

Assessing Municipal Operations as a Stormwater Pollution Prevention Management Strategy:
a Possible Approach for the City of Durham, North Carolina

by

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ABSTRACT

Across the United States, federal and state policy on surface water quality is actively expanding to require local governments to address non-point source pollution from stormwater runoff into impaired streams. Many local governments have recently initiated their local comprehensive stormwater programs in order to meet minimum measures of the National Pollution Discharge Elimination System (NPDES) stormwater program for Phase I and Phase II communities. Water quality regulations require local governments, at minimum, to act as good stewards of the environment as urban areas age, undergo repairs or revitalization, or add new development. While the adage of “setting a good example” is simple in concept, local governments and communities struggle with the process of developing their own effective and comprehensive pollution prevention/good housekeeping program to address local water quality problems and meet watershed restoration objectives. As a Phase II NPDES (or MS4) community, the City of Durham, North Carolina is responsible for complying with their state permit that allows the release of runoff into waterways from the City stormwater system. In order to foster a comprehensive and long-term commitment to preventing pollution by the City’s municipal operations, the Stormwater Services Division (SSD) in Durham’s Public Works Department identified the need to outreach to other city departments that undertake municipal maintenance activities.

Through document and media review combined with email, phone or in-person interviews with stormwater professionals, this project first examines existing concerns, attitudes, approaches and resources available for local governments to utilize when self-evaluating their own municipal pollution prevention/good housekeeping practices. Towards the second part of this project, a municipal operations survey was developed in consultation and on the behalf of SSD staff, targeted for the staff of the Landscape Maintenance Division of Durham’s General Services Department. This initial internal survey serves as a step in needs assessment, a documentation process whereby SSD staff can gather baseline information on current municipal maintenance activities and practices that stand to impact water quality. By identifying current practices and possible information gaps, the SSD staff will be better equipped to develop and customize targeted training sessions on pollution prevention for all City employees.

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Table of Contents

Acknowledgements	<i>i</i>
Abstract	<i>ii</i>
1.0 Introduction	
1.1 Project Objectives	1
1.2 Nonpoint Source Pollution.....	2
1.3 Urban Development and Urban Runoff.....	3
1.4 Riparian Area, Riparian Buffers and Urban Riparian Buffer Performance.....	4
1.5 Legacy of Land Uses, Stream Health, and Urban Riparian Function Considerations.....	7
1.6 Drought Implications for Urban Riparian Buffers and Stormwater Management.....	9
1.7 The City of Durham and Durham County.....	12
1.8 Drought Implications for the City of Durham.....	13
2.0 Legal and Jurisdictional Histories and Frameworks	
2.1 Federal Legislation	14
2.2 State Legislation	16
2.3 Municipal Roles, Local Authority, and Local Watershed Restoration	
2.3.1 Cities, Municipalities, and the NPDES Program.....	19
2.3.2 Durham’s Comprehensive Plan and the Unified Development Ordinance (UDO).....	20
3.0 Methods	
3.1 Literature, Professional Opinion and Digital Media Review.....	22
3.2 Municipal Operations Survey.....	23
4.0 Project Findings	
4.1 Literature, Professional Opinions, and Digital Media Review Findings	
4.1.1 Water Quality and Stormwater Management in the City of Durham.....	25
4.1.2 Challenges and Concerns for Assessing Municipal Operations.....	27
4.1.3 Civil Infrastructure Management (Thinking in Systems).....	33

4.2 A Step in Assessing Municipal Operations: Survey Considerations and Possible Outcomes	37
5.0 Discussion and Recommendations	
5.1 Consideration of Natural Research Council’s Recommendations	39
5.2 Recommendations for the Municipal Operations Survey.....	42
5.3 The Importance of Maintaining Stormwater Infrastructure.....	43
6.0 References.....	46
7.0 Appendices	
7.1 Appendix A: Supplemental Tables and Figures	
<i>Tables</i>	
Table 1: Constraints on the specification of restoration success criteria in natural vs. urban environments.....	50
Table 2: Reported Best Management Practices Land Area Requirements for Effective Treatment.....	51
Table 3: Fiscal Year Comparison for Water Quality Programs at the California EPA, Los Angeles Regional Water Board.....	51
<i>Figures</i>	
Figure 1: The Biological Condition Gradient.....	52
Figure 2: Conceptual Model of Stormwater Management in Relation to Stream Ecology and Urban Ecology.....	53
Figure 3: Organizational Chart for the City of Durham.....	54
Figure 4: Organizational Chart for the Public Works Department, City of Durham.....	55
Figure 5: Durham’s total drainage system and reported facts on streets.....	56
7.2 Appendix B: Sample of Municipal Operations Survey of Landscape Maintenance Staff in General Services, City of Durham, NC.....	57
7.3 Appendix C: Summary of Recommendations from Literature Review.....	62

1.0 Introduction

“An ounce of prevention is worth a pound of cure.”

-Benjamin Franklin, quoted by M. Novotney (in CWP, 2008)

“As with most resource impacts, an ounce of stormwater prevention is worth a pound of cure.”

Paraphrased version in the Stormwater Management Program for Nutrient Control for the City of Washington, NC (Washington, 2004)

1.1 Project Objectives

Human development of land into cities, towns and suburbs inherently alters lands that formerly were forested or open space, often degrading hydrologic, chemical, and biological processes. Across cities and metropolitan regions in the United States of America, municipal resource managers, city planners, and communities are reassessing local growth trajectories, seeking planning tools, and embarking on various initiatives to reduce urban environmental impacts to the nation’s water quality. Federal and state water regulations require, at minimum, that local governments act as good stewards of the environment as urban areas age, undergo repairs or revitalization (redevelopment), or add new development. (EPA/CWP, 2006)

Public works management of civil infrastructure requires significant planning and design, financing, construction, and the operation and maintenance of a myriad of framework structures in the urban landscape. First, this project examines existing concerns, approaches and resources available for local governments to utilize when self-evaluating their own municipal pollution prevention/good housekeeping practices. Second, an internal survey on current municipal operations and activities for landscape maintenance staff was created and provided to the City of

Durham, North Carolina. Internal targeted surveys of this nature can provide valuable benefits in the planning, development and refinement of municipal stormwater management plans.

1.2 Nonpoint Source Pollution

Throughout the 1980s in the United States, increasing trends towards urbanization, combined with higher additions of nutrients and chemicals from agricultural practices, posed significant challenges to water quality protection and improvements. Growing public awareness extended beyond point-source pollution¹ as the sole threat to waterbodies. Researchers, the public, and the federal government recognized that diffuse sources of natural or manmade pollutants also impacted the water quality and biologic integrity of lakes, rivers, reservoirs, and coastal waters. These diffuse pollution sources are collectively referred to as nonpoint source pollution.

Nonpoint source pollution (hereafter shortened to NPP) results from the movement of water across and through the ground, typically after rainfall or storm events. In urban areas, precipitation generates runoff which mobilizes and carries terrigenous pollutants, (e.g. sediments or organic nutrients), or anthropogenic pollutants (e.g. tire dust which contains organotoxins, heavy metals, poly-aromatic hydrocarbons PAHs from parking lot sealants, and environmental androgens and estrogens, grease or oils from automobile pollution on streets) into waterways. Second only to agricultural land use, the United States Environmental Protection Agency (EPA) identifies urbanization within watersheds as the next greatest nonpoint source pollution contributor. (EPA, 2008)

¹ Point source pollution is defined by the U.S. EPA, in section 502(14) of the Clean Water Act, as “any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.”

1.3 Urban Development and Urban Runoff

“Urban stormwater is listed as the “primary” source of impairment for 13 percent of all rivers, 18 percent of all lakes, and 32 percent of all estuaries. Although these numbers may seem low, urban areas cover just 3 percent of the land mass of the United States, and so their influence is disproportionately large. Indeed, developed and developing areas that are a primary focus of stormwater regulations contain some of the most degraded waters in the country.” (NRC, 2008)

Traditional urban water management emphasizes waste disposal, flood control and/or addressing public safety and health concerns for drinking water sources impacted by urbanized rivers. (Walsh et al., 2000; Walsh et al., 2005) Urban development reduces soil’s water storage capacity by removing dips in the land surface, vegetated swales, and ephemeral streams. Instead of keeping these natural landscape features and rather than allowing smaller ephemeral streams to flow naturally, urban areas have installed artificial drainage networks in the form of sewers, road culverts and highly channelized streams (Booth, 1991) Urban stream networks are generally much less complex than natural stream networks and have fewer and larger tributaries. (Brown, 1988; Dunne & Leopold, 1978; Paul & Meyer, 2001)

Stormwater control systems—namely gutters, curbing, and storm drains—remove and direct runoff away from a house or commercial development as fast as possible and designs were made to anticipate heavy flow or rainfall events to minimize flood damage to property. (Davis & McCuen, 2005) Storm drains are connected pipes that typically drain directly into the nearest streams. When urban runoff and stormwater discharge into a watercourse, they exert a polluting load on that waterbody and can cause significant erosion and environmental degradation within a watershed (Davis et al., 2001). Urban development typically adds impervious areas, reducing the percolation of rainwater into the ground, and leading to greater volumes of runoff and stormwater reaching waterways. Added impervious areas increases the flow velocities of runoff into local waterways. (EPA, 2008) Thus, the common impacts of magnified stormwater

discharges to urban streams (summarized in Table 1) include pollution loading, sedimentation, flash flooding, channel incisement and fluvial instability. (Doll et al., 2002; EPA, 2008; Thrash, 2007) Such hydrologic changes affect both physical and biologic conditions of streams, lakes and wetlands as well as industries reliant on these natural resources. (Also see Figures 1 and 2 in Appendix A)

Table 1: Cumulative impacts associated with inadequate stormwater management during urbanization

Hydrologic	Geomorphic	Environmental	Socioeconomic
Increased flooding and elevated flood stages	Eroded streambanks	Nonpoint-source pollution loading	Increased cost of water treatment
Decreased groundwater recharge	Widening and deepening stream channels	Impaired fish and aquatic life	Loss of recreation and fisheries-related industries
Magnification of small storms	Floodplain loss	Threats to public health and welfare	Property damage and lower property value

Source: Thrash, J.P. (2007) "Ecologically Functional Stormwater Basin Retrofits," *Stormwater*.

1.4 Riparian Area, Riparian Buffers and Urban Riparian Buffer Performance

Broadly defined, riparian areas are ecosystems occurring along watercourses and waterbodies. These areas are transitional places between the terrestrial and aquatic environments. Riparian areas are distinctly different from surrounding uplands. Defined by their unique soil properties, they are strongly influenced by soil water saturation and vegetation. Thus, riparian areas include the stream valley, the slopes to that valley, and the upland areas that interact with the stream. Researchers have defined riparian areas as a "collection of ecosystems" best described as "riparian ecotones" where an ecotone is defined as a gradient across ecosystems; as such, the shape of adjacent upland slopes in a valley ultimately define a riparian area. (Verry et al., 2004) Riparian areas are places of natural water storage and retention, slowing movement of surface and ground waters into streams after storms.

Additionally, the vegetation of riparian areas, aside from providing habitat to a diverse biota, offers overhanging tree cover which shades and reduces stream temperature fluctuations and provides the organic matter, decaying leaves and branches which form the base of aquatic food webs (Allan, 1995). Bank-side tree root systems stabilize stream banks both in-stream and above ground, reducing erosion and sediment loads to downstream areas (Beeson and Doyle, 1995; Booth, 1991). Riparian areas, including wetlands, provide nutrient cycling, and so reduce the nutrient inputs (e.g. nitrogen and phosphorous) into streams (Groffman et al., 1996; Groffman et al., 2002; Walsh et al., 2005). Without ecologically functioning riparian areas, freshwater and marine systems experience human-induced, accelerated eutrophication which results in persistent harmful algal blooms, hypoxic (low oxygen areas) or “dead” zones, and drastic ecosystem degradation, including biodiversity loss from fish kills and negative impacts to other aquatic organisms. (Muthukrishnan et al., 2004; Walsh et al., 2005; EPA 2008b)

Riparian buffers, on the other hand, are areas defined by regulations and laws, or voluntary programs. Riparian buffers are defined areas bordering rivers, streams, or waterbodies that are protected and managed by humans to mitigate the impacts of human activities. Riparian buffers can also be designated in response to habitat requirements of protected or endangered species, or to conserve ecosystems at a scale that will allow the survival of these species (Crow et al., 2000).

Determining the actual buffer width of a riparian buffer is viewed as somewhat arbitrary by watershed scientists—a product of either political or administrative decisions rather than of scientific research for a particular riparian area (Castelle et al. 1994). Riparian buffers partially preserve the ecological function of riparian areas, but in the urban setting these areas must process higher amounts of nutrients, sediments, terrigenous and newer anthropogenic pollutants in a significantly smaller area and in a much shorter amount of time than that provided by an

undisturbed riparian area. (NRC, 2002) Urban ecologists further assert that the physical environment of cities place *a priori* constraints on riparian and wetland restoration goals and success criteria of urban environments compared to natural environments². (Stander and Ehrenfeld, 2009; Ehrenfeld, 2000)

The long-term effectiveness of riparian buffers depend on many interrelated factors—including soil type, surface and groundwater hydrology, topography, vegetation and upland surrounding land uses, (Addy et al., 1999; Castelle et al., 1994). Regional and local watershed characteristics and climate also impact buffer effectiveness, influencing the residence times of water, nutrients, sediments, pollutants and pesticides in the soils of a buffer. An urban area's water table depth, or the unsaturated zone of soils, is often lower because of the reduced infiltration. Urban stream channels often deepen, or incise, over time because of the higher volumes and speeds of water entering the stream during storm events. (Walsh et al., 2005)

Seasonal variability is an additional variable to consider in evaluating urban riparian buffer effectiveness. The residence time of water in riparian buffer soils can vary with storm events or annually; consequently, riparian buffer effectiveness can vary seasonally in relation to the rates of biological activity, e.g. above- or below-ground plant growth and reproduction, in the buffer. (Stander and Ehrenfeld, 2009; Ehrenfeld, 2000; Groffman et al. 2000; Groffman et al., 1996)

Nitrification, an aerobic process, forms nitrates in soils. Nitrates, in limited quantities are beneficial for plants; but when present in excess, become toxic for plants and so become nutrient pollutants for surface and ground water. (Groffman et al. 1996; Novotny, 2003)

² Appendix A provides Ehrenfeld's comparison of the constraints on the specification of wetland or riparian restoration success criteria in natural versus urban environments.

1.5 Legacy of Land Uses, Stream Health & Urban Riparian Function Considerations

The report, “Stormwater Management in the United States,” published last year by the National Research Council(NRC),³ identified a broad disconnect between scientific research efforts and stormwater management approaches, stating that efforts to:

“create mechanistic links between population growth, land-use change, hydrologic alteration, geomorphic adjustments, chemical contamination in stormwater, disrupted energy flows and biotic interactions, and changes in ecological communities are still in development. Despite this assessment, there are a number of overarching truths that remain poorly integrated into stormwater management decision-making, although they have been robustly characterized for more than a decade and have a strong scientific basis that reaches even farther back through the history of published investigations.”

(p. 231, NRC, 2008)

The summary section of this NRC report detailed four “truths” that need better consideration in stormwater management approaches and programs. The first stated truth is that “a direct relationship [exists] between land cover and the biological condition of downstream receiving waters,” and that “the lowest levels of biological condition are inevitable with extensive urban transformation of the landscape, commonly seen after conversion of about one-third to one-half of a contributing watershed into impervious area.” (NRC, 2008)

The second overarching truth proposed by the NRC report, is that “the protection of aquatic life in urban streams requires a [stormwater management] approach that incorporates all stressors” which lead to the “Urban Stream Syndrome.”⁴ On this point, the NRC’s example posits that alterations in hydrologic conditions are associated with impaired biological conditions even without elevated pollutant concentrations reaching receiving waters. The third truth,

³ See NRC 2008, Summary section, p. 6. Available at: <http://www.nap.edu/catalog/12465.html>

⁴ Walsh et al. (2005) describe the consistent symptoms of the Urban Stream Syndrome as including a flashier hydrograph (one of more extremes), elevated concentrations of nutrients and contaminants, altered channel morphology and stability, reduced biotic richness with an increased dominance of tolerant species, including invasive or non-native species, reduced baseflow and increased suspended solids.

closely related to the second, states that “the full distribution and sequence of flows [the flow regime of urban streams] should be taken into consideration when assessing the impacts of stormwater on streams.” In other words, other than higher stormwater volumes in urban areas, changes to stream flows—the frequency of high flows, the season when high flows occur—and the rate of the rise or fall of an urban stream’s hydrograph⁵, needs monitoring and consideration in order to fully mitigate broader scale changes that occur because of urban development. Thus, the report further states that “effective hydrologic mitigation cannot just aim to reduce post-development peak flows to predevelopment peak flows.” (NRC, 2008)

Harding et al. (1998) conducted a study to compare the legacy of historic land uses for entire watersheds in western North Carolina streams. By comparing forested watersheds, agricultural watersheds, and former agricultural watersheds that had undergone reforestation by 1990, researchers (Groffman et al. 2002) found that a reforestation of both the watershed and riparian buffer did not sufficiently overcome the influence of historic agricultural land use that had prompted declines in riparian biodiversity. Research from the Baltimore Ecosystem Study in Maryland, suggested that the lowered de-nitrification potential of urban buffers makes urban soils more nitrate enriched than forest soils in reference watersheds where much of the land remains forested (Groffman et al. 2002). Reduced denitrification rates combine with increased rates of nitrification and increased nitrogen loads from urban land uses and contribute to the NPP problem. Furthermore, invertebrate populations in reforested streams remained most similar to those found in continuously farmed watersheds. For urban areas, biodiversity as measured by biotic indices remains consistently poor if urban land use or total impervious areas exceed

⁵ USGS defines a hydrograph as a “graph showing flow rates or water levels with respect to time. A stream hydrograph commonly shows rate of flow.” (Available at: <http://pubs.usgs.gov/ha/ha747/pdf/definition.pdf>)

40 percent of a watershed's total area, even in areas where riparian buffers are restored or conserved (Booth et al., 2004; Booth, 1991).

1.6 Drought Implications for Urban Riparian Buffers and Stormwater Management

Numerous water-stressed areas now exist across the United States. In the past five years, the Southeastern states—Alabama, Georgia, South Carolina, and North Carolina—have all experienced magnified drought conditions for communities which rely on rainfall as a primary source of recharge for drinking water reservoirs. With growing guidance from the EPA, water managers are developing collaborative watershed approaches to try to improve the amount and quality of available water resources for humans and other dependent biota. (Fitzhugh & Richter, 2004; Walsh et al., 2000; Klein, 1979)

Within the past decade, research on water quality has led to the development and application of biophysical simulation models to estimate NPP levels and to identifying the source areas of pollutants. Using calibrated models of watersheds, researchers have simulated the effects of different land uses and best management practices (BMPs).⁶ Modeling storm events becomes important when developers choose which structural BMP or suite of different BMPs for a site. In exceptionally dry years, research indicates that periods of rain that increase available soil moisture may reduce pollutant loading to streams that occurs with the first flush of storms. (Bhuyan et al., 2001; Flynn & Boudouris, 2005; Mankin et al., 1999) However, other research suggests that in wet seasons or wet years (following drought), saturated or water logged soils

⁶ EPA defines a Best Management Practice as a “technique, measure, or structural control that is used for a given set of conditions to manage the quantity and improve the quality of stormwater runoff in the most cost-effective manner.” Synonymously used with the term BMP, in the National Research Council report (2008), is the term Stormwater Control Measure, or SCM. In this document, the term BMP is used predominantly, but both terms are utilized interchangeably.

allow pollutant transfer from uplands into streams at high rates and before riparian areas can process pollutant loads. (Groffman et al., 1996)

Other research suggests that, as impervious land conversion and watershed urbanization increases, the smaller and more frequent storms contribute significantly to local flooding and receiving-water quality. Impervious areas across a watershed impact the frequency that streams fill and flow at their maximum capacity. Klein (1979) accredited Leopold's (1968) research with documenting that when watershed imperviousness⁷ reaches 40 percent, bankfull⁸ flows of streams occur "3 times annually" instead of "recurring once annually" as in "rural watershed or under natural conditions." With completely developed drainage areas, Leopold found that streams were filled with runoff on an average of 5.6 times per year. (Klein, 1979; Leopold, 1968)

According to Konrad (2003), the "relative increase in peak discharge is greater for frequent, small floods than infrequent, large floods"—by as much as an order of magnitude. The resultant annual increase in magnitude from small or medium flood events can become significantly greater than infrequent, large flooding events—storms occurring only every 10, 25, 50, or 100 years. Konrad also identifies that the "effects of development in urban basins are most pronounced for moderate storms following dry periods." (Konrad, 2003; Thrash, 2007) Thus, polluted runoff from small or medium storms is often quickly captured by storm sewer systems without either detainment or any water-quality treatment.

⁷ The phrase watershed imperviousness refers to two terms defined by the EPA: Impervious cover refers to "any surface in the urban landscape that cannot effectively absorb or infiltrate rainfall," such as sidewalks, rooftops, roads, and parking lots. Imperviousness reflects "the percentage of impervious cover by area within a development site or watershed, often calculated by identifying impervious surfaces from aerial photographs or maps" using digital mapping techniques.

⁸ Doll et al.(2002), citing Leopold's book *A View of the River* (1994), defines bankfull flows as corresponding to the discharge that fills a channel to the elevation of the active floodplain; typically, bankfull discharge describes the "channel forming flow, maintaining channel dimension and transporting the bulk of sediment over time."

Stormwater professionals are critical of urban stormwater structures, synonymously referred to as Stormwater Control Measures, (SCMs) or Best Management Practices, (BMPs), that are designed solely to detain or treat runoff generated only from large, less frequent storm events⁹ because the impacts of polluted runoff from smaller storms—those occurring monthly, every six months, or over one or two years—is “magnified in greater proportion by watershed urbanization.” (Thrash, 2007) Weiss and colleagues (2007)¹⁰ argue that the “knowledge of the impact or effectiveness [of] a particular storm-water BMP will have on water quality is just as important as the cost.” (See Appendix A, Table 2) If aged or expensive storm-water BMPs have minimal functional impact on water quality, they are of little value for water quality improvements.

⁹ The NRC report (p. 152, 2008), defines “design storms” as “a specific temporal pattern of rainfall at a location, created using an overall storm duration and frequency relevant to the design problem at hand.”

¹⁰ To address this need, Weiss et al. (2007) analyzed and estimated the removal of total suspended solids and phosphorous over a 20-year time span, estimated as a function of the water quality volume different BMPs are supposed to treat. See Table 2, Appendix A for a summary of research findings.

Raleigh presently relies on “one of the most important drinking water reservoirs” in North Carolina—the Falls Lake Reservoir.¹¹ The Neuse River Foundation reports that “most of the Falls River Lake[or Reservoir] suffers from algal blooms, high turbidity, and low dissolved oxygen, caused by excess nutrients in the water,” the hallmark symptoms of NPP and stormwater pollution. (UNRB, 2006 and 2009)

1.8 Drought Implications for the City of Durham

During the drought of 2007, in a water quality report to citizens in Durham, North Carolina, the City’s Stormwater Services Division suggested that lower rainfall or less stormwater, in effect, pointed to “continuous” or “disguised” sources of pollution—namely leaking sewers, failing septic systems, and improper maintenance practices. (CDSSD, 2007) Improving stormwater management in urban areas stands to play a role in maintaining river water levels and flows, as well as improving the overall water quality for within a water basin. (Holman et al., 2007)

¹¹In 1978, Falls Lake Reservoir, referred to as Falls Lake, was originally constructed for flood control and “to provide an additional source of drinking water to the growing Raleigh/Wake County area.” When full, the waters of Falls Lake cover approximately 12,500 acres and stretch approximately 22 miles—from the historic headwaters of the Neuse, located at the confluence of the Eno and Flat Rivers, all the way to the present headwaters at Falls Lake Dam. (citing the U.S. Army Corps of Engineers, NRF 2009)

2.0 Legal and Jurisdictional Histories and Frameworks

2.1.0 U.S. Federal Regulation on Water Pollution for Water Quality Protection

The U.S. Environmental Protection Administration (EPA) is the federal agency which sets federal minimum standards, is responsible for the enforcement of environmental compliance and assisting states to develop and improve pollution control programs. With passage of the federal Clean Water Act (CWA) of 1972 and subsequent 1977 and 1987 amendments, point source pollution, specifically from municipal sewage discharges and industrial-process wastewater, was successfully reduced through the establishment of the National Pollutant Discharge Elimination System (NPDES) program. Point source pollution can be more easily regulated as it is easily identified and treated ‘at the end of pipe.’ Industrial storm water discharges and discharges from municipal separate storm sewer systems, also known as MS4s¹², were required to meet two technology-based standards: Best Practicable Control Technology Currently Available (BPT) and Best Available Technology Economically Achievable (BAT). In the 1980s, the National Urban Runoff Project (NURP), a four-year research initiative, was launched in multiple sites across the United States. NURP’s report to Congress led to the enactment of an urban stormwater permitting program for urban and industrial runoff sources. The 1987 reauthorization of the CWA, under Section 319 or the Water Quality Act (WQA), required that the EPA and individual states undertake information gathering steps, report to U.S. Congress on NPP impacts, as well as present a nonpoint source pollution plan to address impacts. (EPA, 2008a)

¹² MS4s are defined by EPA as “a conveyance or system of conveyances that are: owned by a state, city, town, village, or other public entity discharging into the waters of the U.S.; designed or used to collect or to convey stormwater (i.e. storm drains, pipes, ditches, etc.); not combined sewers; and not part of a publicly owned treatment works (i.e. sewage treatment plant). (EPA, 2008a, also available at: <http://cfpub.epa.gov/npdes/stormwater/munic.cfm>)

Water quality standards became the basis of water quality-based control programs. The WQA set goals for states to set and meet minimum water quality standards based on the designated use(s) of a waterbody. (Novotny, 2003; EPA 2008a) Designated uses of waterbodies are based on a range of descriptive and numeric water quality criteria for biological, chemical and physical parameters which measure the attainment, (or failure of attainment), of designated use(s) for a jurisdictional area. A designated use represents a level of scientific understanding for the processes that impact a waterbody as well as value judgments on what a local waterbody can and should be used for. (EPA, 2008a) In order to guide the application of state standards to individual water bodies and watershed, §303(d) of the CWA established the Total Maximum Daily Load¹³ (TMDL) Program¹⁴ by 1992. The TMDL process of classification is meant to offer a flexible assessment and planning framework that identifies pollutant load reductions and/or other actions required to attain water quality standards.

In 1996, the EPA reported that over one-third of surveyed streams, lakes, rivers, and estuaries failed to support their designated uses—including recreational and drinking water uses. The EPA attributed these failures to NPP sources. (EPA, 2008a) By the late 1990s, under the CWA, the EPA focused on finding ways to address NPP, leading to changes in the NPDES Program, and the program's second phase. Phase II expanded Phase I, extending to regulate small or medium MS4s¹⁵ (<100k people) and constructions under 5-acres, and requires more of

¹³ According to EPA's glossary, a TMDL is defined by EPA as a sum of: individual wasteload allocations, (WLAs), for point sources; load allocations (LAs) for nonpoint sources and the natural background; and a margin of safety (MOS) which accounts for uncertainty in the response of a waterbody to loading reductions. TMDLs can be expressed as mass per time, toxicity, or using other appropriate measures that relate to a state's water quality standard. (EPA's glossary is available at: <http://www.epa.gov/owow/tmdl/glossary.html#303dthreatenedimpairedwaters>)

¹⁴ Regulations currently governing the TMDL Program were first issued in 1992, and now are detailed in Section 130.7, Part 130 of Title 40 of the Code of Federal Regulations.

¹⁵ The term MS4 refers to a municipal separate storm sewer system. 40 CFR 122.26(b)(8) describes an MS4 as the infrastructure or the "conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains);" MS4 also commonly refers to the owner/operator of the infrastructure that is permitted to discharge this runoff.

construction sites to control erosion. The National Research Council (p. 80, NRC 2008)

summarized the current status of stormwater programs across the United States, stating:

“almost all Phase II and some Phase I communities are still in the early stages of program implementation although deadlines for permit applications were years ago—16 years for Phase I and six years for Phase II. EPA has acknowledged that it does not currently have a system in place to measure the success of the Phase I program on a national scale. Therefore, it is reasonable to conclude that the level of implementation of the stormwater program ranges widely, from municipalities having completed a third-term permit (such as Los Angeles County MS4 permit) to municipalities not yet covered by a Phase II MS4 permit.” (NRC, 2008)

Phase II of the NPDES Program requires six minimum measures: public education/outreach, public participation, illicit discharge detection and elimination, complete construction site and post-construction runoff control, and pollution prevention efforts. The NPDES Program utilizes a tiered implementation strategy, requiring a public comment process of an MS4’s permit review to include a wide range of stakeholders impacted by the amended CWA. (EPA, 2008a)

2.2 State Legislation in North Carolina

Stricter federal water pollution discharge laws have led to increasingly aggressive state laws. States have choices on how to enforce laws and ultimately how to enact their own measures. States determine the level of resources—both in capital and in manpower—they devote to implementing environmental legislation. (Rabe, 2006) In the case of riparian buffers, each state, through the laws and regulations it establishes, can define a range of riparian buffer widths which may or may not capture the true riparian area’s extent (Castelle et al., 1994)

Overall, North Carolina is currently a leader among Region 4 states in water quality management. (NCDENR, 2009; EPA 2008a) Since environmental measures implemented since the 1980s and 1990s have proved insufficient in protecting stream and reservoir water quality, Durham officials face increased pressures—public presser, regional political pressure, and

financial burdens—to reduce pollution in their urban streams feeding into Falls Lake Reservoir, an important stretch of the upper Neuse River Basin (UNRBA, 2006; NCDENR/DWQ, 2009). Given declining water quality issues and populations pressures within the Upper Neuse River Basin, by 1996, “13 local governments with local planning and zoning control and Soil and Water Conservation districts in the 771-square mile basin above Falls of the Neuse Dam,” took action and established the Upper Neuse River Basin Association (UNRBA), (UNRBA, 2006). Effective by 1998, the Environmental Management Commission (EMC) of North Carolina adopted a permanent set of rules to implement the Neuse River Nutrient Sensitive Waters Management Strategy (15 A NCAC 2B .0233¹⁶ and Rule .0235¹⁷) also known as ‘The Neuse Rule’ or the Neuse Nutrient Strategy. Rule .0235 addressed urban stormwater and required that local governments in the Neuse River Basin—including the neighboring jurisdictions of Durham, Durham County and Orange County—to develop a local stormwater management program plan to control nutrients, specifically tailored to reducing nitrogen inputs, entering the tributaries of the upper Neuse River.

The National Research Council (2008) commends North Carolina for the strengths of the Neuse Rule and Program and the positive outcome of Nitrogen load reduction:

“the state was concerned about nutrient enrichment of estuary waters and imposed an aggregate cap on industrial and municipal wastewater dischargers equivalent to a 30 percent reduction in nitrogen loads...the state granted individual point source dischargers a choice:
(1) accept new requirements to control nitrogen through individual NPDES permits or
(2) form and join a discharger association. The rigidities associated with individual NPDES permits provided enough incentive for most point source dischargers to opt for the second

¹⁶ 15A NCAC 2B .0233 has been adopted as published in 14:4 NCR 287-301; The stated purpose of this rule was “this Rule shall be to protect and preserve existing riparian buffers in the Neuse River Basin to maintain their nutrient removal functions.” The rule also provided definitions of terms relating to this rule, distinguishing between ephemeral and intermittent streams as they relate to the influence of stormwater in the urban setting. (Available at: <http://h2o.enr.state.nc.us/nps/2b-0233.pdf>)

¹⁷ The “Neuse River Basin-Nutrient Sensitive Waters Management Strategy: Basinwide Stormwater Requirements.” Available at: h2o.enr.state.nc.us/nps/2b-0235.pdf

choice. Compliance associations were then created and issued permits. The Neuse River rules cover nonpoint agricultural sources as well as point discharges. Counties are responsible for reducing nutrient loads, and farmers must either join county associations that apply different strategies or individually contribute to meeting objectives by setting aside 50- to 100-foot buffers along all streams... In the Neuse program, a single “group compliance permit” was issued to the association. Both legal mechanisms established financial penalties for the two associations if aggregate discharges of the group exceed the association cap. A key advantage of the association is similar to that of a formal effluent trading program—granting dischargers flexibility to decide how best to meet the aggregate load cap [on Nitrogen]. To date, the associations have managed to keep nitrogen loads considerably below their respective caps. Compliance costs have also fallen below original projections. Further, there is some evidence that the association concept is producing incentives for strong cooperative behavior that did not exist prior to implementation.”
(p. 505 NRC 2008)

In their praise for the Neuse Rule, the NRC cite a paper presented by Stephenson and Shabman in 2005,¹⁸ for the argument that “new organizational forms that consolidate multiple regulated entities under a single organizational umbrella...used to coordinate and manage jointly the collective obligations of a group of regulated parties at lower costs to members. Private and public regulated entities alike...benefit.” In 2008, the EPA recognized the NC Division of Water Quality NPDES Program for exceeding federal expectations and “for outstanding innovation and sustained commitment to the review of State waters to ensure the highest attainable designated use providing the highest level of protection possible.” (NCDENR/DWQ, 2008)

¹⁸ Stephenson, K., and L. Shabman. 2005. The use and opportunity of cooperative organizational forms as an innovative regulatory tool under the Clean Water Act. These authors presented their paper at the Southern Agricultural Economics Association Annual Meetings Little Rock, AK, February 5-9, 2005.

2.3.0 *Municipal Roles, Local Authority, and Local Watershed Restoration*

2.3.1 *Cities, Municipalities, and the NPDES Program*

“Durham County adopted new watershed-based zoning standards in the Lake Michie and Little River Reservoir watersheds. Although the new Durham County standards do not [yet] fully meet the recommendations of the Upper Neuse Plan, they are likely to better protect the watershed by reducing overall densities. Orange County has also incorporated the development density recommendations directly into the county’s draft comprehensive plan, and work on that plan continues.” (UNRBA, 2006)

Local governments are required to use structural stormwater BMPs for high density developments of urban centers. Phase II of the NPDES Program requires cities to require NPDES permits for facilities of specific categories of point sources which share common design elements. These general permits are only issued to dischargers within a specific, defined geographical area—including a city, county, or state political boundary, designated planning area, a sewer district or sewer authority, state highway systems, defined urbanized areas, and standard metropolitan statistical areas. The general permit covers all stormwater point sources: facilities involving same or similar types of operations; facilities discharging similar waste types or sludge use (or disposal) practices; facilities which require identical effluent limits, operating conditions, or standards for sewage sludge use or disposal; and facilities that require similar if not exactly the same monitoring requirements. This general permit must detail appropriate effluent limits for the area covered, special conditions present within the area to meet effluent limits (such as BMPs in place or BMPs anticipated planned for important areas within a city), as well as monitoring and reporting activities that ensure compliance with permit conditions.

A permitted municipality (or an MS4 community) in the NPDES stormwater program must follow federally approved procedures in accordance with 40 CFR §124¹⁹ in order to obtain and

¹⁹ Available at: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=/ecfrbrowse/Title40/40cfr124_main_02.tpl

renew their municipal stormwater permit every 5 years. Municipal stormwater management is undertaken in an iterative manner and a city's permit renewal must meet new requirements to include and accommodate for change (i.e. population growth and development) within a municipal jurisdiction or to meet new regulations. This adaptive approach seeks to ensure that as cities grow, they also continue to grow their own stormwater management programs to protect surface water resources.

The City of Durham must meet its Municipal Stormwater Discharge Permit (NCS000249) permit conditions every 5 years, but can revise its management plans annually and report changes to the NC Department of Water Quality (DWQ). (40 CFR § 124, EPA 2008) If a submitted local stormwater management program plan is “unacceptable” after North Carolina’s DWQ review, or if the plan is not “properly implemented,” item (7) of Rule .0235 (15 A NCAC 2B .0235) states that the “stormwater management requirements for existing and new urban areas within its jurisdiction shall be administered through the NPDES municipal stormwater permitting program per 15A NCAC 2H .0126,” which essentially requires that stricter stormwater management practices be adopted when jurisdictional overlap occurs for local authorities and governments.

2.3.2 Durham’s Comprehensive Plan and the Unified Development Ordinance

In public hearings in 2004 and 2005, the City and County of Durham initiated and committed themselves to a Unified Development Ordinance (UDO) to implement Durham’s Comprehensive Plan. The UDO is meant to address and reconcile inconsistencies between existing city and county ordinances. The UDO also updates and supersedes prior regulations to bring both jurisdictions into compliance with state regulation changes—in particular, for the 50-ft riparian buffers that line the Upper Neuse River, where certain buffer activities are prohibited within the

30-feet closest to the stream because of the Neuse Rule (Wilbur, 2009). Presently perennial and intermittent streams²⁰ in the Neuse River Basin require 50-ft buffers on each side of the stream. With the adoption of the most recent stormwater rules, the Cape Fear River Basin also now shares this 50-foot minimum buffer-size requirement. In Durham, for areas that fall within the Watershed Protection Overlay, perennial streams can require protective buffers up to 150-feet; for non-perennial streams that are in the Falls Lake Critical Area, a 100-foot buffer is required to protect this valuable drinking water source. (DUDO, 2009)

²⁰ The EPA uses the U.S. Geological Survey (USGS) definition of a perennial stream as “a body of water flowing in a natural surface channel,” whereas intermittent streams are ones “which flow only during wet periods.”

3.0 Methods

3.1 Literature, Professional Opinion, and Digital Media Review

Through document and media review combined with email, meetings, phone or in-person interviews with stormwater professionals, this project first examines existing concerns, approaches and resources available for local governments to utilize when self-evaluating their own municipal pollution prevention/good housekeeping practices. The literature and media I reviewed towards this project included: EPA documents, national conference proceedings, National Research Council documents, state and non-profit websites, online workshops and podcasts; pertinent manuals from the Center for Watershed Protection; and journal articles on stormwater, public works, civil engineering and general management. From these sources, I sought to gather examples that addressed the following questions on the process of developing and refining effective municipal pollution prevention practices:

- 1) What are some of the common barriers or challenges in the process of developing municipal pollution prevention/good housekeeping program?
- 2) How can local governments or communities overcome these challenges? What are existing tools and approaches? How can they be adapted and utilized for municipal stormwater programs undertaking self-assessment?

3.2 Municipal Operations Survey

Simultaneous to the first research component of my project, and from attending citizen participation sessions towards Durham's comprehensive stormwater management plan, the City of Durham's Stormwater Services Division of Public Works (SSD) became both advisors and clients for this survey portion of my project. The SSD assists other City departments in two key ways. First, the SSD assists other municipal departments with applications for site-specific NPDES permits. (Smith, 2009) Secondly, the SSD assists other departments in developing Stormwater Pollution Prevention Plans. One of the six "minimum measures" of the City of Durham's NPDES permit (NCS000249) is to undertake Pollution Prevention/Good Housekeeping for all municipal operations.

In order to create a more comprehensive municipal training program, the Stormwater Services Division of the City's Public Works Department, recognized the need to gather inter-departmental information on current municipal maintenance operations. (Smith, 2009) The SDD seeks to outreach and collaborate with different municipal departments—especially the departments who conduct activities that disturb soil or otherwise generate possible pollutants to water quality. The SSD's outreach efforts aim to work towards the development of cohesive and unified stormwater pollution prevention guidelines for municipal maintenance activities across the City.

A simple way for the SSD to gather baseline information on existing pollution prevention practices is through online surveys of project managers across Durham's divisions and departments. This project starts with the Landscape Maintenance Division of Durham's General Services Department. With online surveys, the results and feedback from participants occur in a shorter time frame and the response rate can be greater than from traditional paper-based

surveys. (Crawford & Rowe, 2009) This initial internal survey serves as a step in “needs assessment,” a necessary documentation process whereby SSD staff can gather baseline information on current municipal maintenance activities and practices that stand to impact water quality.

4.0 Project Findings

4.1 Literature, Professional Opinions, and Digital Media Review Findings

4.1.1 Water Quality and Stormwater Management for Durham City and County

"It ain't what you don't know that gets you into trouble.

It's what you know for sure that just ain't so."

-Gary Minton, *Ph.D., P.E* quoting Mark Twain on the subject
of urban stormwater myths (Stormwater Authority, Articles 2009)

According to City Planning and Stormwater staff, the City of Durham employs some of the most stringent stormwater control measures in North Carolina (Smith, 2009; Wilbur, 2009); yet, the sections of streams flowing through the City and Durham County remain impaired, as listed on the State's 303(d) list, and erosion hotspots are concerns for a few of the larger creeks and sections of the stream networks in the City and County jurisdictions (Hornkhol, 2009).

In 2005, all urban streams within the City of Durham failed to meet one or more state water quality standards. (DENR 2008; See Appendix A, Figure 5 for publicly reported information on Durham's drainage system and reported street maintenance) Important impaired streams include Ellerbee Creek, New Hope Creek, Little Lick Creek, Northeast Creek and Third Fork Creek. Officials in the Durham City and County, despite agreeing to a Unified Development Ordinance, recognized that development restrictions alone cannot address persistent water quality problems in these streams. Durham's impaired urban streams either are high in fecal coliform bacteria, or have problems with excessive turbidity and sediment, and have impaired aquatic life support. Jim Wise, a local staff writer for a Durham-based newspaper (October 2009), chronicled events for Durham's Ellerbee Creek—relaying a brief history of the sources of pollution and legal battle that ensued prior in the 1960s. Wise identifies Ellerbee Creek as both a historical and present "point of contention" between Durham and Raleigh residents (Wise, 2009). In 2006, when

Durham adopted its Stormwater Management and Pollution Control Ordinance, this measure provided citizens and staff with a measure of assurance such that once problems are identified—either from city surveys or voluntary citizen reports—that there exists a mechanism and procedure to prioritize and resolve them. As part of Durham’s Stormwater Management Plan, the City’s Water Quality Program is actively working to assess stream conditions and have initiated and continue to prioritize and plan for stream restorations throughout the City. Public education, outreach, and public participation are integral features of the City’s stream restoration projects.

For a recent restoration example from November 2007, The City initiated the Ellerbe Creek Watershed Improvement Project, surveying approximately 37 miles of Ellerbe Creek’s drainage area. This crew evaluated existing stream conditions, identified sources of pollution that likely contribute to water quality concerns and the impaired status of the stream, and identified reaches of the stream and riparian buffer areas that needed restoration or better preservation measures (Wilbur, 2007). Similarly in October 2009, the City of Durham initiated the Third Fork Creek Watershed Improvement Project in order to study and identify restoration goals to revitalize this creek’s health; furthermore, the SSD has utilized a water quality index as a measurement tool that is easily understandable to the public in annual “State of Our Streams” reports, made available on their website. Overall, Durham seeks to address the eight principles of good

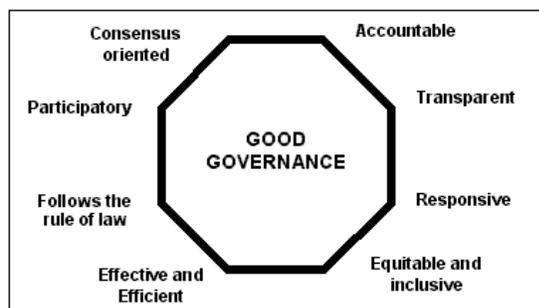


Figure 2: Eight Principles of Good Governance (UNESCAP, 2009)

governance, as illustrated by the adjacent United Nation’s schematic.

4.1.2 Challenges and Concerns for Assessing Municipal Operations

“Despite these bursts of activity, most state and local governments have not taken the initiative to fill the gaps in the EPA’s federal program. They involve some expense, stormwater discharge requirements can increase resident taxes, anger businesses, and strain already busy regulatory staff. Moreover, if the benefits of stormwater controls are not going to materialize in waters close to or of value to the community instituting the controls, then the costs of the program from the locality’s standpoint are likely to outweigh its benefits. Federal financial support for state and local stormwater programs is very limited. Until serious resources are allocated to match the seriousness and complexity of the problem and the magnitude of the caseload, it seems unlikely that states and local communities will step in to fill the gaps in EPA’s program.” (p. 109, NRC 2008)

While far from the exhaustive coverage as that provided in the NRC’s report (2008), from literature reviews and discussions with local stormwater practitioners on municipal operations and maintenance, two overriding challenges or concerns emerged repeatedly :

(1) Institutional Inertia

Simply stated, institutional inertia stems from a mindset that “change is bad,” just a “necessary evil,” and an adherence to “what is done now.” Reluctance to change practices and behavior is common across governments and sectors of the society. The “carrot vs. stick” approach in environmental regulation serves as testament to inertia within a government or industry. State and local governments have historically struggled with the inspection, enforcement and compliance portions of many water resource programs. According to Tom Scheuler,²¹ “a lot of Phase II programs have a long way to go to institutionalize some pretty basic features into their maintenance programs.” In a 2006 survey by the Clean Watershed Protection Center, 50 percent of a total of 94 Phase II communities reported that they didn’t have a regular [BMP] inspection or maintenance program. Furthermore, only 10 % of the responding local

²¹Tom Scheuler serves as the Director of Watershed Research and Practice at the Center for Watershed Protection. He has helped Phase I and Phase II communities meet their minimum management measures to comply with MS4 Municipal Stormwater Permits. His work has included the development of national stormwater monitoring database and national guidance on illicit discharge detection and elimination. Additionally, Scheuler has conducted extensive research on the pollutant removal performance, costs, and longevity of stormwater management practices.

governments fully accepted the maintenance responsibility while the rest believed that maintenance rested with either private land or home owners. (EPA/CWP, 2006)

Thrash (2007), an Ohio-based water resource specialist, described opposing viewpoints that local governments and officials had for Phase II minimum measures:

*“The effects of urban development are difficult to evaluate from a watershed perspective, but data collected from research professionals and empirical observations...highlight the need for ecologically informed approaches to stormwater management with respect to water quality. **The EPA has weighed in on these issues with NPDES Phase I and Phase II stormwater regulations; however, the specifics behind minimum control measures set forth in those regulations are intentionally left open-ended to regulated communities on everything from ordinance updates to best management practice (BMP) selection.***

For some municipalities and their elected officials, Phase II regulation is viewed as an opportunity to update local ordinances or enforcement measures and to invest in surface-water resources previously ignored at the local government level. For others, even within the same watershed, Phase II stormwater requirements are a necessary evil packaged and presented to citizens as six de minimus control measures mandated to them by the federal government.

From both perspectives, short- and long-term economic growth associated with urban development is understandably of greater importance than the NPDES program and its potential ecological significance.

But even when the priority of individual community goals is justifiable, the lack of an investment in comprehensive planning to address urban hydrology, riparian resource protection, and water quality under the auspices of NPDES Phase II is not.”

Thrash’s opinion aligns with the current movement towards comprehensive watershed-based resource management as well as with EPA’s intent of Phase II regulations. According to Nikos Singelis,²² the last minimum measure, Municipal Pollution Prevention/Good Housekeeping:

“asks municipalities to be good stewards of the environment, so that in their day to day operations, whether it be public works or parks and recreation or road maintenance, or trash pick-up or those sorts of activities...[The EPA is] looking for a good plan there to cover all of those kinds of activities. We want folks to think about their highest priorities for action and where you have the greatest potential for causing stormwater pollution.” (EPA/CWP, 2006)

²² Nikos Singelis is the senior program analyst with EPA’s NPDES Stormwater Program at the EPA Office of Wastewater Management

Counter to Trash's view, in his article "Better defined, more strictly enforced," Don Talend (2009), optimistically stated that:

"Stormwater management, a relatively new discipline for many public works managers, is nonetheless starting to mature. Several professionals from around the country who primarily focus on stormwater management say that, increasingly, system maintenance requirements—and in some cases, even maintenance training—are getting incorporated into their local jurisdictions' regulations.... They also report that maintenance requirements for specific best management practices (BMPs) generally are being defined more clearly in local water district or municipal regulations. The results of the stricter enforcement of private systems will include a reduced burden on municipalities and their taxpayers, and cleaner lakes, streams, and rivers."(Talend, 2009)

That Talend mentions maintenance training as almost a novelty points to Scheuler's observation from the Center for Watershed Protection's report—that maintenance training has not been previously considered (before Phase II minimum measures) nor actively incorporated into local regulations and plans (EPA/CWQ, 2006). Focusing on the enforcement of individual private systems alone, partly what Phase I regulations sought to do, is not enough to truly reduce the burden on municipalities. Municipalities must self-enforce sound stormwater management controls (SMC). Phase II communities must identify critically needed repairs or necessary retrofits of older BMPs, as well as install new BMPs to serve public infrastructure growth. The causes for institutional inertia are closely linked to the burdens of time, staffing constraints and ultimately, to the financial burdens faced by municipalities.

(2) *The Burdens of Time, Staffing, and Financial Limitations*

“If local or state governments required mandatory monitoring or more rigorous and less ambiguous [Stormwater Control Measures], they would make considerable progress in developing a more successful stormwater control program.” (p.109, NRC 2008)

“Pretty predictable, any time you run a Phase II local stormwater program, it doesn’t come with a lot of staff.”

-Tom Scheuler (EPA/CWP, 2006)

In a 2004 report by the Rural Economic Development Center, Durham and Orange counties, North Carolina were conservatively estimated to need approximately 4.54% of the total statewide capital needs for water, sewer, and stormwater systems combined. Stormwater capital needs for North Carolina communities were conservatively estimated at approximately \$1.47 billion between 2011 and 2030. (REDC, 2004) Municipalities are increasingly pressured to enforce and implement potentially expensive BMPs following changes in federal and state legislation. (NRC, 2008) Given the current economic downturn, local governments and counties have limited fiscal resources with which to fund and support city infrastructure improvements in addition to environmental monitoring and compliance programs.

In spite of The American Recovery and Reinvestment Act of 2009, many communities and local authorities feel the pinch of local cuts and state budget shortfalls:

“At the local level, 62% of respondents to a National League of Cities survey have delayed or canceled non-stimulus projects as a result of the economic downturn even though 80% reported that infrastructure needs have increased. This is the third time in four years finance directors in cities with more than 50,000 residents have reported lower revenues...Many public works operations were short-funded and short-staffed long before the stimulus package was being considered.” (Fielding, 2009)

Smaller cities, low density counties, and other communities must effectively do more with drastically less. Larger cities are just as, if not more challenged because of the way

different departments and divisions are structured. According to the NRC (2008):

“While states and local governments are free to pick up the large slack left by the federal program, there are effectively no resources and very limited infrastructure with which to address the technical and costly challenges faced by the control of stormwater. These problems are exacerbated by the fact that land use and stormwater management responsibilities within local governments are frequently decoupled.” (p. 119, NRC, 2008)

Additionally, current administrative structures at the local scale can pose challenges in

stormwater permit program implementation, and so the report explains that:

“Municipal departments in general are not designed to address the issue of pollution in urban runoff....because of the complexities of the task, many duties are spread among various municipal departments, and more often than not coordination is still lacking. Perhaps most problematic is the fact that the local governmental entities in charge of stormwater management are often different from those that oversee land-use planning and regulation. This disconnect between land-use planning and stormwater management is especially true for large cities. It is not unusual for program responsibilities to be compartmentalized, with industrial aspects of the program handled by one group, construction by another, and planning and public education by other distinct units.” (p.115, NRC 2008)

Consequently, cost-effective, time-efficient, and results-based tools and approaches to planning and initiating stormwater management programs are needed. After consultation with local municipal staff, the work and approaches offered by the non-profit, the Center for Watershed Protection seemed the most promising tool and framework approach to use in addressing the topic of pollution prevention from daily municipal operations.

(3) Existing Guidance Resources: EPA and the Center for Watershed Protection

The EPA works closely with other organizations, such as the Center for Watershed Protection, to support the development of resources for these initiatives—be it through grants or awards for programming, or grants that support the development of reference materials. One example of the latter is the Center for Watershed Protection’s “Urban Subwatershed Restoration Manual Series.” A total of 11 manuals have been developed since 2004 that work to support the

watershed approach to managing water resources.²³ Released in September 2008, “Manual 9: Municipal Pollution Prevention/Good Housekeeping Practices–Version 1.0,” seeks to present a “framework for planning and developing” programming for smaller NPDES Phase II communities. This manual (pp.18) proposes that a successful municipal prevention program should focus on outcome-based and output-based goals; initially ensuring that output-based goals assist in measuring whether or not outcome-based goals are realized. Of course, the timeframe and priorities suggested in this manual may not match the time constraints of staff charged with developing and launching a Pollution Prevention/Good Housekeeping Program. Every community must still assess the level of effort needed to meet measurable benchmarks for their prevention programs, as well as their own timeframes for achieving larger implementation steps.

²³ While some manuals are under revision, a selection of these manuals are currently available at the Center for Water Protection’s website:
<http://www.cwp.org/Store/usrm.htm>

4.1.3 *Civil Infrastructure Management (Thinking in Systems)*

“Managers are not confronted with problems that are independent of each other but with dynamic situations that consist of changing problems that interact with each other. I call such situations messes....Managers do not solve problems, they manage messes.”

-From *Thinking in Systems – A Primer* by
Donella H. Meadows (2008)

“Maintenance can be depressing.”

-Tom Scheuler, Center for Watershed Protection
(EPA/CWP, 2006)

Civil public service experts apply a conceptual systems model (Sparrow 2001; Puttman and Vizzini 2009) to describe the set of physical components (streets, bridges, pipes, facilities, electrical wires, and rails) and human actions (constructing, building, operating, or maintaining) which “convert inputs into outputs that add value for the users,” where the users are citizens and beneficiaries of these components and actions (Sparrow 2001). Dynamic systems models are not predictive, but are designed to explore what would happen if the driving factors of a system act in a range of different ways. (Meadows, 2008; Puttman & Vizzini, 2009) Sparrow (2001) describes a systems model as useful because it captures the interchange—positive and negative—with the larger environment at every phase of development.

Sparrow points to education as the principle means of shaping these values and skills. (Sparrow, 2001) Changing public perception and behavior is certainly no easy task, yet behavior change is a necessity for reducing pollution-generating activities. To do so, civil infrastructure managers occasionally (must) act as interdisciplinary thinkers, planners, social theorists, social scientists, public educators, leaders, and the inspectors or enforcers of pollution reduction initiatives and regulations—a tall order. At best, managers must actively work and collaborate with institutions, and professionals who offer these skills.

Successful management of civil infrastructure is complex and with changes in both transportation and environmental regulations, that decision-making outcomes for urban regions require changing the values, practices, and skills of both managers and professionals. The NRC (p. 114, 2008) identifies knowledge gaps and a shortage in stormwater expertise and qualified personnel, stating: “In areas where SCMs are just beginning to be introduced, many municipalities, industrial operators, and construction site operators are not prepared to address water quality issues.” The NRC (p. 115, 2008) assures report readers: “The profession [current stormwater practitioners] and academia are moving to correct this shortfall.”

In the revised Neuse River Basin Management Plan, the NC Department of Water Quality (DWQ) offers the following justifications for interdisciplinary and collaborative initiatives:

“Local organizations and agencies are able to combine professional expertise in a watershed. This allows groups to holistically understand the challenges and opportunities of different water quality efforts. Involving a wide array of people in water quality projects also brings together a range of knowledge and interests, and encourages others to become involved and invested in these projects. By working in coordination across jurisdictions and agency lines, more funding opportunities become available, and it is easier to generate necessary matching or leveraging funds. This will potentially allow local entities to do more work and be involved in more activities because their funding sources are diversified. The most important aspect of these local endeavors is that the more localized the project, the better the chances for success... DWQ applauds the foresight and proactive response to potential water quality problems. Federal and State government agencies are interested in assisting local governments and citizen groups in developing their water quality management programs.”

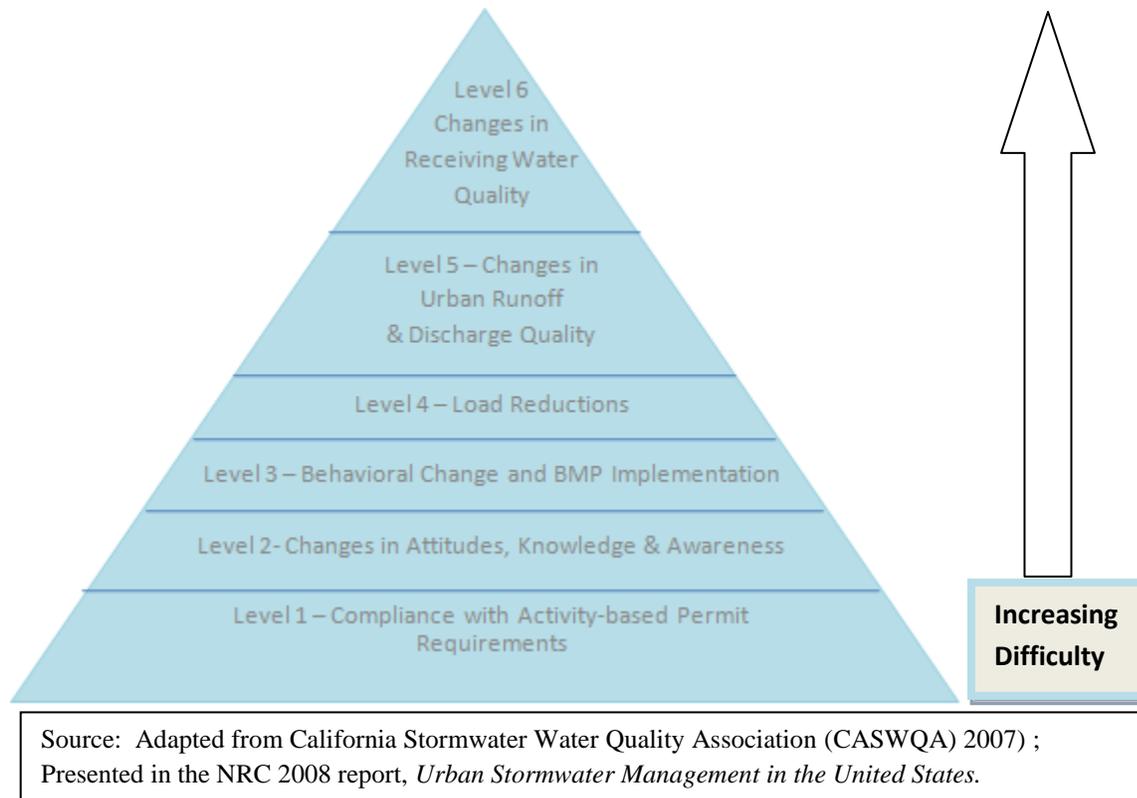
(NCDENR/DWQ, 2009b)

Other than DWQ’s praise, cooperation proves a positive incentive for monetary gain: Share the knowledge and the burden, gain the “wealth” to do more locally towards preventing stormwater pollutants from reaching impaired or critically sensitive water in your subwatershed.

The California Stormwater Water Quality Association (CASQA) proposed six levels of achievement of assessing municipal program effectiveness using a schematic model (adapted in Figure 3 on the next page). The City of Durham, through ongoing water quality improvement programming and citizen stakeholder meetings for its municipal permit renewal with the State,

demonstrates a commitment to the first two levels in attaining a more effective municipal for stormwater pollution prevention and management.

Figure 3: Schematic Model of Assessing Municipal Program Effectiveness



The NRC reports that most MS4s are struggling to simply organize and document program activities (Level 1), so few have actually been able to provide a documented quantitative link from their program to water quality improvements. Meeting the goals of Levels 2 up to Level 5 becomes “increasingly difficult”—unquestionably an understatement—and the paths to achieving these goals are many and interrelated. The NRC encourages regulators to “work with permitted municipalities to define increasingly more specific quantitative measures of program performance with each succeeding permit cycle (p. 550, NRC, 2008)

In Section 1.6 of this project, the importance of BMP design was mentioned in the context of managing water resources in the context of drought; drought persistence can be an important symptom of regional climatic shifts. According to the Inter-governmental Panel on Climate Change (IPCC), cited by the NRC's urban stormwater report (2008), more extreme precipitation events are projected and the types of precipitation, as well as precipitation patterns, may change. Given the uncertainty posed by future weather patterns and since current design standards for many flood-control and water management structures are based on past historical data, the NRC predicts that existing design standards will need conservative revision. The NRC, referencing predictions for the western United States, warns that:

“Even with revised design standards....new SCMs will need to be designed conservatively to allow for additional storage that will be required for regions with predicted trends in increased precipitation. In addition, existing SCM designs based on old standards may prove to be undersized in the future. Implementation of a monitoring program to check existing SCM inflows against original design inflows may be prudent to aid in judging whether retrofit of existing facilities or additional stormwater infrastructure is needed.” (p.151, NRC 2008)

While more storage may be needed for the Western U.S., the southern states must consider water infrastructure and BMP designs that promote water retention within river basins, allowing for groundwater recharge, as well as BMP designs that successfully perform to meet changing local rainfall conditions and pollutant loads.

On addressing changing BMP design standards and a volume-based approach in stormwater management, the NRC (p. 115, NRC, 2008) mentions that two associations, the Water Environment Federation (WEF) and the American Society for Civil Engineers²⁴ (ASCE), are co-

²⁴ Additionally, North Carolina Section of ASCE issued the first N.C. Infrastructure Report Card in 2006, (modeled after the first ASCE national report card in 2005), to “raise public awareness that crumbling infrastructure” impacts daily life. According to ASCE, a committee of state-based professional engineers compile, review, and evaluate data to determine grades for nine “critical areas:” Airport, Bridges, Dams, Drinking Water, Rail, Roads, Schools, Stormwater and Wastewater. The committee sought “objective and consistent perspective” for findings and grades by relying on a review panel of other professional engineers to evaluate and grade each category. Overall in 2006, N.C. received a C- “GPA” overall, a C- for stormwater, bridges, wastewater, and schools, a C+ for drinking water, a D for schools and for roads, a D+ for airports, and a B- for Rail. The 2009 report card maintained the C- GPA, with only two grade improvements that countered two grade declines: drinking water

authoring an update of the WEF/ASCE Manual of Practice “Design of Urban Runoff Controls.”

The revisions to this manual will “integrate quality and quantity” instead of keeping “separate manuals of design and operation for the water quality and water quantity elements of stormwater management.”

4.2 A Step In Assessing Municipal Operations: Survey Considerations and Possible Outcomes

“All new municipal staff receive safety training when they start their jobs in this city...it’s part of the introduction to how things are done....Why then, can’t (and shouldn’t) stormwater pollution prevention training be as ‘regular’ an occurrence on the job as safety training? We all need clean water....”

--Anonymous stormwater practitioner, 2009

Durham’s SSD recognized the need for better communication, integration across departments on municipal activities near storm drains, other municipal structural stormwater BMPs and in and near the City’s urban riparian buffers. (Smith 2009, Ferrance-Wu, 2009) Current SSD and General Services head staff have met and agreed on the need to re-align and ground the goals of the City’s SMP by working towards standardizing pollution prevention practices throughout the City (2009). With a team of SSD staff, through discussions and draft revisions of questions, a municipal operations survey was created, targeting staff of a landscape maintenance division within the General Services Department of the City.

The proposed municipal operations survey (Appendix B) first asks managers about current activity levels, seasonal considerations and/or precautions for activity in certain areas (near urban riparian buffers or near storm drains), or after disturbing soils; the survey also seeks to document

became a B- and wastewater a C+ but Rail fell to a C grade and roads dipped down to a D-. Public awareness tools such as these are becoming more and more common in environmental and social advocacy efforts. (ASCE, 2009)

existing pollution prevention practices and existing written procedures. Also, for planning purposes, SSD staff would benefit from knowing what current training occurs in other departments and what type of training is typical. Project leaders/managers can further identify what information they may need towards projects that involve larger structural repairs in/or near riparian buffers, or at or near municipal stormwater control structures. SSD would benefit from asking current project leaders about what equipment and pollution prevention control measures project managers use (or anticipate needing to use) on a regular basis or under special circumstances.

Given the current reality of a constricted economy, City departments are facing shrunken budgets for capital improvements. Multiple departments within the City of Durham are responsible for maintaining stormwater structures and could benefit from streamlined and prioritized maintenance procedures, including the public works department, general services, and the parks and recreation departments (See Appendix A, Figures 3 and 4). Departments have separate budgets but share in the use of fleet vehicles. Expensive equipment and vehicles can require a great deal of maintenance and post-use attention. Consistent maintenance of vehicles and equipment provides extended utility for employees and speeds up the execution of multiple projects, preventing delays due to malfunctioning or broken fleet equipment. Lastly, feedback from staff for these kinds of internal targeted surveys can allow municipal staff to gauge which best management practices work best over time for certain types of municipal operations. These types of online surveys can be easily adapted and launched so that SSD staff can adapt training programs and effectively enhance employee knowledge of pollution prevention practices.

5.0 Discussion and Recommendations

5.1 Consideration of National Research Council Recommendations

The Clean Water Act (CWA) limits the discharge of certain pollutants into surface waters but, the NRC identified that “the volume of discharges is secondary and generally not regulated at all;” furthermore, the CWA offers “few if any incentives to anticipate or limit intensive future land uses which generate large quantities of stormwater.” (p. 119, NRC 2008) Overall, the NRC (p. 567, NRC 2008) identifies a “lack of monitoring requirements in the Phase II stormwater program [which] makes it virtually impossible to measure or track actual pollutant load or runoff volume reductions achieved.” MS4s, if they are to work systematically towards a framework, such as the one proposed by CASQA (2007), need to establish sound monitoring within their purview before they can evaluate their program’s effectiveness.

Instead of a sole focus on pollutant loading (as in the TMDL process), in another recommendation, the NRC suggests that flow and impervious cover, “be considered as proxies” or “analogs,” because they “provide specific and measurable targets, while at the same time they focus regulators on water degradation resulting from increased volume as well as increased pollutant [loads],” or the Urban Stream Syndrome. NRC’s main critique stems from the trend that a TMDL is usually established *after* waters are classified as impaired—the process is reactionary instead of preventative or cautionary. For this reason, the NRC states that a current TMDL can “[do] nothing to anticipate and channel land development before waters become degraded,” (pp.108-109, NRC 2008), and alludes again to the current disconnect between land practices and stormwater management. The NRC proposes that TMDL use could be expanded to waters that are classified in the categories of threatened or even, in some instances, non-impaired waters; in any case, the NRC feels that MS4s need specific and improved guidance for

complying with a TMDL in their permit applications and annual reports. (p.121, NRC 2008)

Also, the NRC suggests that terms, such as “design storm” or “MS4 standard of Maximum Extent Practicable,” (p. 554, NRC 2008) need clarification, updating or, in the case of the latter term, need numerical expressions.

Another NRC recommendation (p. 120, NRC 2008) is that the EPA “engage in more vigilant oversight” and “utilize its existing licensing authority to regulate” products that contribute significantly to stormwater pollution—such as, “de-icing chemicals, materials in brake linings, motor fuels, asphalt sealants, and fertilizers.” NRC gives the examples of states and localities that have either entirely banned substances, citing Austin’s ban on coal-tar sealants (p. 116 NRC 2008), or that have opted for milder alternatives, citing that states and localities opt to avoid utilizing caustic de-icing agents known to have toxic environmental effects on biota (p. 121 NRC 2008).

In the literature and media review for this project, the issue of underfunding for stormwater programs remains a significant hurdle for the implementation and execution of “rigorous” stormwater management at the local scale. The NRC report (p. 121-122, NRC 2008) calls strongly for federal financial support of state and local efforts. Since stormwater management receives inadequate federal funding, even in states which collect stormwater fees towards their stormwater permit program, these programs remain underfunded when compared to other water pollution initiatives (See Appendix A, Table 2 for an example) The NRC recommends a redirection of funds from the NPDES wastewater permittees to the NPDES stormwater management program. The NRC’s rationale in suggesting this is two-fold. First, the current stormwater permittees “outnumber wastewater permittees more than five-fold.” Secondly, the NRC contends that diffuse pollution sources continue to degrade the nation’s waterbodies. This

suggestion, in principle, would garner financial support for stormwater programming however the feasibility of redirecting funds was not addressed in the NRC's report.

To date, since SCM implementation at the watershed scale has been inconsistent or “piecemeal” and the existing studies indicate individual SCMs are inadequate, the NRC suggests that SCM implementation “be designed as a system, integrating structural and nonstructural SCMs...incorporating watershed goals, site characteristics, development land use, construction erosion and sedimentation controls, aesthetics, monitoring, and maintenance.” Since current stormwater conveyance systems were designed for flood control, but fail to address and treat pollution from smaller rain events (which are needed in many areas to recharge groundwater and baseflow), the NRC suggests that SCMs that “harvest, infiltrate, and evapotranspire stormwater” can reduce both volume and pollutant loads from smaller storms. Local authorities (MS4s) undertaking watershed and land-use planning approaches, could agree to actively consider and utilize nonstructural SCMs (i.e. substitutes, downspout disconnects, better site design, the use of low impact designs) and practices of “Green Infrastructure,”²⁵ then the NRC suggests that such simpler and more direct prevention approaches reduce the reliance on structural SCMs. The NRC recognizes the need for research on the effectiveness of utilizing suites of SCMs at the watershed scale, as well as research and guidance on nonstructural SCMs; but states that the EPA “should be a leader in SCM research, both directly by improving its internal modeling efforts and by funding state efforts to monitor and report back on the success of SCMs in the field.” The NRC suggests that the EPA and states work towards regional design

²⁵ Green Infrastructure promotes low impact design (LID) approaches,(referred to as “aquatic resources conservation design (ARCD) in the NRC (2008) report that include: watershed and land-use planning (re-zoning, zoning code updates,etc), product substitution, natural area conservation, soil conservation, reforestation, aquatic buffers and managed floodplains, runoff volume reduction (using vegetation, rainwater harvesting, and subsurface retention methods), minimized impervious cover, minimized earthwork movement in construction and maintenance, and illicit discharge detection and elimination.

guidance that municipal and industrial permittees could adapt and adopt for their programs; nationwide design guidance was not advised because not all SCMs apply well in all “physiographic, climatic, and ecoregions,” (p. 465, NRC, 2008).

5. 2 Recommendations for the Municipal Operations Survey(s)

- 1) Administer self-assessment survey(s) that target typical pollution generating activities and also solicit information from on-the-ground staff on the frequency of maintenance activity throughout the year.
- 2) After each survey, follow up in-person or with personal correspondence with participants who agree to provide further feedback beyond their immediate survey responses. The primary goal of “teaching the teachers” applies well to the educational role of the SSD.
- 3) The City of Durham could survey field maintenance crews, in addition to project managers. SSD staff may need to tailor training workshops, in collaboration with field crew managers, to meet the language and education needs of employees in the field crews. Periodic training of field crews would reinforce best practices as well as offer an opportunity to update field crews on changes to water quality management approaches or allowed practices.
- 4) A common theme in the education materials of other MS4 cities (i.e. Charlotte-Mecklenburg county and The City of Los Angeles) capitalized on the softer themes of “community” and the right of future generations to clean water. Here in the Southeast, given long-term regional drought concerns, public messaging on “prevention at the source of our activities” seems a practical message to pair with simple water conservation measures during training of field crews and city staff. Indeed, nonstructural BMPs—can be easier, more effective in function, and are often preferential to the total life-long costs of structural BMPs.

5.3 The Importance of Maintaining Functioning Stormwater Infrastructure

“Designers get all the glory, but they don’t do all the work. The people that maintain the stormwater BMPs are the ones who actually protect water quality because they’re making sure that the stormwater practices last for the 30-50 years that they’re supposed to, they help maintain the pollutant removal rates over time.

If we don’t maintain, we don’t get the pollutant removal rates that we have initially...

Maintenance is the ultimate form of pollutant removal.”

-Nikos Singelis (EPA/CWP, 2006)

The value of maintaining public infrastructure, of stormwater BMPs and other SCMs, has often been underestimated or overlooked in the development rush of hasty urbanization. In a 2006 webcast presentation, Nikos Singelis (EPA/CWP, 2006) answered the question “Why Stormwater [Infrastructure] Maintenance?” with important justifications for sound maintenance practices:

- 1) To protect water quality,
- 2) To improve longevity of stormwater BMPs,
- 3) To ensure BMP pollutant removal rates over time,
- 3) To physically transfer trapped stormwater pollutants to safe upland areas, and
- 4) To ensure that public facilities are safe, functional and attractive.

If we don’t maintain our infrastructure, if BMP designs are inadequate, if we don’t monitor BMPs, if we don’t retrofit aged or failed BMPs and crumbling infrastructure, if we fail to communicate and address the importance of doing so, then we—the citizens and the public works manager—turn a public amenity into an even larger chronic public problem.

The NRC report calls for the great need in stormwater management to more aggressively work towards a national watershed-based permitting program. In the final chapter of the report (starting on p. 475, NRC, 2008), suggests a “new permitting paradigm,” which suggests “more modest and easily implementable recommendations” for improving the current stormwater program to “lay the groundwork in the near term for an eventual shift to watershed-based permitting” and stormwater management. Finally, the NRC predicts that since overhauling the current stormwater permit program will take considerable efforts (across federal, state, and municipal levels) and time to complete, but suggests that a new structure for an improved program be established within 5 years and then fully implemented across the U.S. within 10 years. Meanwhile, funding to support stormwater programming with adequate staff remains a critical limiting factor in the near term.

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7.0 Appendices

7.1 Appendix A: Supplemental Tables and Figures

Table 1: Constraints on the specification of restoration success criteria in natural vs. urban environments.

Natural	Urban
Watershed-based approach is ideal	Municipality-based approach is often necessary
Ecological characteristics and functions are readily identified and are primary	Ecological functions may be less important than human values, which may be difficult to specify
Natural disturbance regimes are critical	Natural disturbance regimes may be impossible to restore
Restoration work is implemented by professionals or consultants, possibly supplemented by volunteers	Volunteers are extensively involved
Nutrient limitations are the norm	Nutrients are often present in abundant or over abundant amounts, and cannot be reduced
Habitat patches can vary greatly in size and connectedness	Habitat patches are often small and isolated; connections are difficult or impossible to re-establish
Climate and microclimate reflect regional geography	Climate and microclimate are significantly altered from the geographically based expectations
Hydrology is a function of regional climate, geology, physiography	Hydrology is usually highly altered, in amounts, sources, and flow rates of water

Source: Ehrenfeld, J. G. (2000). "Evaluating wetlands within an urban context." *Urban Ecosystems*. 4: 69-85.

7.1 Appendix A(continued)

Table 2: Reported Best Management Practices Land Area Requirements for Effective Treatment

Best management practice	Best management practice area (% of impervious watershed) ^a	Best management practice area (% of watershed) ^b
Bioretention	5	—
Wetland	3–5	3–5
Wet/retention basin	2–3	—
Sand filter	0–3	—
Dry DET Basin	—	0.5–2.0 ^c
Infiltration trench	2–3	—
Filter strips	100	—
Swales	10–20	—
Pond	—	2–3
Infiltration	—	2–3
Filter	—	2–7

Note: DET=Detrital valley groundwater.

^aUSEPA (1999).

^bClaytor and Schueler (1996).

^cUDFCD (1992).

Source: Table 1 (in Weiss et al., 2007)

Table 3: Fiscal Year Comparison for Water Quality Programs at the California EPA, Los Angeles Regional Water Board

TABLE 2-10 Comparison of Fiscal Year (FY) 02–03 Budget with FY 06–07 Budget for Water Quality Programs at the California EPA, Los Angeles Regional Water Board

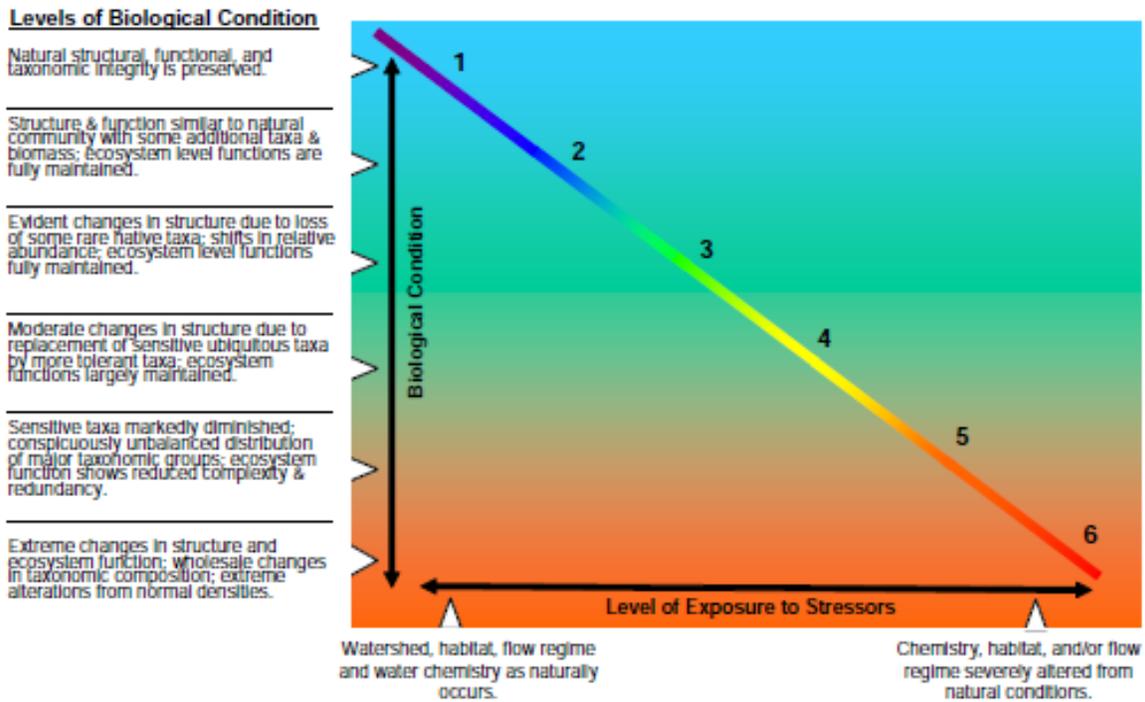
Program	Funding Source	2002–2003	2006–2007
NPDES ¹	Federal	\$2.8 million	\$2.6 million
Stormwater	State	\$2.3 million	\$2.1 million
TMDLs	Federal	\$1.47 million	\$1.38 million
Spills, Leaks, Investigation Cleanup	State	\$1.32 million	\$2.87 million
Underground Storage Tanks	State	\$2.78 million	\$2.74 million
Non-Chapter 15 (Septics)	State	\$0.93 million	\$0.93 million
Water Quality Planning	Federal	\$0.2 million	\$0.21 million
Well Investigation	State	\$1.36 million	\$0.36 million
Water Quality Certification	Federal	\$0.2 million	\$0.23 million
Total		\$17.1 million	\$15.82 million

¹The NPDES row is entirely wastewater funding, as there is no federal money for implementing the stormwater program. Note that the stormwater program in the table is entirely state funded.

Source: (p. 113, NRC, 2008)

7.1 Appendix A (continued)

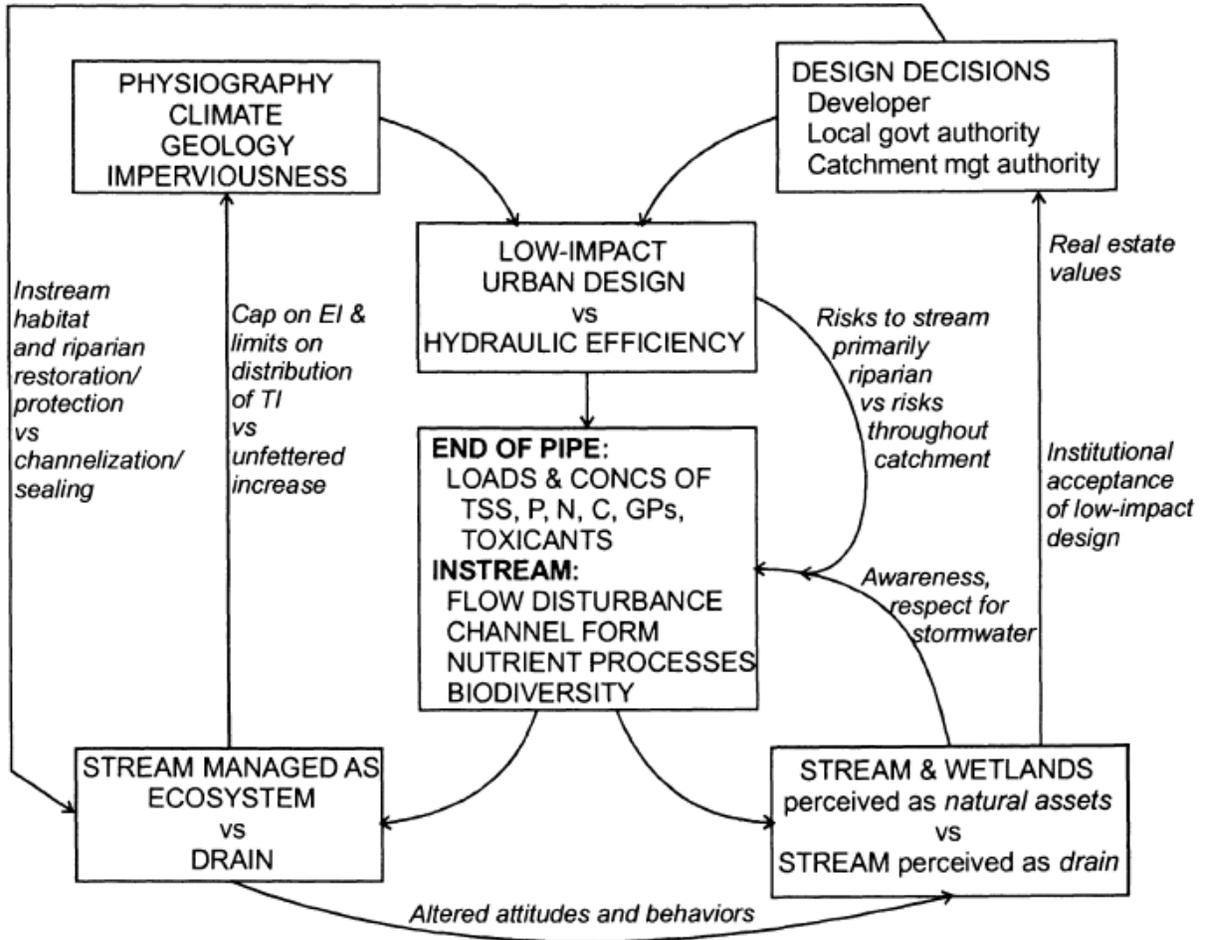
Figure 1: The Biological Condition Gradient: Biological Response to Increasing Stress Levels



SOURCE: Modified version presented (p. 209) in NRC 2008 report; NRC cites EPA's publication by Davies and Jackson (2006).

7.1 Appendix A (continued)

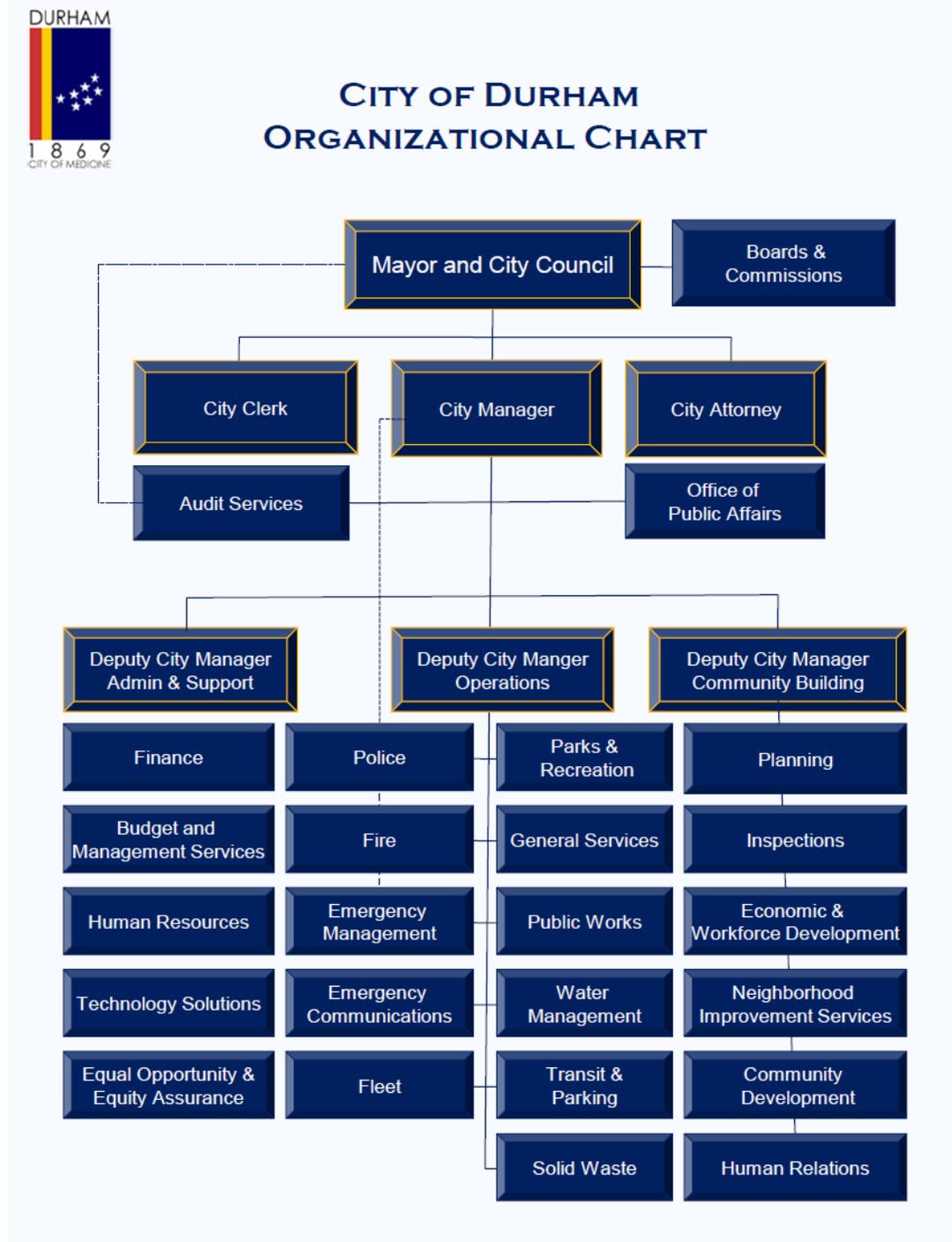
Figure 2: Conceptual Model of Stormwater Management in Relation to Stream Ecology and Urban Ecology.



EI = effective imperviousness, TI = total imperviousness, GPs = gross pollutants, TSS = total suspended solids, CONCS = concentrations
 Source: Walsh et al. (2005), pp. 718 Figure 3.

7.1 Appendix A (continued)

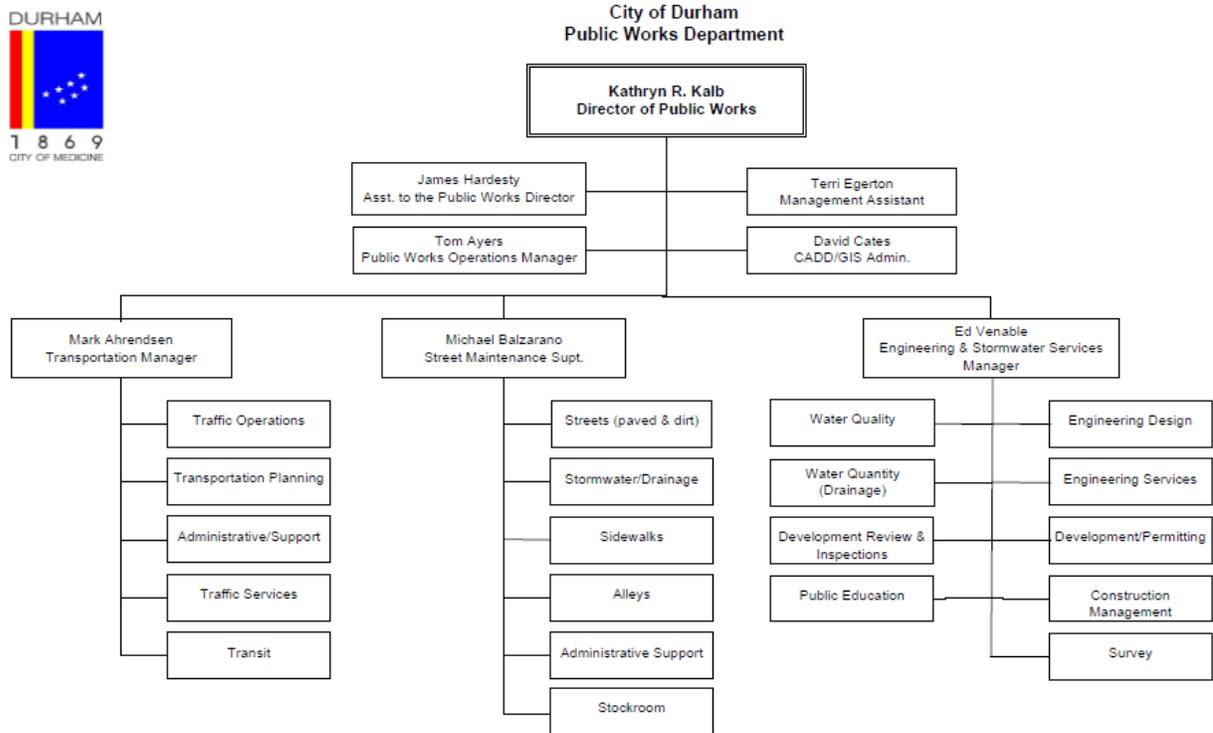
Figure 3: Organizational Chart for the City of Durham



Source: City of Durham website (2009)
 Available at: http://www.ci.durham.nc.us/departments/manager/pdf/cityorgchart_1.pdf

7.1 Appendix A (continued)

Figure 4: Organizational Chart for the Public Works Department, City of Durham

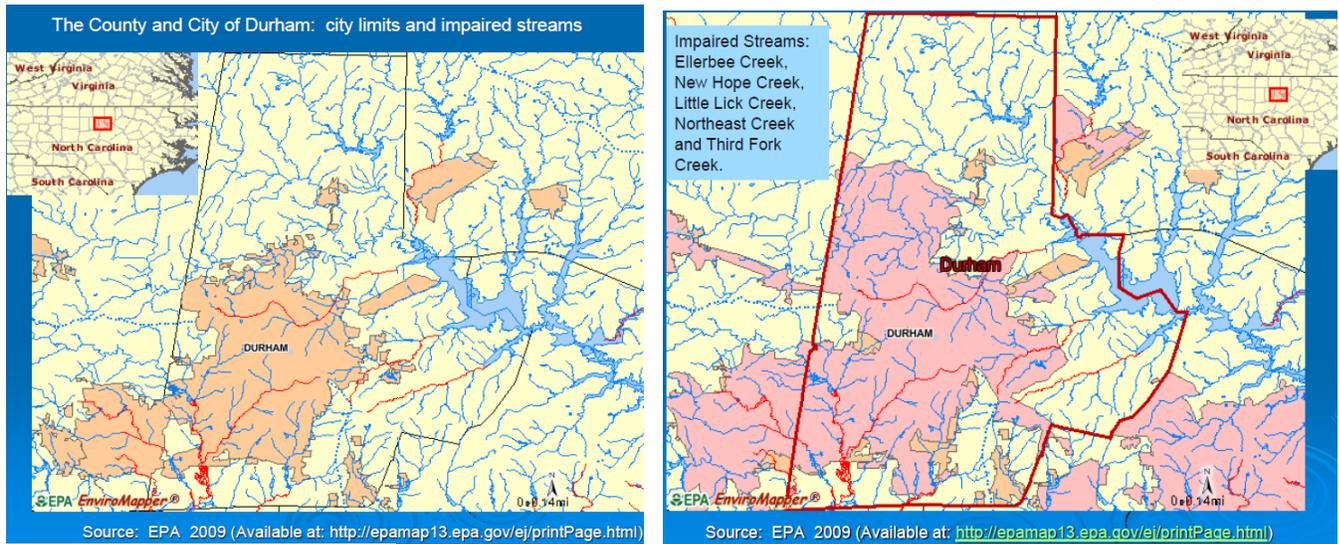


Source: City of Durham website. Available at:
http://www.durhamnc.gov/departments/works/pdf/pub_works_org_chart.pdf

7.1 Appendix A (continued)

Figure 5: Durham’s total drainage system extent and reported street maintenance and litter facts

(a): Durham’s Drainage System Extent and Key Drainage Infrastructure Issues

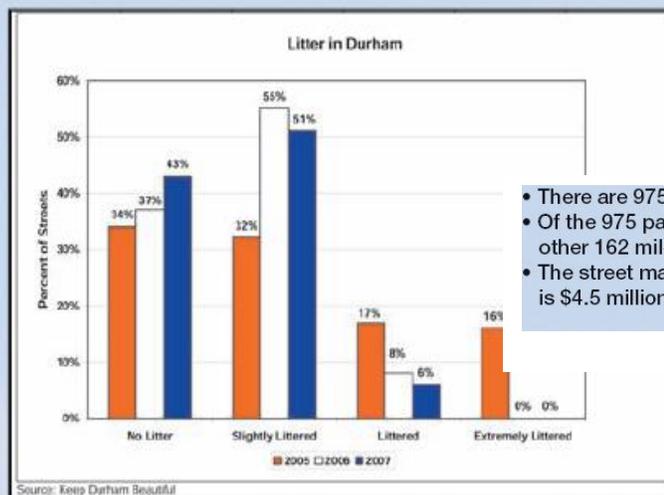


Streams, rivers	1,250 miles	➤ Channel Erosion
Storm drain pipe	750 miles	➤ Pipe Failure
Ditches, open channels	260 miles	➤ Flooding
Stormwater inlets	39,386	➤ Obstructions
Stormwater outlets	9,325	➤ Grading/Landscaping

Source: Sokol, 2008

(b) Durham’s Self-reported Facts on Street Maintenance and Street Litter (Source: DARBAR 2007)

👍 According to the 2007 annual survey, only 6% of Durham’s streets were considered to be littered.



- There are 975 miles of paved streets in the City of Durham
- Of the 975 paved miles, 813 miles are maintained by the City; the other 162 miles are maintained by the state
- The street maintenance budget was \$4.6 million for FY 2006-2007 and is \$4.5 million for FY 2007-2008

7.2 Appendix B: Sample Municipal Operations Survey

Operations Survey for Landscape Maintenance Division of the General Services Department, City of Durham

Introduction to this Operations Survey

U.S. federal and state policy regulating surface water quality has expanded, requiring local governments to regulate the levels of pollution in stormwater runoff entering local urban streams. Ultimately, this large task of reducing pollution into local waterways, falls to the staff of the City of Durham.

SSD staff knows that other departments, actively working to improve the infrastructure of the City, play an important role in minimizing the pollution that reaches Durham's urban streams. Stormwater Service Division (SSD) staff would like to build, reinforce and foster a long-term commitment to the best stormwater management practices by all city staff.

Through short targeted surveys, the SSD would like to engage and outreach to your department, General Services, to gather your input on typical maintenance crew activities and practices. Your feedback will be an invaluable first step in standardizing and improving pollution prevention efforts across the city.

From this survey, we would like to:

- I. Identify your work unit
- II. Identify work unit activities
- III. Identify equipment and vehicle maintenance activities
- IV. Identify post-use maintenance of equipment and vehicles
- V. Identify existing training within your work

Name: _____

Position: _____

IDENTIFY YOUR WORK UNIT

- Park Maintenance (park clean-up, following snow & ice sand & salt trails)
- Horticulture & Landscaping (install, mulch, weed, and irrigate trees, shrubs, seasonal plantings, and perennial beds with special focus on Downtown)
- Turf Management (maintain grassed areas at athletic fields, play meadows, and along the rights-of-way of greenways and trails; maintain naturalized areas in stream buffers and along trails)
- Other: _____

IDENTIFY WORK UNIT ACTIVITIES

1) Does your work involve digging or otherwise disturbing soil (clearing, excavating, removing stumps, etc.) _____ YES _____ NO

If YES, then answer the following:

a. Is the disturbed soil stabilized using one or more of the following methods (check all that apply):

- Mulch
- Seed and straw
- Hydroseeding
- Erosion control matting (especially on steep slopes)
- Erosion control fencing
- PAM (POLYACRYLAMIDE)
- In-drain filter bags
- Other (please specify) _____

b. On average, how many days is the soil left exposed before stabilization or final cover? _____

c. Is disturbed soil ever **not** stabilized using one of the methods in (5(a))? _____ YES _____ NO

d. Are different methods applied to steep slopes?
_____ YES _____ NO _____ Not applicable
(i.e. Don't disturb slopes greater than 4 to 1)

2) In your work group, do you use vehicles or equipment that move over disturbed soil?
_____ YES _____ NO

If YES, then answer the following:

a. Do you use controls to prevent track-out of soils onto roadways?
_____ YES _____ NO

If YES, please check all that apply:

- Rock track-out pads
- Rumble strip track-out control (e.g. Grizzly®)
- Wheel-wash systems (e.g. MobyDick)
- Street sweeping of roads
- Dirty equipment is moved on carrier vehicles and cleaned at central location
- Other _____

3) Does your section have written procedures for this type of work? _____ YES _____ NO

Please list the title of these procedures and, if known, the contact person for these procedures.

EQUIPMENT AND VEHICLE MAINTENANCE ACTIVITIES

4) Please check off and include what equipment crews use:

- | | |
|---|---|
| <input type="checkbox"/> lawn mowers | <input type="checkbox"/> pressure washers |
| <input type="checkbox"/> leaf blowers | <input type="checkbox"/> wood chippers |
| <input type="checkbox"/> earth mover (BobCat, Backhoe, etc) | <input type="checkbox"/> vacuum sweepers |
| <input type="checkbox"/> wood chipper | <input type="checkbox"/> broom sweeper |
| <input type="checkbox"/> ditch witch | <input type="checkbox"/> motorized auger |
| <input type="checkbox"/> Gator | |
| <input type="checkbox"/> Others, please list _____ | |

5) Are any of the equipment (listed in #4) ever re-fueled while at a job site (i.e. in the field)?

____ YES ____ NO

6) In your work, it may be necessary to perform maintenance activities on equipment while in the field/on a job site rather than at a fuel station (such as the Fuel Island at Fleet Maintenance) or a central location (General Services Maintenance Facility).

a. Do you have established written procedures for spills of equipment fuel or machine lubricants?

____ YES ____ NO

b. Please consider the following and identify all current activities/descriptions you are aware of while performing maintenance on equipment in the field:

- Nozzles have automatic shut-off to control drips
- Fueling operations are never left unattended
- Fueling/lubricating must be at least 50 ft from downstream drainage facilities and watercourses
- Fueling/lubricating is performed on level-grade areas
- Drip pans or absorbent pads are used during fueling and lubricating
- Use absorbent spill kits are available in fueling areas and on fueling trucks
- Absorbent spill kits are disposed of properly after use.
- Other _____

c. Are staff required to inspect vehicles and equipment on each day of use for leaks?

____ YES ____ NO

d. Are leaks required to be repaired immediately?

____ YES ____ NO

e. Do you have written procedures for disposing of or recycling used oils, fluids, lubricants, used batteries, and spill cleanup materials? ____ YES ____ NO

POST-USE MAINTENANCE OF EQUIPMENT

7) Do you have written guidelines for cleaning equipment after it has been used in the field?

____ YES ____ NO

8) Are certain kinds of equipment cleaned/washed differently from others? ____ YES ____ NO

9) Do you clean/wash any equipment (list not included in this sample survey) off in a particular way?

Equipment	Frequency of post-use maintenance: (drop down menu)	Possible Method(s) of cleaning equipment (select all that apply):			
		Wash with water (Yes/No)	Dry brush (Yes/No)	Does cleaning occur in the field? (yes/no)	Other, (please list)

IDENTIFY EXISTING TRAINING WITHIN YOUR WORK UNIT

10) Is training/orientation provided to field crew members?
 (Please check all that apply and specify the frequency of these types of training.)

Type of Training	Frequency of Training			
	Annually	Monthly	Quarterly	Other schedule (please specify)
New Staff Training, in addition to City New Employee Training (NET)*				
Safety Training				
Pesticide Training				
Work Procedures training				

11) Which of the following approaches are used most often for work unit training?

- Tailgate training
- In-field supervision
- Training at regular staff meetings
- Classroom training
- Staff are sent to workshops or seminars

12) All new city employees receive general stormwater pollution prevention training as part of New Employee Training (NET). Are staff members who use leaf blowers specifically trained *not* to blow leaf and organic matter into storm drains?

____ YES ____ NO

13) (i) Do new employees to your work unit also receive training in pollution prevention that is:

- A) job specific or
- B) task specific to your work unit?
- C) both (A) and (B)

(ii) Please list the title of any written guidelines that you follow OR list the name of the person who may have the written guidelines.

14) Are **all** field crew staff trained and/or instructed on these guidelines?

____ YES ____ NO

15) Do you keep a record of attendance?

____ YES ____ NO

16) Do you keep a record of topics covered during training?

____ YES ____ NO

Thank you for your input! Your contributions and knowledge are appreciated by the Stormwater Service Division Staff. Please contact (insert contact email) if you have questions or would like SSD input on your future pollution prevention training efforts in your department.

7.3 Appendix C: Summary of Recommendations from Literature Review

TOPIC AREA: SUGGESTION/ RECOMMENDATIONS	APPLICABLE LEVEL OF GOVERNANCE (federal, state, local, or multiple), or INDUSTRY, or COOPERATIVE FORUM	KEY RATIONALE POINTS PROVIDED FOR RECOMMENDATION	Examples?
MS4s should establish sound monitoring of stream conditions	Local action with guidance from State EPA	Need sound information before meaningful program evaluation can occur	
Link land use practices with stormwater management. Utilize flow and impervious cover measurements as proxies/analogs alongside pollutant load measurements (TMDL programs)	Federal guidance Local monitoring Cooperative Forum	TMDLs are established <i>after</i> the “impaired” designation (reactive instead of preventative); flow and impervious cover are specific and measurable targets that focus policy-makers on volume impacts to urban streams (as well as pollutants)	
Expand the TMDL use to waters classified as threatened or, possibly even, as non-impaired	State guidance with Local action	Preventative action is needed to avoid further watershed-wide degradation. MS4s would benefit from planning ahead and receiving specific guidance for compliance with TMDL requirements	
Reconsider contributor chemicals to stormwater pollutants	Federal	Vigilant oversight and utilization of U.S. EPA’s licensing authority of harmful chemicals.	Ex. Ban de-icing chemicals, materials in brake linings, motor fuels, asphalt sealants, and fertilizers Ex. Austin, TX banned coal-tar sealants

7.3 Appendix C (continued): Summary of Recommendations from Literature Review

<p>TOPIC AREA:</p> <p>SUGGESTION/ RECOMMENDATIONS</p>	<p>APPLICABLE LEVEL OF GOVERNANCE (federal, state, local, or multiple), or INDUSTRY, or COOPERATIVE FORUM</p>	<p>KEY RATIONALE POINTS PROVIDED FOR RECOMMENDATION</p>	<p>Examples?</p>
<p>Increase and re-consider current funding allocations under the NPDES program; increase funding for stormwater permittees</p>	<p>Federal State Local</p>	<p>Other permitted water pollution programs(i.e. wastewater) are disproportionately funded. Stormwater permittees outnumber wastewater permittees more than five-fold.</p>	<p>Los Angeles funding example (See Table 2, Appendix A)</p>
<p>Watershed-based management should be at the forefront in SCM implementation; better guidance is needed from the EPA for state and local programming</p>	<p>State, Regional Cooperation, Industry, Local</p>	<p>SCM/BMP implementation needs to integrate structural and non-structural practices/designs Site characteristics, development LU, construction, erosion and sedimentation controls, monitoring, and maintenance need to align with watershed goals</p>	

Note: These recommendations are in reference to the National Research Council’s 2008 report (NRC, 2008)