Figures

Tables

1.0 INTRODUCTION

This guidance is provided as support of Westport Zoning By-Law Article 20, Low Impact Development (LID) Site Plan Approval. LID is a comprehensive approach to managing stormwater that is integrated into a project's design to minimize the hydrologic impacts of development. This is different from the conventional pipe-to-pond stormwater management approach. Conventional stormwater controls for new development and redevelopment projects often have been ineffective in mitigating the potentially negative impacts on natural resources and ecosystems. It is now widely recognized that a new system of practices is required to avoid, minimize or manage such potential impacts. Land development changes the landscape in numerous ways, for instance vegetated areas are replaced by impervious cover such as rooftops, parking lots, roads, and sidewalks that are impermeable to rainfall. Consequently, instead of infiltrating into the soil, stormwater runs off these impervious surfaces carrying significant quantities of water and pollutants into lower points of the watershed. This increases the likelihood of flooding and decreases the water quality of rivers, ponds and other water resources. Stormwater, including snow melt, is the single largest source responsible for water quality impairment in the Commonwealth[1]. LID practices reduce both the volume of stormwater runoff and the concentration of pollutants running off into surface waters, enhance groundwater recharge, and promote the natural treatment of stormwater.

The LID Bylaw was established in 2011 as a way to address the problem of excessive run-off onto Town and subdivision roads. It will establishes minimum requirements and controls to protect and safeguard the general health, safety, and welfare of the public as well as the environment and natural resources within the Town's jurisdiction from the adverse impacts of soil erosion, sedimentation, and stormwater runoff.

Years ago, before modern zoning was in place, there was no or very little control over development in any meaningful way. In Westport, the Zoning By-Law has slowly evolved from requiring a minimum of 20,000 square feet, then 40,000 square feet and now to 60,000 square feet of area, or approximately 1~ acres, to become a legal building lot. These changes reflect reaction to the rapid development of many areas in Town during the 1960's and 70's, and the desire to decrease the impact of development on our local groundwater supplies from individual cesspools, and now Title 5 septic systems. This type of land use pattern can contribute to large impervious areas, loss of natural resources and habitat, increase in non-point source pollution, and alteration of hydrologic systems

In accordance with the By-Law, the following three main objectives of LID should be considered whenever a new or redevelopment project is proposed:

- ✓ Avoid the impacts - identify and preserve natural areas that can be used to protect water resources;
- ✓ Reduce the impacts - minimize impervious areas at the maximum extent possible; and
- ✓ Manage impacts at source - implement Best Management Practices close to source.

The first objective is largely being addressed in the Open Space Residential Development (OSRD) document for the Town of Westport which encourages less sprawling development and a more efficient

[1] Massachusetts Stormwater Management Standards. Chapter 1, page 1.

form of development that minimizes the amount of disturbance and promotes permanent preservation of open space. While OSRD is largely a strategy that promotes avoidance of impacts, other design activities that are not directly related to OSRD include grading with the natural terrain and avoidance of impacts to water resource buffers. The two remaining objectives are the focus of this guidance document.

Applicants are encouraged to utilize the guidelines presented in this document along with the Massachusetts Stormwater Management Standards (*MASWMS*) and the Board of Health "Stormwater Quality and Quantity Control Regulation when preparing a site plan and design. Additionally, a checklist is included which will be useful for applicants to verify that all the requirements are met prior the LID plan submission.

2.0 LID GOALS

The purpose of LID is to reduce the environmental "footprint" of a development site while retaining and enhancing the owner/developer's purpose and vision for the site. The goals of LID include:

- Preserve natural areas, native vegetation, and reduce the impact on watershed hydrology;
- Protect natural drainage pathways as a framework for site design;
- Reduce impervious cover and, thus, the generation of stormwater runoff volume;
- Prevent impacts to natural drainage ways, surface waters, and wetlands;
- Manage water (quantity and quality) as close to the source as possible and minimize the use of large stormwater collection and conveyance systems;
- Utilize less complex, non-structural methods for stormwater management that have lower cost and lower maintenance requirements than conventional structural controls; and
- Create a multifunctional landscape.

These goals are consistent with the By-Law's purpose which is to "*establish minimum requirement controls to protect and safeguard the environment, natural resources, general health, safety and welfare of the public residing in watersheds within the town's jurisdiction*" from impacts resulted from soil erosion, sedimentation and stormwater runoff.

3.0 AVOID IMPACTS (THOSE NOT ALREADY COVERED BY OSRD)

LID site planning and design process is to avoid disturbance of natural features. This includes identification and preservation of natural areas that can be used in the protection of water resources. It is important to understand that minimizing the hydrologic alteration of a site is just as important as stormwater treatment for resource protection.

CLEARING AND GRADING

Figure 1. Clearing and Grading

Impacts may be avoided by development design that takes into account the natural factors of the site and its surroundings. One of the most disturbing and destructive stages in the development process is clearing vegetative cover and then grading the site. Soils are exposed to erosion, the site is compacted by heavy equipment, and the natural terrain and drainage are completely altered. This can result in sedimentation of water bodies, less vegetative cover and degradation of riparian areas.

A way to avoid these negative impacts is to create or modify the ordinances and regulations that require applicants to maintain natural conditions to the maximum extent practicable. The tools to do this include: allowing steeper slopes to be stabilized with low/no maintenance vegetation and erosion control blankets; limiting the amount of site disturbance to no more than a prescribed amount (such as five acres) at a time; requiring applicants to more closely balance earthwork when grading smaller site areas; and limiting the maximum amount of cut or fill on a site to prescribed amount (such as five feet) that will limit the total grading amount.

WATER RESOURCES BUFFERS

Impacts to water resources such as streams, wetlands and groundwater can be avoided by preserving natural buffers within riparian areas. Given their location between water resources and land, these riparian buffer zones are essential to maintaining the ecology of aquatic systems and provide a range of important functions.

Protecting riparian buffers during the development process can help provide undisturbed open space, maintain predevelopment hydrology, and allow precipitation to naturally infiltrate into the ground. Also, maintaining these natural areas will maximize the protection of natural drainage areas, streams, surface waters, wetlands, and jurisdictional wetland buffers.

Figure 2. Water Resources Buffers

- Trapping/removing phosphorus and nitrogen from runoff, as these pollutants can lead to eutrophication of aquatic ecosystems;
- Trapping/removing sediment and other contaminants;
- Providing habitat and contiguous corridors for wildlife;
- Stabilizing stream banks and reducing channel erosion;
- Storing flood waters, thereby decreasing damage to property;
- Maintaining habitat for fish and other aquatic organisms by moderating water temperatures and providing woody debris;
- Improving the aesthetics of stream corridors (which can increase property values); and
- Offering recreational and educational opportunities.

BENEFITS OF IMPLEMENTATION

Projects can benefit from practices that avoid impacts by maintaining the construction with the lowest disturbance possible and taking advantage of the natural functions of resources at the site. The more destructive the activity, the more it will affect the original landscape and the more costly the stormwater management system will likely be.

Table 1. Benefits of Implementation Activities for Avoiding Stormwater Impacts

Activities	Stormwater and Cost Benefits
Minimizing clearing and grading	• Preservation of natural hydrology of the site and surroundings • Protection of site's vegetation and topography that help maintain groundwater recharge • Construction costs can be reduced by reducing disturbed area (less equipment, materials, land area to be stabilized, etc.)
Preserving water resource buffers	• Attenuation of flood and erosive velocities that otherwise will be increased • Reduction of overall stormwater runoff in the watershed by reducing streambank erosion and flooding • Sheet flow across vegetation can remove sediment, nutrients, bacteria and other pollutants • The presence of buffers may improve the market value of adjacent properties • Reduces the need for floodwater storage and stormwater treatment

4.0 REDUCE IMPACTS

If stormwater impacts cannot be avoided, practices to minimize such impacts should be considered and implemented. Stormwater runoff is generated by primarily impervious surfaces, such rooftops, roadways or any hardened low permeability surface that prevents or limits water from absorbing into the ground. Development normally adds impervious cover in the watershed, which if not properly managed, may alter natural drainage features, increase peak flow rate and volume, reduce recharge to groundwater and increase the discharge of pollutants to water resources. Minimizing impervious areas as part of the planning, design and implementation of development and redevelopment projects is a key element of LID design.

STRATEGIES THAT CAN REDUCE STORMWATER IMPACTS

- **Reduction of Roadway Area** – involves site design techniques where excessive roadway lengths and widths are minimized on a development site to the extent practical to reduce overall imperviousness.
- **Reduction of Sidewalk Area** – is a design approach where overall sidewalk area is minimized on a development site to the extent possible to reduce overall imperviousness.
- **Reduction of Driveway Area** – employs approaches such as shared driveways that connect two or more homes together, alternative driveway surfaces, and smaller lot front building setbacks to reduce total driveway imperviousness (Refer to Article 21, Common Driveways).
- **Reduction of Cul-de-Sac Area** – involves approaches that minimize the number and size of cul-de-sacs and incorporates landscaped areas to reduce their impervious cover.
- **Reduction of Building Footprint Area** – is a strategy where residential and commercial building footprint area is reduced by using alternate or taller buildings while maintaining the same floor-to-area ratio.
- **Reduction of Parking Lot Area** – involves a range of strategies to reduce the overall size of parking lots, including eliminating unnecessary spaces, providing some compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, utilizing multi-storied parking decks, using permeable surfaces, and reducing parking ratio requirements.

Table 2 summarizes the objectives and recommended practices for each of the LID reduction practices that are likely applicable in Westport and the regulations described in the By-Law.

Table 2. LID Objectives and Recommended Practices

LID Reduction Practices		Objectives	Recommended Practices
Reduction of Roadway Area	Travel way (pavement) width	Design residential streets as narrow as possible considering future traffic without compromising safety	- Roadways should be wide enough to accommodate all traffic services - Consider local pavement standards that encourage impervious cover reductions
	Right-Of-Way (ROW) width	Design ROW with the minimum width that allows for safely accommodating travel lanes, pedestrians, and vegetated open channels.	- See Table 3. ROW standards in Westport - Alternative approaches to roadway design such as allowing utilities to be placed beneath the paved section would allow for reduced ROW widths and may create a path for conveying stormwater through open channels.
Reduction of Sidewalk Area		Adopt design standards that are based on safe pedestrians movement while limiting impervious cover	- Where practical, sidewalks should be graded to drain into front lawns to avoid unnecessary costs and minimize the runoff effect of sidewalk impervious cover. - Alternative surfaces such as permeable asphalt or gravel could be considered - At low design speeds (10-15 miles per hour), sidewalks may be integrated with the road surface (Burden, 1999).
Reduction of Driveway Area		Minimize driveway lengths and encourage alternative pervious surfaces, and whenever possible allow shared driveways	- From a typical 10-foot width driveway standard, widths of nine feet may be sufficient for each automobile lane depending on the location of the driveway relative to the structure. Proper slopes, sights distances and radii should always be considered. - Use of shared driveways reduces the total amount of impervious area, providing fewer curb cuts and therefore increasing safety.
Reduction of Cul-de-Sac Area		Modify cul-de-sacs design, dimensions and surface material resulting in less impervious areas	- Reduce the size or radius of the cul-de-sac - Use a pervious landscaped center island (i. e. , native vegetation or engineered bioretention system) that can also be used to receive and treat stormwater - Alternative designs include the "tee or hammer head" or "loop road" - Build narrow streets with sharper turns as alternative accomplishes the same goal of reducing traffic while maintaining essential connectivity between neighborhoods.

<table>
<tr><th colspan="2">LID Reduction Practices</th><th>Objectives</th><th>Recommended Practices</th></tr>
<tr><td colspan="2">Reduction of Curb Requirements</td><td>Eliminate curbs in streets whenever possible to allow road drainage to flow in open channels</td><td>- Where practical, curbing should be eliminated and open drainage swales should be used in lieu of closed drainage systems.
- If there are concerns about unattractive or difficult to maintain open drainage, the dry swales can be used that includes a design without standing water and which can be maintained similar to adjacent lawn.</td></tr>
<tr><td rowspan="4">Reduction of Parking</td><td>Parking ratios</td><td>Establish both maximum and minimum parking ratios to provide adequate parking while reducing excess of impervious cover</td><td>- To more appropriately control the supply of parking local zoning ordinances can be revised or “tailored to provide” for more accurate local parking demand and conditions,
- A strategy for setting a maximum parking requirement is to consider using the town’s current minimum parking ratio as the new maximum.
- Alternative materials such as pervious pavers can replace conventional asphalt or concrete for parking area and/or overflow parking areas to reduce impervious areas, and increase recharge.</td></tr>
<tr><td>Shared parking</td><td>Encourage and implement whenever feasible shared parking in order to reduce demand of parking space thus impervious cover</td><td>- Since peak parking demand often varies with business type, there is often an opportunity for shared parking arrangements between common users without creating conflict.
- A simple peak demand analysis can significantly reduce the combined requirements for office and retail use and the sharing of parking spaces.
- Since ownership is subject to change, tailoring the ordinance with contingency plans allows for future conditions to avoid conflicts and accommodate additional future parking.</td></tr>
<tr><td>Stall and aisle geometry</td><td>Reduce parking stalls to the extent feasible to decrease total impervious surface</td><td>- Reducing stall dimensions from the typical 10 feet wide by 20 feet long to 9 feet by 18 feet would result in a 28% reduction of stall area.
- Angled parking and one-way aisles may reduce the amount of aisle space needed to access to each stall.
- Allocate some compact car spaces of 8 feet 16 feet stalls.</td></tr>
<tr><td>Parking for handicapped people</td><td colspan="2">The widths for parking designated to handicapped people cannot be reduced.</td></tr>
</table>

TECHNICAL CONSIDERATIONS

At a minimum, the following street and parking standards should be evaluated to determine if they are contributing to the unnecessary generation of surplus impervious cover from new development or redevelopment projects:

- **Reduction of Roadway Area**

Pavement widths should be set based on number of homes served, anticipated vehicle usage, and on-street parking requirements. Establish minimum and maximum standards to meet these needs while avoiding excessively wide streets.

Figure 3. Example of Roadway Area

Table 3. ROW Standards in Westport

ROW Standards	Collector Streets	Residential Streets	Secondary Streets
Minimum Traveled Way Width	30’	26’	16’-20’
Minimum ROW Width	50’	40’	40’

- **Reduction of Sidewalk Area**

Consider pedestrian preferences when designing sidewalks, rather than the blanket application of a requirement for the placement of sidewalks on both sides of the roadway. Allow for sidewalks to be paved with pervious materials.

Figure 4. Example of Sidewalk Area. CWP, 1998

Table 4. Reduction of Sidewalk Standards

Standards	Institute of Transportation Engineers (ITE)	Better Site Design (Recommended)
Examples of Sidewalk Dimensions	Sidewalk dimensions: 4 to 6 foot	Sidewalk dimensions: 3 by 4 foot
	Offset: 1 foot	On one side of the street

- **Reduction of Driveway Area**

Figure 5. Example of Shared Driveway

Shared driveways and reduced width and length are recommended practices to reduce impacts due to impervious surfaces associated to urban development. Driveway dimensions can be minimized through reduced minimum widths and front yards setbacks. Standards should allow for pervious driveway materials, allow a "two track" designs (i.e., paved tired track with pervious median), and prohibit direct rooftop discharge on to impervious driveway surfaces. Shared driveways should be considered and sample agreements should be provided in accordance with Article 21, Common Driveways.

Table 5. Shared Driveway Standards

Standards	Institute of Transportation Engineers (ITE)	Recommended Reduction of Driveway
Examples of Driveway Widths	One car garage: 10 foot Two car garage: 20 foot	Width of 9 feet may be sufficient for each vehicle lane

- **Reduction of Cul-de-Sac Area**

Road layouts that reduce the number of dead ends streets are preferable. Options for turnaround designs include cul-de-sac with landscaped island, loop road and t-shaped shown in Figure 6. To minimize impervious cover, maximum paved diameters fo the cul-de-sacs should be based on the required turning radius of emergency response vehicles. Options of cul-de-sac layouts are shown in Figure 6.

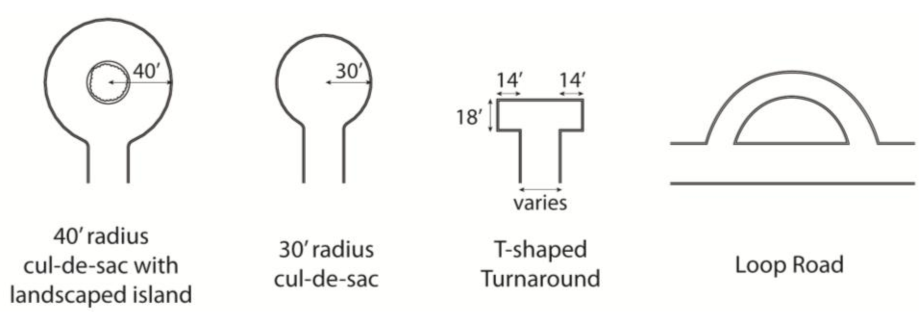

Figure 6. Examples of Cul-de-sac Alternative Layouts. Adapted from CWP, 1998

Alternative layouts, such as a tee- or hammer-shaped turnaround, may be appropriate for streets shorter than 200 feet in length. A loop road is also good option as they provide multiple access points for emergency vehicles and can carry double the traffic volume of a cul-de-sac. A cul-de-sac must be wide enough to accommodate the turning radii of large vehicles such as fire trucks and school buses.

Table 6. Cul-de-sac Dimension Standards

Standards	Local standards	Recommended Cul-de-sac Dimension
Examples of Cul-De-Sac Dimensions	Radius: 50 – 60 feet which equates to paved areas over 11,000 square area	Radius: 30 – 40 feet due to new fire trucks (ASCE, 1990)

In addition to reducing the radius of the cul-de-sac, there are some alternatives to minimize impervious areas by creating a vegetated center or changing the layout of the cul-de-sac. A vegetated center can also be used to receive and treat stormwater to meet water quality requirements and enhance the landscape.

Figure 7. Example of Vegetated Center for Cul-de-sac

- **Reduction of Parking Lot Area**

Figure 8. Example of Shared Parking Between Church and Office Building

The number of required parking spaces is often based on parking demand studies that are not locally applicable, expressed only as a minimum standard for the worse case scenario, and often result in a oversupply of parking. In these cases communities should be comfortable establishing maximum parking requirements at current minimum standards and new minimums set 1/3 below these revised maximums.

Additionally, minimizing parking requirements by estimating parking demand at peak hours for different land uses can help reduce significantly impervious area and the associated negative impacts such as increase of runoff volume and urban heat island effect. This can also be achieved also by encouraging shared parking and parking garages between business in the same development area.

Excessively wide stalls and driving aisles should be avoided by implementing recommended dimensions.

Table 7. Stall and Driving Aisle Standard Dimensions and Recommendations

Standards	Standard Stall Dimensions	Driving Aisle Recommendation
Examples of Stall and Aisles Dimensions	9 feet x 18 feet	Widths should be based on orientation of parking stalls and whether traffic flow is single or two-way

BENEFITS OF IMPLEMENTATION

Development and redevelopment projects taking advantage of LID practices implementation for reducing impacts of stormwater runoff can help reduce impervious cover and enhance groundwater recharge by applying recommended standards in their design. New or existing roads, sidewalks and parking lots designed for different land uses can also assist in reducing the costs burden for construction and maintenance of oversized areas of impervious surfaces.

Table 8. Benefits of LID Practices Implementation for Reducing Stormwater Impacts

Activities	Stormwater and Cost Benefits
Implementing LID Roadway Design	• Less impervious areas attributed to roadways can reduce the amount of runoff and peak flow that contribute to neighborhood flooding • A better drainage network system that allows for greater infiltration and water treatment • Construction and maintenance costs can be reduced significantly by decreasing the total amount of pavement, curbing, sidewalks and stormwater infrastructure required for a development
Implementing LID Parking Lot Design	• Character of the town is likely to be more appealing as unused parking areas, especially in commercial developments are minimized • Incorporating more landscaping to improve aesthetics, reduce heat island effect, and in some cases, if stormwater practices are implemented, treat pollutants carried by runoff • Reduces the need for floodwater storage and stormwater treatment

5.0 MANAGE THE IMPACTS AT THE SOURCE

Techniques that manage the impacts include "disconnecting" impervious surfaces and implementing small-scale, "natural system"-based BMPs close to the source. Best Management Practices (BMPs) are an array of stormwater control solutions that provide effective treatment of stormwater runoff and where feasible, reduction in runoff volume. Disconnecting impervious surfaces means that runoff from these sources is diverted to flow over pervious areas of sufficient length and permeability to infiltrate the small frequent storm events (i.e. , less than one inch of precipitation).

Impervious surfaces that are separated from drainage collection systems by pervious surfaces or infiltrating BMPs contribute less runoff and reduced pollutant loading. Isolating impervious surfaces promotes infiltration and filtration of stormwater runoff.

Small-scale BMPs applied at the source—or as close as practicable—can offer significant advantages over conventional, engineered facilities such as ponds or enclosed conveyances. These small-scale practices can decrease the use of typical engineering materials such as large-scale piping, concrete and earthworks. By using materials such as native plants, soil, and gravel, these systems can be more easily integrated into the landscape and appear to be much more natural than these more engineered systems.

The natural characteristics may also increase homeowner acceptance and willingness to adopt and maintain such systems. Small, distributed systems also offer a major technical advantage—one or more of the systems can fail without undermining the overall integrity of the site control strategy. Designers and developers can receive a Stormwater Credit for disconnecting impervious areas to qualified pervious areas in accordance with Massachusetts Stormwater Standards.

This guidance presents BMP practices primarily targeted at meeting Standard 3 of the Massachusetts Stormwater Management Standards.

Standard 3: Loss of annual recharge to groundwater shall be eliminated or minimized through the use of environmentally sensitive site design, low impact development techniques, stormwater best management practices, and good operation and maintenance. At a minimum, the annual recharge from the post-development site shall approximate the annual recharge from pre-development conditions based on soil type. This Standard is met when the stormwater management system is designed to infiltrate the required recharge volume as determined in accordance with the Massachusetts Stormwater Handbook.

Site planning and design strategies that Manage the Impacts at the Source include the following:

- ✓ Disconnecting Impervious Areas – involves a series of strategies that divert runoff over pervious surfaces to foster infiltration, runoff reduction, and pollutant removal.
- ✓ Mitigation of Runoff at the Source– is a broad-based strategy involving several techniques such as bioretention, swales, infiltration, and filter strips that generally utilize surface vegetated systems to promote recharge and treatment of runoff.

BEST MANAGEMENT PRACTICES

Applicants should review the different stormwater management practices available that can best suit the location and conditions of the project. Selecting the appropriate BMPs is imperative for overcoming the environmental and economical constraints inherent of the project. By implementing techniques that allow precipitation to recharge into groundwater, stormwater runoff volume decreases as water filters through the soil instead of running over impervious surfaces; water quality improves as the process of filtering and plant uptake in certain BMP practices enhances pollutant removal; and landscape features and wildlife habitat areas increase as most structures are designed to act as natural components. Not all BMPs contribute to groundwater recharge at the same rate or performance, therefore a menu of applicable stormwater management techniques for Westport, considering local conditions, is presented in this guidance. These BMPs are ranked based on their recharge performance as described below.

BMP Toolbox

1. Surface infiltration;
2. Bioretention;
3. Underground infiltration;
4. Swales; and
5. Constructed wetlands.

1. Surface infiltration ranks as the highest preferred LID practice because it is the most reliable recharge practice and incorporates vegetation and associated uptake with habitat benefits.
2. Bioretention ranks second only because it is often designed with an underdrain system (in areas with poor soils, high groundwater, or other constraints) and is, therefore, not always recharging all stormwater to groundwater.
3. Underground infiltration ranks third because it is below the surface and therefore does not have the benefits associated with vegetative uptake and enhanced microbial activity that exists in surface practices.
4. Swales rank fourth because their recharge is variable depending on soils, slopes, depth to groundwater, among other factors.
5. Lastly, while constructed wetlands offer excellent pollutant removal capabilities, they offer little recharge capabilities and therefore, little runoff reduction.

CRITERIA FOR BMP SELECTION

In order to select BMPs for a specific site, physical limitations are one of the most important factors that should be taken into account for the design, construction and maintenance stages of the project.

This section presents advantages and disadvantages, design, construction and maintenance parameters for a number of BMPs including:

- Surface infiltration
- Bioretention
- Underground infiltration
- Swales
- Constructed wetlands

Additionally, Table 9 summarizes other factors such as stormwater management suitability, implementation considerations and pollutant removal efficiency that should be considered to help prioritize BMP selection**.**

5.1.1 Surface Infiltration

Surface infiltration techniques, such as infiltration basins, dry wells, trenches, are the most efficient BMPs for groundwater recharge. Stormwater infiltration practices capture and temporarily store stormwater before allowing it to infiltrate into the soil over a maximum period of 48 hours.

Figure 9. Example of BMP- Infiltration Basin

Advantages and Disadvantages of Surface Infiltration BMPs

✓ **Infiltration Basins**: Stormwater water impoundments constructed on permeable soil.

Advantages	• Reduces local flooding • Maintains the natural water balances of the project site • Provides excellent groundwater recharge
Disadvantages	• Work best with smaller drainage areas • Frequent maintenance required • Poor design, improper siting, and lack of maintenance may lead to a performance failure

✓ **Dry Wells**: Small excavated structures, backfilled with aggregate (often with perforated chambers of HDPE, concrete of PVC), and used to infiltrate uncontaminated runoff.

Advantages	• Feasible for retrofit areas and new development • Provides groundwater recharge
Disadvantages	• Small drainage areas of one acre or less • Clogging is likely • Not recommended for treating large loads of pollutants and sediment • Limited to rooftop runoff applications

✓ **Infiltration trenches:** Shallow excavations filled with stone (or perforated chambers) provides underground storage for stormwater runoff which gradually exfiltrates into the subsoil and eventually into the water table.

Advantages	• Practical for small areas or where space is limited • Efficient runoff pollution control • Reduces downstream flooding as well as the size and cost of stormwater facilities when these structures are installed upland. • Provides groundwater recharge
Disadvantages	• Restricted to small drainage areas • Potential risks for groundwater contamination depending on runoff quality • Clogging likely

Infiltration Design Considerations Based On Environmental/Site Constraints	
Constraints	**Consideration**
Soils	For meeting water quality standard, the bottom of infiltration practices must be located in the soil profile
	Pervious soils required; less than 20% clay and 60% silt
Groundwater	Runoff from designated land use with high pollutant loadings or associated activities shall not be directed to an infiltration facility
	Minimum of two foot separation of the facility bottom to the seasonal high groundwater table and bedrock layer
Setback	Minimum horizontal setbacks to other water resources or facilities such as on-site wastewater treatment facilities
Infiltration rate	Designated for different soil textures
Water quality	100% of the water quality volume shall be treated by an acceptable water quality process prior to entry into an infiltration facility
Slope	The bottom of the stone reservoir should be completely flat or nearly so for encouraging infiltration through the entire bottom surface
Drainage area	Maximum drainage area: Basins- 15 acres or less; Chambers/Trenches – 5 acres; Dry wells – 1 acre

Infiltration Construction Elements	
Elements	**Consideration**
Soils compaction	Construction vehicles and other heavy equipment within the above or surrounding area of the subsurface structure may cause compaction
Stabilization	Runoff should never come from any disturbed areas on the site to flow to the structure

Infiltration Maintenance Practices	
Practices	**Consideration**
Sediment removal	If sedimentation or organic debris build-up has limited the infiltration capabilities to below the design rate, the basin bottom should be restored to original design specifications
Dewatering	If failure occurs, dewatering methods should be used
Access	Direct access should be provided to infiltration practices for maintenance and rehabilitation
Slope	The bottom of the stone reservoir should be completely flat or nearly so for encouraging infiltration through the entire bottom surface
Vegetation	Mow upland and adjacent areas, and provide vegetative stabilization of bare areas

5.1.2 Bioretention

Figure 10. Example of BMP - Bioretention Basin

This technique uses plants, soils, and microbes to treat stormwater runoff before it infiltrates and/or discharges. Sometimes referred to as rain gardens (in a residential setting, with minimum soil amendments or underdrains), these structures are shallow depressions filled with sandy soil and planted with native vegetation. The soil media acts as a filter allowing runoff percolation. Removing pollutant through filtration, microbe activity and uptake by plants contributes to better water quality treatment.

There are two types of bioretention BMPs: Filtering and exfiltrating. Filtering bioretention is designed with an underdrain system in areas where infiltration is not feasible, while exfiltrating bioretention allows stormwater recharge to groundwater followed by treatment.

Advantages and Disadvantages of Bioretention BMP	
Advantages	• Can be used as stormwater retrofit by modifying existing landscape • Offers aesthetical features enhancing the landscape. Also provide windbreaks, absorbs noise, supplies wildlife habitat and reduces the urban heat island effect • Helps to maintain the natural water balance of the project site • An exfiltrating bioretention area provides groundwater recharge
Disadvantages	• Small drainage areas • Frequent maintenance required and landscaping • Not recommended in areas with steep slopes

Bioretention Design Considerations Based On Environmental/Site Constraints	
Constraints	**Consideration**
Groundwater	The bottom of exfiltrating systems shall be located above the season high groundwater table (filtering systems can be designed within or near groundwater with a properly design underdrain and impermeable liner)
Soils	Same as infiltration for exfiltrating systems. There are no restrictions for filtering systems

Vegetation	Include mix of herbaceous perennials, shrubs and (if conditions permit) understory trees that can tolerated intermittent ponding, extended dry periods and occasional saline conditions due to road salt
Drainage area	Typical maximum drainage area: 10 acres

Bioretention Construction Elements	
Elements	**Consideration**
Soils compacting	Compacted soils around the bioretention areas and accumulating silt around the drain field should be avoided
Stabilization	Runoff should never be directed to the cell until contributing drainage areas and the cell are completely stabilized
Sedimentation	Minimize sediment loading in the treatment areas

Bioretention Maintenance Practices	
Practices	**Consideration**
Landscaping	While plants are being established and on seasonal basis
Soil inspection	Eroded areas should be repaired. Re-mulch. Replace media and vegetation as needed
Vegetation removal	Remove and replace dead vegetation in spring and fall. Discard invasive species. Plant maintenance is imperative for the performance of this BMPs
Slope	The bottom of the facility for exfiltration systems should be completely flat or nearly so for encouraging infiltration through the entire bottom surface
Vegetation	Mow upland and adjacent areas, and provide vegetative stabilization of bare areas

5.1.3 Underground infiltration

Sub-surface chambers are underground systems that capture runoff volume, and gradually infiltrate it into the groundwater through rock and gravel.

Figure 11. Example of BMP - Underground Infiltration

Advantages and Disadvantages of Bioretention BMP	
Advantages	• Can be installed in small areas or where space is limited • Useful in stormwater retrofit applications • Minimizes flooding for downstream areas • Provides groundwater recharge
Disadvantages	• Performance is best for smaller drainage areas • System failures can go unseen unless flooding or other surface impacts are observed • Clogging potential is high • Requires pre-treatment • Difficult to maintain

Underground Infiltration Design Considerations Based On Environmental/Site Constraints

Constraints	**Consideration**
Soils	Soils with suitable infiltration capacities
Location	Areas with limited space and land value
Groundwater and bedrock	Depth to groundwater and bedrock to ensure the structure and performance of the system will not be affected
Observation ports	For inspection to see if the system is working properly and for cleanout mechanisms

Underground Infiltration Construction Elements	
Elements	**Consideration**
Soils compaction	Construction vehicles and other heavy equipment within the above or surrounding area of the subsurface structure may cause compaction
Stabilization	Runoff should never come from any disturbed areas on the site to flow to the structure
Erosion and Sedimentation	Implement erosion and sediment control techniques to prevent sheet flow or windblown sediment from entering the leach field

Underground Maintenance Practices	
Practices	**Consideration**
Debris removal	Clogging can be caused due to debris accumulation through the openings of the structure where infiltration is occurring
Sediment removal	Pretreatment is required
Inspections	Standing water at the location of the BMP should be inspected, this may indicate failure in the system an corrective actions are necessary

5.1.4 Swales

Figure 12. Example of BMP – Wet and Dry Swales

Open channels systems are vegetated open channels that are explicitly designed to treat required water quality volume and provide stormwater pollutant removal and runoff reduction.

Advantages and Disadvantages of Swales BMP	
Advantages	• Can be used to retrofit drainage channels and grass channels • Roadside swales improve water quality and control water quantity • Blends in the natural landscape • Replace enclosed drainage systems with pipes, curbs and gutters
Disadvantages	• Erosion may occur during large storms • Wet swales can create habitat conditions for mosquitoes breeding • Dry swales are practical for treating only small areas • Roadside swales are prone to be impacts from traffic conditions such as off-street parking, snow plowing and winter deicing • Location constraints include: flat and steep grades and poorly drained soils

Swales Design Considerations Based On Environmental/Site Constraints	
Constraints	**Consideration**
Soils	Dry swales: Permeable soils for preventing surface pounding Wet swales: Soils with poor drainage
Topography	Maximum slope of approximately 5% and appropriate cross-sectional area to avoid erosion as result of flow velocity

Vegetation	Flow velocity decreases when vegetation is at its maximum growth for the year. Assess the ability of the swale to convey the 2-year 24 hour storm without erosion. Wetland hydrophytes[2] or obligate species[3] are good selection for wet swales, whereas plants adapted to varying conditions should be used for dry swales
Drainage area	Maximum drainage area to any one inflow point: 5 acres

Swales Construction Elements	
Practices	**Consideration**
Erosion and sediment control	Practices that minimize erosion and sediment transport do to up-gradient disturbance and land development activities
	Requires erosion control blankets where side slopes are steeper than 4:1 and/or if up-gradient inflow is concentrated
Vegetation	Suitable for the characteristics of the site
Seedling	Requires mulching with adequate materials

Swales Maintenance Practices	
Practices	**Consideration**
Stabilization	Inspection is required to make sure vegetation is appropriated and slopes are not eroding. Erosion correction is required
Vegetation	Dry swales require mowing. Wet swales may not need mowing depending on the vegetation. Vegetative cover required (re-seeding)
Sediment removal	Remove sediment build-up and pretreatment sediment removal

[2] Plants adapted to grow in water.
[3] Species that occur 99% of the time under natural conditions in wetlands

5.1.5 Constructed wetlands

Figure 13. Example of BMP - Shallow and Gravel Constructed Wetlands

This BMP provides little or no recharge to groundwater; therefore it's ranked as the lowest in priority in the LID toolbox. Constructed wetland systems are designed to provide pollutant removal through plant uptake, retention and particle settling.

There are two types of constructed wetlands: shallow and gravel.

Shallow constructed wetlands temporarily stores runoff in shallow pools and provide appropriate conditions for wetland plant growth. On the other hand, gravel-based constructed wetlands act as a filter providing treatment by stormwater movement through the gravel bed and the plant/soil media.

Advantages and Disadvantages of Constructed Wetlands BMP	
Advantages	• Requires low maintenance • Effectively removes highly levels of nitrogen, phosphorus, oil and grease • Provides wildlife habitat
Disadvantages	• Larger areas are required in comparison with other BMPs • Until wetland plants are well established, pollutant removal efficiency may be lower than anticipated • Construction costs may be higher that other BMPs • Does not provide recharge • Can create potential for mosquito breeding habitat

Constructed Wetlands Design Considerations Based On Environmental/Site Constraints	
Constraints	**Consideration**
Jurisdictional waters	Constructed wetlands shall not be designed within jurisdictional waters or wetlands[4]. Exceptions may apply for already developed sites.
Stream channels	Constructed wetlands shall not be located within stream channels to provide negative impacts to stream habitat
LUHPPL [5] runoff	Ground water separation is required where land uses and/or activities cause a potential risk of contamination, otherwise ok to intercept groundwater.
Setback from septic systems	Setback shall be consistent with the state regulations
Soils	Soils must be impermeable to "retain" water, otherwise need a liner
Drainage area	Minimum drainage areas: Gravel – 5 acres; Shallow – 10 acres

Constructed Wetlands Construction Elements	
Elements	**Consideration**
Geometry	Minimum flowpath for either system which should be graded to create maximum internal flow path and microtopograhpy[6]
Inlet areas	Ensure non-erosive conditions exist for at least 1-year frequency storm event
Outfalls	Should not increase erosion or have undue influence on the downstream geomorphology of any natural watercourse
Vegetation	Planting plan that indicates methods to establish and maintain coverage.

[4] The procedure of identifying and locating jurisdictional waters of the US regulated by the Corps under Section 404 of the Clean Water Act and Section 10 of the Rivers & Harbors Act of 1899 is commonly referred to as the "JD process", a "wetland determination" or a "delineation". More information at: http://www. usace. army. mil/CECW/Documents/cecwo/reg/cwa_guide/jd_guidebook_051207final. pdf

[5] Land Uses with Higher Potential Pollutant Loads (*LUHPPL*)

[6] Microtopography (complex contours along the bottom of the constructed wetland, providing greater depth variation) is encouraged to enhance habitat diversity

Constructed Wetlands Maintenance Practices	
Practices	**Consideration**
Permanent pool inspection	Practices include preserving the hydraulic and removal efficiency of the constructed wetland and maintaining the structural integrity
Sediment removal	If runoff not received from LUHPPL, excavated sediment from a constructed wetland is not considered hazardous material and can be safely disposed by either land application or landfill in accordance to an approved comprehensive operation and manual plan
Slope inspection	Erosion and gullying may occur. Re-vegetate slopes as necessary for stabilization
Stormwater structures	All structural components should be inspected for damage/or accumulation of sediment
Vegetation	Dead or dying vegetation within the extents of the constructed wetland should be removed. Also herbaceous vegetation rootstock when hampering flowage of the facility and any invasive vegetation encroaching upon the perimeter of the facility should be pruned or removed

Table 9. Ranked BMPs Selection Factors – Source: Rhode Island Stormwater Design and Installation Standards Manual, 2010.

Group	Practices	Stormwater Management Suitability		Implementation Considerations		Pollutant Removal Efficiency			
		Water Quality	Recharge	Capital Cost	Maintenance Burden	Total Phosphorus	Total Nitrogen	Metals	Pathogens
Surface Infiltration	Infiltration Trenches/ /Dry Wells	✓	✓	H	H	G	F	G	G
	Infiltration Basin	✓	✓	H	H	G	F	G	G
	Permeable Paving	✓	✓	M	H	G	G	G	G
Filtering practices	Bioretention	✓	✓	M	M	F	G	G	G
Underground Infiltration	Chambers	✓	✓	H	H	G	F	G	G
Open channels (Swales)	Wet swales	✓	✓	L	L	G	G	G	F
	Dry swales	✓	✓	L	L	G	G	G	F
Constructed wetlands	Shallow	✓	X	M	M	G	G	F	G
	Gravel	✓	X	M	M	G	G	F	G
Key		✓ Yes X No		L=Low M=Moderate H=High		G=Good F=Fair P=Poor			

LOW IMPACT DEVELOPMENT SITE DESIGN CREDITS FOR MASSACHUSETTS

The Low Impact Development Site Design Credits[7] encourage environmentally sensitive site design and Low Impact Development techniques for managing stormwater that minimize impervious surfaces and preserve natural hydrologic conditions. The credits allow project proponents to reduce or eliminate the structural stormwater BMPs otherwise required to meet Standards 3 and 4 by directing stormwater runoff to qualifying pervious surfaces that provide recharge and treatment.

Available Credits:

CREDIT 1. Environmentally Sensitive Development
This credit is given for environmentally sensitive site design techniques that "cluster development" or reduce development scale, to leave a significant amount of the site undisturbed in its natural state. If a site is designed, constructed, operated and maintained in accordance with the requirements of this credit, a project proponent need not develop and implement additional structural stormwater BMPs to meet Standards 3 and 4.

CREDIT 2. Rooftop Runoff Directed to Qualifying Pervious Area
This credit is available when rooftop runoff is directed to a qualifying pervious area where it can either infiltrate into the soil or flow over it with sufficient time and reduced velocity to allow for filtering. Qualifying pervious areas are flat locations, where the discharge is directed via sheet flow and not as a point source discharge. Dry water quality swales are not "qualifying pervious areas" for purposes of this credit. The credit may be obtained by grading the site to induce sheet flow over specially designed flat vegetated areas that can treat and infiltrate rooftop runoff.

CREDIT 3. Roadway, Driveway or Parking Lot Runoff Directed to Qualifying Pervious Area

Credit is given for practices that direct runoff from impervious roads, driveways, and parking lots to pervious areas where plants provide filtration (through sheet flow) and the ground provides exfiltration. This credit can be obtained by grading the site to promote overland vegetative filtering. This credit is available for paved driveways, roads, and parking lots associated with all land uses, except for high-intensity parking lots that generate 1,000 or more vehicle trips per day or runoff not segregated from LUHPPL.

[7] Information on the LID Site Design Credit is found in Volume 3 of the *MASWMS*.

6.0 MAINTENANCE AGREEMENTS

A major contributor to unmaintained stormwater facilities is a lack of clear definition of ownership and responsibility. In order for an inspection and maintenance program to be effective, the roles for each responsibility must be clearly defined prior to construction of a system. This can be accomplished with a maintenance and access agreement between the site owners and the responsible authority.

A key aspect of these maintenance and access agreements is the clear delineation of responsibilities, such as:

- Identification of who will perform inspection duties and how often.
- Listed duties that are to be performed by the owner, such as mowing, debris removal, and replanting of vegetation.
- Defined roles for the responsible authority, such as inspection, and/or modifications to the system such as resizing an orifice.
- Determination of a course of action to be taken if the owner does not fulfill their obligations (i. e. repayment to the responsible authority for activities that the owner did not perform).
- Development of a pollution prevention plan by the owner.
- Requirement of a report, possibly annually, that would serve to keep the owner involved and aware of their responsibilities.

A sample maintenance agreement is attached below.

Sample Stormwater Facility Maintenance Access Agreement

THIS AGREEMENT, made and entered into this ___ day of _________, 20___, by and between (Insert Full Name of Owner) ____ hereinafter called the "Landowner", and the [Local Jurisdiction], hereinafter called the Town of Westport WITNESSETH, that WHEREAS, the Landowner is the owner of certain real property described as (Tax Map/Parcel Identification Number) ___________________________ as recorded by deed in the land records of [Local Jurisdiction] Deed Book __________ Page __________, hereinafter called the "Property".

WHEREAS, the Landowner is proceeding to build on and develop the property; and WHEREAS, the Site Plan/Subdivision Plan known as _________________________________, (Name of Plan/Development) hereinafter called the "Plan", which is expressly made a part hereof, as approved or to be approved by the [Town/City], provides for detention of stormwater within the confines of the property; and

WHEREAS, the [Town/City] and the Landowner, its successors and assigns, including any homeowners association, agree that the health, safety, and welfare of the residents of [Local Jurisdiction] require that on-site stormwater management facilities be constructed and maintained on the Property; and

WHEREAS, the [Town/City] requires that on-site stormwater management facilities as shown on the Plan be constructed and adequately maintained by the Landowner, its successors and assigns, including any homeowners association.

NOW, THEREFORE, in consideration of the foregoing premises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree as follows:

1. The on-site stormwater management facilities shall be constructed by the Landowner, its successors and assigns, in accordance with the plans and specifications identified in the Plan.
2. The Landowner, its successors and assigns, including any homeowners association, shall adequately maintain the stormwater management facilities in accordance with the required Operation and Maintenance Plan. This includes all pipes, channels or other conveyances built to convey stormwater to the facility, as well as all structures, improvements, and vegetation provided to control the quantity and quality of the stormwater. Adequate maintenance is herein defined as good working condition so that these facilities are performing their design functions. The Stormwater Best Management Practices Operation, Maintenance and Management Checklists are to be used to establish what good working condition is acceptable to the [Town/City].
3. The Landowner, its successors and assigns, shall inspect the stormwater management facility and submit an inspection report annually. The purpose of the inspection is to assure safe and proper functioning of the facilities. The inspection shall cover the entire facilities, berms, outlet structure, basin areas, access roads, etc. Deficiencies shall be noted in the inspection report.
4. The Landowner, its successors and assigns, hereby grant permission to the [Town/City], its authorized agents and employees, to enter upon the Property and to inspect the stormwater management facilities whenever the [Town/City] deems necessary. The purpose of inspection is to follow-up on reported deficiencies and/or to respond to citizen complaints. The [Town/City] shall provide the Landowner, its successors and assigns, copies of the inspection findings and a directive to commence with the repairs if necessary.
5. In the event the Landowner, its successors and assigns, fails to maintain the stormwater management facilities in good working condition acceptable to the [Town/City], the [Town/City]

may enter upon the Property and take whatever steps necessary to correct deficiencies identified in the inspection report and to charge the costs of such repairs to the Landowner, its successors and assigns. This provision shall not be construed to allow the [Town/City] to erect any structure of permanent nature on the land of the Landowner outside of the easement for the stormwater management facilities. It is expressly understood and agreed that the [Town/City] is under no obligation to routinely maintain or repair said facilities, and in no event shall this Agreement be construed to impose any such obligation on the [Town/City].

6. The Landowner, its successors and assigns, will perform the work necessary to keep these facilities in good working order as appropriate. In the event a maintenance schedule for the stormwater management facilities (including sediment removal) is outlined on the approved plans, the schedule will be followed.

7. In the event the [Town/City] pursuant to this Agreement, performs work of any nature, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, and the like, the Landowner, its successors and assigns, shall reimburse the [Town/City] upon demand, within thirty (30) days of receipt thereof for all actual costs incurred by the [Town/City] hereunder.

8. This Agreement imposes no liability of any kind whatsoever on the [Town/City] and the Landowner agrees to hold the [Town/City] harmless from any liability in the event the stormwater management facilities fail to operate properly.

9. This Agreement shall be recorded among the land records of [Local Jurisdiction] and shall constitute a covenant running with the land, and shall be binding on the Landowner, its administrators, executors, assigns, heirs and any other successors in interests, including any homeowners association.

WITNESS the following signatures and seals:

____

Company/Corporation/Partnership Name (Seal)

By: ____

____

(Type Name and Title)

The foregoing Agreement was acknowledged before me this ____ day of ____________, 20___, by

____.

____

NOTARY PUBLIC

My Commission Expires: ____________

By: ____

____

(Type Name and Title)

The foregoing Agreement was acknowledged before me this ____ day of ____________, 20___, by

____.

____

NOTARY PUBLIC

My Commission Expires: ____________

Approved as to Form:

___________________________ __________

[Town/City] Attorney Date

7.0 STORMWATER MANAGEMENT CHECKLIST

The first thing that applicants and designers should do before beginning a project is to make sure they are familiar with this guidance that will help them review and meet the requirements Westport's By-Law, Board of Health "Stormwater Quality and Quantity Control Regulation" and the MASWMS.

Next, designers should review the available LID site planning and design strategies and BMPs in the Handbook to determine which would work best at their site. This checklist serves as a guide for engineers and designers to refer to during all stages of a project to ensure that they are meeting all applicable requirements. In addition, designers must include a completed checklist with their final stormwater management plan.

CHECKLIST FOR STORMWATER MANAGEMENT PLAN PREPARATION AND REVIEW

This check list reflects the LID Plan Contents in accordance with Article 20 – Low Impact Development (LID) Site Plan Approval – of the most current version of Westport's zoning bylaw.

- [ ] Contact Information of applicant name, mailing address, and telephone number of all persons having a legal interest in the property and tax reference number and parcel number of the property or properties affected
- [ ] Locus map
- [ ] Existing site plan (for comparison to recharge area analysis, see below)
- [ ] Existing zoning, and land use at the site
- [ ] Proposed land use
- [ ] Location(s) of existing and proposed easements
- [ ] Location of existing and proposed utilities
- [ ] The site's existing and proposed topography with contours at 2-foot intervals
- [ ] Existing site hydrology (both groundwater recharge and surface runoff)
- [ ] A description and delineation of existing stormwater conveyances, impoundments, wetlands, drinking water resource areas, shellfishing areas, swimming beaches or other critical environmental resource areas, on or adjacent to the site into which stormwater flows
- [ ] A delineation of 100-year flood plains, if applicable
- [ ] Estimated seasonal high groundwater elevation in areas to be used for stormwater retention, detention, or infiltration
- [ ] The existing and proposed vegetation and ground surfaces with runoff coefficients for each
- [ ] A drainage area map showing pre and post construction watershed boundaries, drainage area and stormwater flow paths, including municipal drainage system flows
- [ ] A recharge area analysis that calculates pre-and post-project annual groundwater recharge rates on the parcel

A description and drawings of all components of the proposed LID Management system including:

- ☐ *A.* Locations, cross sections, and profiles of all brooks, streams, drainage swales and their method of stabilization
- ☐ *B.* All measures for the detention, retention or infiltration of water
- ☐ *C.* Description of non-structural BMPs
- ☐ *D.* All measures for the protection of water quality
- ☐ *E.* The structural details for all components of the proposed drainage systems and LID Management facilities
- ☐ *F.* Notes of drawings specifying materials to be used, construction specifications, and expected hydrology with supporting calculations
- ☐ *G.* Proposed site plan including location of buildings or other structures impervious surfaces, and drainage facilities, if applicable
- ☐ *H.* Any other information requested by the Planning Board

Hydrologic and hydraulic design calculations for the pre-development and post-development conditions for the design storms specified in this Bylaw. Such calculations shall include:

- ☐ *A.* Description of the design storm frequency, intensity and duration
- ☐ *B.* Time of concentration
- ☐ *C.* Soil Runoff Curve Number (RCN) based on land use and soil hydrologic group
- ☐ *D.* Peak runoff rates and total runoff volumes for each watershed area
- ☐ *E.* Information on construction measures used to maintain the infiltration capacity of the soil where any kind of infiltration is proposed
- ☐ *F.* Infiltration rates, where applicable
- ☐ *G.* Culvert practices
- ☐ *H.* Flow velocities
- ☐ *I.* Data on the increase in rate and volume of runoff for the specified designs storms
- ☐ *J.* Documentation of sources for all computation methods and field test results

- ☐ Post-Development downstream analysis if deemed necessary by the Planning Board
- ☐ Soils Information from test pits performed at the location of proposed LID Management facilities, including but not limited to soil descriptions, depth to seasonal high groundwater, depth to bedrock, and percolation rates. Soils information will be based on site test pits logged by a Massachusetts Registered Soil Evaluator, or a Massachusetts Registered Professional Engineer
- ☐ Landscaping plan describing the woody and herbaceous vegetative stabilization and management techniques to be used within and adjacent to the stormwater practice.

A. LID Stormwater Practices

☐ **LID Site Planning and Design Strategies**

Document specific LID site planning and design strategies and associated methods that were employed for the project in the following table:

LID Site Planning and Design Checklist
The applicant should document specific LID site planning and design strategies applied for the project. If a particular strategy was not used, a justification and description of proposed alternatives must be provided. If a strategy is not applicable (N/A), applicants must describe why a certain method is not applicable at their site. For example, preserving wetland buffers may be not applicable for sites located outside any jurisdictional wetland buffers.
1. Strategies to Avoid the Impacts (Those not already covered by OSRD)
A. Water Resource Buffers ☐ Not Applied or N/A. *Use space below to explain why:* *Select from the following:* ☐ Applicable vegetated buffers of coastal and freshwater wetlands and perennial and intermittent streams have been preserved, where possible. ☐ Limits of disturbance included on all construction plans that protect applicable buffers ☐ Other (describe): *Explain constraints and/or proposed alternatives in space below:*

LID Site Planning and Design Checklist

B. Minimized Clearing and Grading

☐ Not Applied or N/A. *Use space below to explain why:*

Select from the following list:

☐ Site fingerprinting to extent needed for building footprints, construction access and safety (i. e. , clearing and grading limited to 15 feet beyond building pad or 5 feet beyond road bed/shoulder).

☐ Other (describe):

Explain constraints and/or proposed alternatives in space below:

2. Strategies to Reduce the Impacts

Reduce Impervious Cover

☐ Not Applied or N/A. Use space below to explain why:

Select from the following list:

☐ Reduced roadway widths	☐ Reduce driveway areas	☐ Reduced building footprint
☐ Reduced sidewalk area	☐ Reduced cul-de-sacs	☐ Reduced parking lot area

☐ Other (describe):

Explain constraints and/or proposed alternatives in space below:

3. Strategies to Manage the Impacts

A. Disconnecting Impervious Area

☐ Not Applied or N/A. Use space below to explain why:

Select from the following list:

☐ Impervious surfaces have been disconnected to QPAs to the extent possible.

☐ Other (describe):

Explain constraints and/or proposed alternatives in space below:

B. Best Management Practices

Provide detailed information for all structural stormwater best management practices (BMPs) to be implemented.

Fill in the following table to document which proposed practices meet which requirement(s). Number each BMP and label them accordingly on the site map:

BMP No.	**Type of BMP**	**Check the function provided by the BMP**		
		Pretreatment	Recharge Volume	Water Quality Volume

Summary of Stormwater Treatment Practice Criteria

Criteria	**Description**	**Post-Development Storm Magnitude**
Groundwater Recharge	*Groundwater Recharge Volume (Re_v)** Maintain pre-development annual groundwater recharge volume to the maximum extent practicable through the use of infiltration measures Re_v = (1")(F)(I)/12 Re_v = groundwater recharge volume (ac-ft) F = recharge factor I = Impervious area (acres)	Soils: A-0.6"/Impervious area B-0.35"/Impervious area C-0.25"/Impervious area D-0.1"/Impervious area
Pollutant Reduction	*Water Quality Volume (WQ_v)** Volume generated by one inch of runoff on the site VWQ = (1.25/12 inches) (RwQv) (Site Area in square feet); Where: RwQv= 0.05 + 0.009(1); I = the % impervious area	1.25" - Critical area ½" - Everywhere else

8.0 ADDITIONAL SOURCES

- **Massachusetts Stormwater Handbook:** Contains stormwater standards, practices and technical specification for the implementation of Best Management Practices throughout the state.

  http://www.mass.gov/dep/water/laws/policies.htm#storm

  Volume 1, Chapter 1: The Stormwater Management Standards MS Word

  Volume 1, Chapter 2: Legal Framework for Stormwater Management.MS Word

  Volume 2, Chapter 1: The Three Components of Stormwater Management.MS Word

  Volume 2, Chapter 2: Stormwater Best Management Practices (BMPs). PDF

  Volume 2, Chapter 3: Checklist for Redevelopment Projects. MS Word

  Volume 2, Chapter 4: Proprietary Stormwater BMPs. MS Word

  Volume 2, Chapter 5: Miscellaneous Stormwater Topics. MS Word

  Volume 2 Appendix: Operating and Source Control BMPs. MS Word

  Volume 3, Chapter 1: Documenting Compliance. MS Word

  Stormwater Report: Checklist. MS Word

  TSS Removal Calculation Worksheet. MS Excel

- **Better Site Design:** A handbook for changing development rules in your community www.cwp.org

- **Parking Spaces/Community Places:** Finding the balance with smart growth solutions www.epa.gov/smartgrowth/pdf/EPAParkingSpaces06.pdf

- **Sustainable Neighborhood Road Design:** A guidebook for Massachusetts Cities and Towns www.apa-ma.org/resources/publications/nrb-guidebook

- Massachusetts Smart Growth/Smart Energy Toolkit www.mass.gov/envir/smart_growth_toolkit/

- 2011 Rhode Island LID Site Planning and Design Guidance Document

  http://www.dem.ri.gov/programs/benviron/water/permits/ripdes/stwater/t4guide/lidplan.pdf

`

9.0 APPENDIX- WESTPORT LID BYLAW

ARTICLE 20

LOW IMPACT DEVELOPMENT (LID) SITE PLAN APPROVAL

20.1 PURPOSE

The purpose of this bylaw is to establish minimum requirements and controls to protect and safeguard the environment, natural resources, general health, safety, and welfare of the public residing in watersheds within the Town's jurisdiction from the adverse impacts of soil erosion, sedimentation, and stormwater runoff. This section seeks to meet that purpose through the following objectives:

20.1.1 To eliminate or reduce the adverse effects of soil erosion and sedimentation;

20.1.2 To minimize stormwater runoff from any development;

20.1.3 To minimize nonpoint source pollution caused by stormwater runoff from development;

20.1.4 To provide for groundwater recharge where appropriate; and

20.1.5 To ensure controls are in place to respond to objectives in Subsections 20.1.1 and 20.1.2 and that these controls are properly operated and maintained.

20.2 APPLICABILITY

This bylaw shall apply to all activities that result in a land disturbance activity of 40,000 sq. ft. of land, or that will disturb less than 40,000 sq. ft. of land but is part of a larger common plan of development or sale that will ultimately disturb equal to or greater than 40,000 sq. ft. of land. No person shall perform any activity that results in a land disturbance activity of 40,000 sq. ft. or more of land without site plan approval by the Planning Board, by majority vote, following review at a duly posted meeting, but without a formal public hearing, of soil erosion and sediment control plan and a stormwater management plan. Normal maintenance and/or improvement of land in agricultural or aquaculture use, as defined by the Wetland Protection Act Regulation 310 CMR 10.4, shall be exempt from this by-law. In addition, as authorized in the Phase II Small MS4 General Permit for Massachusetts, stormwater discharges resulting from the above activities that are subject to jurisdiction under the Wetland Protection Act and demonstrate compliance with the Massachusetts Stormwater Management Policy as reflected in an Order of Conditions or Request for Determination of Applicability (RDA) issued by the Town of Westport Conservation Commission shall be deemed to be in compliance with this bylaw.

20.3 AUTHORITY

This stormwater site plan review bylaw is adopted under the authority granted by the Home Rule Amendment of the Massachusetts Constitution, G.L. c.40 and G.L. c.40A, and the Federal Clean Water Act and applicable regulations, including 40 CFR 122.34.

20.4 RESPONSIBILITY

The Planning Board shall administer, implement and enforce this bylaw. The Planning Board may distribute plans to other boards, commissions, departments, and outside technical and legal consultants and agencies for their review and recommendations.

20.5 DESIGN STANDARDS

The applicant shall submit a plan to the Planning Board that illustrates how the following LID site design standards were utilized to the maximum extent feasible and explains any site and financial constraints which limited application of items 1 through 10 below and how items 11 and l2 were considered for implementation:

20.5.1 Preservation of the site's natural features and environmentally sensitive areas such as wetlands, existing vegetation, slopes, drainage ways, permeable soils, flood plains, woodlands and soils to the greatest extent possible;

20.5.2 Minimization of grading and clearing;

20.5.3 Clustering of buildings and a reduction in size of building footprints;

20.5.4 Use of stormwater management components that provide filtration, treatment and infiltration such as vegetated areas that slow down runoff; maximizing infiltration and reducing contact with paved surfaces;

20.5.5 Creation of subwatersheds to treat and micromanage runoff in smaller, decentralized, innovative stormwater management techniques to treat and recharge stormwater close to the source;

20.5.6 Lengthen flow paths and maximize sheet flow;

20.5.7 Emphasis on simple, nonstructural, innovative, low-cost methods including open drainage systems, recharging of roof runoff, parking areas and/or roadways, to recharge on site as close to the source as possible.

20.5.8 A maintenance program including information on regular street and parking lot sweeping shall be provided to the Planning Board for approval;

20.5.9 Reduction of impervious surfaces wherever possible through alternative street design, such as omission of curbs and use of narrower streets, the use of porous pavement or permeable pavers, shared driveways and through the use of shared parking areas;

20.5.10 Reduction of the heat island effect;

20.5.11 Use of vegetation in buffer strips and in rain filter runoff);

20.5.12. Techniques integrated into every part of site design to create a hydrologically functional lot or development site, including but not limited to the following:

A. Grass swales along roads;

B. Rain gardens;

C. Buffer areas;

D. Use of roof gardens where practicable;

E. Use of amended soils that will store, filter and infiltrate runoff;

F. Bioretention areas;

G. Use of rain barrels and other cisterns to provide additional stormwater storage;

H. Use of permeable pavement and/or pavers in driveways, overflow parking, outside sales areas, etc.

I. Use of native plants and grasses

20.6 LID PLAN CONTENTS

The LID Management Plan shall contain sufficient information for the Planning Board to evaluate the environmental impact, effectiveness, and acceptability of the site planning process and the measures proposed by the applicant for reducing adverse impacts from stormwater runoff. This plan shall be in accordance with the criteria established in these Bylaws and must be submitted with the stamp and signature of a Professional Engineer

(PE) licensed in the Commonwealth of Massachusetts. The LID Management Plan shall fully describe the project in drawings, narrative, and calculations. It shall include:

20.6.1 Contact Information. The name, address, and telephone number of all persons having a legal interest in the property and the tax reference number and parcel number of the property or properties affected;

20.6.2 A locus map;

20.6.3 Existing site plan (for comparison to 20.6.15 below);

20.6.4 The existing zoning, and land use at the site;

20.6.5 The proposed land use;

20.6.6 The location(s) of existing and proposed easements;

20.6.7 The location of existing and proposed utilities;

20.6.8 The site's existing & proposed topography with contours at 2-foot intervals,

20.6.9 The existing site hydrology (both groundwater recharge and surface runoff);

20.6.10 A description and delineation of existing stormwater conveyances, impoundments, wetlands, drinking water resource areas, shellfishing areas, swimming beaches or other critical environmental resource areas, on or adjacent to the site or into which stormwater flows;

20.6.11 A delineation of 100-year flood plains, if applicable;

20.6.12 Estimated seasonal high groundwater elevation in areas to be used for stormwater retention, detention, or infiltration;

20.6.13 The existing and proposed vegetation and ground surfaces with runoff coefficients for each;

20.6.14 A drainage area map showing pre and post construction watershed boundaries, drainage area and stormwater flow paths, including municipal drainage system flows;

20.6.15 A recharge area analysis that calculates pre-and post-project annual groundwater recharge rates on the parcel;

20.6.16 A description and drawings of all components of the proposed LID Management system including:

A. Locations, cross sections, and profiles of all brooks, streams, drainage swales and their method of stabilization;

B. All measures for the detention, retention or infiltration of water;

C. Description of non-structural BMPs;

D. All measures for the protection of water quality;

E. The structural details for all components of the proposed drainage systems and LID Management facilities;

F. Notes on drawings specifying materials to be used, construction specifications, and expected hydrology with supporting calculations;

G. Proposed site plan including location of buildings or other structures, impervious surfaces, and drainage facilities, if applicable;

H. Any other information requested by the Planning Board.

20.6.17 Hydrologic and hydraulic design calculations for the pre-development and post-development conditions for the design storms specified in this Bylaw. Such calculations shall include:

A. Description of the design storm frequency, intensity and duration;

B. Time of concentration;

C. Soil Runoff Curve Number (RCN) based on land use and soil hydrologic group;

D. Peak runoff rates and total runoff volumes for each watershed area;

E. Information on construction measures used to maintain the infiltration capacity of the soil where any kind of infiltration is proposed;

F. Infiltration rates, where applicable;

G. Culvert capacities;

H. Flow velocities;

I. Data on the increase in rate and volume of runoff for the specified design storms; and

J. Documentation of sources for all computation methods and field test results.

20.6.18 Post-Development downstream analysis if deemed necessary by the Planning Board;

20.6.19 Soils Information from test pits performed at the location of proposed LID Management facilities, including but not limited to soil descriptions, depth to seasonal high groundwater, depth to bedrock, and percolation rates. Soils information will be based on site test pits logged by a Massachusetts Registered Soil Evaluator, or a Massachusetts Registered Professional Engineer;

20.6.20 Landscaping plan describing the woody and herbaceous vegetative stabilization and management techniques to be used within and adjacent to the stormwater practice.

20.7 OWNERS ASSOCIATION

As a condition of approval of a LID Management Plan the Applicant shall create and properly fund an Owners Association and all purchasers of land within the project shall be required to belong to the Owners Association. The Owners Association shall be responsible for the perpetual operations and maintenance of the components of the approved LID management Plan. The Owners Association shall maintain permanent ownership of any drainage basins or ponds in the subdivision, including all pipes and other appurtenant devices, and shall have the permanent responsibility of maintaining, repairing and replacing said drainage systems, as necessary. The Owners Association documents shall be reviewed and approved by the Planning Board, in consultation with Town Counsel, and the Owners Association shall have an initial fund that is deemed satisfactory to the Planning Board, in consultation with the Planning Board's technical consultant. The Owners Association shall send correspondence to all members of the Association twice a year, once during March and once during September, to advise each member of the Association's duties and responsibilities to: (1) operate and maintain the components of the approved LID management Plan; and (2) maintain, repair and replace the drainage systems. At the same time, the Owners Association shall provide a written reminder to each individual member to maintain any portion of the systems on each member's property, including the mowing and clearing of drainage swales and berms.

20.8 CONNECTIONS TO MUNICIPAL SYSTEMS

There shall be no connections to the Town of Westport Municipal Storm Drain Systems (MS4)

20.9 PROMULGATION OF RULES AND REGULATIONS

The Planning Board may promulgate rules and regulations to effectuate the purpose of this bylaw. Failure by the Planning Board to promulgate such rules and regulations shall not have the effect of suspending or invalidating this bylaw.

20.10 INSPECTIONS, SUBMISSION OF FINAL PLANS, MAINTENANCE

20.10.1 The Planning Board, or designated agent, shall make inspections as hereinafter required and either shall approve that portion of the work completed in accordance with the approved plans or shall notify the owner or person responsible for the implementation of the plans wherein the work fails to comply with the approved soil erosion and sediment control plan, or the approved stormwater management plan as described in Planning Board's Rules and Regulations. Plans for grading, removal, stripping, excavating, and filling work approved by the Planning Board and shall be stored on site during the progress of the work. To obtain inspections, the permittee shall notify the Planning Board agent at least two working days before each of the following:

A. Installation of sediment and erosion control measures.

B. Start of construction.

C. Completion of site clearing.

D. Completion of rough grading.

E. Installation of stormwater controls.

F. Close of the construction season.

G. Completion of final landscaping.

20.10.2 The person responsible for the implementation of the approved plans shall make regular inspections of all control measures in accordance with the inspection schedule outlined on the approved soil erosion and sediment control plan(s). The purpose of such inspections will be to determine the overall effectiveness of the control plan and the need for additional control measures. All inspections shall be documented in written form and submitted to the Planning Board Agent at the time interval specified in the approved permit.

20.10.3 The Planning Board, or designated agent, shall enter the property of the applicant as deemed necessary to make regular inspections to ensure the validity of the reports filed as noted above.

20.10.4 The applicant shall submit an "as-built" plan for the stormwater controls after the final construction is completed. The plan must show the final design and specifications of all stormwater management systems and must be prepared by a professional land surveyor.

20.10.5 An Operation and Maintenance plan (O&M Plan) is required at the time of application for all projects. The maintenance plan shall be designed to ensure compliance with the Permit and this Bylaw during all seasons and throughout the life of the system. The Operation and Maintenance Plan shall remain on file with the Planning Board and shall be an ongoing and enforceable requirement. The O&M Plan shall include:

A. The name(s) of the owner(s) for all components of the system;

B. A map showing the location of the systems and facilities including catch basins, manholes/access lids, main, and stormwater devices;

C. Maintenance agreements that specify:

a. The names and addresses of the person(s) responsible for operation and maintenance;

b. The person(s) responsible for financing maintenance and emergency repairs;

c. An Inspection and Maintenance Schedule for all LID Management facilities including routine and non-routine maintenance tasks to be performed;

d. A list of easements with the purpose and location of each;

e. The signature(s) of the owner(s).

D. LID Management Easement(s)

a. LID Management easements shall be provided by the property owner(s) as necessary for:

1. Access for facility inspections and maintenance;

2. Preservation of stormwater runoff conveyance, infiltration, and detention areas and facilities, including flood routes for the 100-year storm event;

3. Direct maintenance access by heavy equipment to structures requiring regular maintenance.

b. The purpose of each easement shall be specified in the maintenance agreement signed by the property owner.

c. Stormwater Management easements are required for all areas used for off-site stormwater control, unless a waiver is granted by the Planning Board.

d. Easements shall be recorded with the County Registry of Deeds prior to issuance of a Certificate of Completion by the Planning Board.

E. Changes to Operation and Maintenance Plans

a. The owner(s) of the LID Management system shall notify the Planning Board of changes in ownership or assignment of financial responsibility.

b. The maintenance schedule in the Maintenance Agreement may be amended to achieve the purposes of this Bylaw by mutual agreement of the Planning Board and the Responsible Parties. Amendments shall be in writing and signed by all Responsible Parties. Responsible Parties shall include owner(s), persons with financial responsibility, and persons with operational responsibility.

20.11 PROJECT CHANGE

The permittee, or his or her agent, shall notify the Planning Board in writing of any change or alteration of a land-disturbing activity authorized in either the soil erosion and sediment control plan or the stormwater management plan before any change or alteration occurs. If the Planning Board determines that the change or alteration is significant, based on the design requirements listed in this bylaw and accepted construction practices, the Planning Board may require that an amended soil erosion and sediment control plan and/or stormwater management plan application be filed. If any change or deviation from these plans occurs during a project, the Planning Board may require the installation of interim measures before approving the change.

20.12 FEES

The appropriate application fee as established by the Planning Board shall accompany each application. Applicants shall pay review fees, as determined by the Planning Board, sufficient to cover any expenses connected with any public hearing, review of the soil erosion and sediment control plan, and site inspection.

20.13 APPEAL

The appeal of any decision of the Planning Board hereunder shall be made in accordance with the provisions of Mass. Gen. L. Ch. 40A or other such provision of the General Laws.

(2011 ATM, Article 36)