment or Underdrain Stormwater Planter with Pre-treatment w/o Underdrain Stormwater Planter with Underdrain Stormwater Planter with Pre-treatment & Underdrain Stormwater Biofilter (Filtration Only Bioretention) - Impervious Bottom Bioretention Curb Extension/Bump-out w/o Pre-treatment or Underdrain Bioretention Curb Extension/Bump-out	**BP_OMP1** Description: Inspect and clean inlets Frequency: Bi-annually (spring/late fall) Equipment: Handwork Personnel: One individual Hours: 0.25 hrs/inlet	**KEY AREAS OF CONCERN/INSPECTION FREQUENCY:** • Contributing drainage area condition (bi-annually) • Inlet structural integrity/obstruction/erosion (annually) • Inlet sediment accumulation (bi-annually) • Pretreatment sediment accumulation inspection (bi-annually) • Slide slope erosion (annually) • Surface ponding: perimeter/filter bed (annually) • Standing water: filter bed (monthly through warranty perioud, bi-annually beyond warranty) • Garbage (bi-annually) • Filter bed erosion/sediment accumulation/surface shrinking (monthly through warranty perioud, bi-annually beyond warranty) • Mulch depth (annually) • Vegetation density/health/composition (bi-annually) • Monitoring well condition (annually) • Overflow outlet obstruction (monthly through warranty perioud, bi-annually beyond warranty) • Sub-drain obstruction (monthly through warranty perioud, bi-annually beyond warranty) • Sediment accumulation testing (bi-annually) • Inspection and maintenance log	**OBSTRUCTED SUB-DRAIN** • Snake or vacuum truck to remove obstruction as required. **CONCENTRATION OF FLOWS** • Add flow spreading device or regrade existing to level as required **MULCH REPLACEMENT** • Add mulch (maintain 2-4" layer, puled back not less than 3" and no more than 6" from the trunk) **SURFACE PONDING** • Remove accumulated sediment. Till filter media to 8" or remove and replace top 6" of filter media necessary **FILTER MEDIA CLOGGING** • Remove mulch and plantings. Core aerate to 8" and replace with non-compacted filter media as necessary. **SALT ACCUMULATION** • Flush with fresh water to alleviate
	BP_OMP2 Description: Cultivate surface and weed planting bed Frequency: Once in spring Equipment: Handwork Personnel: One individual Hours: Area dependent		
	BP_OMP3 Description: Removal of garbage and natural debris on or around tree base Frequency: Once in spring and after major wind storm events as required Equipment: Handwork Personnel: One individual Hours: Area dependent		
	BP_OMP4 Description: Pruning Frequency: Annually, by certified arborist Equipment: Handwork/chainsaw Personnel: One individual Hours: ~ 0.25 hrs/tree		

	GI/LID OPTION	OPERATIONS & MAINTENANCE PROTOCOLS (OMP)	INSPECTIONS/MONITORING	REPAIRS/REPLACEMENT
VEGETATED SYSTEMS	with Pre-treatment w/o Underdrain Bioretention Curb Extension/Bump-out with Underdrain Bioretention Curb Extension/Bump-out with Pre-treatment & Underdrain Biofilter Curb Extension/Bump-out (Filtration Only Bioretention) - Impervious Bottom Bioretention Basin w/o Pre-treatment or Underdrain Bioretention Basin with Pre-treatment w/o Underdrain Bioretention Basin with Underdrain Bioretention Basin with Pre-treatment & Underdrain Biofilter Basin (Filtration Only Bioretention) - Impervious Bottom	**BP_OMP5** Description: Watering Frequency: Bi-weekly through establishment only Equipment: Water truck Personnel: One individual Hours: Area dependent **BP_OMP6** Description: Redistribute mulch to maintain >2" depth throughout, as necessary Frequency: Quarterly Equipment: Handwork/rake Personnel: One individual Hours: Area dependent **BP_OMP7** Description: Flush sub-drain (if applicable) Frequency: Annually Equipment: Water truck Personnel: One individual Hours: System dependent **BP_OMP8** Description: Sweep contributing area and remove sediment from pretreatment Frequency: Bi-annually to annually Equipment: Mechanical sweeper/handwork Personnel: One individual Hours: System dependent	• Quantitative flow monitoring • Water quality monitoring **SPECIALIZED TRAINING:** • Inspection and cleanout procedures • Drainage system training • Sediment removal procedure • Sub-drain flushing procedure • Arborist certification for tree pruning/care	excess salt in the soil as necessary **SEDIMENT ACCUMULATION** • Remove accumulated with vacuum truck. In extreme cases remove plant material and top 2" of contaminated filter media. Replace with 2" of new filter media and plant material, if necessary. **POOR PLANT GROWTH** • Replace top 2" of soil with compost; as necessary • Amend soil with limestone or compost/sulphur to raise or lower pH of soil as required. • Replace dead/diseased plant material as required.
	Enhanced Grass Swale Enhanced Grass Swale with Check Dam Enhanced Grass Swale with Check Dam & Underdrain Bioswale w/o Pre-treatment or Underdrain Bioswale with Pre-treatment w/o underdrain Bioswale with Underdrain Bioswale with Pre-treatment & Underdrain Bioswale with Pre-treatment, Underdrain & Impermeable Liner	**EBS_OMP1** Description: Inspect and clean inlets Frequency: Bi-annually (spring/late fall) Equipment: Handwork Personnel: One individual Hours: 0.25 hrs/inlet **EBS_OMP2** Description: Cultivate surface and weed planting bed Frequency: Once in spring Equipment: Handwork Personnel: One individual Hours: Area dependent **EBS_OMP3** Description: Removal of garbage and natural debris on or around tree base Frequency: Once in spring and after major wind storm events as required Equipment: Handwork Personnel: One individual Hours: Area dependent	**KEY AREAS OF CONCERN/INSPECTION FREQUENCY:** • Contributing drainage area condition (bi-annually) • Inlet structural integrity/obstruction/erosion (annually) • Inlet sediment accumulation (bi-annually) • Pretreatment sediment accumulation inspection (bi-annually) • Slide slope erosion (annually) • Surface ponding: perimeter/filter bed (annually) • Standing water: filter bed (monthly through warranty perioud, bi-annually beyond warranty) • Garbage (bi-annually) • Filter bed erosion/sediment accumulation/surface shrinking (monthly through warranty perioud, bi-annually beyond warranty) • Mulch depth (annually) • Vegetation density/health/composition (bi-annually) • Monitoring well condition (annually) • Overflow outlet obstruction (monthly through warranty perioud, bi-annually beyond warranty)	**BARE SOIL AREAS** • Reseed bare soil areas bi-annually or annually as needed • Maintain 2-4" depth mulch as necessary to planted bioswales **POOR PLANT GROWTH** • Replace top 2" of soil with compost; as necessary • Amend soil with limestone or compost/sulphur to raise or lower pH of soil as required. • Replace dead/diseased plant material as required. **EROSION AREAS** • Regrade & replant eroded areas as necessary • Add flow spreading or turf reinforcing

	GI/LID OPTION	OPERATIONS & MAINTENANCE PROTOCOLS (OMP)	INSPECTIONS/MONITORING	REPAIRS/REPLACEMENT
VEGETATED SYSTEMS		**EBS_OMP4** Description: Pruning Frequency: Annually, by certified arborist Equipment: Handwork/chainsaw Personnel: One individual Hours: ~ 0.25 hrs/tree	• Sub-drain obstruction (monthly through warranty periound, bi-annually beyond warranty) • Sediment accumulation testing (bi-annually) • Check dam condition and function (annually) • Vegetation density/health/composition (bi-annually) • Inspection and maintenance log • Quantitative flow monitoring • Water quality monitoring **SPECIALIZED TRAINING:** • Inspection and cleanout procedures • Aerator operation • Mower operation • Sub-drain flushing procedure • Arborist certification for tree pruning/care	device if required **SEDIMENT ACCUMULATION** • Remove sediment accumulation to at least 2" depth with rake and shovel where feasible and as necessary **COMPACTED SOILS** • core aerate, or remove stone and vegetation cover adn till topsoil to a depth of 8", or remove and replace with non-compacted filter media or topsoil that meets design specifications (once every 3-5 years) **SALT ACCUMULATION** • Flush with fresh water to alleviate excess salt in the soil as necessary **SURFACE PONDING** • Remove accumulated sediment. Till filter media to 8" or remove and replace top 6" of filter media as necessary.
		EBS_OMP5 Description: Watering Frequency: Bi-weekly through establishment only Equipment: Water truck Personnel: One individual Hours: Area dependent		
		EBS_OMP6 Description: Redistribute mulch to maintain >2" depth throughout, as necessary Frequency: Quarterly Equipment: Handwork/rake Personnel: One individual Hours: Area dependent		
		EBS_OMP7 Description: Flush sub-drain (if applicable) Frequency: Annually Equipment: Water truck Personnel: One individual Hours: System dependent		
		EBS_OMP8 Description: Sweep contributing area and remove sediment from pretreatment Frequency: Bi-annually to annually Equipment: Mechanical sweeper/handwork Personnel: One individual Hours: System dependent		
		EBS_OMP9 Description: Mowing (if applicable) Frequency: Bi-monthly or as required (do not mow in wet conditions) Equipment: Light weight riding mower Personnel: One individual Hours: System dependent		

	GI/LID OPTION	OPERATIONS & MAINTENANCE PROTOCOLS (OMP)	INSPECTIONS/MONITORING	REPAIRS/REPLACEMENT
VEGETATED SYSTEMS	Green Wall Green Roof	**GWR_OMP1** Description: Watering Frequency: As required (seasonal/temperature dependent) Equipment: Irrigation system Personnel: One individual Hours: Area dependent **GWR_OMP2** Description: Weeding Frequency: As required Equipment: Handwork Personnel: One individual Hours: Area dependent **GWR_OMP3** Description: Fertilizing (injection through irrigation system) Frequency: Once in spring Equipment: Irrigation system Personnel: One individual Hours: System dependent **GWR_OMP4** Description: Irrigation stat-up and winterization Frequency: Spring and fall Equipment: Air compressor Personnel: One individual Hours: 1 hr/system	**KEY AREAS OF CONCERN/INSPECTION FREQUENCY:** • Structural integrity inspection (annually) • Irrigation system inspection (annually) • Drainage system inspection (annually) • Vegetation density/health/composition (bi-annually) • Irrigation system testing (annually) • Plant fertility/soil testing (annually) **SPECIALIZED TRAINING** • Green wall/roof maintenance training • Irrigation systems training • Drainage systems training	**PLANT REPLACEMENT** • To occur under supervision of Green Wall/Roof maintenace specialist **IRRIGATION SYSTEM REPAIR AND REPLACEMENT** • By irrigation specialist familiar with green walls/roofs.

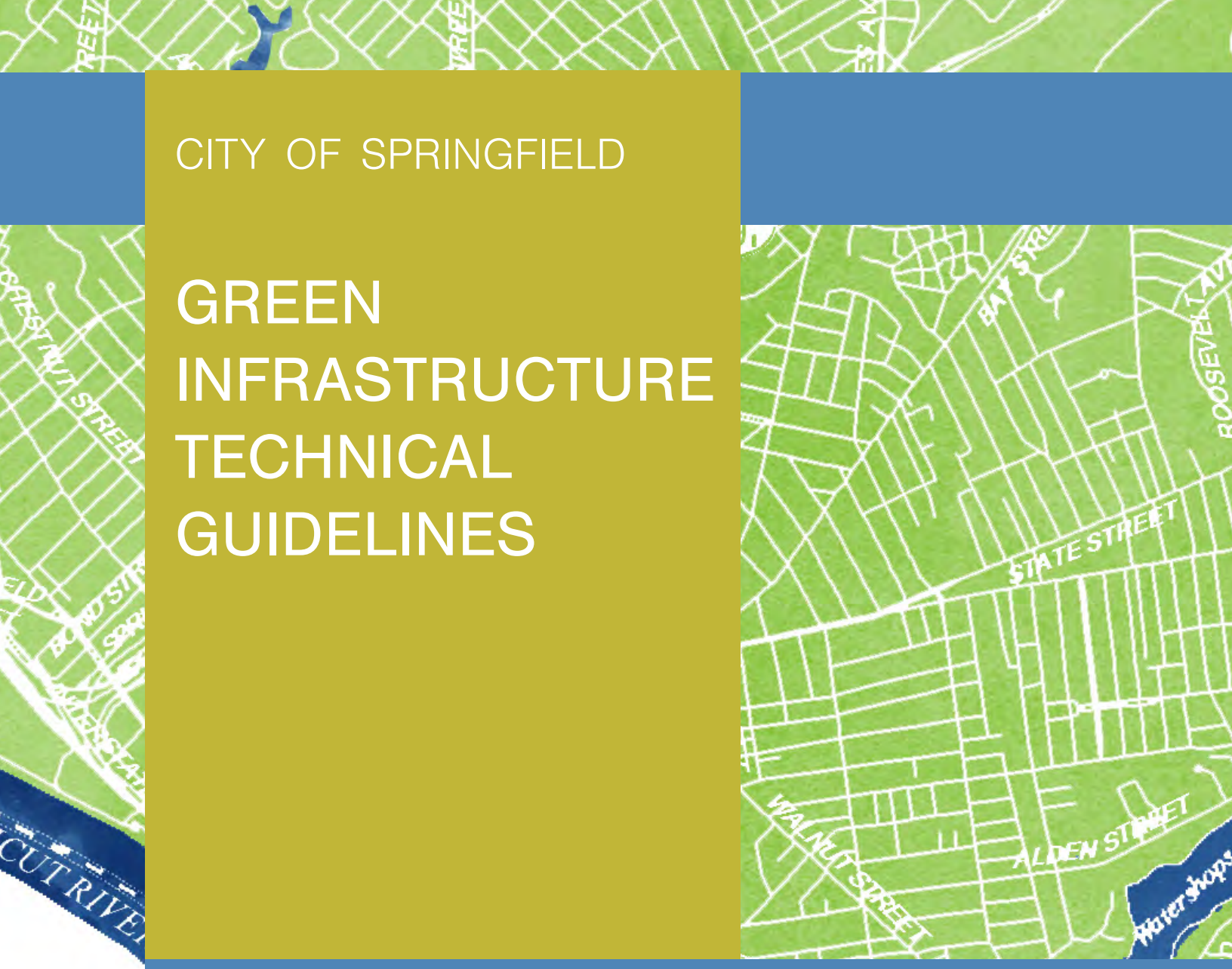
	GI/LID OPTION	OPERATIONS & MAINTENANCE PROTOCOLS (OMP)	INSPECTIONS/MONITORING	REPAIRS/REPLACEMENT
NON-VEGETATED SYSTEMS	Dry Well with Pretreatment Perforated Pipe System with Pretreatment Soakaway with Pretreatment Soakaway with Pre-treatment & Underdrain Infiltration Trench Infiltration Trench with Pretreatment Infiltration Trench with Pretreatment & Underdrain Infiltration Chamber Infiltration Chamber with Pretreatment	**UI-OMP1** Description: Removal of litter and debris from contributing drainage area, inlets, pretreatment devices, and overflower outlets Frequency: Quarterly to bi-annually, as needed Equipment: Handwork Personnel: One to two individuals Hours: Area dependent **UI-OMP2** Description: Reseed bare soil in contributing areas (if applicable) Frequency: Bi-annually to annually, as needed Equipment: Handwork Personnel: One individual Hours: Area dependent **UI-OMP3** Description: Removal of accumulated sediment (inlets/outlets/control structure) Frequency: Bi-annually to annually, as needed Equipment: Handwork Personnel: One to two individuals Hours: Area dependent **UI-OMP4** Description: Removal of accumulated sediment (sub-drain) Frequency: Annually Equipment: Vacuum/JetVac Personnel: One to two individuals Hours: System dependent **UI-OMP5** Description: Removal of oil and grease from pretreatment device (if applicable) Frequency: As needed Equipment: Vacuum Truck Personnel: One individual Hours: System dependent	**KEY AREAS OF CONCERN/INSPECTION FREQUENCY:** • Contributing drainage area condition (bi-annually) • Inlet structural integrity/obstruction/erosion (annually) • Inlet sediment accumulation (bi-annually) • Pretreatment sediment accumulation inspection (bi-annually) • Filter bed erosion/sediment accumulation/surface shrinking (monthly through warranty perioud, bi-annually beyond warranty) • Vegetation density/health/composition (bi-annually) • Monitoring well condition (annually) • Overflow outlet obstruction (monthly through warranty perioud, bi-annually beyond warranty) • Sub-drain obstruction (monthly through warranty perioud, bi-annually beyond warranty) **SPECIALIZED TRAINING:** • Inspection and cleanout procedures • Sediment removal procedures • Oil and grease removal and disposal training • Confined space entry training	**CLOGGING** • Remove accumulated sediment from when 2" depth or obstructing inflow into the system with hydrovac truck • Add pretreatment device to prevent debris from entering the facility • Snake or pressure vacuum to remove sub-drain obstructions • Replace missing or damaged subdrain caps **CONTROL STRUCTURE/PIPE CONNECTION LEAK** • Drain facility and repair/seal leak **NOTES** • Prohibit storage of soil, compost, sand, salt, or unwashed granular in contributing drainage area and inlets.

	GI/LID OPTION	OPERATIONS & MAINTENANCE PROTOCOLS (OMP)	INSPECTIONS/MONITORING	REPAIRS/REPLACEMENT
NON-VEGETATED SYSTEMS	Permeable Paving - Pervious Concrete Permeable Paving with underdrain - Pervious Concrete Permeable Paving with underdrain & Impermeable Liner - Pervious Concrete Permeable Paving - Porous Asphalt Permeable Paving with underdrain - Porous Asphalt Permeable Paving with underdrain & Impermeable Liner - Porous Asphalt Permeable Paving - Interlocking Precast Concrete Pavers Permeable Paving with underdrain - Interlocking Precast Concrete Pavers Permeable Paving with underdrain & Impermeable Liner - Interlocking Precast Concrete Pavers Permeable Paving - Pervious Flexible Rubber Paving	**PP_OMP1** Description: Removal of litter and debris Frequency: Quarterly to bi-annually, as needed Equipment: Handwork Personnel: One to two individuals Hours: Area dependent **PP_OMP2** Description: Removal of accumulated surface sediment Frequency: Bi-annually to annually Equipment: High efficiency regenerative air or pure vacuum sweeper Personnel: One individual Hours: Area dependent **PP_OMP3** Description: Replace/top-up joint material (if applicable) Frequency: Bi-annually Equipment: Handwork Personnel: One individual Hours: Area dependent **PP_OMP4** Description: Repaint parking space divisions (if applicable) Frequency: Every three years as necessary Equipment: Road marking machine Personnel: Two individuals Hours: Area dependent **PP_OMP5** Description: Flush sub-drain (if applicable) Frequency: Annually Equipment: Water truck Personnel: One individual Hours: System dependent **PP_OMP6** Description: Snow removal Frequency: As required Equipment: Snow plow (to be raised 0.25" above surface) Personnel: As required Hours: Areas dependent	**KEY AREAS OF CONCERN/INSPECTION FREQUENCY:** • Contributing drainage area condition (bi-annually) • Standing water (bi-annually) • Garbage (quarterly) • Pavement surface condition/sediment accumulation (annually) • Monitoring well condition (annually) • Subdrain/overflow obstruction (annually) • Control structure condition/sediment accumulation (annually) • Inspection and maintenance log • Quantitatve flow monitoring **SPECIALIZED TRAINING** • Sediment removal procedures • Road marking procedures • Snow plowing procedure for Permeable Paving	**CRACKED/MISSING PAVEMENT** • Fill with materials consistent with original (if applicable) • For large potholes, cut and replace surface layer • Replace or reset unit pavers (if applicable) **SURFACE PONDING** • Sweep/vacuum thoroughly • Pressure wash or wire brush may also be required for heavily clogged areas **SUBDRAIN OBSTRUCTION** • Snake or pressure vacuum for removal as required **NOTE** • Prohibit access by construction vehicles • Prohibit storage of snow, soil, compost, sand, salt, or unwashed granular • Adjace landscape areas must be covered with vegetation with no soil runoff possibility • Minimize application of de-icers.

	GI/LID OPTION	OPERATIONS & MAINTENANCE PROTOCOLS (OMP)	INSPECTIONS/MONITORING	REPAIRS/REPLACEMENT
NON-VEGETATED SYSTEMS	Rainwater Cistern with Pre-treatment	**RC_OMP1** Description: Removal of litter and debris and sediment from contributing drainage area, inlets, pretreatment devices and overflow outlets Frequency: Quarterly to bi-annually Equipment: Visual/handwork, snake or pressure vacuum Personnel: One to two individuals Hours: System dependent **RC_OMP2** Description: Prune trees in contributing areas Frequency: Annually Equipment: Handwork/chainsaw Personnel: One to two individuals Hours: Area dependent **RC_OMP3** Description: Removal of accumulated sediment in cistern Frequency: Annually Equipment: Pressure washer and vacuum/JetVac Personnel: One to two individuals Hours: System dependent	**KEY AREAS OF CONCERN/INSPECTION FREQUENCY:** • Contributing drainage area condition (bi-annually) • Inlet structural integrity/obstruction/erosion (annually) • Inlet sediment accumulation (bi-annually) • Pretreatment sediment accumulation inspection (bi-annually) • Overflow outlet obstruction (annually) • Control structure condition (annually) • Cistern structural integrity/sediment accumulation (annually or as required) • Cistern water quality monitoring (turbidity, discoloration) • Cistern pump testing • Inspection and maintenance log **SPECIALIZED TRAINING** • Sediment removal procedure	**INLET PIPE DAMAGE/DISPLACEMENT** • Repair or replace **CISTERN CRACK OR LEAK** • Repair in accordance with manufacturers/vendor, licensed plumber, or electrician. **OUTLET OBSTRUCTION** • Snake or vacuum.

CITY OF SPRINGFIELD

GREEN INFRASTRUCTURE TECHNICAL GUIDELINES



F APPENDIX F: PAVING SPECIFICATIONS FOR THE CITY OF SPRINGFIELD

ITEM XXX.X CLEANING AND SEALING CRACKS FOOT

A. DESCRIPTION

The work covered under this item shall consist of performing all operations and furnishing all materials, labor, and equipment necessary for preparing, cleaning, drying, and sealing cracks in the existing pavement, and vegetation removal and sterilization of cracks where necessary. All materials and equipment shall be approved by the Engineer prior to work commencing.

B. MATERIALS:

1. Asphalt: The asphalt material shall conform to the following requirements:

PERFORMANCE GRADE BINDER: PG 58-28 (formerly AC-10), PG 64-22, or PG 64-28 (formerly AC-20) with a penetration of 75-100. The penetration shall be conducted in accordance with AASHTO T49.

The Asphalt Binder shall be a Performance Graded Asphalt Binder (PG) which meets the specification requirements of AASHTO Provisional Standard MP1 and AASHTO PP-6. Acceptance of the PG will be in accordance with AASHTO PP26-96 (June 1996) “Standard Practice For Certifying Suppliers of Performance Graded Asphalt Binders”. PG shall be provided by an Approved Supplier (AS) under the Approved Supplier Certification (ASC) system.

The Contractor shall furnish vendor's certified test reports for each load of asphalt binder material shipped to the project. The vendor's certified test report for the asphalt binder material can be used for acceptance or tested independently by the Engineer.

The blending at the project site of PG binders from different suppliers is strictly prohibited. Contractors who blend PG binders will be reclassified as a supplier and required to certify the binder in accordance with AASHTO PP-26.

A copy of the Material Certificate shall be provided in accordance with the frequency requirements established in the latest version of AASHTO MP-1, and shall include the following:

a. Flash point
b. Rotational viscosity at 135°C and 165°C
c. Specific gravity at 25°C
d. Original G*/sinδ and phase angle at test temperature
e. RTFO percent mass loss
f. RTFO - G*/sinδ and phase angle at test temperature
g. PAV Residue - G*(sinδ) and phase angle at test temperature
h. Creep stiffness and m-value at test temperature
i. Direct tension results (when equipment available)
j. Strain sweep in accordance with AASHTO TP-5 (optional)
k. Physical hardening after 24 hours in accordance with AASHTO TP-1 (optional)

2. Fiber Reinforced Asphalt Cement: The sealing compound may be a liquid asphalt material, conforming to the PG requirements above, which is reinforced with a polyester or polypropylene fiber conforming to the following properties:

(a) Fibers: Polyester fiber

Concentration – 5% by weight to asphalt
Length - 1/4 inch (6.25mm)
Diameter - 0.0008 inch ± 0.0001 inch
Specific Gravity - 1.32 to 1.40
Melt Temperature - 480 F minimum
Ignition Temperature - 1000 F minimum
Tensile Strength - 75,000 psi ± 5,000 psi
Break Elongation - 33% ± 9% (Fully drawn)

This fiber is a polyester which is the polymerized product of crude oil components. These fibers will not shrink, distort, or lose their strength at temperatures below 480 deg. F. The fibers are produced by continuous melt-spinning.

Composition: 5% minimum by weight of the asphalt material.

(b) Fibers: Polypropylene drawn fiber

Concentration – 7% by weight to asphalt
Length – 10mm
Denier – 15 dpf
Color – natural
Crimp – none
Tensile Strength – 40,000 psi, minimum
Tenacity – 4 gpd

Composition: 7% minimum by weight of the asphalt material.

3. Hot-Poured Elastomeric (SS-S-164): The sealing compound may be a hot-poured rubberized joint-sealing material, which will form a resilient and adhesive compound conforming to the following:

(a) Pour Point - minimum of 20 deg. F. lower than the safe-heating temperature;

(b) Penetration (AASHTO M301)- @ 77 deg. F./load 150 grams./5 sec. shall not exceed 0.90 cm.;

(c) Resilience (AASHTO M301) - @ 77 deg. F, minimum recovery of 60%;

(d) Flow (AASHTO M301) - @ 140 deg. F. shall not exceed 0.3 cm.;

(e) Bond (AASHTO M301)- @ -20 deg. F. for three cycles, at any time during the test, there shall not develop a crack, separation, or other opening which is at any point over 1/4" deep, in the sealer or between the sealer and mortar block;

The sealant shall be composed of a mixture of materials that will form a resilient and adhesive compound capable of effectively sealing cracks in asphaltic pavements against the infiltration of moisture and foreign material throughout repeated cycles of expansion and contraction with temperature changes, and that will not, at ambient temperatures, flow from the crack or be picked up by vehicle tire. The material shall be capable of being brought to a uniform pouring consistency suitable for completely filling the cracks without inclusion of large air holes or discontinuities and without damage to the material. It shall remain relatively unchanged in application characteristics for at least six hours at the recommended pouring temperature in the field.

4. Cover Materials: Cover Materials to eliminate tracking from traffic shall be stone screenings, crusher dust, slag, toilet paper, or other material found to prevent adhesion of the crack sealer to tires or pedestrians.

C. EQUIPMENT:

Equipment used in the performance of the work required by this section of the specification shall be subject to the approval of the Engineer and maintained in a satisfactory working condition at all times.

(a) Equipment for cleaning, heating, drying cracks: Equipment for cleaning, heating and drying cracks shall be a hot air lance or approved equal. The hot air lance shall have a minimum heat capacity of 2500°F (1370°C) and a minimum blast velocity of 2001 ft/s (610 m/s).

(b) Air Compressor: Air compressors for cleaning cracks shall be portable and capable of furnishing a blast pressure not less than 100 lbs per square inch (690 kPa) and a minimum blast flow of 2.5 cubic feet of air per second at the nozzle. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water.

(c) Self-Propelled Vacuum Sweeper: Small self-propelled vacuum sweeper designed especially for use in cleaning highway and airfield pavements shall be used to remove debris, dirt, and dust from cleaned and dried cracks.

(d) Hand Tools: Hand tools shall consist of brooms, shovels, metal bars with chisel shaped ends, and any other tools which may be satisfactorily used to accomplish this work.

(e) Melting Kettle: The unit used to melt the joint sealing compound shall be a double boiler, indirect fired type. The space between the inner and outer shells shall be filled with a suitable heat transfer oil or substitute having a flash point not less than 530 deg. F. The kettle shall be equipped with separate automatic temperature controls for the oil and melting chamber. The kettle shall have accurately calibrated material and heating oil temperature gauges. The kettle shall be equipped with a satisfactory means of agitating the crack sealer at all times. This may be accomplished by continuous stirring with mechanically operated paddles and/or by a continuous circulating gear pump attached to the heating unit. The kettle must be equipped with thermostatic control calibrated between 200 deg. F. and 550 deg. F.

For fiberized sealants, the use of kettles with heavy duty application pumps, large hoses, and full-sweep agitation equipment is required. A 20 HP (15 kW) engine with a 2” (50mm) recirculating pump and discharge line is recommended.

(f) Applicator: The application hose shall be insulated and the applicator wand shall meet or exceed the kettle manufacturer’s specifications.

(g) Routers:
Vertical-Spindle Router – equipped with sharp carbide tipped or diamond router bits.
Rotary-Impact Router – equipped with sharp carbide tipped router bits.

(h) Wirebrushing: Mechanical, power-driven wirebrushes shall be used in conjunction with some form of compressed air. The brush attachment shall contain bristles flexible enough to allow penetration into the crack channel, yet rigid enough to remove dirt and debris.

(i) Finishing Tools: Squeegee - heavy-duty, industrial rubber U- or V- shaped squeegee. Prior to installation the Contractor shall demonstrate to the Engineer, by the test strip, that the desired configuration is achieved with the finishing tool.

D. SAMPLING AND TESTING:

The Engineer shall be notified in writing of the proposed sources of crack sealants at least 60 days prior to the date the materials will be required at the project site. The contractor shall supply to the Engineer

copies of all test reports for each load of sealant prior to use of the materials. Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the materials and are in conflict with these specifications, printed copies of these recommendations shall be furnished to the Engineer prior to use on the project. Installation of the material shall not be allowed until the recommendations are received and reviewed by the Engineer.

Crack sealants may be tested for conformance to the referenced applicable material specifications.The Contractor shall furnish samples of materials, in sufficient quantity to be tested, upon request, at no additional cost. If a sample fails to meet specification requirements, the material represented by the sample shall be removed and replace at no additional cost.

E. CONSTRUCTION DETAILS:

Prior to applying the crack sealant material, the cracks are to be routed and cleaned of all foreign material. All cracks shall be thoroughly dried and heated using a hot air lance or approved equal.

In areas where hot poured joint material was previously used and where bond has broken, that area shall be cleaned prior to sealing. After the cleaning of the cracks, all material removed from the cracks shall be removed from pavement surface by means of power sweepers, hand brooms or air brooms, to the satisfaction of the Engineer. No crack sealing material shall be applied in wet cracks or where frost, snow or ice is present nor when the ambient temperature is below 40 deg. F. All cracks are to be dried prior to material application.

The type of crack sealant material, crack preparation, and placement procedure to utilize will be determined by the maintenance or rehabilitation needs of the pavement and the type of cracks. Pavements that are to receive an overlay in conjunction with the cracking sealing operation can be sealed with fiber reinforced crack sealant. Rubberized crack sealant can be utilized on pavements receiving an overlay provided a leveling course is utilized prior to the overlay unless the Contractor warrants that no deformations will result in the subsequent overlay. Rubberized crack sealant or fiberized crack sealant can be utilized on roadways receiving routine or preventative maintenance.

Preparation of Cracks:
The cracks shall be routed in a manner that will widen the cracks without deepening them. The cracks shall be routed with a vertical spindle router to a width of 0.5” to 0.75” (12mm to 19mm) and a depth of 0.5” to 0.75” (12mm to 19mm). Every effort shall be made to follow the cracks while cutting and centering the cut over the crack. Secondary cracks spaced farther than 12 inches (300mm) from a primary crack shall be cut. Secondary cracks closer than 12 inches (300m) to the primary crack shall be cleaned and sealed only. The percentage of missed cracks shall be less than 5%. If the percentage of missed cracks exceeds 5%, the routing operation shall be shut down and adjustments to the procedures, personnel, and/or equipment corrected.

The cracks shall be thoroughly cleaned, dried, and heated prior to application of the crack sealant. The hot air lance shall be utilized to remove dirt, debris, vegetation, and moisture, just prior to installation of the crack sealant. Loosened fragments encountered while cleaning shall be removed. The hot air lance shall provide a continuous stream of hot, high pressure air with no flame at the exit nozzle. The hot airblasting shall be conducted in two steps. The first pass shall be made along the crack in a steady fashion and should clean and heat but not burn the crack sidewalls. The hot air lance shall be held approximately 2” (50mm) above the crack channel. Proper heating is manifested by a slightly darkened color. The pavement shall not be burned, which is apparent by a black color and gritty texture. The second pass of the hot air lance shall completely remove all debris and particles. The crack sealant shall follow the second pass of the hot air lance at a maximum distance of 5 minutes or 164 feet (50 meters).

A. Fiber-Reinforced Crack Sealing: The pre-packaged fibers shall be supplied in polyethylene bags which will dissolve when introduced into the hot (above 275 deg. F) asphalt binder. The melting

kettle shall mix and agitate the compounds until a homogenous mixture is achieved. Prior to applying the sealant, it should be heated to a temperature recommended by the manufacturer. Following appropriate cleaning, the sealant should be applied to a slightly overfilled condition and then leveled with a squeegee. All applied sealant shall be "warm-rolled" or "squeegeed" in place such that the sealant forms a 3” to 5” (75mm to 125mm) band with a thickness of 0.06” to 0.10” (1.5mm to 2.5mm) over the crack. Any sealant which is greater than 3/16" below the pavement surface when cooled shall be resealed to the satisfaction of the Agency or designated agent. Any sealant sunk into the crack or in insufficient quantity from the pavement surface shall be re-sealed such that its surface is not greater than 1/16" to 1/8” above the pavement surface. The finished band width shall not exceed 6”.
For pavements receiving an overlay the cracks shall be filled flush with the pavement surface such that the membrane is well bonded to the pavement

B. Hot-Poured Elastomeric Crack Sealing: The sealant must be melted in a jacketed double boiler type melting unit equipped with both agitation and recirculation systems. The unit must be capable of safely heating the sealant to 410 deg. F. Prior to applying the sealant, it should be heated to a temperature recommended by the manufacturer. Following appropriate cleaning, the sealant should be applied to a slightly overfilled condition and then leveled with a squeegee in a 3" to 5" wide (75mm to 25mm) band across the crack with a thickness of 0.06” to 0.10” (1.5mm to 2.5mm). Any sealant sunk into the crack or in insufficient quantity from the pavement surface shall be re-sealed such that its surface is not greater than 1/16" to 1/8” above the pavement surface. The finished band width shall not exceed 6”.

The crack sealant materials shall not be overheated, subject to prolonged heating, or reheated beyond the manufacturers’ recommendations. Carbon buildup should be cleaned off the melting vat walls before the kettle is used. The heating oil temperature should be kept no more than 82°F to 108°F above the safe heating temperature of the material, as stated on the manufacturer’s recommendations. Continuous recirculation of the material through the wand into the melting vat during idle periods is required.

Application:
Joint sealing material shall be heated and applied at the temperature specified by the manufacturer and approved by the Engineer. The minimum application temperature shall be 320 degrees F. The crack sealant material shall be applied with the nozzle in the crack channel, so that the channel is filled from the bottom up and air is not trapped beneath the material. The material shall be applied in a continuous motion to the desired level. Material must be reapplied to crack segments where the material has sunk into the crack or an insufficient amount was furnished in the previous pass.

Following the filling operation, the crack sealant shall be leveled with a squeegee. The squeegee shall follow closely behind the wand and be centered over the crack channel. The squeegee shall be kept free of buildup material by regular scraping or use of a propane torch.

The crack sealant shall be installed and finished such that it conforms to the dimensions stated in preparation of cracks. Where traffic requires immediate use of the roadway, an approved covering material shall be utilized. The covering material shall be applied immediately after finishing and in a thin layer fully covering the exposed treatment material.

Spilled or excess material shall be removed from the pavement surface.

Asphalt Kettle Cleanout:

Prior to work commencing, the Contractor shall provide written details on the clean out operations to the Engineer. At the end of each day’s work, the applicator lines must be purged of sealant material. Non-heatable materials must be removed from the melting vat and discharged into containers for disposal. Reheatable materials may remain in the melting vat provided the quantity is minimized as much as

possible. If flushing solvents are utilized, the operator must ensure that they do not contaminate the sealant or filler materials.

F. PERFORMANCE:

Prior to work commencing, the Contractor must submit to the Engineer a list of six (6) jobs, which he/she has successfully completed, giving the name and address of these projects so they can be investigated by the Engineer.

The Contractor shall successfully perform a 200-foot test strip in the field prior to commencing work.

The Engineer reserves the right to reject the contract award if it is deemed in the best interest of the agency.

G. MEASUREMENT AND PAYMENT:

The "Cleaning and Sealing of Cracks" shall be measured by the actual number of gallons acceptably applied to the pavement.

The Engineer reserves the right to impose penalties or reject material not conforming to the dimensional criteria established by these specifications.

"Cleaning and Sealing Cracks" will be paid for at the contract unit price bid per gallon or linear feet, complete and accepted, including all materials, labor, equipment, all cleaning, drying, sealing and incidentals necessary to complete the work as specified.

PAY ITEM	DESCRIPTION	PAY UNIT
XXX.X	CLEANING AND SEALING CRACKS	GAL

ITEM XXX.X COLD IN-PLACE RECYCLING WITH FOAMED ASPHALT SQUARE YARD

DESCRIPTION

This item specifies a process for the Col-In-Place Recyling (CIR) of an HMA roadway. The work requires full and/or partial depth milling of the existing HMA pavement to the width and depth specified on the plans, blending the processed material with foamed asphalt stabilizing agent, Portland cement, water and other additives as necessary and required by the mix design, placement, compaction and fog sealing of this mixture in accordance with the plans and specifiactions.

A. ***PAVEMENT SAMPLING***

Core sampling and mix design are required to determine a road(s) viability for the Cold In-place Recycling process. Core sampling may be performed prior to bidding and must be performed prior to the mixture design process.

1. Cores shall be obtained using a pattern that results in a representative sample of the pavement to be recycled including at or near lane lines, within and between wheel paths, at the pavement edge, and within shoulders, if shoulders are to be recycled. The roadway shall be sampled in accordance with staggered or offset sampling (as illustrated in Diagram 1a) or crossroad sampling with no offset (as illustrated in Diagram 1b).

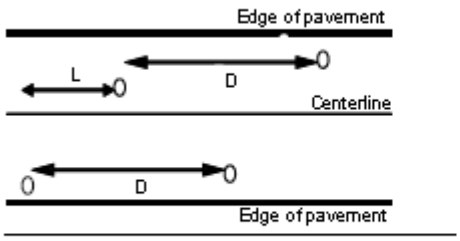


Diagram 1a – Staggered (offset) sampling.

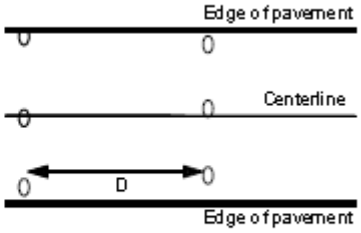


Diagram 1b – Crossroad sampling.

2. Core samples shall be obtained to the full depth of the asphalt layers including any penetrated stone macadam or Portland cement concrete subbase layers down to the top of the granular subbase/subgrade. If a core breaks off prior to penetrating the underlying materials, coring shall continue to the bottom of the pavement for thickness-measurement purposes. On retrieval, each core shall be measured to the nearest 1/8th inch, and then placed in a separate container and labeled. A coring log summarizing the date, station, offset, and core thickness shall be recorded for each core location and provided to the mix design laboratory.

   D – 1 mile maximum
   L – 0.5 mile maximum

   a) At least 15% of the cores shall be in the shoulder, if the shoulder is to be recycled.

   b) At least 25% of the cores shall be on or within 3 feet of the centerline.

3. Sampling Interval – The sampling interval and frequency shall be based on the class of roadway.

   Arterial and Industrial Streets

   D – 2,000 feet maximum
   L – 1,000 feet maximum

a) At least 25% of the cores shall be in the shoulder, if it to be recycled, or within 3 feet of gutter.

b) At least 25% of the cores shall be on or within 3 feet of centerline.

Residential Streets

1. For streets less than 250 feet long, one core when grouped with other streets to obtain the quantity of material required for mix design.

2. For streets 250 feet to 500 feet long, two cores when grouped with other streets to obtain the quantity of material required for mix design (one within 3 feet of gutter, and the other within 3 feet of centerline).

3. For streets over 500 feet long, three cores when grouped with other streets to obtain the quantity of material required for mix design (one within 3 feet of gutter, one within 3 feet of centerline, and the third between the two).

4. **Filling Sample Holes**

Each sample hole shall be filled in accordance with the procedures described below. After sampling and filling the holes, the roadway shall be cleaned of all loose debris.

A high quality cold patch material shall be used to fill core or milling holes. The cold mix shall be compacted flush with a tamping rod, Marshall hammer, or via reciprocating tamper. Approximately the same amount of cold patch (350lbs) will be required to fill the holes, as is required for each mix design.

B. ***MIX DESIGN***

A mixture design is required for every roadway as described herein. Once pavement sampling has occurred as described in Section A, the Contractor shall utilize an AASHTO accredited laboratory to perform the mixture design.

Develop and submit a material sampling plan to the Engineer for review and approval prior to obtaining cored samples of the existing pavement.

Obtain cored samples for the project mix design. Three hundred and fifty pounds (350 lbs.) of representative material to be recycled is required for each mix design.

Develop and submit a Job Mix Formula (JMF) for approval prior to the start of the CIR operation. Develop the JMF conforming to the requirements of Table 2B below.

Table 1 – CIR Minimum Mix Design Requirements for Stabilizing Agents

Test Method	Specification	Criteria
Gradation of RAP (Sieve Analysis of Aggregates)	ASTM C117 and C136	1 ½" sieve-100% passing 1" sieve-95 to 100% passing
Bulk Specific Gravity of Compacted Samples	ASTM D6752 or D2726	Report Only; Ndes=30
Maximum Theoretical Specific Gravity	ASTM D2041	Report Only

Test Method	Specification	Criteria
% Air Voids		Report Only
Tensile Strength (Resistance of Compacted Mixture to Moisture): Dry, psi	ASTM D4867 Part 8.11.1, 25ºC, psi	Minimum 45
Wet (conditioned), psi	Conditioned ITS, ASTM D 4867, psi	Minimum 30
Ratio (TSR), %		Minimum 70%
RAP Coating Test	AASHTO T 59	Minimum Good
Minimum Virgin Asphalt Content		1.5%
Foamed Asphalt Expansion Ratio		Minimum 8.0 Times
Foamed Asphalt Half-life		Minimum 6.0 Seconds

The lab equipment used to simulate the asphalt foaming process and RAP stabilization shall be substantially similar to the contractor's recycling equipment to be used on the project.

The mix design JMF shall be the baseline measure for the rate of stabilizing agent application and water blended with the RAP to construct the CIR mixture. The mix design shall indicate the allowable tolerance for field adjustments for the stabilizing agent and/or water so as not to jeopardize the performance of the mix in regard to Table 1, but allow the contractor to adjust the mix in response to field conditions in consultation with the Engineer.

Provide the mix design report with the following minimum information:

a) Gradation of RAP

b) Density, maximum specific gravity, air void content, indirect dry tensile strength, indirect wet (conditioned) tensile strength, and tensile strength ratio at each recycling agent content iteration (minimum of 4, inclusive of recommended moisture and stabilizing contents) and at the recommended moisture and stabilizing agent contents

c) Recommended water content range as a percentage of dry RAP

d) Optimum stabilizing agent content as a percentage of dry RAP

e) Stabilizing agent designation, PG grading of asphalt binder, if applicable, supplier name and location, and certificates of compliance

f) Application means of recycling agent

g) Allowable tolerances for field adjustments for stabilizing agent and/or water

h) Portland Cement, if needed

C. ***MATERIALS***

1. Reclaimed Asphalt Pavement (RAP) Material

   Mill the RAP from the existing roadway and process it in-place.

   a. The RAP shall be free of contamination of concrete, silt, clay, or other deleterious materials.

   b. Remove rubberized crack filler, pavement markers, loop wires, fabric, or other materials as observed from the roadway during the recycling process. Appropriately size and homogenously blend any residual materials with the RAP.

   c. The milled and processed material shall conform to the following gradation prior to addition of the stabilizing agent:

Sieve Size	**Percent Passing**
1 ½"	100
1"	95 to 100

2. Stabilizing Agent

   The asphalt stabilizing agent shall be Foamed Asphalt.

3. Foamed Asphalt

   a. Provide asphalt binder performance grade for foamed asphalt of PG 64-22 or PG 64-28.

   b. Sufficiently heat asphalt binder to meet the mix design expansion and half-life criteria; not to exceed 375° F.

   c. Asphalt binder shall produce asphalt foam with a minimum expansion ratio of 8 and half-life of no less than 6 seconds.

4. Strengthening Agent

   If required by the mix design, the strengthening agent shall be Portland Cement.

5. Water

   Provide water added to the RAP for foaming asphalt. Water may be added to the RAP at the milling head and/or in a mixing chamber.

6. Asphalt Pricing and Price Adjustments

   a. Contractor's bid prices below shall be based upon the MassDOT Liquid Asphalt period price posted exactly two (2) weeks prior to the due date for receipt of bids ("Bid Index"). If the posted MassDOT Liquid Asphalt period price in place when the work is performed differs by more than 5% from the Bid Index, then Contractor's invoices shall include price adjustments for the asphaltic materials based on the actual gallons incorporated into the work.

   b. The owner agency reserves itself the option to extend the use, terms, conditions and prices of this bid for an additional three (3) years after the first year in which the contract is awarded. Such extension will be subject to the Owner reviewing and approving the Contractor's annual request for a price adjustment based on and limited to the prior year's actual rate of inflation. If such price adjustment cannot be mutually agreed upon between the Owner and Contractor, Owner may choose to re-bid the work in lieu of extending this contract.

D. ***QUALITY ASSURANCE***

1. Personnel

   Provide a qualified and certified technician for performance of field density and field moisture content testing.

2. Equipment

   a. Furnish the necessary equipment and supplies for performing quality control testing. Ensure that all testing equipment conforms to the equipment specifications applicable to the required testing methods. The Engineer may inspect the measuring and testing devices to confirm both calibration and condition. Calibrate all testing equipment according to the applicable AASHTO and/or ASTM specifications and maintain a calibration record at the laboratory.

   b. Furnish a nuclear gauge and ensure that the gauge manufacturer or an approved calibration service calibrates the gauge the same calendar year it is used on the project. Retain a copy of the calibration certificate with the gauge.

   c. Conform to ASTM D 6938 for density testing and gauge monitoring methods.

3. Quality Control (QC) Testing

   a. Roadway production lots will be defined as 4000 lane-feet. Each roadway production lot will consist of two 2000 lane-feet sub lots.

   b. Take roadway samples at a minimum frequency of 1 per lot of production.

   c. For each roadway sample, report the gradation of material, determined in accordance to AASTHO T27, for the Number 4 (4.75mm) sieve and larger.

   d. Report stabilizing agent foaming properties, if applicable, (i.e. half-life and expansion ratio) at a minimum frequency of 1 per lot of production.

   e. Conduct and report density testing at a minimum frequency of 3 random tests per sub lot.

   f. Conduct and report mill depth checks at a minimum frequency of 1 per sub lot.

   g. Report stabilizing agent temperature and application rate at a minimum frequency of 1 per sub lot.

   h. Provide a Daily Inspection Report to the Engineer summarizing the: daily beginning and ending stations, applicable mix design, sub lot test (mill depth check, density test, stabilizing agent temperature and application rate) locations and values, lot roadway sample locations, and any adjustments to the application rate of the stabilizing agent or water.

   i. If stabilizing agent adjustments exceed the allowable limits defined in the mix design, or reduce the stabilizing agent application rate below the 1.5% mix design minimum specified in Table 2B, based on a single test or meter adjustment, re-evaluate the entire process. Obtain approval by the Engineer before resuming production.

4. Acceptance Testing

   a. The owner may conduct acceptance testing to validate the quality of the product. The owner will provide the contractor with a listing of all acceptance testing personnel for the project, and provide test results to the contractor.

   b. If the owner identifies a deficiency, and after further investigation confirms it, the contractor shall correct that deficiency. If the contractor does not correct or fails to cooperate in resolving

identified deficiencies, the Engineer may suspend placement until action is taken.

E. ***CONSTRUCTION***

1. General

   a. Unless the contract provides otherwise, keep the road open to traffic during construction.

   b. Perform CIR operations only between the dates of April 15 and October 15 when the air temperature approximately 3 feet above grade, in shade, and away from artificial heat sources is above 50°F, and when the nighttime ambient air temperature is above 45°F the night prior and following, unless approved otherwise by the Engineer.

   c. Do not perform CIR operations during inclement weather such as heavy rain that will not allow proper mixing, placing, and/or compacting of the mixture.

   d. Complete CIR operations and recycled pavement curing to allow adequate time for placement of the finish wearing course prior to the onset of winter. The finish wearing course should be applied to protect the CIR no later than 14 days after the CIR process begins.

2. Equipment

   a. Equipment used for CIR shall be subject to approval by the Engineer.

   b. Tankers supplying hot stabilizing agent components shall be equipped to constantly monitor temperature within the tank.

   c. Portland cement bulk spreader must be fully automated and capable of achieving the application rate specified in the mix design. Portland cement spreader shall also be equipped with a water misting spray bar to reduce the amount of airborne cement dust from the spreading operation.

   d. Milling Machine

      1) Utilize milling units not inclusive of pre-mill/wedge-cut milling units capable of milling the existing pavement full lane width (12'- 6" minimum) to the depth shown on the plans, specified in the contract or directed by the Engineer, in a single pass.

      2) Utilize units equipped with automatic depth control that maintain constant cutting depth and width, uniform grade, and uniform slope.

      3) For processes not incorporating additional screening, sizing, or crushing, utilize a milling unit capable of producing RAP sized as specified in 3.A.3.

      4) Use of a heating device to soften the pavement is not permitted.

   e. Mixing Unit

      1) Processed RAP shall be mixed with the stabilizing agent and water in a mixing unit which shall be the milling machine cutter housing, a separate mixing chamber, or a pug mill.

      2) The asphalt stabilizing agent shall be applied uniformly at the predetermined application rate using a computer controlled additive system. The system shall utilize a mass flow meter capable of continuously monitoring output as well as providing an end-of-day total of liquid utilized. Monitor the metering of the stabilizing agent through a calibrated pump providing a continuous readout of quantities.

3) The additive system shall contain separate pumping systems for adding stabilizing agent and water. Each system shall have an inspection or test nozzle for stabilizing agent and/or water sampling.

4) The system shall be capable of producing a uniformly mixed, homogenous recycled pavement mixture.

f. Paving Equipment

1) The placement and shaping of the recycled pavement mixture shall be completed using a self-propelled paver, with a minimum 10' and maximum 20' screed width.

2) The screed shall not be heated when paving the recycled mix.

3) The material shall be transferred directly into the paver hopper from the recycling equipment or with a pick-up device. When a pick-up device is used, the entire windrow shall be removed from the milled surface and transferred to the paver hopper.

g. Compaction Equipment

1) Compaction equipment shall be a minimum of 10 tons, self-propelled and include both dual smooth drum vibratory and pneumatic rollers.

2) The number and types of rollers shall be as necessary to achieve the specified compaction and surface smoothness required for the finish wearing course.

3. Preparation

a. Inspect the pavement surface for any areas of failing subgrade. If needed, repair areas will be saw cut, and all inferior material shall be taken out. Removed materials shall be replaced with clean granular material compacted in lifts not to exceed 6" in thickness, up to within 6" of the road surface. The final 6", bringing the repair to road grade, shall be done with 19mm hot mix binder.

b. If pre-milling to remove material ahead of recycling is warranted, it will be paid under the "Pre-milling".

c. Where required, the existing roadway shoulders shall be bladed away from the asphaltic surface edge to minimize contamination of the CIR pavement and will be the responsibility of the City.

d. Saw cutting cost shall be incidental to repairs. Gravel to be priced by the cubic yard, and hot mix asphalt to be priced by the ton.

4. Processing and Placement of Recycled Pavement Mixture

a. Mill the existing pavement to the required depth and width indicated on the plans.

b. Blend the RAP material with the mix design specified proportions of stabilizing agent and water; produce a uniform and homogeneous recycled mixture.

c. Spread the recycled mixture to the grade, elevations, and slopes specified on the plans; avoiding tearing or scarring of the recycled pavement surface.

d. Ensure proper material transfer, handling, and spreading to prevent particle segregation.

e. Overlap longitudinal joints between successive CIR operations a minimum of 3 inches. Overlap transverse joints between successive CIR operations a minimum of 2 feet. Control the addition of foamed asphalt to the CIR in overlap areas in order to avoid excessive localized high asphalt content in the CIR layer.

5. Compaction - Control Strip Construction

   a. On the first day of production, construct a control strip to identify the target wet density for the CIR layer. Perform the control strip construction and density testing under the direct observation and/or assistance of the Engineer.

   b. Unless the Engineer approves otherwise, construct control strips to a minimum dimension of 500 feet long and one full lane width.

   c. Completed control strips may remain in-place to be incorporated into the final roadway cross-section.

   d. Construct additional control strips at a minimum, when:

   e. The CIR layer thickness changes in excess of 2.0 inches, or

   f. The percent of target density is less than 90% or exceeds 105.0%, and is outside the range of the 10 random measurements defining the control strip, on three consecutive sub lots.

   g. Construct control strips using equipment and methods representative of the operations to be used for constructing the CIR layer.

   h. After compacting the control strip with a minimum of 2 passes, mark and take density measurements at 3 random locations, at least 1½ feet from the edge of the CIR layer. Take subsequent density measurements at the same 3 locations.

   i. After each subsequent pass of compaction equipment over the entirety of the control strip, take density measurements at the 3 marked locations. Continue compacting and testing until the increase in density measurements is less than 2.0 lb/cubic feet, or the density measurements begin to decrease.

   j. Upon completion of control strip compaction, take 10 randomly located density measurements within the limits of the control strip, at least 1½ feet from the edge of the base. The final measurements recorded at the 3 locations under paragraph (f) of this section may be included as 3 of the 10 measurements. Average the 10 measurements to obtain the control strip target density.

6. Compaction Requirements

   Compact the CIR layer to a required minimum density of 95% of the target density.

7. Surface Requirements

   a. Test the pavement surface at regular intervals using a 10-foot straightedge or other Engineer-specified device.

   b. The Engineer may direct the repair of surface deviations greater than 1/4 inch between two surface contact points. Correct high points by reworking, rerolling, trimming, milling, or grinding. Minor depressions greater than 3/4 inch may be corrected by reworking, or have a tack coat applied and be filled with HMA immediately prior to placement of the surface treatment.

8. Maintaining the Work

   a. After compaction is complete, determine whether the CIR is sufficiently stable and cured adequately to open to traffic.

b. Apply a fog seal to minimize raveling and reduce water intrusion into the recycled pavement by the end of each CIR treatment day. Fog seal shall be a diluted CSS-1h emulsion (50% emulsion, 50% water), or approved equal.

c. After opening to traffic, and prior to placing a surface treatment, maintain the surface of the recycled pavement in a condition suitable for safe movement of traffic.

d. Repair any damage to the recycled pavement prior to placement of the wearing course at no additional cost to the owner.

9. Curing and Surfacing

a. Application of a surface treatment will not be allowed until the moisture content of the CIR layer is not more than 1.5%.

b. If the moisture content of the CIR layer does not reduce to 1.5%, the surface treatment may be applied after the change in moisture content is less than 0.10 percentage points for three consecutive calendar days

c. The finish wearing course should be applied as soon as curing is complete**,** generally not more than 14 days after the recycling process begins.

d. Immediately before the application of the finish wearing course, the wearing course contractor shall apply an asphalt emulsion tack coat at a minimum rate of 0.05 gal/SY.

e. Do not use a hot asphaltic cement tack coat.

F. ***MEASUREMENT AND PAYMENT***

Measurement and Payment for all items shall be as shown in Table 2.

Table 2

PAY ITEM	DESCRIPTION	PAY UNIT
Bid Item XXX.X	Pavement coring	Day
Bid Item XXX.X	CIR Mixture Design	Each
Bid Item XXX.X	Liquid Asphalt Stabilizing Agent	GAL
Bid Item XXX.X	Portland Cement Stabilizing Agent	TON
Bid Item XXX.X	Pave Processed RAP Ahead of Recycler	SY
Bid Item XXX.X	Cold In-place Recycling (CIR) (4” or less) Including Fog Seal	SY
Bid Item XXX.X	Cold In-place Recycling (CIR) (4.5” or greater) Including Fog Seal	SY
Bid Item XXX.X	Pavement Milling	SY
Bid Item XXX.X	Gravel Borrow for Base Repairs	CY
Bid Item XXX.X	HMA for Localized Repairs	Ton

1. The owner will measure the Cold In-place Recycling (CIR) bid item as acceptably completed by the square yard.
2. The owner will measure the Liquid Asphalt and Portland Cement Stabilizing Agents incorporated into the work by the gallon and by the ton, respectively, as metered through a calibrated pump, calibrated auger, or through delivered ticket quantity, acceptably completed.
3. Payment is full compensation for measured quantities as specified above; all material including mixing and milling water; equipment necessary for milling and sizing, mixing, paving, compacting the completed CIR and fog seal to maintain the completed CIR.
4. For roadways where owner elects to have contractor install additional RAP on top of the existing pavement ahead of the milling machine to thicken the recycled layer, owner shall furnish and deliver the screened and sized RAP (1" minus) to contractor's spreading equipment. RAP shall be delivered at a rate adequate not to slow down the subsequent recycling operation. Contractor shall be paid for spreading this additional RAP layer, by the SY, under the separate bid item. A sample of the RAP to be used will be supplied to the contractor to develop mix design.

G. ***METHOD OF AWARD***

1. To ensure contractor accountability, the Owner intends to award all items to a single contractor. Accordingly, contractors must bid on all items of work, and the low bidder will be the contractor whose total bid price is the lowest. The bid quantities are not guaranteed, and their primary purpose is for the determination of the low bidder.
2. To ensure the contractor's capabilities, the bidder shall provide with his bid evidence of his current State DOT prequalification status, for the categories of work contained herein. Bidder shall also submit with his bid documented experience of at least three (3) foamed asphalt stabilized CIR jobs including the street names and limits, year completed, owner agency name and contact information for verification purposes.

ITEM 8
PRE-MILLING PAVEMENT

1. Description

Work under this item shall be done in conjunction with the CIR. The work shall consist of removing, by cold-planer, asphalt pavement in designated areas. The milled material shall become the property of the owner to be disposed of or recycled.

2. Equipment

A. The cold-planer, and any other motorized vehicular equipment, shall be equipped with taillights, headlights, and necessary reflectors so that they can be operated in traffic with complete safety.

The cold-planing machine shall be adjustable as to crown and minimum depth of 1/8". The width of the cutting drum shall be a minimum of 51".

The equipment shall be capable of accurately and automatically establishing profile grade along each edge of the machine (within 1/8-inch, more or less) by referencing from the existing pavement by means of a ski or matching shoe controlling cross slope at a given rate.

The machine shall be capable of being operated at speeds from 18 to 40 feet per minute and designed so that the operator can, at all times, observe the operations without leaving his control area.

The equipment furnished by the contractor shall be in good repair and shall be maintained so as to produce a clean cut into the pavement at all times.

The machine shall be equipped with an integral loading and reclaiming means to immediately remove material being cut from the surface of the roadway and discharge the cuttings into a truck, all in one operation. All planing machinery shall be equipped with dust control devices to prevent any dust

produced in the cutting operation from escaping into the air, in compliance with EPA air quality standards. The equipment shall meet the standards set by the Air Quality Act for noise and pollution. This machine shall be equipped with a floating moldboard cutting device which is behind the mandrel, and such moldboard must have an infinitely variable down pressure from 0-300 PSI.

3. Construction Method

A. The cold planing machine shall be delivered to the project limits on a trailer. The machine shall be loaded on to the trailer to be transferred from work site to work site. The owner shall not "walk" the machine to the next site unless prior approval from the Engineer is granted.

Once the cold-planing process has begun, the contractor is obliged to carry this effort forward without interruption, yet in accordance with all work hour restrictions unless otherwise directed by the Engineer

Cold-planing operations shall not be limited to just the primary roadway surface, but shall also extend into the adjacent intersections as well. The limit of this work shall be determined in the field by the Engineer so as to best meet the existing conditions and to further provide for a smooth pavement transitioning.

No asphalt millings shall remain on-site at the end of each day. Material resulting from the operation shall become the property of the owner and disposed of at an owner-furnished disposal site. Existing catch basins shall be protected in place to not allow loose material to enter structures

4. Method of Award

To ensure contractor accountability, the Owner intends to award all items to a single contractor. Accordingly, contractors must bid on all items of work, and the low bidder will be the contractor whose total bid price is the lowest. The bid quantities are not guaranteed, and their primary purpose is for the determination of the low bidder.

5. Payment

Pre-Milling: The bid price per SY will be multiplied by the number of inches of depth milled to calculate the final payment amount per square yard.

BASE REPAIR

ITEM 10
GRAVEL

ITEM 11
HOT MIX ASPHALT

1. Description

If needed, repair areas will be saw cut, and then all inferior material shall be removed. Gravel will then be placed and compacted in 6” lifts. The final 6”, bringing the repair area to road grade, shall be done with ¾” hot mix binder.

2. Method of Award

To ensure contractor accountability, the Owner intends to award all items to a single contractor. Accordingly, contractors must bid on all items of work, and the low bidder will be the contractor whose total bid price is the lowest. The bid quantities are not guaranteed, and their primary purpose is for the determination of the low bidder.

3. Measurement and payment

Saw cutting cost shall be incidental to the repair. Gravel to be paid by the cubic yard, and hot mix asphalt to be paid by the ton.

A. METHOD OF AWARD

To ensure contractor accountability, the Owner intends to award all items to a single contractor. Accordingly, contractors must bid on all items of work, and the low bidder will be the contractor whose total bid price is the lowest. The bid quantities are not guaranteed, and their primary purpose is for the determination of the low bidder.

B. MEASUREMENT AND PAYMENT

The cost of coring labor, equipment and materials shall be paid per day for each day of coring operations conducted.

ITEM 12
LOWERING AND RAISING OF EXISTING STRUCTURES
(FRAMES AND GRATES OR FRAMES AND COVERS)

1. Materials

A. Concrete collars will be constructed using 4,000 PSI cement concrete masonry, at no additional cost. A minimum of four (4) inches of hot mix asphalt shall be placed and compacted to the underlying grade of the proposed wearing surface and will be considered incidental to the above Item's unit price. All concrete collars will be completely coated with (RS-1) asphaltic emulsion before placement of hot mix asphalt. The brick to be used shall be clay brick.

B. Concrete collars shall be constructed with high early strength cement. Concrete collars shall be incidental to the item of work to which they pertain.

C. Use of steel plates to cover open structures shall be considered incidental to the work and not cause for additional compensation. Multiple adjustments that may be necessary as a result of the work sequence shall be considered part of the one-time measurement and payment and not cause for additional compensation

2. Engineering

A. In all roadways, the castings shall be lowered to the top of the structure base.

B. After the CIR, castings shall be raised to the final grade.

C. Damaged or obsolete castings shall be replaced with new castings as directed by the Engineer. Frames, grates and covers will be furnished by the Owner.

D. The Contractor shall properly dispose of the old damaged or obsolete castings. No additional compensation will be made for disposal of the old castings.

3. Method of Award

To ensure contractor accountability, the Owner intends to award all items to a single contractor. Accordingly, contractors must bid on all items of work, and the low bidder will be the contractor whose total bid price is the lowest. The bid quantities are not guaranteed, and their primary purpose is for the determination of the low bidder.

4. Measurement and payment

Compensation for all labor, materials (including cement concrete, hot mix asphalt, and asphaltic emulsion), equipment and incidentals to construct the collars shall be included in the contract unit price of this item. The quantity to be measured for payment will be the number of catch basins and manholes adjusted, to be paid for at the unit price per each. Measurement shall be by each catch basin or manhole adjusted and approved by the Engineer.

item 13
Structure Rebuild

1. Method of Award

To ensure contractor accountability, the Owner intends to award all items to a single contractor. Accordingly, contractors must bid on all items of work, and the low bidder will be the contractor whose total bid price is the lowest. The bid quantities are not guaranteed, and their primary purpose is for the determination of the low bidder.

2. Measurement and payment

The unit price payment for this item will be by the vertical foot.

ITEM 14
ADJUSTMENT OF EXISTING WATER GATES
AND OTHER SMALL STRUCTURES (BOX OR SERVICE)

1. Construction method

A. Valve boxes are to be lowered prior to the CIR process and raised after the CIR process. They shall be installed vertically, centered over the operating nut, and the elevation of the top shall be adjusted to final grade.

B. Boxes shall be continuously and adequately supported during backfilling to maintain vertical alignment.

C. Bricks shall be placed at the base of the flange to properly support the box.

D. Backfill around valve boxes, and anywhere excavation is made in the street, shall be compacted in lifts not exceeding 12 inches.

E. The boxes and tops shall be furnished by the Owner.

F. The contractor shall properly dispose of any old damaged or obsolete castings. No additional compensation will be made for disposal of old castings.

2. Method of Award

To ensure contractor accountability, the Owner intends to award all items to a single contractor. Accordingly, contractors must bid on all items of work, and the low bidder will be the contractor whose total bid price is the lowest. The bid quantities are not guaranteed, and their primary purpose is for the determination of the low bidder.

3. Measurement and payment

The unit price payment for this item will be for all work described above, for each water gate or other small structure adjusted.

item 15
Backing Up Road Edge

1. Construction method

A. If determined by the owner that backing up of road edge is required, additional material shall be placed at a maximum width of 2'.

B. Owner to provide material and trucking.

2. Method of Award

To ensure contractor accountability, the Owner intends to award all items to a single contractor. Accordingly, contractors must bid on all items of work, and the low bidder will be the contractor whose total bid price is the lowest. The bid quantities are not guaranteed, and their primary purpose is for the determination of the low bidder.

3. Measurement and payment

A. Cost of placement shall be charged by the linear foot.

B. If owner wishes to have contractor provide trucking, it will be paid under ITEM 7 "Trucking", at a unit rate of per hour, per truck.

	Bid Item	Bid Quantity	Bidder's Unit Price	Bid Total
1	Core Sampling	DAY	$ /DAY	$
2	Mix Design	EA	$ /EA	$
3	Cold In-place Recycling Including Fog Seal (4" or less)	SY	$ /SY	$
4	Cold In-place Recycling Including Fog Seal (4.5" or greater)	SY	$ /SY	$
5	Liquid Asphalt Stabilizing Agent	GAL	$ /GAL	$
6	Portland Cement Stabilizing Agent	TON	$ /TON	$
7	Trucking- minimum body size 14 CY (per hour, per truck)	HR	$ /HR	$
8	Pre-milling**(see footnote)*	SY	$ /SY	$
9	Pave Processed RAP Ahead of Recycler	SY	$ /SY	$
10	Gravel for Base Repair	CY	$ /CY	$
11	Hot Mix Asphalt for Base Repair	TON	$ /TON	$
12	Adjust Manholes/Catch Basins for CIR	EA	$ /EA	$
13	Structure Rebuild for CIR	VF	$ /VF	$
14	Adjust Water Gates /Small Structures for CIR	EA	$ /EA	$
15	Backing up Edge of Road	LF	$ /LF	$
			Total Bid Price	$
	Total Bid Price in Words			

Company	
Address	
Signature	Date / /
Printed Name	Title

***Pre-Milling: The unit cost per SY will be multiplied by the number of inches of depth required.**

ITEM XXX.X HOT MIX ASPHALT ROADWAY PAVEMENT TON

A. DESCRIPTION

SCOPE

Work under this item shall consist of furnishing hot mix asphalt composed of mineral aggregate and asphalt binder, mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and conformance to the lines, grades, thickness and typical cross sections shown on the plans or as directed by the Engineer. Where reference is made to MASSDOT Standard Specifications, Form 1995 shall apply for section references; latest edition shall apply for specifications.

Each course shall be constructed to the depth, typical section, or elevation required by the contract and/or plans and shall be rolled, finished, and approved before the placement of the next course. Each course shall be placed to a smooth, dense and uniform appearance.

Many state agencies are implementing Quality Assurance specifications. It is the intent of these municipal quality-based HMA specifications to move toward the goal of quality assurance implementation but tailored toward the real world of municipal construction. To that end, the Contractor is required to establish, provide, and maintain a Quality Control System (QCS) that will detail the methods and procedures that will be taken to assure that all materials and completed construction conform to project specifications, plans, technical specifications and other requirements, whether manufactured or processed by the Contractor or procured from subcontractors or vendors.

B. QUALITY ASSURANCE

The Contractor assumes the responsibility of the quality for all materials and construction incorporated into the work and will control all the processes leading to the final result through this function. Quality Control activities should include:

1. Maintain a Contractor Quality Control System
2. Proficiency testing prior to/during production with Engineer
3. Inspection and Testing of Hot Mix Asphalt Production
4. Inspection and Testing of Hot Mix Asphalt Placement

See Section G "Contractor Quality Control of HMA Pavement" of these specifications for additional information.

The City of Springfield or their authorized agent may perform the Quality Acceptance function for this work. All material will be considered for acceptance through a sampling, testing and inspection program performed by the Engineer or their agent.

C. MATERIALS

Aggregate – Aggregate shall meet the requirements of MASSDOT M3.11.04 latest edition of the Standard Specifications and as further stipulated herein.

1. Coarse Aggregate

   The sodium sulfate soundness loss shall not exceed nine (9) percent, nor the magnesium soundness loss exceed twelve (12) percent, after five cycles, when tested in accordance with AASHTO T104.

   The coarse aggregate shall not contain more than one (1) percent of material such as crusher dust, sand or soft, disintegrated pieces. The coarse aggregate shall not contain more than ten (10) percent, by weight, of flat or elongated pieces, when tested in accordance with ASTM D4791 at a ratio of 5:1.

For the Superpave mixes contained in Table 4, the coarse aggregate shall conform to the coarse aggregate angularity requirements listed in Table 2 for the traffic level and depth within the pavement structure.

The use of steel slag or blast furnace slag shall not be permitted as a coarse aggregate.

2. Fine Aggregate

   Fine aggregate shall consist of clean, sound, durable, angular particles produced by crushing natural stone, or gravel that meets the requirements for wear and soundness specified for the coarse aggregate. The aggregate particles shall be free from coatings of clay, silt, or other objectionable matter and shall contain no clay balls. The combined materials that passed the No. 100 mesh sieve shall not have sufficient plasticity to permit the performing of the plastic limit test using AASHTO T90.

   Fine aggregates shall conform to the sand equivalent and fine aggregate angularity values listed in Table 2 for the traffic level and depth within the pavement structure. The sand equivalent value and the uncompacted void content shall be determined for the combined mix aggregates, including coarse and fine aggregates and mineral filler portions.

3. Mineral Filler

   If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of AASHTO M17.

4. Reclaimed Asphalt Pavement (RAP)

   The use of a maximum of 15% recycled asphalt pavement (RAP) will be allowed in the HMA courses.

   The RAP, incorporated into the HMA mixtures, shall be maintained as a separate captive stockpile and shall not be added to without prior approval. RAP shall consist of asphalt pavement recovered by cold milling or other removal techniques. The RAP shall be crushed so that 100 percent passes the maximum aggregate size of the HMA mix in which it will be used. The Contractor's Quality Control system shall assure that the RAP is free from detrimental amounts of contaminating substances such as joint seal compound and, is reasonably uniformly graded from fine to coarse.

   The coarse aggregate in the RAP shall be crushed stone and the top-size shall not exceed the maximum aggregate size established by the JMF. The final HMA mixture containing RAP shall conform to all the specification requirements contained herein.

   For mixtures containing 15% or less RAP, the asphalt binder shall be a PG 64S-28 or PG 64S-22. RAP content shall not exceed 15%.

   The laboratory RAP-virgin binder blend viscosity value established from the RTFO residue at 140°F (60°C) shall establish the maximum viscosity allowed for the binder after discharge from the HMA plant and/or silo storage, if applicable, when recovered by AASHTO T170 and tested in accordance with AASHTO T202 and AASHTO T316.

   For design purposes, the specific gravity of the combined aggregate blend with RAP used in a HMA mixture shall be determined in accordance with the attached test method for BULK SPECIFIC GRAVITY OF AGGREGATE BLENDS WITH RAP.

Sampling and Testing

All aggregate samples required for testing shall be furnished by the Contractor when requested. AASHTO-T2 shall be used in sampling coarse aggregate and fine aggregate, and AASHTO T127 shall be used in sampling mineral filler. All tests for initial aggregate submittals necessary to determine compliance with requirements specified herein will be conducted by the Contractor under their Quality Control System. No aggregate shall be used in the production of mixtures without prior approval.

Sources of Supply

Sources of aggregate shall be selected well in advance of the time the materials are required in the work. Preliminary approval may be given when the materials are obtained from a previously approved source or an existing quarry source producing aggregates that has a satisfactory service record in hot mix asphalt construction for at least five years. Samples shall be submitted upon contract award. When time permits, samples shall be submitted fourteen days prior to the start of production. An inspection of the producers operation will be made by the Engineer. When new sources are to be developed, the Contractor shall indicate the sources and submit a plan of operation thirty days in advance of starting production. Samples from test pits, borings and other excavations shall be submitted at the same time. Approval of the source of aggregate does not relieve the Contractor in any way of the responsibility for delivery at the job site of aggregates that meet the requirements specified herein.

Samples

Samples of aggregates shall be furnished by the Contractor at the start of production and at intervals during production of HMA mixtures. The intervals and points of sampling will be designated by the Engineer.

Asphalt Binder Material - The types, grades, and controlling specifications, the maximum mixing temperatures and compaction temperatures for the asphalt binder materials shall conform to the following:

Performance Graded Asphalt Binder: The Asphalt Binder shall be a Performance Graded Asphalt Binder (PGAB) which meets the specification requirements of AASHTO M320 or M332 and AASHTO R29. Acceptance of the PGAB will be in accordance with AASHTO R26 “Standard Practice for Certifying Suppliers of Performance Graded Asphalt Binders”. PGAB shall be provided by an Approved Supplier (AS) under the Approved Supplier Certification (ASC) system.

THE PGAB GRADE SELECTED FOR THIS WORK IS PG 64S-28 or 64S -22 under AASHTO M332 or PG 64-28 or 64-22 under AASHTO M320 - If traffic speed and/or level warrant, the PGAB may be adjusted by the Engineer for the design traffic conditions. A separate JMF with TSR results shall be submitted for each PGAB grade proposed for use on this project.

1. Limit one binder grade per production day unless otherwise adjusted by the Engineer for the City of Springfield traffic conditions.

2. Documentation of the type of binder used per production day is to be stated on the weigh slips.

The Contractor shall furnish manufacturers' certified test reports for each carload or equivalent of binder shipped to the project as well as applicable Materials Certificates for the shipment of each carload or equivalent to the production plant. The reports shall be delivered to the Engineer before production of the HMA. The furnishing of the vendor's certified test reports and material certificates for the PGAB material can be used as the basis for final acceptance of the bituminous material, or, tested by the Engineer. If the Engineer elects to test the binder material at their costs, then the Contractor shall set aside one (1) 1-qt samples of the asphalt binder material obtained from each truckload, shipment, or equivalent of asphalt binder material shipped to the production facility. Each sample shall be labeled with the PG grade, source and batch number, quantity, project name, plant, date, and the sampling inspector. The Contractor shall maintain documentation in the form of a Materials Certificate of each shipment, with a copy attached to each quart sample.

After receiving the quart samples, obtained by the Contractor, the Engineer may test the samples for verification of the performance grade. Material shall conform to the specification requirements for the applicable performance grade as specified herein. Material not conforming to specification requirements shall be subject to corrective action, production suspension, rejection, removal, or reduced payment as determined by the Engineer.

The blending at the HMA plants of PG binder from different suppliers is strictly prohibited. Contractors may switch to another approved source of PG binder, upon written notification to the Engineer, and by certifying that the tank to be utilized has been drained to an un-pumpable condition. The tank shall not retain more than 0.5% in volume capacity of previous residue source. Contractors who blend PG binders will be reclassified as a supplier and required to certify the binder in accordance with AASHTO M320 or AASHTO M332 and AASHTO R26 at a frequency of one random sample for every 24,000 tons. Also if any modifications, blending, or addition of additives occurs, the Contractor shall re-certify the material in accordance with AASHTO M320 or AASHTO M332 and AASHTO R26. All samples shall consist of two 1-quart containers of PG binder and shall be split prior to testing. The untested portion retained for a minimum of 60 days.

The Contractor shall submit to the Engineer a Supplier's certified test report along with copies of the certified AASHTO M320 or AASHTO M332 test results for each Supplier Lot of PG from which the Producer's PG was obtained.

Asphalt Binder Anti-Stripping Additive - This specification provides for an additive to asphalt to assist in the coating of wet aggregate and to increase the resistance of the binder coating to stripping in the presence of water. The additive shall be chemically inert to asphalt (heat stable) and when blended with asphalt shall withstand storage at a temperature of 400°F (204°C) for extended periods without loss-of effectiveness.

Composition: Anti-stripping compound shall be an organic chemical compound, free from inorganic mineral salts or inorganic mineral soaps. It shall contain no ingredient harmful to the binder material or to the operator, and shall not appreciably alter the specified characteristics of the binder material. The hot mix asphalt materials and asphalt binder material that require antistrip additives (either liquid or mineral) shall continue to meet all requirements specified herein for binder and HMA. The anti-strip agent shall be included in the bid price.

Tack Coat: Emulsified asphalt; AASHTO M140/ASTM D 997 or AASHTO M 208/ASTM D 2397, RS-1, RS-1h or CRS-1

PRELIMINARY MATERIAL ACCEPTANCE - Prior to delivery of HMA materials to the job site, the Contractor shall submit certified test reports to the Engineer for the following materials certified under the Contractor's quality control system:

Coarse Aggregate

1. Percent of wear
2. Soundness
3. Flat and Elongated
4. Coarse aggregate

angularity Fine Aggregate

1. Liquid limit
2. Plastic index
3. Sand equivalent
4. Fine aggregate

angularity Mineral Filler

Performance Graded Asphalt Binder: The certification(s) shall show the appropriate AASHTO and/or ASTM test(s) for each material, the test results, and a signed statement that the material meets the specification requirement.

The Engineer may request samples for testing, including but not limited to, modifiers, truck coatings, and emulsion, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

D. COMPOSITION OF HMA MIXTURES

Hot Mix Asphalt - HMA plant mix may be composed of a homogeneous mixture of aggregate, filler if required, bitumen, and/or additives, combined to meet the composition limits by weight and other characteristics as specified. The several aggregate fractions shall be sized, uniformly graded and combined in such proportions that the resulting mixture meets the grading requirements of these specifications.

Hot Mix Asphalt Mix Design - The Contractor shall be responsible for the development of all job mix formulas. All job mix formulas other than for Surface Treatment and Base mix shall be based on and supported by Superpave volumetric mix designs. Superpave mix designs shall be based on Asphalt Institute SP-2 and AASHTO M323, R35, R30, T312, and the requirements contained herein. For the Superpave volumetric mix design, the mixture of asphalt and aggregate shall be oven aged at the mixture's specified compaction temperature in accordance with AASHTO R30.

JOB MIX FORMULA (JMF) - Work shall not begin nor shall any mixture be accepted until the Contractor has submitted a job mix formula, samples of the existing and new materials intended for use, and has established a separate, job mix formula (JMF) for each mixture. A separate job mix formula shall be submitted for each mixture and each approved RAP stockpile (the stockpile shall be of a uniform quality throughout).

JMF Submittal - The job mix formula shall establish the percentage of each additional aggregate required, a single percentage of aggregate passing each required sieve size, a single percentage and the grade of asphalt binder to be added, the percentage of recycling additive, and a single temperature at which the mixture is to be discharged from the plant, and the number of seconds for dry mixing time and the number of seconds for wet mixing time. The moisture content of all hot mix asphalt upon discharge from the mixer shall not exceed 0.5 percent when tested in accordance with AASHTO T110. The job mix formula shall also specify a single source or uniform blend of particular sources for fine aggregate, a single source for each nominal size of coarse aggregate, and a single source of supply for mineral filler and for asphalt. The JMF shall be submitted in writing by the Contractor to the Engineer at least 30 days prior to the start of paving operations and shall include as a minimum:

a. Percentage of each individual aggregate and percent passing each sieve. Combined percent passing each sieve size and target gradation desired.
b. Percent of asphalt binder.
c. Performance grading test results and Material Certificate certifying the PG grade.
d. Number of gyrations for the estimated design ESAL loading.
e. Mixing temperature.
f. Compaction temperature.
g. Temperature of mix when discharged from the mixer.
h. Plot of the combined gradation on the Federal Highway Administration (FHWA) 0.45 power gradation curve.
i. Percent natural sand.
j. Percent fractured faces.
k. Percent flat or elongated particles.

l. Tensile Strength Ratio (TSR).

m. Antistrip agent – type and quantity.

n. Sand equivalent value.

o. Fine aggregate angularity value.

p. Percentage of wear.

q. Sulfate soundness loss.

r. Individual and combined aggregate specific gravity.

s. Dust to effective asphalt ratio.

t. Graphical plot of air voids, voids in mineral aggregate (VMA)(Table 1), and voids filled with asphalt (VFA) versus asphalt content. The Superpave mixes shall also show density at $N_{initial}$, density at N_{design}, and density at $N_{maximum}$ versus asphalt content.

The Contractor shall submit samples to the Engineer, upon request, for JMF verification testing.

The JMF for each mixture shall be in effect until modified in writing by the Engineer. Should a change in sources of materials be made, a new JMF must be approved by the Engineer before the new material is used.

JMF Tolerances - The job mix formula, operating within the allowable action limits for individual measurements as specified in Table 6 herein, shall be set within the design master limits specified for each mixture in Table 4.

Plant Trial Mixtures - After receiving the job mix formula prepared by the Contractor, the Engineer will notify the Contractor regarding a verification of the optimum asphalt content and/or pre-production trials and Control Section for those mixtures so designated by the Engineer. A minimum of one trial mix shall be produced at the Contractor's proposed asphalt binder content and aggregate gradation.

JMF Approval - The Contractor will be notified by the Engineer if the JMF submittals are approved for production. The approved job mix formula for the mixture shall be in effect until modified in writing. As indicated in Section D, Plant Trial Mixtures, of this specification, the Engineer will notify the Contractor regarding the placement of a Control Section (See Section E). Following placement and testing of the Control Section, the JMF may have to be modified to meet both production and placement requirements of this specification. If warranted, the JMF resubmittal shall follow the applicable requirements of Section D of this specification. A JMF, once approved, will not be required for further mix approval for the construction season unless a change has occurred that warrants a new JMF approval or as directed by the Engineer. The approval of all JMFs will terminate on December 31st each year, regardless if the work is carried over to the following year. Control sections are required by the contractor for in-place mat thickness, uniformity, longitudinal joint characteristics, and density requirements before approval.

HMA MIXTURE DESIGN CRITERIA (Tables 1-4)

TABLE 1. PERCENT VOIDS IN MINERAL AGGREGATE (VMA)

Nominal Maximum Aggregate Size	Percent Minimum
#4 (4.75mm)	16.0
3/8" (9.5 mm)	15.0
1/2" (12.5 mm)	14.0
3/4" (19.0 mm)	13.0
1.0" (25.0 mm)	12.0
1.5" (37.5 mm)	11.0

TABLE 2: Hot Mix Asphalt Aggregate Properties

Traffic Levels	Design ESALs (80 kN)	Coarse Aggregate Angularity [5] ASTM D5821		Fine Aggregate Angularity [5] AASHTO T-304		Flat or Elongated Particles ASTM D-4791	Sand Equivalent AASHTO T-176
	(million)	(Depth from final surface) ≤ 100 mm	(Depth from final surface) > 100 mm	(Depth from final surface) ≤ 100 mm	(Depth from final surface) > 100 mm	> 9.5 mm	- - - - -
1	< 0.3	55/- -	- -/- -	- -	40	- - -	40
2	0.3 to < 3.0	75/- -	50/- -	40	40	10	40
3	3.0 to < 30.0	95/90 [6]	80/75 [6]	45	40	10	45
4	≥ 30.0	100/100	100/100	45	45	10	50
	Design ESALs are the anticipated project traffic level expected on the design lane, projected over a 20-year period, regard les s of the actual expected design life of the roadway.	Criteria presented as minimum values. 95/90 denotes that a minimum of 95% of the coarse aggregate, by mass, shall have one fractured face and that a minimum of 90% shall have two fractured faces.		Criteria presented as minimum percent air voids in loosely compacted fine aggregate passing the 2.36 mm sieve. AASHTO T304, Method A		Criteria presented as maximum Percent by mass of flat or elongated particles of materials retained on the 4.75 mm sieve, determined at 5:1 ratio. Not applicable for the 4.75 mm Nominal Max Aggregate size mix	Criteria presented as minimum values for fine aggregate passing the 4.75 mm sieve.

Note 5: If less than 25 % of a given layer is within 100 mm (4 inches) of the anticipated top surface, the layer may be considered to be below 100 mm (4 inches) for mixture design purposes.

Note 6: For Superpave mixtures with design ESALs between **3.0 and 10.0 million**, the coarse aggregate angularity criteria shall be **85/80** for layers < 100 mm depth from final surface and a criteria of **60/- -** for layers >100 mm from final surface.

TABLE 3: Hot Mix Asphalt and Volumetric Properties for Superpave Mixtures.

Traffic Levels	Design ESALs (million)	Number of Gyrations by Superpave Gyratory Compactor			Percent Density of Gmm from HMA specimen			Voids Filled with Asphalt (VFA) Based on Nominal mix size					
		Nini	Ndes	Nmax	Nini	Ndes	Nmax	4.75 mm	9.5 mm	12.5 mm	19.0 mm	25.0 mm	37.5 mm
1	< 0.3	6	50	75	≤ 91.5	95 - 97	≤ 98.0	70 – 80	70 - 80	70 - 80	70 - 80	67 – 80	64 – 80
2	0.3 to < 3.0	7	75	115	≤ 90.5	95 - 97	≤ 98.0	65 – 78	65 - 78	65 - 78	65 - 78	65 - 78	64 - 78
3	3.0 to < 30	8	100	160	≤ 89.0	95 - 97	≤ 98.0	75 – 78	73 - 76	65 - 75	65 - 75	65 - 75	64 - 75
4	≥ 30.0	9	125	205	≤ 89.0	95 - 97	≤ 98.0	75 - 78	73 - 76	65 - 75	65 - 75	65 - 75	64 - 75

TABLE 4. SUPERPAVE HOT MIX ASPHALT MIXTURES

	Percent by Weight Passing Sieves											
Sieve Size in. (mm)	**4.75mm** Control Points		**9.5mm** Control Points		**12.5mm** Control Points		**19.0mm** Control Points		**25.0mm** Control Points		**37.5mm** Control Points	
	Min %	**Max %**	**Min %**	**Max %**	**Min %**	**Max %**	**Min %**	**Max %**	**Min %**	**Max %**	**Min %**	**Max %**
2" (50.0)									-	-	100.0	
1-1/2" (37.5)	-	-	-	-	-	-	-	-	100	-	90.0	100.0
1" (25.4)	-	-	-	-	-	-	100.0	-	90.0	100.0	-	90.0
3/4" (19.0)	-	-	-	-	100.0	-	90.0	100.0	-	90.0	-	-
1/2" (12.5)	100.0	-	100.0	-	90.0	100.0	-	90.0	-	-	-	-
3/8" (9.5)	95.0	100.0	90.0	100.0	-	90.0	-	-	-	-	-	-
#4 (4.75)	90.0	100.0	-	90.0	-	-	-	-	-	-	-	-
#8 (2.36)	-	-	32.0	67.0	28.0	58.0	23.0	49.0	19.0	45.0	15.0	41.0
#16 (1.18)	30.0	60.0	-	-	-	-	-	-	-	-	-	-
#30 (0.600)	-	-	-	-	-	-	-	-	-	-	-	-
#50 (0.300)	-	-	-	-	-	-	-	-	-	-	-	-
#100 (0.150)	-	-	-	-	-	-	-	-	-	-	-	-
#200 (0.075)	6.0	12.0	2.0	10.0	2.0	10.0	2.0	8.0	1.0	7.0	0	6.0
Dust to Binder Ratio(Note):	0.9	2.0	0.6	1.2	0.6	1.2	0.6	1.2	0.6	1.2	0.6	1.2

Additional HMA Criteria - In addition to the above HMA design requirements, the HMA mixtures shall also conform to the following:

1. Stripping

   Each mixture shall be evaluated for stripping by performing indirect tensile tests on compacted mixtures. The specimens for the AASHTO procedure shall be 4" (100mm) in diameter, compacted with the Marshall hammer or the Superpave gyratory compactor to the desired air void level of 7.0 + 1.0%. If the Tensile Strength Ratio (TSR) of the composite mixture, as determined by AASHTO T283 with the freeze/thaw cycle, is less than 80, the aggregates shall be rejected, or the asphalt treated with an approved anti-stripping agent. The amount of anti-stripping agent added to the asphalt shall be sufficient to produce a TSR of not less than 80. If an antistrip agent is required, it will be provided by the Contractor at no additional cost.

2. Aggregate Composition:

   The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation or gradations specified in Table 4, when tested in accordance with AASHTO Standards T27 and T11. The gradations in Table 4, represent the limits which shall determine the suitability of aggregate for use from the sources of supply. The aggregate, as selected (and used in the JMF) and blended, shall have a gradation within the limits designated Table 4 and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be well graded from coarse to fine.

3. JMF Deviations:

   Deviations from the final approved mix design for asphalt binder content and gradation of aggregates shall be within the action limits for individual measurements as specified in Table 6. The limits still will apply if they fall outside the master grading band in Table 4.

Warm Mix Asphalt (WMA) - All SUPERPAVE Hot Mix Asphalt Mixtures may be modified using a WMA additive capable of lowering plant production temperatures to below 260° F. Warm Mix Asphalt additives reduce compaction effort and permit lower production temperatures than conventional hot mix asphalt. The WMA additive shall be a product listed on the Northeast Asphalt User Producer Group (NEAUPG) website - http://www.superpave.psu.edu/NEAUPG.html , except that no WMA foaming technology will be permitted which requires the mechanical injection of steam or water into the liquid asphalt.

The WMA additive must be compatible with polyphosphoric acid modified binders, polymer modified binders, and the HMA producer's HMA anti-stripping agents. The WMA additive shall be introduced in accordance with the Manufacturer's dosing rates and approved blending methods. The WMA additive Manufacturer shall have an on-site representative at the beginning of paving operations as directed by the Engineer. The Manufacturer's representative shall be available for consultation during Warm Mix production.

All work done under this Item shall conform to the provisions of City of Springfield - Hot Mix Asphalt Roadway Pavement Specification. The WMA mixture design shall incorporate the requirements of AASHTO R35. All WMA additive equipment shall be fully automated and integrated into the plant controls.

When the asphalt binder is modified with the WMA additive at the HMA plant, all WMA additive equipment shall be fully automated and integrated into the plant controls and shall record actual dosage rates on the plant printouts.

The HMA QC Plan shall incorporate the modification of asphalt binders when the WMA additive is blended with the asphalt binder at the plant. This plan shall conform to the most current Northeast Asphalt User Producer Group (NEAUPG) binder testing requirements and specifically address WMA metering requirements, tolerances and other QC measures.

All costs associated with these provisions will be considered incidental. No additional compensation will be provided for the Manufacturer's representative, production of samples, the Warm Mix additive or other incidental costs.

E. HMA CONTROL SECTION

If required by the Engineer and prior to full production for the City, the Contractor shall place a quantity of hot mix asphalt according to the JMF and the project specifications. The amount of mixture should be sufficient, at a minimum, to construct a test section 300 feet long and 20 to 30 feet wide placed in two lanes, with a longitudinal joint, and shall be of the same depth specified for the construction of the course which it represents. The underlying grade or pavement structure upon which the Control Section is to be constructed shall be the same as the remainder of that project course represented by the Control Section. The equipment used in construction of the Control section shall be the same type and weight to be used on the remainder of the course represented by the Control Section. The control section may be as large as one production day on a City street as long as a longitudinal joint has been constructed.

Two Random sample(s) shall be taken at the plant by the Engineer and tested for air voids, aggregate gradation and asphalt binder content in accordance with the Section H, “Plant-Produced Material”.

Three randomly selected cores shall be taken from the finished pavement mat in the Control Section, and three from the longitudinal joint, and tested in accordance with Section H, “Field Placed HMA Material”. Random sampling shall be in accordance with procedures contained in ASTM D3665.

Mat density and air voids shall be evaluated in accordance with Section H, “Field Placed HMA Material”. Joint density will be evaluated in accordance with Section H, “Field Placed HMA Material”.

The Control Section shall be considered acceptable if the uniformity, thickness, and 1) mat density, plant air voids, and VMA are within the requirements of this specification and 2) gradation and asphalt binder content are within the action limits specified herein for individual Measurements.

If the initial Control section should prove to be unacceptable, the necessary adjustments to the JMF, plant operation, placing procedures, and/or rolling procedures shall be made. A second Control section shall then be placed. If the second test section also does not meet specification requirements, both sections shall be removed at the Contractor's expense. Additional Control sections, as required, shall be constructed and evaluated for conformance to the specifications. The Contractor will be responsible for all testing and oversight costs associated with all required control sections beyond the first and second. Any additional sections that are not acceptable shall be removed at the Contractor's expense. Full production shall not begin until an acceptable section has been constructed and accepted by the Engineer. Any control section that meets specification requirements shall be paid for in accordance with the Section J, “PAYMENT”

F. EQUIPMENT

Hot Mix Asphalt Mixing Plant - Shall meet MASSDOT M3.11.07. Sufficient storage space shall be provided for each size of aggregate. The different aggregate sizes shall be kept separated until they have been delivered to the cold elevator feeding the drier. The storage yard shall be neat and orderly, and separated stockpiles shall be readily accessible for sampling.

1. Sampling Platform: A safe and adequate platform or catwalk with stairway and railing shall be provided to accommodate the inspector while checking temperatures and obtaining samples of the mixture from haul vehicles. The height of the platforms and raised platforms shall be adequate to accommodate safe acquisition of mix samples from the type of hauling unit(s) being utilized on the project.

2. Testing Laboratory - The Contractor or producer shall provide a testing laboratory at the production plant for quality control and quality acceptance functions during periods of mix production, sampling, and testing, and whenever materials subject to the provisions of these specifications are being supplied or tested. The laboratory shall contain adequate equipment, space, and utilities as required for the performance of the specified tests.

It shall be available for joint use by the Contractor for quality control testing and by the Engineer for acceptance testing. The testing laboratory must have adequate equipment for the performance of the tests required by these specifications and the requirements of NETTCP. The Engineer shall have priority in use of the equipment necessary for acceptance testing. All the necessary testing equipment shall be located at the HMA plant supplying material to the project. In addition, all ancillary and miscellaneous equipment needed to perform the testing in accordance with these specifications shall be provided by the Contractor at no additional cost.

The effective working area of the laboratory shall be a minimum of 150 square feet with a ceiling height of not less than 7.5 feet. Lighting shall be adequate to illuminate all working areas. It shall be equipped with heating and air conditioning units to maintain a temperature of 70°F + 5°F.

The plant laboratory shall further contain and be kept supplied with the following laboratory equipment: Scale (digital): 20,000gm capacity minimum, sensitivity 0.1gm.

Superpave Gyratory Compactor conforming to the requirements of AASHTO R30, R35, M323, T312 and the Asphalt Institute Manual SP-2.

Bulk specific gravity determination equipment (AASHTO T166), and theoretical maximum specific gravity equipment (AASHTO T209).

Laboratory facilities shall be kept clean and all equipment shall be maintained in proper working condition. The Engineer shall be permitted unrestricted access to inspect the Contractor's laboratory facility and witness quality control activities, if applicable. The Engineer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to be adversely affecting test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected.

Hauling Equipment - Trucks used for hauling hot mix asphalt mixtures shall have tight, clean smooth metal beds which have previously been cleaned of all foreign material. To prevent the mixture from adhering to them, the beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, soluble oils or other approved material. When coating is applied, truck bodies shall be raised immediately prior to loading to remove any excess coating material in the truck bed. Containment of the excess anti-adhesive material may be required for environmental concerns depending on the type of anti-adhesive agent used. Each truck shall have a securely fastened, both front and rear, waterproof cover to protect the mixture at all times. The use of mesh type tarps will **not** be permitted. When necessary, so that the mixture will be delivered to the site at the specified temperature within 25°F of the approved JMF, truck beds shall be insulated.

Pavers - Pavers shall be self-contained, heated, power-propelled units with an automated controlled screed, and shall be capable of spreading and finishing courses of hot mix asphalt material which will meet the specified thickness, smoothness, and grade. Pavers used for shoulders and similar construction shall be capable of spreading and finishing courses of hot mix asphalt material in widths shown on the plans.

The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed. The hopper shall be maintained in excess of 25% volume of hot mix during normal paving operations thereby eliminating exposure of the drag slat conveyor. The screed assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, segregating or gouging the mixture.

The paver shall be capable of operating at forward speeds consistent with satisfactory laying of the mixture. The paver shall be maintained with non-worn reverse augers or kickback paddles at the center of the screed at the auger bearing box.

The paver shall be equipped with hoppers and distributing screws of the reversing type to place the mixture evenly in front of adjustable screeds. They shall be equipped with a quick and efficient steering device and shall have reverse as well as forward traveling speeds.

The paver shall employ mechanical devices such as equalizing runners, straight edge runners, evener arms or other compensating devices to adjust the grade and confine the edges of the mixture to true lines. To construct tight longitudinal paving joints, the end gate, or an edge plate, and the notched wedge joint maker, must be down just off the surface to ensure a light compaction and setup of the material on the joint. The paver shall be capable of spreading the mixture without segregation in layers to the depths and widths required. They shall be equipped with a single joint automated tracker device for proper matching of the elevation of longitudinal joints between adjacent strips or courses of the same thickness. Extensions shall contain auger and tunnel extensions if the end gate exceeds 18" from the end of the auger shaft.

An approved device will be required for heating the screed to the temperature required for the laying of the mixtures without pulling or marring.

The term "screed" includes any device operated by cutting, crowding, or other practicable action, which is effective on the mixtures at permissible workable temperatures without tearing, shoving, or gouging and which produces a finished surface of the evenness and texture required.

The pavers employed on Springfield projects shall operate by the use of a sensing grid for operation to a stringline and an automated joint matcher for joints, and an automatic grade control device for profile. The paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent.

The controls shall be capable of working in conjunction with any of the following attachments:

1. Ski-type device of not less than 30 feet (9.14 m) in length.
2. Taut stringline (wire) set to grade.
3. Short ski or shoe.
4. Laser control.
5. Sonic control.

The paver screed may be equipped with a Longitudinal Notched - Wedge Joint paver attachment or Straight Wedge Joint paver attachment and screed mounted roller attachment. When placing HMA pavement courses at a thickness of 1.5" or greater, the notched wedge is recommended; when placing HMA pavement courses less than 1.5", the straight wedge is recommended. The notched wedge joint includes a variable notched vertical edge (the notch vertical height to be equal to the mixture's maximum aggregate size). The sloped surface of the diagonal wedge joint shall not exceed a 6:1 slope.

Rollers - Rollers of the vibratory, steel wheel, oscillatory, and pneumatic-tired type may be used. They shall be in good condition, capable of reversing direction without backlash, and operating at slow speeds to avoid displacement of the hot mix asphalt. Static rollers shall be operated at speeds not to exceed 3 mph and vibratory rollers shall be operated at a minimum of 10 to 12 impacts/ft. in vibratory mode. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition.

The use of equipment which causes excessive crushing of the aggregate or that which does not produce a smooth, dense and uniform HMA mat will not be permitted.

The Contractor shall exercise great caution when using vibratory rollers so as not to cause damage to buried infrastructure or adjacent infrastructure. Damage to buried or adjacent infrastructure will be the responsibility of the Contractor. The new Oscillation type rollers are acceptable for use for intermediate compaction and back rolling of HMA in the City of Springfield.

The Contractor is encouraged, when applicable, to use a pneumatic square edge-tired compaction roller (either one or both axles) as another acceptable alternate for the Intermediate and Final rolling of hot mix in the City of Springfield.

G. HMA CONSTRUCTION

Weather Limitations - The HMA/WMA shall not be placed when weather conditions of fog or rain prevail or when the pavement surface or base shows signs of free moisture (film of water). When the surface temperature of the underlying course is less than 50°F but above 40°F, the Contractor shall determine the time available for compaction. No material will be placed by the Contractor when the surface temperature is below 40°F, unless approved by the Engineer. The time available for compaction shall be calculated based on the time, date, air temperature, average wind speed, sky conditions, latitude, mix type, PG grade, lift thickness, mix delivery temperature, existing surface type, existing moisture content of surface, existing state of moisture in surface, and surface temperature. The estimated time available for compaction can be calculated with computer programs, e.g., Pave Cool Tool 2.4.

This program is available at the following web location:

http://mnroad.dot.state.mn.us/research/mnroad_project/restools/cool tool.asp

The information regarding the air temperature, average wind speed, sky conditions, mix delivery temperature, and existing moisture conditions shall be evaluated by the Engineer and a Contractor's representative located at the paving operation. The estimated time available for compaction shall be provided by the Contractor to the Engineer. The Engineer and the Contractor shall determine if there is an adequate amount of time available to compact the mixture. Options can be explored to extend the time available for compaction. If there is an adequate amount of time available to compact the mixture, the temperature requirements may be waived by the Engineer; however all other requirements including compaction shall be met. The Contractor assumes responsibility for constructing the pavement to meet compaction, bonding to the underlying surface and specification requirements.

The Engineer will not permit work to continue when overtaken by sudden storms until the pavement surface shows no signs of free moisture. The material in transit at the time of shutdown will not be placed until the pavement surface shows no signs of free moisture, provided the mixture is within temperature limits as specified.

The construction of HMA/WMA concrete pavements shall terminate on November 15 and shall not be resumed prior to April 1 except as determined and directed in writing by the Engineer.

Thermometer - The Contractor will supply an approved dial type thermometer with a temperature range of 50°F to 500°F and an infrared pistol thermometer for use during HMA placement. The infrared pistol thermometer shall be Fahrenheit or Celsius selectable and conform to the following requirements:

Portable and battery operated	Accuracy of +/- 2%
Repeatability of +/- 3°C	Emissivity preset at 0.95
LCD Display to nearest 1°	Temp. Operating range of 4°F to 752°F

The thermometers will remain the property of the Contractor upon completion of the project.

Pre-Paving Conference - Prior to the placing of any HMA, a pre-paving conference (approximately 5 hours in length) shall be held to discuss and approve the paving schedule, source of HMA, job mix formula approvals, type and amount of equipment to be used, sequence of paving pattern, rate of HMA supply, all sampling, testing and reporting procedures to be used, traffic control, safety, and general continuity of the operation. Engineer's representatives, Contractor's plant, quality control and field representatives and Engineer's testing and inspection agents (any and ALL personnel anticipated to be on job site) shall attend this meeting. All equipment used shall be approved on the project site prior to starting up each day. **It will be mandatory for the Contractor and the paving subcontractor, if utilized, to attend this conference.** The Contractor will be responsible for all costs associated with additional training.

The Engineer, upon 48 hours' notice, may be able to hold this conference preferably on the forecast of an inclement day.

Preparation of the Underlying Surface - Immediately before placing the hot mix asphalt, the underlying course shall be thoroughly cleaned of all dust and debris by a self-propelled sweeper. Areas inaccessible by power sweepers shall be broom swept until the pavement surface is clean. Extra care shall be required during fall leaf fall.

Proof roll prepared base material surface, if applicable, to identify areas requiring removal and re-compaction, and to provide a uniform degree of compaction over the entire pavement area.

Do not begin paving work until deficient base material areas and utility trenches have been corrected and are ready to receive paving. Paving shall not be applied until the Engineer inspects and approves the finished base.
When an existing surface or new base upon which the lower course is to be placed contains unsatisfactory irregularities, in the Engineer's judgment, such irregularities may be eliminated by an adequate placing and compaction of HMA mixture so as to furnish a surface with true contour and grade before placing any specified course of mixture.

Check all frames, covers, grates, water valve boxes and other miscellaneous castings that are located in the proposed pavement areas to ensure that all have been correctly positioned and set to the proper slope and elevation. All covers and grates shall be set flush with the required finished surface. No depressions or mounds will be permitted in the pavement to accommodate inaccuracies in the setting of castings.

For Reclaimed base, reconstruction or where new base is graded, the Contractor shall furnish, set, and maintain all line and grade stakes necessary to guide the automated grade control equipment. Where required these control stakes shall be maintained by the Contractor and used throughout the operations, from the grading of the subbase material up to and including the final layers of the pavement.

Adequate artificial lighting shall be provided during night placements. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to an internal temperature of 140°F minimum.

Proper precautions shall be taken to prevent damage by construction operations to edges adjacent to the hot mix asphalt. These edges may be, but are not limited to, gutters, catch basins, curbs, concrete structures, and hot mix asphalt concrete. If damage occurs, repairs shall be made to the satisfaction of the Engineer with no additional payment.

Tack Coat - Contact surfaces of manholes, structures, vertical pavement edges, etc. shall be painted with a thin, uniform tack coat just before the material is placed against them.

Tack coat is required on all surfaces to be paved; this includes leveling, base or intermediate layers of HMA, unless the underlying HMA layer was placed during the same day. Particular attention should be made during the application that the longitudinal joint areas be treated with no bare spots. Missing areas adjacent to the longitudinal joint area will require either re-application or localized hand work application as directed by the Engineer.

Tack coat shall be applied at a residual binder amount on the pavement between 0.03 to 0.05 gallons per square yard. Use the lower application amount between new lifts and the higher application rate on milled or Portland cement surfaces. This amounts to a very thin application that needs to be carefully applied. Massachusetts uses RS-1, RS-1h and CRS-1 type asphalt emulsions for tack coating. These can be applied, as an emulsion, between 0.05 to 0.08 gallons per square yard. Tack coat shall be supplied as part of the HMA operation.

Allow tack coat to dry from a brown color to a black color prior to paving.

HMA Production - The aggregates and the asphalt binder material shall be weighed or metered and introduced into the mixer in the amount specified by the JMF and within the allowable action limits as stated in Table 6 HMA PRODUCTION LIMITS. These limits shall be applied to the target values established in the JMF. Corrective action shall be taken by the Contractor when the calculated individual result for gradation

or asphalt content falls outside the target JMF value beyond the action limit listed in Table 6. The Contractor shall take the appropriate action when results indicate the material is out of tolerance. The Contractor shall be required to suspend production when the calculated individual result for gradation or asphalt content falls outside the target JMF value beyond the suspension limit listed in Table 6. The Contractor shall be required to suspend production if two points in a row fall outside the Action Limits for individual measurements or if three nonconsecutive samples fall outside the Action limits. The Contractor shall be required to suspend production if one point falls outside the Suspension Limits for individual measurements. The Contractor shall also be required to suspend production if one point falls outside the Suspension Limits for range, Table 7.

1. Plant Trials - If production is suspended, the production facility shall be required to produce material on a trial basis for testing purposes without shipment to the project. No payment will be made for material and labor employed for nonconforming plant trials. The Engineer or his representative shall pay for acceptance sampling and testing for the first set of trials necessary to determine conformance with the specification requirements. If the first set of trials does not conform to specification requirements, the Contractor shall pay for any additional trial sampling and testing for acceptance. When trials have been approved, the plant will return to its normal operation.

Failure to stop production and make adjustments when required due to an individual test(s) not meeting the specified requirements may subject all of the mix from the stop point to be considered unacceptable.

The temperature of the mixture shall be in accordance with the Performance Graded Asphalt Binder (PGAB) allowable mixing and compaction temperature range. The temperature of the mixture when discharged from the mixer or silo shall be ± 20°F (-6°C) from the value stated in the job mix formula. Mixtures exceeding these limits shall be subject to rejection.

RAP VERIFICATION - The City will randomly test HMA mixtures from the production plant or storage silos to determine the quality of the PG binder. For non-modified binder mixtures, the absolute viscosity of the recovered asphalt shall be no greater than 6,000 poises at 140^{O}F. If the absolute viscosity is greater than 6,000 poises, then a full PG binder test verification will be run for conformance to the PG grade specified.

For modified asphalt binder mixtures, a full PG binder test verification will be run for conformance to the PG grade specified. Failure of the PGAB to conform to specification requirements may be cause for rejection of the Lot. Further PGAB tests may be conducted on previous Lots; all costs for the PGAB tests will be the responsibility of the Producer if the results do not meet specifications [TMAX for G*/Sin (d) DSR (RTFO Aged] for PG 64S-28 or 64S-22 (whichever is applicable) recently placed.

Transporting, Placing and Finishing - HMA deliveries shall be scheduled so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver.

Upon arrival, the mixture shall be placed to the full width by a hot mix asphalt paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the hot mix asphalt mat. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The mixture shall be placed in consecutive adjacent strips having a minimum width of 10 feet except where edge lanes require less width to complete the area. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least one (1) foot, however, the joint in the top layer shall be at the centerline of the pavement. Transverse joints in one layer shall be offset by at least two feet from transverse joints in the previous layer. The placement of the material along the longitudinal joint may be performed by setting the screed to overlap the first mat. The elevation of the screed above the surface of the first mat should be equal to the amount of roll-down expected during compaction of the new mat. The overlapped material shall be bumped by the lutes, if necessary, to optimize the density along the longitudinal joint. Under no circumstances should the overlapped material be broadcast across the mat. Excess material should be removed by hand. Transverse joints in adjacent lanes shall be offset a minimum of 10 feet.

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools. When hand spreading is permitted, the mixture shall be distributed into place by means of hot shovels and spread with lutes in a loose layer of uniform density and correct depth. The use of rakes to spread the hot mix asphalt shall not be permitted. Loads shall not be dumped any faster than they can be properly handled by the shovelers and the shovelers shall not distribute the dumped load any faster than it can properly be handled by the luters. The luting shall be carefully and skillfully done to avoid segregation and so that, after the first passage of the roller over the luted mixture, no back patching will be necessary. Compaction must immediately follow hand spreading such that specification density is achieved while the mixture temperature is above the manufacturers recommended compaction temperature for the performance graded binder.

The mixtures shall be placed and compacted only at such times as to permit the proper inspection and checking by the Engineer.

The mixtures shall only be placed in the work when they can be efficiently and satisfactorily placed, compacted, smoothed, and made uniform in accordance with these specifications. Unless otherwise permitted by the Engineer for special particular conditions, only machine methods of placing shall be used.

No mixture shall be placed unless the breakdown and intermediate rolling can be completed by the time the material has cooled to 150°F, or that minimum compaction temperature specified by the binder manufacturer and provided that the density and uniformity of the completed pavement attains specification compliance.

No traffic of any kind shall be permitted on the HMA intermediate or HMA base when dirt or any other foreign substance may be tracked thereon.

Immediately after any course is screeded and before roller compaction is started, the surface shall be checked, any irregularities adjusted, any accumulation from the screed removed by rake or lute, and all fat spots in any course removed and replaced with satisfactory materials. Irregularities in alignment and grade along outside edges shall be corrected by the addition or removal of mixture before the edges are rolled. Indiscriminate casting of mix on the new screeded surface, where irregularities are not evident, shall not be permitted.

All hot mix shall be placed and compacted in such a manner as to ensure a continuous bond between the tacked hot mix pavement surfaces and obtain the required density.

1. Production Trial - If it is determined, during the performance of the contract, that the pavement does not conform to the surface tolerance, density and uniformity requirements, the Engineer may order the Contractor to cease all operations and construct an additional HMA CONTROL SECTION consisting of a sufficient quantity of surface course mixture. The Contractor shall construct a control section as directed by the Engineer either: a minimum of 100 feet long by 12 feet wide, or a minimum of 50 feet long by a minimum of 24 feet wide depending upon the problem. A control section may be required each time a change is made in the Job Mix Formula, sources of supply or paving and rolling equipment.

The mixture shall be prepared, placed, and compacted in accordance with this specification. When the control section pavement has cooled sufficiently, a total of six (6) core samples of the finished pavement shall be taken and tested in accordance with the requirements of Section E.

If the tests by the Engineer indicate that pavement does not conform to specification requirements, necessary adjustment to plant operation and placement/rolling procedures shall be made.

Where the average density of the core samples does not conform to specification requirements, the pavement shall be removed at no cost to the Engineer. No payment will be made for material and labor employed, either in placement or removal of the nonconforming control section.

The control section may be removed at the direction and at no cost to the Engineer if the test result of any one mat core density falls below 90% of theoretical maximum laboratory density and/or any one longitudinal joint density falls below 88% of theoretical maximum laboratory density.

The Contractor shall not be permitted to place surface course pavement until a control section is approved by the Engineer.

Joints - The formation of all joints shall be made in such a manner as to ensure a continuous bond between the courses and obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade. When abutting a previously placed lane, the longitudinal joint should be rolled first followed by the regular rolling procedure.

1. Transverse Joints - The roller shall not pass over the unprotected end of the freshly laid mixture except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by temporarily tapering the course, in which case the edge shall be cut back to its full depth and width on a straight line to expose a vertical face. In both methods, all contact surfaces shall be given a coat of hot-pour rubberized asphalt sealer before placing any fresh mixture against the joint.

2. Longitudinal Joints - All longitudinal joints shall be constructed with the first paver pass in a neat straight line.

The paver screed may be equipped with a Longitudinal Notched - Wedge Joint or Straight Wedge Joint paver attachment and screed mounted roller attachment when placing HMA pavement courses. Use the Notched Wedge Joint for thicknesses of 1.5" or greater and use the Straight Wedge Joint for thicknesses less than 1.5". The notched wedge joint shall include a variable notched vertical edge (the notch vertical height to be equal to the mixture's maximum aggregate size). The sloped surface of the diagonal wedge joint shall not exceed a 6:1 slope. Prior to placing the adjacent paver pass for sloped joints, all joint contact surfaces shall be given a tack coat prior to placing any fresh mixture against the joint.

Vertical butt joints which are not constructed straight, or are not constructed with an edge restraining device (either a commercial paver screed attachment or by dropping the end gate down to the surface), or are damaged or otherwise defective shall be cut back 3 inches to expose a clean, sound surface for the full depth of the course. All vertical butt joint contact surfaces shall be given a coat of hot-pour rubberized asphalt sealer meeting the requirements of Federal Specification SS-S-1401 or SS-S-164 prior to placing any fresh mixture against the joint. All longitudinal joints on all courses shall be coated.

3. Longitudinal and transverse joints shall have an in-place density when measured by the average of three, six (6") inch cores between 90.0% to 98.0% of maximum theoretical.

Compaction of HMA Mixture After Placing - The mixture shall be thoroughly and uniformly compacted by rolling. The surface shall be compacted as soon as possible when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor. Rolling shall be initiated with the drive roll or wheel towards the paving machine. When rolling on steep grades, the previous procedure may need to be altered.

The speed of the roller shall, at all times, be sufficiently slow and of uniform speed to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. The number of rollers and passes required shall be governed by the compaction results; however, at least two rollers shall be provided for each paver employed on the paving operation. The City of Springfield is encouraging the use of pneumatic or oscillation rollers. If one of the selected rollers is pneumatic, it shall be equipped with the European square edge tires. This will allow the pneumatic roller to handle both the intermediate compaction as well as the back rolling responsibilities on two-roller trains. An alternate to a full pneumatic European tired roller would be a combination 10-ton steel vibratory with large pneumatic square edge rear wheels. An acceptable alternative to the vibratory or pneumatic tired rollers would be the "Hamm" Oscillatory roller. Each roller shall be operated by a competent, experienced roller operator and shall be kept in as nearly continuous operation as practicable while work is underway. A plate shall be attached to each roller showing the

ballasted and un-ballasted weight per length-width of tread.

To prevent adhesion of the mixture to the steel roller, the drums or shall be kept properly moistened, cocoa mats kept clean and scrapers used, but excessive water will not be permitted. Pneumatic rollers shall be operated on adjacent pavement surfaces to get the tires warm to hot from friction, then moved to the fresh mat.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with hand tampers and vibratory plate compactors.

Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching shall not be allowed.

Along any adjoining edge such as curb, gutter or an adjoining pavement, and after the HMA is placed by the paver, just enough of the hot HMA shall be placed by hand method to fill any space left open. These joints shall be properly 'set up' with the back of a lute at the proper height and level to receive the maximum compaction. Any areas where the rollers cannot access shall be hand tamped or plate compacted.

1. Shaping Edges - While the surface is being compacted and finished, the Contractor shall carefully trim the outside edges of the pavement to the proper alignment. Edges so formed shall be beveled while still hot with the back of a lute or smoothing iron and thoroughly compacted by tampers or by other satisfactory methods.

Surface Smoothness - The finished surfaces of the pavement shall be uniform in appearance, free from irregularities in contour and texture and shall present a smooth-riding surface. Smoothness evaluation applies to all hot mix asphalt concrete roadways receiving 1.5" or more in plan (compacted) thickness of HMA pavement.

Tests for conformity with the specified crown and grade shall be made by the Contractor immediately after initial compaction. Any variation shall be corrected by the removal or addition of materials and by continuous rolling.

The finished surface of the pavement, when measured with a 10-foot straightedge, shall not vary more than 1/4 inch for the surface course and 3/8 inch for the intermediate course measured perpendicular and parallel to the centerline. If, in the opinion of the Engineer, the surface visually appears wavy, but meets the surface tolerance test with the 10-foot straightedge, the Engineer reserves the right to additionally test with the use of Inertial Profile Equipment which records cumulative vertical deviations per unit length using a statistic called International Roughness Index (IRI). City of Springfield street upset limit for IRI is set at 135 in/mile using similar equipment that MASSDOT specifies in their Quality Assurance HMA projects.

After the completion of final rolling, the smoothness of the course shall again be tested; humps or depressions exceeding the specified tolerances shall be immediately corrected by removing the defective work and replacing with new material, as directed by the Engineer. This shall be done at the Contractor's expense.

Skin patching will not be permitted.

When profile corrections are required, the Contractor shall use one or more of the following corrective methods:

Removing and replacing the entire pavement thickness; Diamond grinding or micro milling;

Overlaying (not patching) with the specified surface course;

Removing the surface by milling and applying a lift(s) of the specified course(s); Use of other methods that will provide the desired results;

The corrective method(s) chosen by the Contractor shall be performed at the Contractor's expense, including all necessary equipment and traffic control. Areas of removal and replacement shall be removed the full width of the lane. The removal areas shall begin and end with a transverse butt joint which shall be constructed with a transverse saw cut perpendicular to the centerline. Replacement materials shall be placed in sufficient quantity so the finished surface will conform to grade and smoothness requirements. The corrective area shall conform to all material and density specification requirements. When the corrective work consists of an overlay, the overlay shall cover the full width of the pavement including shoulders. The area overlaid shall begin and end with a transverse butt joint which shall be constructed with a transverse saw cut and asphalt removal. All materials shall meet contract requirements. The overlay shall be placed so the finished surface will conform to grade and smoothness requirements. The overlaid area shall be compacted to the specified density.

The Engineer shall retest any sections where corrections were made to verify that the corrections produced a surface that conforms to the grade and smoothness requirements.

Uniformity - The HMA mat shall be smooth, dense, and uniform. Uniformity is generally affected by Thermal and/or Aggregate segregation.

If segregation is evident and discernable by either the Contractor or the Engineer, the Contractor shall immediately cease production and take steps to correct and eliminate the cause(s) of the segregation to the satisfaction of the Engineer.

The Contractor shall review all potential causes of segregation as it relates to its operation, including but not limited to HMA Plant issues, loading and transportation issues, placement issues, thermal segregation, and hand work. The Contractor shall employ additional investigation methods and make the necessary changes in their operation such that segregation is eliminated and mat uniformity is acceptable.
The Engineer shall obtain two (2) six inch diameter cores from the identified (segregated) area and two (2) six inch diameter cores from the non-segregated area. The cores may be evaluated for resilient modulus, dry tensile strength, change in air voids, maximum in place air voids, aggregate gradation and binder content. The results of the data obtained on the cores from the segregated area will be compared to the results of tests performed on the cores from the non-segregated area.

If any mix property is beyond the tolerance limits stated in the table below, that area shall be considered segregated and shall be repaired by the contractor.

TABLE 5. SEGREGATION LIMITS

Change in Mix Properties Expressed as a Percentage of the Properties in the Non-Segregated Areas	
Property	**Limits**
Resilient Modulus, psi @ 77^{o}F	<80%
Dry Tensile Strength, psi @ 77^{o}F	<90%
Aggregate Gradation and Binder Content	Refer to Table 6 (Action Limits)
Change in Air Voids	>2.5%

The samples for the segregation analysis will be considered separately from the mat and joint cores tested for acceptance.

Segregated areas not meeting the requirements stated above or areas having more than 13% air voids shall be removed and replaced for the entire pavement thickness and lane width, or as directed by the Engineer. All corrective methods shall be performed at the Contractor's expense. The removal areas shall begin and end with a transverse butt joint which shall be constructed with a transverse saw cut perpendicular to the centerline. The corrective area shall conform to all grades, smoothness, material, and density specification requirements. The Engineer may retest any areas where corrections were made to verify that the material meets specification requirements.

Thickness - The thickness requirements contained herein shall apply only when each pavement layer is specified to be a uniform compacted thickness of 1 inch or greater. Thickness may be evaluated for acceptance by the Engineer to the requirements shown on the plans. Measurements of thickness may be checked periodically by the Contractor in following their QC system for field operations. Measurements of thickness for acceptance may be made by the Engineer using four-inch minimum diameter pavement cores.

The finished surfaces of each HMA pavement course shall not vary from that specified or cross sections shown on the contract drawings by more than one-quarter (1/4) of an inch. The Contractor shall correct pavement areas varying in excess of this amount by removing and replacing the defective work or as ordered by the Engineer. Skin patching will not be permitted.

Grade - The finished surface of the pavement shall not vary from the gradeline elevations as shown on the plans by more than 1/2 inch. The Contractor shall remove deficient areas and replace with new material. Sufficient material shall be removed to allow at least 1.5 inches of hot mix asphalt to be placed. Skin patching for correcting low areas shall not be permitted. High points may be ground off.

Leveling Course - Any HMA used for truing and leveling shall meet the requirements of the mix design methods and the requirements of TABLE 2, 3, and 4 for the applicable mixtures. Leveling courses shall not be subject to density requirements. The thickness of the Leveling Course shall be measured off the interface with the existing milled or un-milled pavement surface. The leveling course shall be compacted with the same effort used to achieve placement and density of the test section. The truing and leveling course shall not exceed a nominal thickness of 1.5 inches.

Opening to Traffic - No vehicular traffic or loads shall be permitted on the newly completed pavement until adequate stability has been attained and the material has cooled sufficiently to an internal temperature of 140^{o}F or less. If the climatic or other conditions warrant, or if the PGAB manufacturer recommends, the period of time before opening to traffic may be extended at the discretion of the Engineer.

Contractor Quality Control of HMA Pavement

General – The Contractor is responsible for maintaining adequate quality control procedures throughout the production, placement, and compaction operations. The Contractor must ensure that the materials, mixtures, and work provided by Subcontractors, Suppliers, and Producers meet contract specifications. This effort must be documented in Quality Control Plans (QCP) and address the actions, inspection, sampling, and testing necessary to keep the production and placement operations in control, and to determine when an operation has gone out of control and the corrective actions needed to correct the situation in a timely manner. The QCP shall address all elements which affect the quality of the pavement including, but not limited to:

a. Mix Design
b. Aggregates
c. Asphalt Binder
d. Quality of Materials
e. Testing
f. Stockpile Management
g. Proportioning
h. Mixing and Transportation
i. Placing and Finishing
j. Joints
k. Compaction
l. Surface smoothness and uniformity
m. Thickness and grade

The Contractor shall be prepared to discuss and present, at the pre-paving conference, their understanding of quality control for this contract. A thorough and project specific quality control plan (QCP) shall be submitted by the Contractor a minimum of 30 days prior to production.

The Contractor shall perform all quality control sampling and testing, provide inspection, and exercise management control to ensure the production conforms to these specifications. The Contractor shall document these activities for each day of production. The Contractor shall submit complete plant testing and inspection records to the Engineer within 48 hours in a manner acceptable to the Engineer. All acceptance test specimens and supporting documentation shall be retained by the Contractor until directed for disposal by the Engineer. All quality control samples must be clearly labeled and available for pickup for verification testing if directed.

Production lots shall be defined as the total daily estimated tons. Sublots are defined as 300 tons. The sampling and testing shall be selected using stratified random sampling in accordance with ASTM D3665. An estimated lot less than 300 tons shall include a minimum of one sublot.

1. Control Charts

Contractor shall develop production control charts and post for visual reference in the testing laboratory. The control charts should identify the project number, the contract item number, the test number, each test parameter, the Action and Suspension Limits applicable to each test parameter, and the production test results. If the project data during production indicates a problem and the Contractor is not taking satisfactory corrective action, then the Engineer may suspend production or acceptance of the material, in accordance with these specifications.

Individual Measurements: Control charts for individual measurements may be established to indicate production quality control within given tolerances for aggregate gradation and asphalt binder content. The control charts will use the JMF target values as the indicator of central tendency for the following test parameters with associated Action and Suspension Limits:

TABLE 6 HMA PRODUCTION LIMITS FOR INDIVIDUAL MEASUREMENTS		
Sieve Size	**Action**	**Suspension**
1-1/2" (37.5mm)	0%	0%
1" (25.0 mm)	±6%	±9%
3/4" (19.0 mm)	±6%	±9%
1/2" (12.5 mm)	±6%	±9%
3/8" (9.5 mm)	±6%	±9%
#4 (4.75 mm)	±6%	±9%
#8 (2.36 mm)	±5%	±7.5%
#16 (1.18 mm)	±5%	±7.5%
#30 (0.600 mm)	±4%	±5.5%
#50 (0.300 mm)	±3%	±4.5%
#100 (0.150 mm)	±3%	±4.5%
#200 (0.075 mm)	±2%	±3%
Asphalt Binder Content	±0.4%	±0.70%
Design Air Voids (4.0%)	±1%	±1.7%
Voids in Mineral Aggregate	0.4% below mix specified min.	0.7% below mix specified min.

When evaluating the production limits, the sieve sizes above the maximum size aggregate should be deleted from the Individual Measurements Chart and the maximum aggregate sieve size Action and Suspension Limits should be changed to 0%.

Note {1}: Voids Filled with Asphalt will not be evaluated by the Engineer for acceptance. This does not relieve the Contractor from maintaining the material within the requirements specified above.

Range. Control charts for range shall be established to indicate production variability for the test parameters and Suspension Limits listed below. The range may be computed as the difference between the high and low test results per lot for each control parameter. The Suspension Limits specified below are based on a sample size of n = 2. If more than two tests per lot were used, the Suspension Limits shall be adjusted by multiplying the Suspension Limit by 1.18 for n = 3 and by 1.27 for n = 4.

Table 7 CONTROL CHART LIMITS BASED ON RANGE	
(Based on n = 2)	
Sieve	**Suspension Limit**
1-1/2" (37.5 mm)	11 percent
1" (25.0 mm)	11 percent
3/4" (19.0 mm)	11 percent
1/2" (12.5 mm)	11 percent
3/8" (9.5 mm)	11 percent
#4 (4.75 mm)	11 percent
#8 (2.36 mm)	10 percent
#16 (1.18 mm)	9 percent
#50 (0.30 mm)	6 percent
#200 (0.075 mm)	3.5 percent
Asphalt Binder Content	0.8 percent
Design Air Void Content	2.0 percent

Corrective Action. The Contractor should review the control charts on a continuous basis making adjustments to the process when necessary to keep the product consistent. As a minimum, a process shall be deemed out of control and production stopped and corrective action taken, if:

Design Air Void Content or Asphalt Binder Content falls outside the Suspension Limit line for individual measurements or range; or

Design Air Voids and two or more points fall outside the Action Limit line for individual measurements as indicated in Table 6; or

Design Air Voids fall outside the Action Limit and one point falls outside the Suspension Limit for individual measurements as indicated in Table 6; or

Three points in a row fall outside the Action Limit line for individual measurements as indicated in Table 6.

Three nonconsecutive samples out of 5 samples fall outside the Action Limit line for individual measurements as indicated in Table 6.

Two consecutive streets or two consecutive 1,000 ton lots of material tested for mat density or longitudinal joint density falls below the threshold density for 100% adjustment, as noted in Table 8 and Table 9.

The Contractor's Quality Control system shall include an appropriate action to be taken when the process is believed to be out of tolerance. The Contractor should review the control charts on a continuous basis making adjustments to the process when necessary to keep the product consistent.

The Contractor shall provide the required sampling and testing during all phases of the work in accordance with the acceptance testing requirements stated in section H. Quality Acceptance of HMA. The Engineer will verify the Contractor's acceptance test results.

H. QUALITY ACCEPTANCE OF HMA

Additional sampling and testing to determine conformance with the requirements specified in this section may be performed by the Engineer, or their representative, at no cost to the contractor, unless otherwise stated herein. Testing organizations performing these tests shall meet the requirements of ASTM D 3666. All equipment in Contractor furnished laboratories shall be calibrated and verified by a testing organization prior to the start of operations. Such verification/certification shall be furnished to the Engineer prior to production. Engineer's testing personnel shall be certified by the New England Transportation Technician Certification Program (NETTCP). This function does not relieve the Contractor from performing their daily quality control tasks as part of their normal operating business.

The Engineer or their agent shall have access at any time to all parts of the producing plant for:

a. Inspection of the condition and operations of the yard, plant and laboratory.
b. Confirmation of the adequacy of equipment in use.
c. Verification of the character and proportions of the mixture.
d. Determination of temperatures being maintained in the preparation of the mixtures.
e. Inspection of incidental related procedures.

Samples of all material including compacted specimens and certified copies of all reports and printouts shall be made available to the Engineer or its agent as often as requested including: asphalt binder; virgin aggregates; modifiers, loose and compacted mixture specimens; and combined aggregate samples.

1. PLANT-PRODUCED MATERIAL

Plant-produced material shall be sampled and tested for VMA, VFA, gradation, asphalt binder content, and air voids (Superpave at N_{design}), on a lot basis. The Engineer's testing personnel shall be certified by the New England Transportation Technician Certification Program (NETTCP), as HMA Plant Technicians. Sampling shall be from material deposited into trucks at the plant or from trucks at the job site. A lot will consist of:

- one day's production and shall be divided into 300 ton sublots. A minimum of one sample shall be obtained for each lot.

Where more than one plant is simultaneously producing material for, the job, the lot sizes shall apply separately for each plant.

Sampling - Sufficient material for analysis and preparation of test specimens will be sampled on a random basis, in accordance with the procedures contained in ASTM D 3665. A minimum of one set of laboratory compacted specimens will be prepared for each sublot in accordance with AASHTO T312, at the number of gyrations required by Table 3. Each set of laboratory compacted specimens will consist of two test portions prepared from the same field sample.

The sample of hot mix asphalt may be put in a covered metal tin and placed in an oven for not more than 30 minutes to maintain the heat. The compaction temperature of the specimens should be as specified in the JMF.

In addition to the hot mix asphalt samples, the Contractor shall take one, one-quart sample of the PG binder used to produce the hot mix asphalt at the start of the work. The PG sample shall be turned over to the Engineer on the first day of project production.

Testing

Bulk Specific Gravity - Two (2) laboratory fabricated sample specimens shall be tested for bulk specific gravity per sublot in accordance with AASHTO T166 or T331, whichever is applicable, for use in computing air voids and density. Air voids shall be computed in accordance with AASHTO T269.

Gradation and Asphalt Binder Content - The gradation and asphalt binder content of the mixture shall be measured for each sublot in accordance with the following:

Asphalt Binder Content – An extraction test be performed in accordance with AASHTO T164 or AASHTO T308 for determination of asphalt content. The weight of ash portion of the extraction test, as described in AASHTO T164, shall be determined as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture. If utilizing AASHTO T308 for asphalt content determination, the calibration process and calibration factor, as described in AASHTO T308, shall be determined as stated, prior to acceptance testing. A verification shall be performed as part of every twentieth test performed thereafter or when changes in the mix are apparent.

Gradation - Aggregate gradations shall be determined from mechanical analysis of extracted aggregate in accordance with AASHTO T 30 and AASHTO T27 (Dry Sieve).

The Dust-to-Effective Asphalt ratio shall be determined once for each sublot from the mechanical analysis of extracted aggregate and the asphalt binder content. The Dust-to-Effective Asphalt ratio shall be determined by the Engineer in accordance with AASHTO R35.

The Theoretical Maximum Specific Gravity of the mixture shall be measured for each sublot in accordance with AASHTO T209, Type C, D, or E container. Samples shall be taken on a random basis in accordance with ASTM D 3665. The value used in the field placed void computations shall be the average of the maximum specific gravity measurements for the lot.

Temperatures: Temperatures of the HMA shall be checked in the first three (3) haul units departing the production facility for each production day, and additionally once for each sublot. Additionally, temperatures may be checked to determine the temperatures of the dryer, the asphalt binder in the storage tank, the mixture at the plant, and the mixture at the job site for specification conformance.

VMA, VFA, and air voids, for each plant sample, will be determined in accordance with the applicable AASHTO test method. The VMA, VFA and air voids for each sublot shall be computed by averaging the results of the two test specimens representing that sublot.

Acceptance of Plant Produced HMA - Acceptance of plant produced HMA material will be based upon plant air voids, VMA, gradation, asphalt binder content, and temperature, and shall be determined by the Contractor in accordance with these specifications. The Contractor shall submit complete plant test reports to the Engineer within 48 hours in a manner acceptable to the Engineer.

2. FIELD PLACED HMA MATERIAL

HMA material placed in the field shall be tested for mat and longitudinal joint density on a completed street or public facility basis. The Contractor shall be responsible for providing field compaction information within 24hrs after completion of a street or public facility. The Contractor's testing personnel shall be certified by the New England Transportation Technician Certification Program (NETTCP), as HMA Paving Technicians. The Engineer may conduct any necessary testing to monitor or verify the specified density, uniformity and smoothness. A properly correlated density gauge shall be used to monitor the pavement density in accordance with ASTM D2950 or ASTM 7113. Monitoring density with density gauges by the Engineer does not imply acceptance or rejection; the Contractor is ultimately responsible to meet the requirements of the specification.

Sampling - Density gauges shall be used by the Contractor to determine density of the paving course mat and/or longitudinal joints. Cores of the material shall be minimized and only taken at the direction of the Engineer and approval of the City. Mat and longitudinal joint density tests will be located by the Contractor or their representative on a stratified random sampling basis for each street or facility paved. The length of the longitudinal paving joint will be divided into sub-lots for sampling and testing purposes. If more than one longitudinal joint is formed on a street, then the random sample length will be the total lineal feet of longitudinal joint placed. A mat and longitudinal joint test will be taken by the Contractor randomly from each of these sub-lot intervals. Sub-lots will be determined on the basis of five (5) sub-lots per one thousand (1,000) tons of material placed or a minimum of five (5) sub-lots from each street or facility paved. Sampling and testing for density will be conducted in the following manner:

During the CONTROL SECTION, paving courses will be tested with the density gauge (for correlation), then sampled by coring the mat and the centerline of the longitudinal joint for confined edge joint construction, or on the hot side of the longitudinal joint when using notched wedge joint construction. A 6-inch diameter wet-core bit specifically designed for cutting pavement shall be used. The cores will be tested for density and thickness.

When sampling of the longitudinal joint for density determinations by coring, the core will be taken directly over the joint for confined edge construction, on the hot side of the longitudinal paving joint, or adjacent to the vertical edge of an existing longitudinal joint, or as directed by the Engineer.

A density sample will be tested from each sub-lot segment. The total width of the paved surface (curb to curb) will be determined at the longitudinal sub-lot location to sample and test for mat density. A transverse off-set distance from the centerline of the roadway will be established for mat density sampling and testing. The location, either right or left of centerline, will be based on whether a random number is "odd or even" (odd=left; even=right). When the offset location is within 2 feet of the pavement edge, curb, catch basin or structure, or 1 foot off a longitudinal joint, or 10 feet off a transverse joint, the sample shall be relocated.

Once the density gauge has been correlated, all subsequent density testing may be conducted with a density gauge.

For nuclear gauge test locations, four 60 second readings will be taken with the gauge turned 90 degrees for each increment. The average of the four readings will be reported as the density value for each location. For non-nuclear density tests, five readings will be taken, after the first reading is taken the gauge will be moved up and to the right approximately 2" (the 2 o'clock position), three more readings will then be taken at the 4 o'clock, 8 o'clock, and 10 o'clock positions using the manufacturers operating procedures. The average of the five density values will be reported for each location.

If the results of the average density gauge readings for a street or pavement facility are below the threshold for 100% adjustment as indicated in Table 8 or Table 9, pavement cores may be removed as

per this specification, and used for determining the actual pavement density. Pavement cores will only be removed if a written request is received from the Contractor within 14 calendar days of the City's receipt of the density report. If a written request is not received, the average density gauge readings will be utilized for payment adjustment.

In the event that a new density gauge needs to be correlated for this project, cores should be taken from the mat and longitudinal joint representing the test locations. If previous core locations are available, the new density gauge should be correlated in accordance with the "re-correlation" procedure. If "re-correlation" is necessary, take four tests at quarter points around each of five previously cored and tested locations; making sure that the side of the nuclear or non-nuclear gauge is at the edge of the patched core location and firmly seated. Each test must be the average of four test increments turning the gauge 90 degrees.

All core samples shall be neatly cut with a core drill and water-cooled bit where the cutting edge of the core drill bit shall be of hardened steel or other suitable material with diamond chips embedded in the metal cutting edge. The minimum diameter of the sample shall be 6 inches. Samples that are clearly defective, as a result of sampling, shall be documented and retained, then another sample taken for testing. The Contractor shall furnish all tools, labor, and materials for cutting samples and filling the cored pavement. Cored holes shall be filled in a manner acceptable to the Engineer and within one day after sampling.

The average density will be used to determine the percent payment.

Resampling of the pavement shall be in accordance with applicable provisions of the NETTCP Quality Assurance Technologist Manual, latest edition and these specifications.

Apart from any Control Sections, if the Contractor is concerned about the test results obtained by the density gauges, the Contractor may request up to one time per street, that an equal number of random core samples be obtained and tested to replace the original density gauge readings. The coring, patching and testing of the samples will be the responsibility of the Contractor. Cores for the mat and/or longitudinal joint density tests will be located by the Engineer and witnessed by the Contractor. Cores locations will be based on a new stratified random sampling plan for each street or facility paved in accordance with the procedures stated above. Upon approval of the coring operation, the Contractor will notify the Engineer 48 hours in advance of the cores being taken such that the Engineer can witness the sampling. The additional cores must be tested by a NETTCP certified HMA plant technician in the presence of the Engineer or his designated representative.

Only one (1) set of additional mat and/or longitudinal joint cores will be allowed on a street or lot.

Testing - The bulk specific gravity of each cored sample will be measured by the Contractor's NETTCP certified technician in accordance with AASHTO T166 or T331, whichever is applicable. The theoretical maximum specific gravity shall be the average maximum specific gravity for the lot in accordance with the plant-produced material section. The percent density of each sample will be determined in accordance with AASHTO T269, using the bulk specific gravity of each sample and the average theoretical maximum specific gravity. Retesting of pavement shall be in accordance with applicable provisions of the NETTCP Quality Assurance Technologist Manual, latest edition. Core samples shall be retained by the Contractor and available for verification testing unless otherwise directed by the Engineer. All core results shall be submitted to the Engineer within 24hrs after testing.

Adjustment Pay Schedule for Mat Density - The pay factor based on the density adjustment schedule will be applied to the bid price per ton for compacted mixtures greater than or equal to 1-1/2 inches thickness as shown in the contract award.

Table 8.
HOT MIX ASPHALT MAT DENSITY
Adjustment Schedule

Average Percent of Maximum Density (minimum 5 samples)	Percent Payment
100.0 - 98.1	98
98.0 - 95.0	102
94.9 - 92.0	100
91.9 – 89.0	85
88.9 – 87.0	75
86.9 or less	rejection

Adjustment Pay Schedule for Longitudinal Joint Density - The pay factor based on the joint density adjustment schedule will be applied to the bid price per ton for compacted mixtures greater than or equal to 1 1/2 inches thickness as shown in the contract award.

Table 9.
HOT MIX ASPHALT LONGITUDINAL-JOINT DENSITY
Adjustment Schedule

Average Percent of Maximum Density (minimum 5 samples)	Percent Payment
100.0 - 98.1	98
98.0 - 95.0	102
94.9 - 90.0	100
89.9 - 88.0	85
87.9 - 87.0	70
86.9 or less	rejection

The total hot mix asphalt adjustment will be based on the weighted sum as follows:

.60 Mat Adjustment + .40 LJ Adjustment = Total HMA Adjustment

When the construction of the pavement does not include the construction of a longitudinal joint, the payment adjustment will be based on Table 8 only, no weighted sum will be calculated. Any bonus will be credited against any payment adjustment in the contract for HMA, but in no case will the payment for HMA exceed 100%.

Rejection of Inferior HMA The Engineer may at any time, notwithstanding previous plant acceptance, reject and require the Contractor to dispose of any batch of hot mix asphalt which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements. Similarly, the Engineer may at any time, notwithstanding field acceptance for mat density, reject and require the Contractor to correct any HMA pavement that was placed with unacceptable mat uniformity or paving joints due to low density, segregation, improper elevation, or tearing. In the event of such rejection, the Contractor and Engineer may take random split samples of the area(s) in question in the presence of the

Engineer, and if it can demonstrate in the laboratory, in the presence of the Engineer, that such material/pavement was erroneously rejected, payment will be made for the material at the contract unit price.

3. ROUNDING

Numbers used in all calculations shall be carried to the correct significant figures and rounded as follows:

a. When the first digit after those you want to drop is 4 or less, that digit and all others to the right are dropped. Ex. 62.9437 to 3 significant digits = 62.9

b. When the first digit after those you want to retain is 5 or greater, that and all others to the right are dropped and the last digit retained is increased by one. Ex. 1.955234 to 3 significant digits = 1.96.

c. All Intermediate calculations should not be rounded and shall be reported to two more significant figures than the least number of significant figures in the data values.

Test Standards and technical look-up tables take priority over these rounding rules.

4. OUTLIERS

Due to the extremely low probability of an outlier occurring in a small number of samples representing the Lot, no outliers will be considered. If a result is suspect, it would be prudent to take the time to investigate the sampling, testing, equipment calibration, production, and construction operation to identify the cause of the suspect reading.

I. MEASUREMENT

Method of Measurement - The quantity of hot mix asphalt to be paid for shall be the measured by the ton complete in place. The quantity of each truck load shall be obtained from printed tickets indicating the recorded batch weights or certified truck scale weights that have been properly countersigned by an authorized representative of the Engineer at the time of delivery. HMA quantities shall be verified by the Engineer using HMA yield calculations which will include the in-place bulk specific gravity and actual area and nominal depth for the mixture placed.

J. PAYMENT

Basis of Payment

Payment shall be made at the contract unit prices per ton complete in place with any applicable adjustments. This payment shall be full compensation for furnishing and placing all quality hot mix asphalt materials, including tack coat where specified, hot-pour rubberized asphalt sealer, cutting of keyways or milling/stripping of pavement to produce neat joints, mechanical sweeping of streets and for all labor, tools, equipment, materials, and all incidentals necessary to complete the work. No consideration will be given for additional payment for small areas of sidewalk left incomplete during construction.

Adjustment for Density

Adjustment for mat and joint density shall be made when the HMA material varies from the specification target limits but is within the tolerances stated in Sections H "Adjustment Pay Schedule for Density"; the material will be allowed to remain in place with the specified adjustment in payment with the exception of mixtures placed with mat density below 86.9 percent of maximum. Any bonus (102% payment for 95.0% to 98.0% density) will be credited against any payment adjustments in the contract for HMA, but in no case will the Payment for HMA exceed 100%.

PAY ITEM	DESCRIPTION	PAY UNIT
Bid Item XXX.X	Superpave Surface Course 9.5mm, Level 2	TON
Bid Item XXX.X	Superpave Surface Course 12.5mm, Level 2	TON
Bid Item XXX.X	Superpave Surface Course 12.5mm, Level 3	TON

TESTING REQUIREMENTS

AASHTO T104	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
AASHTO T11	Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
AASHTO T96	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
AASHTO T27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T255	Total Evaporable Moisture Content of Aggregate by Drying
AASHTO T2	Sampling of Aggregates
AASHTO M17	Mineral Filler for Bituminous Paving Mixtures
AASHTO T164	Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
AASHTO T176	Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
AASHTO T195	Determining Degree of Particle Coating of Bituminous-Aggregate Mixtures
AASHTO T166	Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
AASHTO T269	Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
ASTM D 2950	Density of Bituminous Concrete in Place by Nuclear Method
ASTM D 3665	Random Sampling of Paving Materials
ASTM D 3666	Inspection and Testing Agencies for Bituminous Paving Materials
AASHTO T287	Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method
AASHTO T89	Determining the Liquid Limit of Soils
AASHTO T90	Determining the Plastic Limit and Plasticity Index of Soils
ASTM D 4791	Flat or Elongated Particles in Coarse Aggregate
ASTM E 178	Practice for Dealing with Outlying Observations
ASTM D5821	Determining the Percentage of Fractured Particles in Coarse Aggregate
AASTHO T304	Uncompacted Void Content of Fine Aggregate
AASHTO T30	Mechanical Analysis of Extracted Aggregate
AASHTO T202	Viscosity of Asphalts by Vacuum Capillary Viscometer
AASHTO T240	Effect of Heat and Air on a Moving Film of Asphalt (Rolling Thin Film Oven Test)
AASHTO T283	Resistance of Compacted Asphalt Mixtures to Moisture Induced Damage

AASHTO T308 Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method The Asphalt Institute's Mix Design Methods for Asphalt Concrete Manual No. 2 (MS-2).

ADDITIONAL REQUIREMENTS

AASHTO M320 Standard Specification for Performance Graded Asphalt Binder

AASHTO M323 Standard Specification for Superpave Volumetric Mix Design

AASHTO M332 Standard Specification for Performance Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) Test

AASHTO R30 Standard Practice for Mixture Conditioning of Hot Mix Asphalt (HMA)

AASHTO R29 Grading or Verifying the Performance Grade of an Asphalt Binder

AASHTO R26 Standard Practice for Certifying Suppliers of Performance Graded Asphalt Binders

AASHTO R35 Standard Practice for Superpave Volumetric Design of Hot Mix Asphalt (HMA)

AASHTO T312 Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

AASTHO T315 Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)

AASHTO T316 Viscosity Determinations of Asphalt Binder Using Rotational Viscometer

1. METHOD OF TEST FOR BULK SPECIFIC GRAVITY OF AGGREGATE BLENDS WITH RAP Scope

This test method covers the procedure to determine the bulk specific gravity (Gsb) of a combined aggregate blend with RAP used in a HMA mixture.

This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with the test method's use. The test method user's responsibility is to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Referenced Documents

AASHTO Standards

T-2 Sampling Aggregates

T-84 Specific Gravity and Absorption of Fine Aggregates

T-85 Specific Gravity and Absorption of Coarse Aggregate T-100 Specific Gravity of Soils

T-164 Quantitative Extraction of Bitumen from Bituminous Paving Mixtures T170 Recovery of Asphalt from Solution by Abson Method

T-209 Maximum Specific Gravity of Bituminous Paving Mixtures

T-228 Specific Gravity of Semi-Solid Bituminous Materials (Pycnometer Method)

Other References

MS-2 Mix Design Methods for Asphalt Concrete by the Asphalt Institute Terminology

Terms and Abbreviations. Definitions for terms and abbreviations shall be in accordance with the Standard Specifications.

Significance and Use

This test method is used to determine the bulk specific gravity of a combined aggregate blend with RAP used in HMA mixture.

The bulk specific gravity (Gsb) of a combined aggregate blend is calculated using an estimate of the bulk specific gravity of the aggregate in the RAP and the actual bulk specific gravity of the other aggregates.

The bulk specific gravity of an aggregate blend is used to perform a volumetric analysis on compacted HMA in accordance with the Mix Design Methods for Asphalt Concrete by the Asphalt Institute.

Apparatus

Apparatus shall be as stated in the referenced test methods. Sampling

Sampling shall be as stated in the referenced test methods.

Procedure

Identify the coarse aggregate(s), fine aggregate(s) and RAP selected for use in the mix designs.

Identify and record the actual percentages for each of the aggregate components used in the combined aggregate blend of the mix design.
Obtain a representative sample of the coarse aggregate, fine aggregate mineral filler and RAP in accordance with the AASHTO procedures.

Determine and record the bulk specific gravity of each of the coarse aggregate(s) in accordance with AASHTO T-85.

Determine and record the bulk specific gravity of each of the fine aggregate(s) in accordance with AASHTO T-84.

Determine and record the maximum specific gravity of the RAP in accordance with AASHTO T-209, Type C, D, or E container.

Determine and record the asphalt content of the RAP using AASHTO T164.

Calculate and record the effective specific gravity of the RAP aggregate in accordance with the following:

$$Gse = (100 - Pbrap)/[(100/Gmmrap) - (Pbrap/Gbrap)]$$

Where:

Gse = Effective specific gravity of the RAP aggregate

Pbrap = Percent binder of the RAP

Gmmrap = Maximum specific gravity of the RAP

Gbrap = Specific gravity of asphalt in the RAP (AASHTO T228)

Calculate and record the effective specific gravity of the combined aggregate blend as follows.

$$GsbBlend = \frac{\%CA1 + \%CA2 + \%FA1 + \%FA2 + \%BHF + \%RAP}{\frac{\%CA1}{Gsb} + \frac{\%CA2}{Gsb} + \frac{\%FA1}{Gsb} + \frac{\%FA2}{Gsb} + \frac{\%BHF}{Gsb} + \frac{\%RAP}{Gse}}$$

Where:

GsbBlend = Bulk specific gravity of the combined aggregate blend. Gsb =

Bulk specific gravity of each respective aggregate.

Gse = Effective specific gravity of the RAP.

%CA1 = Percent of aggregate blend that is coarse aggregate #1.

%CA2 = Percent of aggregate blend that is coarse aggregate #2.

%FA1 = Percent of aggregate blend that is fine aggregate #1.

%FA2 = Percent of aggregate blend that is fine aggregate #2.

%BHF = Percent of aggregate blend that is bag house fines.

%RAP = Percent of aggregate blend that is RAP. Report

Report the Gsb of the combined aggregate blend to the nearest 0.001.

Obtain a representative sample of the coarse aggregate, fine aggregate mineral filler and RAP in accordance with the AASHTO procedures.

Determine and record the bulk specific gravity of each of the coarse aggregate(s) in accordance with AASHTO T-85.

Determine and record the bulk specific gravity of each of the fine aggregate(s) in accordance with AASHTO T-84.

Determine and record the maximum specific gravity of the RAP in accordance with AASHTO T-209, Type C, D, or E container.

Determine and record the asphalt content of the RAP using AASHTO T164.

Calculate and record the effective specific gravity of the RAP aggregate in accordance with the following:

Gse = (100 - Pbrap)/[(100/Gmmrap) - (Pbrap/Gbrap)]

Where:

Gse = Effective specific gravity of the RAP aggregate

Pbrap = Percent binder of the RAP

Gmmrap = Maximum specific gravity of the RAP

Gbrap = Specific gravity of asphalt in the RAP (AASHTO T228)

Calculate and record the effective specific gravity of the combined aggregate blend as follows.

$$GsbBlend = \frac{\%CA1 + \%CA2 + \%FA1 + \%FA2 + \%BHF + \%RAP}{\frac{\%CA1}{Gsb} + \frac{\%CA2}{Gsb} + \frac{\%FA1}{Gsb} + \frac{\%FA2}{Gsb} + \frac{\%BHF}{Gsb} + \frac{\%RAP}{Gse}}$$

Where:

GsbBlend = Bulk specific gravity of the combined aggregate blend. Gsb =

Bulk specific gravity of each respective aggregate.

Gse = Effective specific gravity of the RAP.

%CA1 = Percent of aggregate blend that is coarse aggregate #1.

%CA2 = Percent of aggregate blend that is coarse aggregate #2.

%FA1 = Percent of aggregate blend that is fine aggregate #1.

%FA2 = Percent of aggregate blend that is fine aggregate #2.

%BHF = Percent of aggregate blend that is bag house fines.

%RAP = Percent of aggregate blend that is RAP. Report

Report the Gsb of the combined aggregate blend to the nearest 0.001.

ITEM XXX.X **PROCESSED GRAVEL** **CUBIC YARD**

The work under this item shall conform to the relevant provisions of Sections 150, 401 and M1.03.1 of the MassDOT 1988 Standard Specifications For Highways and Bridges, the 2015 Supplemental Specifications and the following:

A. MATERIALS

Processed aggregate base shall conform to Section M1.03.1 of the Specification and have the following gradation as determined by AASHTO T11 and T27:

Sieve Designation	Percentage by Weight Passing Square Mesh Sieves
2 in	100
1 ½ in.	70-100
3/4 in.	50-85
No. 4	30-60
No. 200	0-10

B. CONSTRUCTION METHODS

Processed gravel shall be spread and compacted in layers not exceeding 8 inches in depth, compacted measurement. All layers shall be compacted to not less than 95 percent of the maximum dry density of the material as determined by the AASHTO Standard Method of Test T99, Method C at optimum moisture content, as determined by the Engineer. If the material retained on the #4 sieves is 50% or more of the total sample this test shall not apply, and the material shall be compacted to the satisfaction of the Engineer. The specific density of the Processed Gravel shall be maintained by determining the number of passes of a roller required to produce a constant and uniform density, as determined by the sand cone test or a nuclear density gauge.

Any stone with a dimension greater than 2 inches shall be removed from the sub-base before the Processed Gravel is compacted. Compaction shall continue until the surface is even and true to the proposed lines and grades within a tolerance of 3/8 inch above or below the required cross-sectional elevations and to a maximum irregularity not exceeding 3/8 inch under a 10 foot line longitudinally. Any specific area of gravel sub-base which, after being rolled, does not form a satisfactory, solid, stable foundation shall be removed, replaced and recompacted by the Contractor without extra compensation. The gravel

C. MEASUREMENT AND PAYMENT

Processed Gravel shall be measured as specified in Subsection 150.80

Processed Gravel will be paid for complete and in place at the contract unit price per cubic yard. No separate payment for shaping, grading, testing, and compacting of the sub-base as specified herein, but all costs in connection therewith shall be included in the price bid for Processed Gravel.

PAY ITEM	DESCRIPTION	PAY UNIT
XXX.X	PROCESSED GRAVEL	CUBIC YARD

ITEM 403 **RECLAIMED PAVEMENT FOR BASE COURSE AND/OR SUB-BASE** **SQUARE YARD (SY)**

DESCRIPTION

The work shall consist of producing a stabilized base course and/or sub-base through the recycling of the existing pavement structure and a specified depth of acceptable sub-base material. This combination of pavement and sub-base material is to be uniformly crushed, pulverized and blended, then spread, graded, and compacted to the lines and grades shown on the plans or established by the Engineer.

The work under this item shall conform to the relevant provisions of Sections 100, 200, 400 and M2.01.0 to M2.01.7 of the MassDOT 1988 Standard Specifications For Highways and Bridges, the 2015 Supplemental Specifications and the following:

MATERIALS

General.

All reclaimed material shall conform to the requirements of Subsection M1.09.0 of Division III, Materials.

Aggregate for Crushed Stone for Blending, used to correct gradation deficiencies, shall conform to the requirements of Subsections M2.01.0 to M2.01.6 of Division III, Materials.

Aggregate for Dense Graded Crushed Stone for Sub-Base shall conform to the requirements of Subsection M2.01.7 of Division III, Materials.

Sampling and Pretesting.

The Department will take and analyze test pits to the depth to be recycled and provide the following information in the bid proposal for each:

1. The location of the test pit.

2. The depth of existing asphalt pavement material to be recycled.

3. The aggregate gradation of the underlying material to be recycled.

The information supplied is intended to be an indication of the existing conditions and in no way releases the Contractor from the responsibility of fulfilling the requirements of this specification.

Any gradation deficiencies in the existing materials, as indicated by the test pits, shall be corrected by blending the appropriate aggregate size(s) into the mixture.

EQUIPMENT

The recycling equipment shall have a positive depth control to ensure a uniform depth of processing. This equipment shall have the ability to process the complete design depth specified into a homogeneous mass. It shall also be capable of crushing all oversize material encountered except ledge, or boulders larger than 8 inches (200 mm) in diameter.

A minimum of 14 calendar days prior to the proposed start of work, the Contractor shall submit in writing to the Engineer for approval, a description of the specific equipment and construction methods to be used in performing the work.

The Contractor will be required to demonstrate to the Engineer the ability of the work crew and equipment to produce reclaimed material conforming to specifications at a rate of production consistent with the time allowed under the Contract.

A test section shall be constructed approximately 500 feet (150 m) long and one lane wide, and be located within the project limits at a location determined by the Engineer. The forward speed and processing direction (e.g. up cutting vs. down cutting) of the recycling equipment shall be recorded during construction of the test section. Representative samples of the reclaimed material shall be taken from this test section for analysis by the Engineer. Full scale production will not be allowed to commence until the Engineer has reviewed the test results and gives written approval of the equipment and construction methods used in the construction of the test strip.

Failure to meet gradation requirements or an insufficient production rate may be considered cause for rejection of the equipment, the construction methods, or both. The Contractor must then submit, in writing, the proposed changes in equipment and/or construction methods and either construct another test section or reconstruct the original section, as determined by the Engineer. This procedure may be repeated until acceptable results are obtained, at no additional compensation.

Failure to meet gradation requirements due to improper equipment or construction methods, shall not constitute a reason for any additional compensation for the import and blending of any aggregate to meet the deficiencies. Approval of equipment includes the speed and processing direction it was operated at during construction of the test section. Therefore, the same operating speed and processing direction must be maintained during normal production.

Changes in the equipment's operating speed and/or processing direction may only be made with the Engineer's written approval.

At least one vibratory roller shall be used on each reclaimed surface, and shall have a compacting width of not less than 5 feet (1.5 m). Each roller shall have a gross weight of not less than 15 tons (14.6 Mg).

Approved equipment shall be maintained in satisfactory working condition at all times.

CONSTRUCTION METHODS

General.

Reclaiming operations shall not be permitted when the existing pavement or sub-base contains frost, when the sub-base is excessively wet as determined by the Engineer, nor when the air or surface temperature is below 40°F.

Reclaiming operations shall not commence before April 15 and shall terminate on or before October 15 unless otherwise approved in writing by the Engineer.

Prior to the start of reclaiming operations, the Contractor shall locate and protect existing drainage and utility structures and underground pipes, culverts, conduits and other appurtenances. The limit of each sequence of the reclamation process shall be 1 mile (1.7 km) full width or as directed by the Engineer in order that the placing of pavement structure, up to the binder course, will be completed before beginning the next sequence of roadway reclamation work.

Structure Lowering and Raising.

All work shall be done in accordance with the applicable provisions of Section 220.

All drainage, utility, and municipality structures are to be referenced and lowered to a minimum depth 6 inches (150 mm) below the bottom of the proposed reclaimed base course. Lowered structures shall be covered with steel plates conforming to the requirements specified in Subsection 7.09. The voids remaining after the structures have been lowered are to be filled with a suitable material as determined by the Engineer. The Contractor will be responsible for the coordination with the respective utility companies for the lowering and raising of privately owned structures and gate boxes. The reclaiming operation shall not begin until all structures and boxes are lowered.

It shall be the Contractor's responsibility to maintain drainage functioning properly in the areas under construction up to the time when the final system is put into use. All structures lowered will be raised to the binder grade elevation upon placement of the binder course material for that section. Adjustment of the castings to final grade will not be allowed until the Engineer approves the placement of hot mix asphalt top course material throughout the project.

Any drainage structure found to be deteriorated below the plated depth shall be rebuilt from the bottom of the deterioration to the plated depth.

Reclaiming Operations.

Prior to the start of reclamation, the existing pavement shall be swept with a power sweeper to remove all trash, sand, dirt, organic matter, and other undesirable material, to the satisfaction of the Engineer.

Also, the existing pavement shall be sawcut full depth within the areas where the adjacent surface is to be protected (curb, side streets, etc.) as shown on the plans and/or as directed by the Engineer. The Contractor shall reclaim only that area of pavement that can be processed and compacted by the end of the same working day, at which time it must be opened to traffic, with the Engineer's approval. In any section, reclamation work shall be done on one-half the road width at a time. One-way traffic will be allowed only during working hours with traffic police present. Two-way traffic shall be maintained at all other times. Suitable ramping shall be in place at the beginning and end of each work zone to allow for smooth and safe travel. This shall be considered incidental to the work for this item. The required density shall be maintained until the hot mix asphalt pavement has been placed. Any imperfections discovered prior to the placement of hot mix asphalt shall be repaired, as directed by the Engineer, at no additional compensation.

The total thickness of the pavement structure, unless otherwise indicated, and uppermost portion of the sub-base layer shall be recycled to the design depth specified on the typical sections. The Engineer shall perform a sieve analysis of the reclaimed material for every 5,000 square yards (4,200 m2) of material processed or as often as conditions may require as determined by the Engineer. Test results shall be made available to the Contractor. If conditions warrant, the Engineer may stop work until the required test results become available. If the Engineer directs, due to grading deficiencies in the existing materials as indicated by the test pits, the appropriate crushed stone aggregate sizes shall be blended with the recycled material to produce a uniform mixture meeting the gradation requirements. Additionally, if the Engineer directs, dense graded crushed stone shall be added for volume purposes.

Any required modifications to the remaining sub-base such as, but not limited to, cuts, fills, and grade realignment shall be made. Existing unsuitable material shall be removed to the lines and grades established by the Engineer and replaced with a suitable material, as determined by the Engineer. Existing surplus reclaimed material shall be used, when available, at no additional compensation.

All unsuitable material and/or excess reclaimed material shall become the property of the Contractor to be properly disposed of outside the project limits.

Compaction and Dust Control.

The reclaimed material shall be rolled, compacted and fine graded to the specified cross section(s) and/or grades as shown or as established by the Engineer.

The reclaimed base course shall be tested for compaction and smoothness and accuracy of grade in accordance with the applicable provisions of Subsection 401.60. The required density shall be measured by a Nuclear Density Gauge supplied by the Department. If any portions are found to be unacceptable by the Engineer, such portions shall be reprocessed, regraded, and recompacted until the required smoothness and accuracy are obtained.

At the end of each days progress, the Contractor shall apply Calcium Chloride in accordance with the applicable provisions of Section 440. Water for roadway dust control shall be applied as directed.

A grader, roller, and water wagon shall be maintained on the project site during the reclamation process. The Contractor shall submit to the Engineer, in writing, a 24 hour availability telephone number for any emergency maintenance dictated by the weather conditions or as determined by the Engineer, for repair, compaction, and dust control.

MEASUREMENTS

Reclaimed Base Course shall be measured in place, to the limits specified on the plans or as directed by the Engineer.

No deductions will be made for surface structures. The lowering and the plating of gates and structures will be considered incidental to this Item and no additional compensation will be allowed.

Structures raised from the plated depth to an intermediate depth of approximately 8 inches (200 mm) below finished grade, as determined by the Engineer, shall be plated and shall be measured by the unit each as a Drainage Structure Remodeled.

Structures adjusted from the intermediate depth to finished grade shall be measured by the unit each as a Drainage Structure Adjusted.

Structures rebuilt shall be measured by the average height in feet and tenths of feet from the bottom of the deterioration to the plated depth. Structures damaged below the plated depth, due to the Contractors negligence, shall be measured and deducted from the depth measurement. Raising the structure from the plated depth will be measured as stated above for a remodeled unit

PAYMENT

The accepted quantity of reclamation as measured above shall be paid for at the contract unit price bid per square yard.

This unit price shall include all compensation for crushing, pulverizing, blending, spreading, grading, sawcutting the existing asphalt pavement at the direction of the Engineer, compacting, test section construction, blending with aggregate, moving the processed material to allow for modifications to the remaining sub-base and/or subgrade, moving reclaimed material from one location to another within the project and any incurred costs resulting from the Contractor's decision to process off site.

The unit price bid shall also include compensation for all costs associated with the removal of the castings and the referencing, lowering, and plating of the structures. It shall also include full compensation for all labor, tools, equipment, materials, and all incidental work necessary to complete the work as specified.

Removal and disposal of unsuitable material, surplus reclaimed material, or any sub-base/subgrade material necessary for grade changes shall be paid for at the contract unit price per cubic yard for Item 120.1, Unclassified Excavation.

Special borrow required to be placed under the reclaimed material shall be paid for at the contract unit price per cubic yard for Item 150.1, Special Borrow. Grading and compacting the sub-base and/or subgrade resulting from the removal of unsuitable material shall be paid for at the contract unit price per square yard (m2) for Item 170., Fine Grading and Compacting.

Adjustment of drainage structures shall be paid for at the contract unit price each for Item 220., Drainage Structure Adjusted.

Rebuilding of drainage structures shall be paid for vertically at the contract unit price per foot (m) for Item 220.2, Drainage Structure Rebuilt.

Raising of lowered structures shall be paid for at the contract unit price each for Item 220.5 Drainage Structure Remodeled.

Aggregate for providing added volume shall be paid for at the contract unit price per ton (Mg) or Item 402.1, Dense Graded Crushed Stone for Sub-base.

Aggregate to correct gradation deficiencies shall be paid for at the contract unit price per ton (Mg) for Item 403.1, Crushed Stone for Blending.

Calcium Chloride for dust control shall be paid for at the contract unit price per pound (kg) for Item 440., Calcium Chloride for Roadway Dust Control.

Water for dust control shall be paid for at the contract unit price per 1,000 gallons (m3) for Item 443., Water for Roadway Dust Control.

ITEM XXX.X **ULTRATHIN BONDED WEARING COURSE** **SQUARE YARD**

DESCRIPTION

This work consists of applying a warm Polymer Modified Emulsion Membrane followed immediately with an ultrathin overlay of hot mix asphalt (HMA).

MATERIALS

Mix Design - The Contractor shall formulate and submit a job mix formula that satisfies the design general limits listed in Table 1.

Table 1
MIXTURE REQUIREMENTS

Composition by weight percentages				
	Type A	**Type B**	**Type C**	
Sieve Size	% Passing	% Passing	% Passing	Tolerance, %
¾ inch			100	
½ inch		100	85 – 100	
⅜ inch	100	85 - 100	60 – 80	± 5
#4	40 - 55	28 - 38	28 –38	± 4
#8	22 - 32	22 - 32	22- 32	± 4
#16	15 - 25	15 - 23	15 – 23	± 3
#30	10 - 18	10 - 18	10 – 18	± 3
#50	8 - 13	8 - 13	8 – 13	± 3
#100	6 - 10	6 - 10	6 – 10	± 2
#200	4 - 7	4 - 7	4 – 7	± 2.0
Asphalt Content, %	5.0 - 5.8	4.8 - 5.6	4.6 - 5.6	± 0.5
Draindown Test, AASHTO T305	0.10% max			
Moisture Sensitivity, CP- L 5109	80% min			
Min. Application, lb/yd^2	40	65	65	
Min. Application, thickness	½ inch	⅝ inch	⅝ inch	
PG Asphalt Grade as specified				
Note: A target of 100% passing the ⅝-inch sieve is recommended. Mixtures containing ⅝-inch aggregate size will require greater placement depth and weight. Specimens for Lottman testing shall be compacted to 100 gyrations according to CP-L 5115, then tested according to CP-L 5109, regardless of void content. Mixture and compaction temperatures shall be as recommended by the binder supplier.				

Coarse Aggregates - The coarse aggregates selected should be those typically used for high performance surfaces. Coarse aggregates shall meet the requirements listed in Table 2.

Aggregates for Ultrathin Bonded Wearing Courses shall consist of clean, hard, durable fragments of crushed stone, crushed gravel, or crushed slag. The aggregate shall conform to the properties listed in Table 2.

Table 2
COARSE AGGREGATE PROPERTIES

TESTS		METHOD	LIMIT
Los Angeles abrasion value, % loss		AASHTO T 96-94	35 max
Soundness, % loss	Magnesium Sulfate or Sodium Sulfate	AASHTO T 104-94	18 max 12 max
Flat & Elongated Ratio		ASTM D 4791	25% max (3:1)
% Crushed, two or more mechanically fractured faces		ASTM D 5821	95 min
Micro-Deval, % loss		ASTM D6928	18 max

Fine Aggregates - The fine aggregates will be part of the asphalt mastic. The fine aggregates shall meet the requirements of Table 3.

Table 3
FINE AGGREGATE PROPERTIES

TESTS	Method	Limit
Sand Equivalent	AASHTO T 176-86	45 min
Methylene Blue (on materials passing 200)	AASHTO TP 57-99	10 max
Uncompacted Void Content	AASHTO T 304-96	45 min

Mineral Filler - Mineral filler may be used as an option to aid in meeting the gradation requirements. When required, hydrated Lime, certain classes of fly ash, baghouse fines and Type 1 portland cement are acceptable as mineral filler. Other materials are to be determined by mixture analysis.

Polymer Modified Emulsion Membrane - The Polymer Modified Emulsion Membrane is a styrene-butadiene block co-polymer (S.B.) modified asphalt emulsion. Its role is to form a water impermeable seal at the existing pavement surface and to bond the new hot mix to the existing surface. Polymer modification of the base asphalt shall be completed prior to emulsification. The emulsion shall be smooth and homogeneous and conform to the requirements of Table 4.

Table 4
POLYMER MODIFIED EMULSION TESTS

TESTS ON EMULSION	METHOD	MIN.	MAX.
Viscosity @ 77°F, SSF	ASTM D88	20	**100**
[1]Sieve Test, %	ASTM D244		0.05
[2]24-Hour Storage Stability, %	ASTM D244		1
[3]Residue from Distillation @ 400°F, %	ASTM D244	63	
Oil portion from distillation, ml of oil per 100 g emulsion	ASTM D244		2
TEST ON RESIDUE FROM DISTILLATION			
Elastic Recovery, 77 ° F, 20 cm elongation, %	AASHTO T 301	58	
Penetration @ 77 °F, 100 g, 5 sec	ASTM D5	60	150

[1]The sieve test is waived if successful application of the material has been achieved in the field.

[2] After standing undisturbed for 24 hours, the surface shall show no white, milky colored substance, but shall be a smooth homogeneous color throughout.

[3] ASTM D244 with modifications to include a 400°F ± 10°F maximum temperature to be held for a period of 15 minutes.

Asphalt Binder for Hot Mix Asphalt (HMA) – The Asphalt Binder shall be a Performance Graded Asphalt Binder (PGAB) which meets the specification requirements of AASHTO M320 or M332 and AASHTO R29. Acceptance of the PGAB will be in accordance with AASHTO R26 “Standard Practice for Certifying Suppliers of Performance Graded Asphalt Binders”. PGAB shall be provided by an Approved Supplier (AS) under the Approved Supplier Certification (ASC) system.

THE PGAB GRADE SELECTED FOR THIS WORK IS PG 64S-28 or 64S -22 under AASHTO M332 or PG 64-28 or 64-22 under AASHTO M320 - If traffic speed and/or level warrant, the PGAB may be adjusted by the Engineer for the design traffic conditions

EQUIPMENT

The Contractor shall use a self-priming paver, designed and built for the purpose of applying the Ultrathin Bonded Wearing Course. All other equipment and tools are subject to approval by the Engineer. All equipment and tools shall be maintained in satisfactory working condition at all times.

The self-priming paving machine shall be capable of spraying the Polymer Modified Emulsion Membrane, applying the HMA overlay and leveling the surface of the mat in one pass at the rate of 30 to 100 feet per minute. The paving machine shall incorporate a receiving hopper, feed conveyor, insulated storage tank for Polymer Modified Emulsion Membrane, Polymer Modified Emulsion Membrane spray bar and a variable width, heated, vibratory-tamping bar screed. The screed shall have the ability to be crown the pavement at the center both positively and negatively and have vertically adjustable extensions to accommodate the desired pavement profile.

CONSTRUCTION METHODS

Application – The Ultrathin Bonded Wearing Course shall not be placed on a wet pavement. The pavement surface temperature shall not be less than 60 °F at the time of placement. A damp pavement surface is acceptable for placement if it is free of standing water and favorable weather conditions are expected to follow for the next two hours.

The Polymer Modified Emulsion Membrane shall be spray applied immediately prior to the application of HMA overlay to produce a homogeneous wearing surface that can be opened to traffic immediately upon sufficient cooling. The finished wearing course shall have a minimum thickness of 1/2 inch for Type A and 5/8 inch for Type B and Type C.

The Polymer Modified Emulsion Membrane shall be sprayed at a temperature of 140 to 180 °F. The sprayer shall accurately and continuously monitor the rate of spray and provide a uniform application across the entire width to be overlaid. The rate of application (typically 0.10 to 0.25 gallons per square yard) shall be determined by the mix design and current pavement condition.

No wheel or other part of the paving machine shall come in contact with the Polymer Modified Emulsion Membrane before the HMA is applied. The paver shall be capable of applying the HMA within 5 seconds of applying the Polymer Modified Emulsion Membrane

The HMA shall be applied at a temperature of 300 to 330 °F and shall be spread over the Polymer Modified Emulsion Membrane immediately after the application of the Polymer Modified Emulsion Membrane. The HMA shall be rolled over the full width of the Polymer Modified Emulsion Membrane with a heated, combination vibratory-tamping bar screed.

The new pavement shall not be opened to traffic until the rolling operation is complete and the material has cooled sufficiently to resist damage.

Surface Preparation. The following items shall be performed prior to the commencement of paving operations:

1. Manhole covers, drains, grates catch basins and other such utility structures shall be protected and covered with plastic or building felt prior to paving and also shall be clearly referenced for location and adjustment after paving.
2. Thermoplastic traffic markings shall be removed. Symbols, characters, or other markings greater than 1/4 inch thick over the existing pavement shall be removed.
3. Crack sealant shall be applied to all major cracks >1/4” wide. The sealant will be applied in accordance with manufacturer’s recommendation and approved by the Engineer.
4. Surface irregularities greater than 1 inch deep shall be filled with a material approved by the Engineer.
5. The entire pavement surface to be overlaid shall be thoroughly cleaned of deleterious material, giving specific attention to accumulated mud and debris. Pressurized water, vacuum systems, or both may be required to ensure a clean surface.

Rolling. Rolling of the wearing course shall consist of a minimum of two passes with a steel double drum asphalt roller of minimum weight of 11 tons, operated in the static mode, before the material temperature has fallen below 185 °F. At no time shall the roller or rollers be allowed to remain stationary on the freshly placed HMA. Rollers shall be well maintained, in reliable operating condition and be equipped with functioning water system and scrapers to prevent adhesion of the fresh mix onto the roller drums. Adequate roller units shall be supplied so the rolling will be accomplished promptly following the placement of the material. A release agent (added to the water system) may be required to prevent adhesion of the mix to the roller drum and wheels.

METHOD OF MEASUREMENT

The Ultrathin Bonded Wearing Course will be measured by the square yards of pavement surface completed and accepted.

PAYMENT

The accepted quantity of Ultrathin Bonded Wearing Course will be paid for at the contract unit price bid per square yard.

Payment will be made under:

PAY ITEM	DESCRIPTION	PAY UNIT
XXX.X	ULTRATHIN BONDED WEARING COURSE	SQUARE YARD

Payment will be full compensation for all labor, materials, and equipment necessary to complete the work