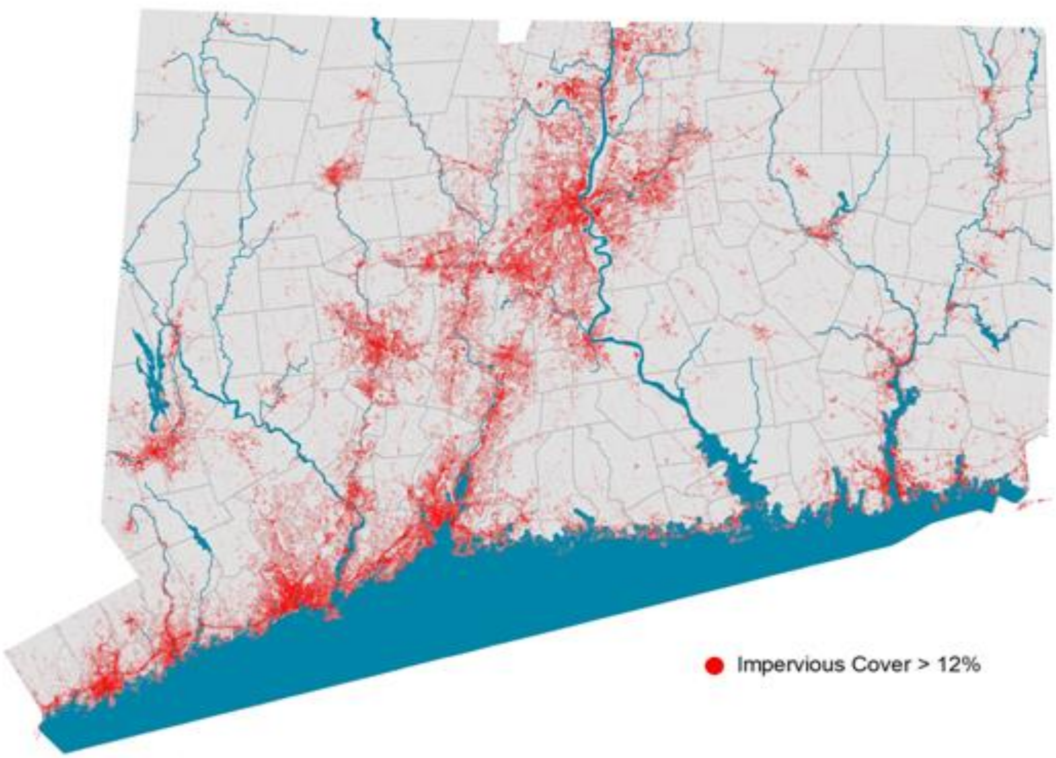
Connecticut Watershed Response Plan
for Impervious Cover

Effects of Stormwater on Water Quality



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Effects of Stormwater on Water Quality

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A. Introduction

The Connecticut Department of Energy and Environmental Protection (CT DEEP) has conducted studies on the relationship between impervious cover (IC) in the upstream watershed and the aquatic life in adjacent surface waters (http://www.ct.gov/deep/imperviouscoverstudies). IC refers to landscape surfaces such as pavement or buildings (hard surfaces) that no longer absorb rain and can direct large volumes of stormwater runoff. The amount of IC affects both the quality and quantity of water resources by disrupting the natural hydrological cycle. IC prevents precipitation from infiltrating into the ground thus increasing surface runoff (quantity) and pollutant transport to the receiving water (quality).These studies indicate that as the amount of IC exceeds 12%, unacceptable impacts to aquatic life can be predicted to occur in surface waters. From these studies, stormwater pollution has also been identified as probable contributing cause to the impairment through the Stressor Identification (SI) process - a method to identify stressors causing biological impairments in aquatic ecosystems.

The waterbodies included in this *Connecticut Watershed Response Plan for Impervious Cover* document have been assessed as not meeting the designated use criteria for Habitat for Fish, Other Aquatic Life and Wildlife contained within the regulations for *Connecticut Water Quality Standards* (CT DEEP, 2013). The waterbodies were included on the 2012 *List of Connecticut Waterbodies Not Meeting Water Quality Standards* (*Impaired Waters List*). These waterbodies were selected as examples of impairments, but the impairment relationship of stormwater pollution and impervious cover is not exclusive to these waterbodies.

Research on impervious cover and stormwater frequently report pollution impacts from issues such as nutrients, metals, polycyclic aromatic hydrocarbons (PAHs), bacteria, temperature and hydrology. The impacts from impervious cover and stormwater pollution are also not a recent problem. As early as the 1960s, impervious cover was reported to effect the urban hydrology compared to the natural environment (Leopold, 1968).

Regardless of whether or not a waterbody is impaired, any watershed with high levels of impervious cover is predicted to contribute to degraded water quality because of stormwater pollution. It is recommended that management measures for waterbodies be planned and implemented in areas that have high levels of impervious cover.

The Plan presents percent reductions of watershed IC for a subset of impaired surface waters and provides recommendations for managing stormwater and impervious cover to support water quality improvements. The target percent impervious cover (%IC) are not regulatory limits but are intended to guide the application of Best Management Practice (BMP) and Low Impact Development (LID) techniques to reduce the *impact* of impervious surfaces. The target also does not represent an actual required reduction in the amount of hard surfaces.

B. Waterbody Description

Connecticut is an urbanizing state, increasing its development footprint by almost 5% from 1985 to 2006, and urbanization is a major cause of water quality impairment in the State (Arnold, et al, 2010). Urban watersheds are characterized by a mosaic of hard surfaces, such as parking lots and rooftops, which do not allow rain to infiltrate. Traveling over these impervious surfaces, large volumes of rapidly moving stormwater can carry a complex array of pollutants and cause other impacts, such as streambank erosion, flooding, and unnatural characteristics of volume and velocity. As shown in Figure 1, urban areas with significant IC are scattered throughout Connecticut, and concentrated within interstate highway corridors of I-395, I-84, I-91 and I-95.

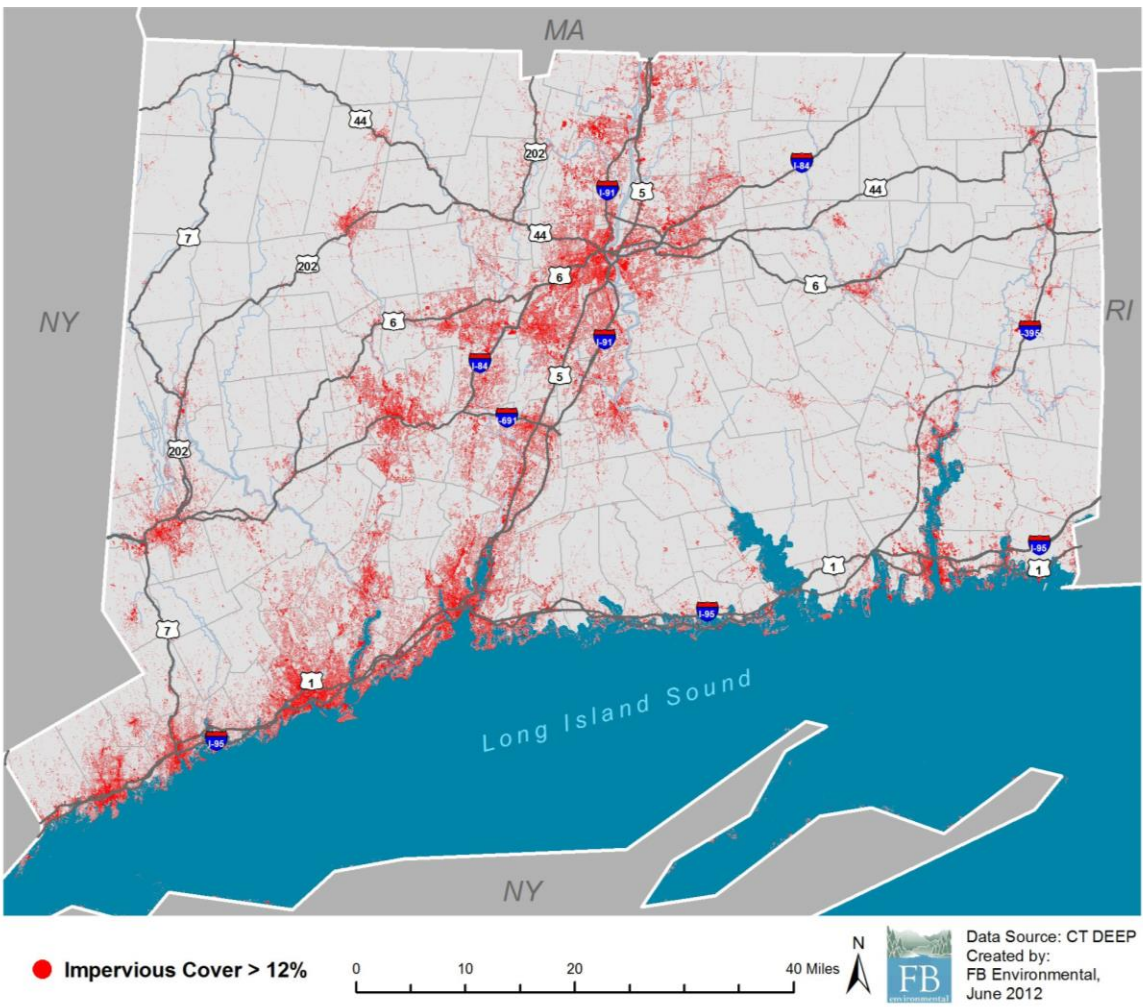


Figure 1: Areas in Connecticut with greater than 12% impervious cover.

Developed watershed characteristics promote excessive erosion and sedimentation from stormwater runoff that can degrade stream habitat. In these watersheds, streams suffer from what has been called urban stream syndrome, a complex and synergistic combination of hydrologic alteration and multiple pollutant stressors (Walsh et al. 2005 and Arnold et al, 2010). Studies by CT DEEP across small Connecticut watersheds indicate that as little as 12% IC has the potential to affect the magnitude, frequency, timing, and duration of the hydrograph as well as the speed, volume and quality of runoff to a stream. From 2005-2006, CT DEEP conducted statewide research comparing stream health, as indicated by metrics for the benthic macroinvertebrate communities, to watershed IC estimates based on 30-meter remotely sensed data (Chabaeva et al., 2007 and Arnold et al., 2010). A total of 125 stream segments were studied, and the results were compelling, in keeping with the literature on the impacts of impervious cover: no stream with over 12% impervious cover in its immediate upstream catchment area met the State's aquatic life criteria for a healthy stream (Bellucci, 2007; see Appendix 2).

The streams identified in Appendix 6 are included on CT's 2012 *Impaired Waters List* for not meeting criteria of Habitat for Fish, Other Aquatic Life and Wildlife. Designated Use assessments conducted by CT DEEP indicated that aquatic life use support goals are not being met in these streams, but the cause of the impairment was determined to be unknown. Given that many of these watersheds are urbanized, reported with a cause unknown, and contain IC levels known to cause impairments to aquatic life, these waterbodies were identified for further study to determine if an IC stressor would be accurate given that stormwater pollution could be contributing to the observed water quality impairment. Therefore CT DEEP performed a screening-level Stressor Identification (SI) on each stream's watershed incorporated in this Plan in order to support application of %IC target reduction. Important watershed characteristics included size of the upstream drainage area (<50 square miles), impaired location beyond 1 mile of a sewage treatment plant discharge, and an upstream drainage area containing a significant amount of IC that exceeded 12%.

The streams in Appendix 6 represent impaired waterbodies where a percent reduction in IC is applicable given the impairment and watershed characteristics. Site-specific information on each stream segment is included beginning with Appendix 6-1 of this report.

C. Pollutant of Concern and Pollutant Sources

An impairment to the aquatic life in these streams was identified using bioassessment protocols as outlined in Connecticut's *Consolidated Assessment and Listing Methodology* (Chapter 1 of the Connecticut Integrated Water Quality Report, CT DEEP, 2012). Although bioassessments can identify impaired aquatic communities, they often do not identify the cause of impairment. Such is the case with these streams where the cause of the aquatic life impairment was unknown. As described above, a screening level analysis was conducted to identify the potential stressor(s) and determine the most likely candidate cause. Watersheds were evaluated to identify potential pollutant sources such as industrial discharges, landfills and sources of potential groundwater contamination. Waterbodies were selected for inclusion in this Plan if these potential sources did not predominate other landscape level stressors associated with stormwater pollution within the watershed. It is possible that additional stressors contributing the observed impairments in addition to the aggregate impacts of stormwater pollution may be identified in the future which may require additional management measures. CT DEEP determined that one most probable cause of the aquatic life impairment in these streams is a complex array of pollutants transported by stormwater.

There is a strong correlation between pollutant loads and stormwater runoff from impervious land cover in the watershed (Appendix 2). Therefore, it is reasonable to rely on the surrogate measure of %IC to represent impacts from stormwater pollution (the effect of stormwater runoff on pollutant loads and hydrology) that ultimately contributes to aquatic life impairment in the streams.

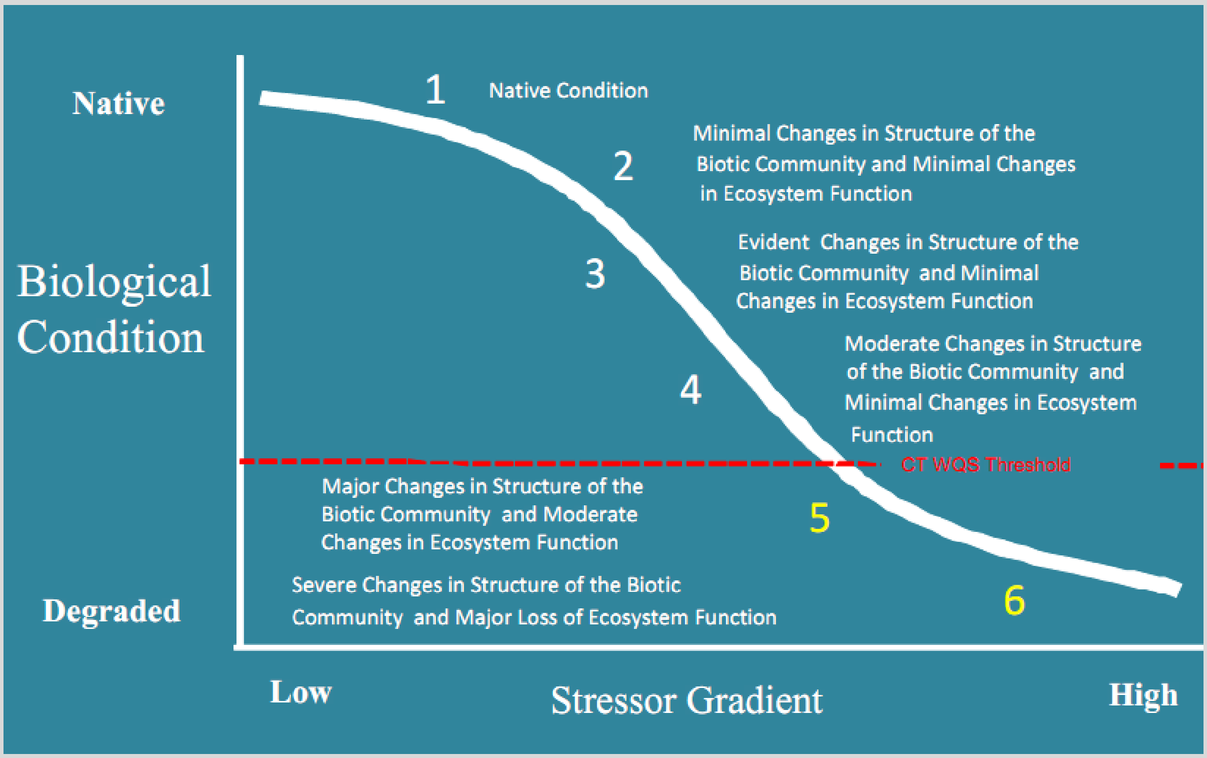
D. Applicable Surface Water Quality Standards

Connecticut's Water Quality Standards (WQS) assign all fresh surface waters to one of three classes (Table 1); each classification is defined by the most sensitive designated uses to be

Table 1: Applicable Water Quality Standards

Surface Water Class	Designated Use
AA	• Existing or proposed drinking water supply; • Habitat for fish and other aquatic life and wildlife; • Recreation; and • Water supply for industry and agriculture.
A	• Potential drinking water supply; • Habitat for fish and other aquatic life and wildlife; • Recreation; • Navigation; and • Water supply for industry and agriculture.
B	• Habitat for fish and other aquatic life and wildlife; • Recreation; • Navigation; and • Water supply for industry and agriculture.
Surface Water Class	**Biological Condition Criteria**
AA, A, B	<u>Sustainable, diverse biological communities of indigenous taxa shall be present.</u> Moderate changes, from natural conditions, in the structure of the biological communities, and minimal changes in ecosystem function may be evident; however, water quality shall be sufficient to sustain a biological condition within the range of Connecticut Biological Condition Gradient Tiers 1-4 (See Figure 2 below).

protected. Biological Condition criteria are used to assess the biological integrity of surface waters in the State. These criteria describe the expected health and composition of aquatic communities inhabiting waters of a given designated use, based on measurements in unimpaired waters (CT DEEP, 2011a). Biological Condition criteria and designated uses for Classes AA, A, and B waters are listed below in Table 1. The Surface Water Classification for each impaired stream segment is listed in Table 2 of Appendices 6-1 thru 6-15.



*The **Connecticut Biological Condition Gradient Model** illustrates the relationship between the amount of stress on the environment and its effect on biological communities. According to the model, as the level of stress gets progressively greater, biological communities, which start out in a natural condition (Tier 1), begin to change as they respond to the stress (CT DEEP, 2011a).*

Figure 2: The Connecticut Biological Condition Gradient Model.

E. Water Quality Target

The reduction targets in the Plan for the impaired streams were developed using percent IC as a surrogate for a complex array of stormwater pollution that impacts aquatic life. The goal of the Plan is to reduce impacts from stormwater pollution on the aquatic life in these streams addressed. Meeting the goals will be assessed by measuring the aquatic life directly and not by measuring the IC reduction. The aquatic life criteria are referenced in Connecticut's WQS (see previous section), and assessment of attainment of aquatic life criteria is described in *Consolidated Assessment and Listing Methodology* (CT DEEP, 2006). A target of 12% IC represents the level of impervious cover in the contributing watershed, below which a stream is likely to support a macroinvertebrate community that meets aquatic life use goals in Connecticut Water Quality Standards. The 12% IC target is within the range of % IC values generally reported in the literature (ENSR, 2005; CWP, 2003; Arnold et al., 2006) and, more specifically, in other New England states such as Maine (Maine DEP, 2005; see Appendix 2 for further information).

Stormwater pollution is categorized under two types of pollutant loads: point and non-point sources. Point sources are permitted a waste load allocation (WLA) and regulated under the National Pollutant Discharge Elimination System (NPDES), but a load allocation (LA) is also contributed by non-point sources where no regulations are applicable. It is not feasible to draw a clear distinction between stormwater pollution originating from point and non-point sources because insufficient data are available for each parcel in the watershed and the fact that stormwater pollution is highly variable in frequency and duration. Consequently, a Margin of Safety (MOS) is incorporated into the %IC target in order to account for uncertainties regarding the relationship between water quality and sources (point and non-point). Therefore, a 1% MOS was subtracted from the %IC target to account for uncertainty in the analysis, resulting in a combined WLA and LA target of 11%. The 11% IC target applies to all drainage areas involving both point and non-point sources in the watershed (WLA=LA=11% IC), in order to reduce pollutant loads and restore hydrologic and biological integrity of the watershed as a whole.

All of the streams highlighted in this document are within an Urban Area regulated under Connecticut's Municipal Separate Storm Sewer Systems (MS4) general permit. However, the %IC target reductions are not permit limits or an explicit requirement to reduce or eliminate the actual amount of hard surfaces within a watershed. The IC target solely focuses on the effect of impervious surfaces on water quality and should not be construed to require a literal reduction in actual amount of road and building surfaces. These percentages are provided to serve as a guideline to reduce the impact of stormwater pollution for waterbodies that are within a watershed with 11% or greater IC. Following these guidelines would lead to improvements in the aquatic life community of a watershed.

This 11% IC target for WLA and LA can also be expressed as a percent reduction in the effect of the existing impervious cover compared to current conditions, and can provide a benchmark for implementation of best management practices (BMPs) to reduce the impacts of impervious cover on aquatic biota living in the stream. The WLA and LA % IC target, and any percent reduction in the effect of IC to achieve the target, can be applied to both the WLA and LA because of the practical difficulty of separating stormwater pollution contributed by background, nonpoint, and point sources.

To calculate the percent reductions for the effect of IC on water quality required to achieve the WLA and LA target:

$$\text{Percent IC reduction} = ((\text{IC Current Condition} - \text{IC Target})/\text{IC Current Condition}) \times 100$$

$$\text{where IC Target} = 11\%$$

To calculate the Current Condition, % IC values for each stream section were derived from the National Land Cover Database 2006 percent imperviousness estimate layer for the conterminous United States (http://www.mrlc.gov/). This 30 meter resolution data is based primarily on the unsupervised classification of 2006 Landsat Enhanced Thematic Mapper satellite data (Fry et al., 2011). The analyses for each of the streams addressed by this Plan are provided in the site-specific appendices. The percent reduction of IC to achieve the IC target is calculated for informational purposes only, to describe the percent reduction needed in the effect of the existing IC on the watershed, and should only be used as an implementation guide.

F. Implementation to Reduce the Effect of IC

As emphasized earlier in this document, IC can be used as a surrogate for the impacts that pollutants and other stressors from stormwater pollution have on the aquatic life community in streams. In order to minimize the effects from a complex array of stormwater pollution to the waters of the State, including those that are impaired, NPDES stormwater permittees can aid in the implementation of control measures which would reduce impacts from stormwater pollution to offset the negative effect of IC. Future development activities have the potential to increase impervious cover, and should be constructed and operated to limit the effect of stormwater pollution due to impervious cover on the aquatic life in these streams.

<u>Permitted Stormwater Sources</u>

The control of stormwater pollution from regulated sources is a significant means of addressing the impairment to aquatic life. Regulated stormwater discharges consist of those authorized under the General Permit for the Discharge of Stormwater from Municipal Separate Storm Sewer Systems (MS4 GP), General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities (Construction GP), General Permit for the Discharge of Stormwater Associated with Industrial Activity (Industrial GP), and General Permit for the Discharge of Stormwater from Commercial Activities (Commercial GP). Each of these general permits requires the implementation of control measures, water quality monitoring and some type of a stormwater management plan.

MS4 GP discharges

MS4 dischargers must implement the Stormwater Management Plan (SMP) required by the MS4 permit reissued on January 9, 2011, and as amended. The SMP includes best management practices (BMPs) grouped into six Minimum Control Measures, which consist of Public Education and Outreach, Public Involvement/ Participation, Illicit Discharge Detection and Elimination, Construction Site Stormwater Runoff, Post Construction Stormwater Management in New Development and Redevelopment, and Pollution Prevention/Good Housekeeping. Compliance with the MS4 GP, as amended, includes implementation of the SMP and six Minimum Control Measures.

Construction GP discharges

The Construction GP regulates the runoff from construction with 5 or more acres of soil disturbance for projects with municipal land use approvals and with 1 or more acres of soil disturbance for projects without municipal land use approvals. The Construction GP requires controls to reduce the discharge of sediment during construction and includes measures to address the long term impacts related to post-construction stormwater discharges. These post-construction discharges require the retention and/or infiltration of stormwater using LID and runoff reduction methods. Although the proposed post-construction performance standards are not based on the percentage of impervious cover, the runoff retention standards specified will serve to reduce and/or disconnect impervious area.

Industrial GP discharges

Industrial facilities are required to develop and implement a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP must include control measures (similar to BMPs) to reduce or eliminate the discharge of pollutants from the site. Typically, industrial sites are highly impervious. However site constraints, and cost considerations will complicate the reduction of impervious cover. To address the effect of IC, industrial sites where site expansion or redevelopment is planned should focus on the reduction and minimization of impervious area. The industrial facility can consider which BMPs may be appropriate for the site as well as those to address specific sources.

Commercial GP discharges

The Commercial GP regulates commercial sites with impervious surfaces exceeding 5 acres, such as malls and “big box” stores. The plan to address the control of stormwater pollutants from these sites is called a Stormwater Management Plan (SMP). The commercial site can consider which BMPs are appropriate for the site as well as those to address specific sources.

Non-Regulated Discharges

Approximately one-third of the municipalities in the State do not fall under the MS4 permit. Non-MS4 municipalities can voluntarily implement the BMPs within the MS4 permit and this document. Any facilities that discharge non-regulated stormwater can update their Pollution Prevention Plans to include BMPs that can reduce pollutants from entering surface waters. These BMPs could include revised housekeeping procedures to reduce pollutants or techniques that increase infiltration to reduce runoff. Additionally, sites or areas that are not regulated by a NPDES permit (such as small scale commercial and construction sites, residential sites, etc.) should consider implementation measures to minimize and/or disconnect impervious areas. Improving water quality within the community to address nonpoint source pollution requires actions, large and small, by the community.

Apart from of these discharge categories, successful implementation will be best accomplished through incorporating an adaptive management strategy on a watershed basis. Additional investigation is necessary for all watersheds in order to fully document problem areas and begin the restoration process. The implementation strategy should include: 1) conducting parcel-level field work to locate directly connected impervious cover; 2) reducing IC where practical; 3) disconnecting IC from the surface waterbody; 4) minimizing additional disturbance to maintain existing natural buffering capacity; and 5) installing engineered BMPs and LID practices to reduce the impact of IC on receiving water hydrology and water quality. Appendices 4 and 5 provide some appropriate strategies and case studies for reducing stormwater pollution on a case by case basis.

G. Water Quality Monitoring

Monitoring is a valuable tool where its design can be tailored for decision-maker or scientific objectives. Common techniques for water quality monitoring include analyses of biological and chemical samples. The information from these analyses can provide strong empirical evidence for determining status, developing models and identifying trends of water quality. However, these techniques are not necessarily required to inform every decision. Monitoring can be a simple technique such as tracking project implementation or land use changes in the watershed. This gathered information can drive decisions at the local level which can provide cost-savings by focusing resources and increasing BMP effectiveness. Data from analyses, tracking or other techniques can be used to further refine efforts to improve water quality. The following provides some background on the development of a monitoring plan strategy.

CT DEEP Monitoring Plan

Surface water chemistry and benthic macroinvertebrate data will be collected by CT DEEP Bureau of Water Protection and Land Reuse as described in the Rotating Basin Ambient Monitoring Strategy (CT DEEP, 1999). Benthic macroinvertebrates will provide the primary metric to measure the progress of meeting the criteria of Habitat for Fish, Other Aquatic Life and Wildlife Use support. The Bureau of Water Protection and Land Reuse may also coordinate with the CT DEEP Inland Fisheries Division to collect fish population data. Fish population data can provide an additional measure for aquatic life use support.

Permittee Monitoring Plans

A comprehensive water quality monitoring program is beneficial to help guide implementation efforts and at a minimum should be designed to accomplish two major objectives: source detection and tracking water quality improvements. Monitoring is crucial to identify specific sources of stormwater runoff which will, in turn, direct BMP implementation efforts.

Progress in BMP implementation can be gauged through implementing a fixed station ambient monitoring program. Supplemental samples can be collected at other key locations within the watershed, such as above and below potential contributing sources or areas slated for BMP implementation. Since watershed borders do not follow town borders there is a possibility CT DEEP did not sample locations in your town. If this is the case then collecting a sample where the waterbody enters your town and another where the waterbody leaves your town maybe helpful to determine how stormwater pollution in your town influences water quality.

Non-regulated Monitoring Plans

Non-regulated areas or sites are not required to develop discharge monitoring plans, but simple tracking techniques can still be beneficial towards water quality improvements. Tracking improvements can help identify areas of concern and assist in future planning. Tracking implementation is simple to establish by noting an area or a total of actions, such as disconnecting rain gutters, stormwater retrofits or installing porous pavement. In some cases, this information is helpful to secure funding or get connected to shovel-ready projects. Tracking information can be used to calculate areas that have implemented BMPs which points to reducing the impact of hard surfaces and showing progress towards reducing pollution. Tracking any activity can assist with defining improvements in water quality, documenting implementation actions and achieving restoration goals.

Recommended Monitoring Parameters

All pollutant parameters should be analyzed using methods prescribed in the Code of Federal Regulations[9]. Electronic submission of data to CT DEEP is highly encouraged. Results of monitoring that indicate unusually high levels of contamination or potentially illegal activities should be forwarded to the appropriate municipal or State agency for follow-up investigation and enforcement. As these parameters are found in the MS4 permit, the following are strongly recommended in any monitoring program:

- pH (SU)

- Temperature
- Dissolved Oxygen (mg/l)
- Hardness (mg/l)
- Conductivity (umos)
- Chloride (mg/l)
- Magnesium (mg/l)
- Cyanide (mg/l)
- Surfactants as MBAS (mg/l)
- Total Petroleum Hydrocarbons (mg/l)
- Oil and grease (mg/l)
- Chemical Oxygen Demand (mg/l)
- Total Suspended Solids (mg/l)
- Total Phosphorous (mg/l)
- Ammonia (mg/l)
- Total Kjeldahl Nitrogen (mg/l)
- Nitrate plus Nitrite Nitrogen (mg/l)
- Total Copper (mg/l)
- Total Lead (mg/l)
- Total Zinc (mg/l)
- E. coli and Total Coliform (col/100ml) (for Class AA, A and B surface waters)
- Fecal coliform and Enterococci (col/100ml) (for Class SA and SB surface waters)

CT DEEP is committed to providing technical assistance in monitoring program design and establishing procedures for electronic data submission.

H. Implementation Assurance

The Department can work with watershed partners, including towns and conservation organizations to implement better stormwater management in the impaired streams and watersheds. Additionally, there is a combination of regulatory and non-regulatory program support in Connecticut, including: regulatory enforcement requirements, availability of financial incentives, and local, State, and federal programs for pollution control. Enforcement of regulations controlling non-point source discharges includes local implementation of Connecticut's Enhanced State Nonpoint Source Management Program (www.ct.gov/deep/nps).

CT DEEP continues to work with watershed stakeholders to draft Watershed Based Plans (WBPs) under the CWA 319 program. As part of these WBPs, watershed stakeholders investigate impairments and promote the implementation of nonpoint source pollution best management practices and stormwater management practices in the watershed. CT DEEP approves various WBPs, including those that recommend watershed-wide and place-based management measures to reduce nonpoint source pollution and source mitigation. These recommended WBP projects may be eligible for CWA 319 funding, as long as such projects are not used for permit compliance.

I. Public Participation

Public participation plays an important role in water quality restoration, and this Plan will be posted on the Department website (www.ct.gov/deep) for public access. This Plan is intended to serve an advisory role to regulatory programs such as the NPDES permitting. The Department welcomes public feedback to assist with the implementation process that will involve the cooperation of citizens, local government and CT DEEP.

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