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Stormwater Management in Tennessee: Guidelines to Preventative Maintenance Practices and Improvements

A Thesis

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Master of Science

Degree

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Jacob S. Chandler

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Abstract

The management of urban stormwater runoff is an important issue throughout Tennessee as urban development keeps expanding. With the rise of urban development, there is an ever-growing need for urban stormwater management systems and facilities which are built to protect downstream property owners from potential flood damage as well as to manage and control the increased stormwater runoff. However well-designed a drainage system or facility might be, adequate maintenance is vital for it to function as intended by the design engineer.

This thesis was written to serve as a document that provides information needed to support an effective maintenance program for urban stormwater management systems and facilities and includes information that can help educate both public and private owners of these systems and facilities about the importance, benefits and methods of maintaining their stormwater management systems and facilities.

The information used to prepare this thesis was derived from a comprehensive literature search, a review of traditional reference sources and internet web sites to help determine what successful methods and programs are being used to ensure and improve maintenance of urban stormwater management systems and facilities. A survey questionnaire was also sent to all 95 counties in Tennessee and Tennessee municipalities with a 1990 census population of 2500 or greater to characterize the existing stormwater maintenance programs throughout the state.

Findings from the survey questionnaire include:

- As can be expected, as the population within a community's jurisdictional boundary increases, the allocated budget for stormwater and street maintenance increases as well
- The results of the survey questionnaire appear to suggest that a preventative maintenance program does not seem to significantly reduce the perceived number of stormwater problems that are attributed to needed maintenance within a community

- Either communities do not have sufficient manpower to provide needed inspections for private stormwater handling facilities or the communities require the owner of the stormwater handling facility to perform the needed inspections and maintenance of the private stormwater handling facilities

- Either respondents do not perceive any serious stormwater-related maintenance problems within their community and that they feel the current funding is adequate to handle these problems or some of the respondents may have anticipated the percentage increase that has been allocated for the next year's budget

As part of this report, the findings include stormwater maintenance protocols that were established based on the information provided by the various survey questionnaire respondents.

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List of Abbreviations

APWA	American Public Works Association
ASCE	American Society of Civil Engineers
BMPs	Best Management Practices
COD	Chemical Oxygen Demand
CSO	Combined Sewer Overflow
CWA	Clean Water Act
EPA	Environmental Protection Agency
ERUs	Equivalent Residential Units
GIS	Geographic Information System
LIDs	Local Improvement Districts
MS4s	Municipal Separate Storm Sewer Systems
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense Council
NURP	Nationwide Urban Runoff Program
O&M	Operation and Maintenance
POTW	Publicly Owned Treatment Works
S4s	Separate Storm Sewer Systems
SWPPP	Stormwater Pollution Prevention Plan
TDEC	Tennessee Department of Environment and Conservation
TSS	Total Suspended Solids
WQA	Water Quality Act

Chapter I. Introduction

Preventative maintenance of stormwater systems and facilities is a common topic of research and study within the water resources community. This is primarily due to a contradiction between conventional wisdom and reality. Conventional wisdom holds that prevention is key to saving time, effort and expense. As summarized by several studies as well as federal regulation, this thought applies to the operation of stormwater drainage systems and facilities. The reality of the situation is that most stormwater maintenance work is done on an as-needed basis with little priority given to the preventative side of stormwater systems and facilities maintenance. In a time of budgetary constraints, preventative maintenance programs promise to reduce the amount of manpower and materials needed to correct stormwater drainage problems, a plan that taxpayers and politicians alike should appreciate.

Purpose and Scope

The objectives for this thesis are:

- Identify and discuss the issues and problems of maintaining urban stormwater management systems and facilities
- Examine all factors relating to the maintenance of stormwater systems and facilities
- Understand how maintenance affects the performance of urban stormwater management systems and facilities is key to proper function of these systems and facilities
- Raise public awareness of individual and government responsibility for the maintenance of stormwater systems and facilities
- Provide information needed to support an effective preventative maintenance program for urban stormwater management systems and facilities
- Include stormwater maintenance protocols

The maintenance of stormwater systems and facilities is generally assumed to be the owner's responsibility. Often, however, the owners are not always aware of their responsibilities for maintaining facilities --

especially when these facilities are located in large subdivisions or where homeowners are second-generation residents and maintenance responsibility becomes forgotten. Once the maintenance needs are identified, owners normally have a better understanding of their roles and responsibilities for maintaining their urban stormwater management systems and facilities as a way for reducing the risk of system failure, potentially flooding their neighbors and the consequential legal expenses. Ultimately, the information in this thesis should be used to convince stormwater management system and facility owners, whether public or private, to be more aware of their legal and community responsibilities as good stewards. Once this responsibility is understood, the community will benefit from reduced property damage and fewer lawsuits, and in the long run, increased property value and less public tax burden.

This thesis was written to serve as a document that provides information needed to support an effective preventative maintenance program for urban stormwater management systems and facilities and includes information that can help educate both public and private owners of these systems and facilities about the importance, benefits and methods of maintaining their stormwater management systems and facilities.

As part of this report, the findings include stormwater maintenance protocols that were established based on the information provided by various survey questionnaire respondents. The survey questionnaire was sent to all Tennessee municipalities and counties with a 1990 census population of 2500 or greater. Questions included both qualitative and quantitative information to determine what are the major maintenance problem(s) and impediments concerning urban stormwater management systems and Best Management Practices (BMP) facilities. Specific information to be obtained included the following:

- How well are systems and facilities within your jurisdiction being maintained by the responsible owner?
- Who is responsible for maintaining these systems and facilities?
- What actions do local jurisdictional governments take when private owners do not adequately maintain their facilities?
- What innovative technologies are design engineers incorporating to minimize maintenance at or to create "maintenance-free" facilities?

- What is the current annual budget being used for stormwater-related activities?
- Does your jurisdiction take a preventative/proactive approach to maintaining urban stormwater management systems and facilities?
- What percentage increase is needed in your annual budget to minimize future problems, address recurrent problems or to improve the existing stormwater management systems and facilities under your jurisdiction?
- What are the major stormwater-related maintenance problems within your jurisdiction?

The protocols that were developed can be used to correct stormwater-related maintenance problems associated with catch basins, detention ponds, open channels, including creeks, streams and ditchlines, pipe/culvert systems and bridges.

Much of the information used to prepare this thesis was derived from a comprehensive literature search and review of traditional reference sources and internet web sites to help determine what successful methods and programs are being used to ensure and improve maintenance of urban stormwater management systems and facilities.

Chapter II. Background

Past Studies

Urban stormwater runoff, such as rainfall or snowmelt, can transport high levels of pollutants including sediment, suspended solids, nutrients (phosphorous and nitrogen), heavy metals and other toxic pollutants, pathogens, toxins, oxygen-demanding substances (organic material) and floatables to nearby water bodies as it moves over the earth's surface.

From 1978 to 1983, the Environmental Protection Agency (EPA) conducted the Nationwide Urban Runoff Program (NURP) study at 28 locations across the Nation in order to better understand the composition of urban stormwater runoff from residential, commercial and industrial areas. EPA's purpose in completing the NURP study was to provide information to governing bodies that could be used to assess potential water quality problems caused by urban stormwater runoff and potential methods for use in alleviating these problems. At each site, samples were taken to screen for 120 priority pollutants in stormwater discharges from residential, commercial and light industrial areas. The results of the screening found 77 priority pollutants (which were composed of 14 inorganic and 63 organic pollutants) present in the stormwater discharges from these areas. The stormwater runoff samples were taken for analysis during a 5-year period and of the 22-urban/suburban areas, 81 samples from residential and commercial properties were analyzed for eight conventional pollutants and three heavy metals. The results of the testing illustrated that discharges from separate storm sewer systems (S4s) contained more than 10 times the annual amount of total suspended solids (TSS) than discharges from municipal sewage treatment plants. It was also shown that runoff from residential and commercial areas carried higher annual loadings of chemical oxygen demand (COD), total lead and total copper than effluent from municipal sewage treatment plants. In addition, the study found that fecal coliform counts in urban runoff ranged from tens to hundreds of thousands per hundred milliliters of runoff during warm weather conditions. The sources of pollution

that could also negatively affect the quality of urban runoff, not covered in the NURP study, include illicit discharges, construction site runoff, industrial site runoff and illegal dumping. While the NURP study is considered the landmark study for determining the impact of urban stormwater runoff on receiving water quality, EPA has also found through additional studies that urban stormwater runoff has been listed as a major cause of designated beneficial use impairment in 38 states. The National Water Quality Inventory (305(b)), reported that urban runoff/storm sewer discharges was found to be a source of pollution for 13% of impaired rivers, 21% of impaired lakes and 45% of impaired estuaries. More recently, it has been found that one of the largest causes of beach closings in the United States has been urban stormwater runoff. Urban stormwater runoff was responsible for 823 beach closings/advisories in 1995, 407 beach closings/advisories in 1996 and more than 1,500 beach closings/advisories in 1998. (EPA, 2000)

As more natural vegetation is removed for development-associated activities, such as the construction of impervious structures, including, but not limited to, buildings, roads and parking lots, the risk for harmful impacts from stormwater runoff increases. Urbanization, which is associated with increases in population density and impervious surfaces, not only increases the amount of pollutants running off a watershed, but creates new sources of pollutants that are associated with car emissions, car maintenance wastes, debris and litter, fertilizers, pesticides and herbicides and household hazardous wastes. These pollutants that are transported to receiving water bodies from urbanized areas can not only impair aquatic life, their habitat and the water quality, but can also negatively affect human health through exposure to the contaminated water and/or the aquatic life. It has been found that recreational swimmers who swim within 400 yards of a storm drain run a 57% higher risk of contracting illnesses such as gastroenteritis, typhoid, dysentery and hepatitis. The NURP study also found that the concentrations of metals in urban stormwater runoff generally exceeded freshwater aquatic life criteria and bacteria concentrations as well as EPA's water quality criteria during and immediately after storm events in most rivers and streams. High concentration levels of nutrients were also found in the urban stormwater runoff, which could cause eutrophication problems. Urbanization not only increases pollutant loadings, but it also (EPA, 2000):

- Alters the natural infiltration ability of the soil compared to predevelopment conditions

- Increases the peak flow rates compared to predevelopment conditions
- Increases the volume of stormwater runoff as compared to predevelopment conditions
- Increases the frequency and severity of flooding
- Increases stormwater runoff velocity due to increased peak flow rates, decreased time of concentration and increased amounts of man made conveyance systems
- Decreases the time needed for stormwater runoff to reach a receiving body
- Decreases stream flow during extended periods of dry weather due to the decrease of infiltration in a watershed

The NURP study also found that the erosion and scour due to the increase in volume and peak flows from urban stormwater runoff could adversely affect the receiving water's aquatic life and the related habitat. The amount of impervious area in a watershed has been shown to have an affect on the quality of nearby receiving water bodies. As reported by the Report to Congress on the Phase II Storm Water Regulations, many studies have shown that a significant reduction in the water quality of these receiving water bodies can occur at low levels of imperviousness, such as between 5 to 20 percent. Additional research has shown that only a few receiving water bodies can support aquatic life if the impervious levels exceed 25 percent. (EPA, 2000)

Regulatory Requirements

"In 1972, Congress amended the Federal Water Pollution Control Act (commonly referred to as the Clean Water Act (CWA)) to prohibit the discharge of any pollutant to waters of the United States from a point source unless the discharge is authorized by an NPDES (National Pollutant Discharge Elimination System) permit." (EPA, 1999) The objective of the CWA was to achieve chemical, physical and biological stability in the Nation's receiving waters. Two goals were established to achieve this objective: "eliminate all pollutant discharges to navigable waters by 1985 and achieve fishable and swimmable waters by 1983." (EPA, 2000)

The NPDES permitting program, which was created under Section 402 of the CWA, was designed to locate point source discharges, such as industrial and municipal wastewater treatment plant discharges, and require that the discharge of pollutants be minimized to prevent further degradation of receiving water quality. After industrial and municipal wastewater treatment plant discharges were regulated, it was apparent that there were other sources of water pollution that was causing negative affects on receiving water quality. It was later discovered that stormwater runoff from agriculture and urban land uses was contributing to the degradation of receiving water quality. (EPA, 2000)

During the creation of the first stormwater regulations in 1973, EPA declared that stormwater runoff not contaminated by industrial or commercial activity was exempted from permit requirements. This exemption was justified because of the potential excessive administrative burden associated with individual permits for stormwater point sources. EPA also believed that stormwater runoff could not be effectively treated with traditional controls. Due to this exemption, the Natural Resources Defense Council (NRDC) challenged EPA's authority to selectively exempt specific point sources. The Court, in agreement with NRDC, ruled that the flexibility of the NPDES permitting process would keep the workload manageable. The Court of Appeals later suggested that general permits might be more applicable in certain situations. (EPA, 2000)

In 1984, EPA promulgated a final stormwater rule that created two classifications of stormwater discharges. The first group, Group I, includes stormwater discharges requiring an NPDES permit. Group II includes stormwater discharges that only require notification to proper authorities, such as EPA or authorized states, that a discharge has occurred. (EPA, 2000)

In 1987, the U.S. Court of Appeals required EPA to revise the 1984-stormwater regulations because of the number of stormwater point sources that were not regulated. As a result, Congress modified the CWA to address stormwater discharges in two phases. (EPA, 2000)

EPA added section 402(p) to the Water Quality Act of 1987 (WQA) as ordered by Congress to develop an outline for addressing stormwater discharges in two phases. On November 16, 1990, EPA promulgated the NPDES stormwater Phase I requirements, which set forth relatively broad requirements and allowed for site-specific procedures for controlling stormwater discharges. The broad and flexible requirements of the Phase I permitting process allowed industrial facilities and municipalities to determine which measures are best for controlling stormwater discharges and avoided duplication of effort where significant progress has already been made. The Phase II requirements would later address stormwater discharges that are not covered by the Phase I program. (EPA, 2000)

EPA NPDES Phase I Stormwater Requirements

The Phase I permitting program that was promulgated on November 16, 1990 required that medium and large municipal separate storm sewer systems (MS4s) serving populations generally over 100,000 as well as specific industrial facilities, including construction sites that disturb five or more acres, obtain an NPDES permit. The Phase I permitting program also allowed for regulation of stormwater discharges that could significantly impact receiving water quality and lists the incorporated places and counties that must obtain an NPDES permit. The final Phase II rule promulgated on December 8, 1999 permanently clarifies the definition of medium and large MS4s based upon 1990 Census population data. Some of the municipalities that were listed in the Phase I ruling have combined sanitary and stormwater sewer systems; however, the Phase I rule only applied to municipalities who have a separated storm sewer system serving a population over 100,000. EPA's National Combined Sewer Overflow (CSO) Control Policy dated April 19, 1994 regulates the municipalities who have combined sanitary and stormwater sewer systems. (EPA, 2000)

It was estimated that about 100,000 industrial facilities would require an NPDES Phase I permit. EPA developed a two-tiered approach strategy for the issuance of permits for stormwater discharges associated with industrial activities. The majority of the regulated facilities were covered using a general permit,

while other facilities, which had a more direct impact on water quality, were permitted on an individual basis. The Phase I permit required the regulated facilities to "develop and implement a site-specific stormwater pollution prevention plan (SWPPP) to prevent, reduce or control stormwater pollutant sources using, among other techniques, low-cost BMPs." (EPA, 2000) Examples of BMPs include, but are not limited to, good housekeeping procedures, employee training, site inspections, spill prevention and response plans and preventive maintenance activities. (EPA, 2000)

The Phase I permitting program also regulated construction activities such as grading, clearing, excavation and other earthmoving activities that disturbed "5 or more acres of land area, including areas that are part of a larger common plan of development or sale." (EPA, 2000) The permits for construction activities were based on a similar tiered approach that was used for the permits for industrial activities. The permit for the construction activities required the "development and implementation of a site-specific SWPPP specifying erosion and sediment control measures that will be implemented at the site." (EPA, 2000) Examples of BMPs that can be used as controls include onsite sediment retention controls, litter prevention controls, construction debris controls, construction chemical controls and temporary and permanent vegetation controls. (EPA, 2000)

Since EPA promulgated the Phase I rule in 1990, the number of regulated MS4s has increased to more than 1,000. An MS4 is defined as a "conveyance or system of conveyances that is owned or operated by a Federal, State, or local government entity and is designed for collecting and conveying stormwater (which is not part of a publicly owned treatment works (POTW) or combined sewer)." (EPA, 2000) Two-part applications were required from the municipalities in order to identify site-specific pollution control measures, source controls and BMPs. Part of the permit requirements includes the development of a stormwater management program that reduces the amount of pollutants discharged into local receiving waters. The program "would include identifying major outfalls and pollutant loadings, detecting and eliminating non-stormwater discharges to the storm sewer system, using pollution prevention techniques to

reduce pollutants in runoff from industrial, commercial and residential areas and controlling stormwater discharges from new development and redevelopment areas." (EPA, 2000)

EPA NPDES Phase II Stormwater Requirements

EPA proposed the Phase II program in January 1998 and promulgated the final NPDES stormwater Phase II regulations on December 8, 1999, as a way to expand and improve upon the NPDES stormwater regulations as well as the progress created by the Phase I program. The Phase II program was created to regulate stormwater dischargers from small MS4s (MS4s that serve less than a population of 100,000), construction sites that result in a land disturbance of 1 to 5 acres and stormwater discharges that could have a significant impact on receiving water quality. The regulations state that the NPDES permitting authority will issue general permits for Phase II-designated small MS4s and small construction activity by December 9, 2002. The operators of Phase II "automatically" designated regulated small MS4s and small construction activity must obtain permit coverage within 90 days of permit issuance, which will be March 10, 2003. The Phase II program also excludes industrial facilities that have no exposure of industrial activities and materials to stormwater runoff. The Phase II program was associated with four objectives as reported by EPA (EPA, 1999), which has sought to:

1. Provide a comprehensive stormwater program that designates and controls additional sources of stormwater discharges to protect water quality
2. Address stormwater discharges from the activities exempted under the 1990 stormwater permit application regulations that were remanded by the Ninth Circuit Court of Appeals in NRDC v. EPA, 966 F.2d 1292 (9th Circuit, 1992)
3. Provide coverage for the so-called "donut holes" created by the existing NPDES stormwater program
4. Promote watershed planning as a framework for implementing water quality programs where possible

EPA (EPA, 1999) has identified six minimum measures required for small MS4 programs that could significantly reduce pollutants in urban stormwater runoff. These minimum measures include:

1. Public Education and Outreach
2. Public Involvement
3. Illicit Discharge Detection and Elimination
4. Construction Site Runoff Control
5. Post-construction Stormwater Management in New Development and Redevelopment
6. Pollution Prevention and Good Housekeeping of Municipal Operations

The Public Education and Outreach program requires that small MS4s implement a program to educate citizens about the potential negative effect of urban stormwater runoff on receiving water and identify steps that each citizen can take to reduce stormwater runoff pollution. The following is a list of ways cited by EPA (EPA, 1999) that can be used to educate citizens:

- Distribute brochures or fact sheets
- Issue public service announcements
- Organize community meetings
- Organize educational programs targeted at school age children
- Organize community projects such as a storm drain stenciling program

The information that is distributed to individuals and households should contain ways to reduce stormwater runoff pollution such as (EPA, 1999):

- Becoming involved in local stream cleanup and restoration activities
- Conducting proper septic system maintenance
- Following proper use and disposal guidelines for fertilizers and pesticides
- Following proper disposal guidelines for used motor oil and other household hazardous wastes

The Public Involvement program requires that MS4s comply with State and local public notice requirements. The reason behind this requirement is that public involvement can increase local support for stormwater programs, which could mean that citizens would be more responsive to any necessary tax

increases in order to fund a stormwater program. The public also provides additional resources such as community groups that could help small MS4s with other parts of the Phase II program requirements. There are numerous ways to get the public involved in a stormwater program such as (EPA, 1999):

- Allowing citizens to serve as representatives on any local stormwater management boards
- Allowing citizens to participate in volunteer stormwater monitoring activities
- Encouraging citizens to attend public hearings
- Encouraging citizens to volunteer in local cleanup groups

Illicit discharges, which are defined "as any discharge to a MS4 that is not composed entirely of stormwater, except discharges pursuant to an NPDES permit and discharges resulting from fire fighting activities" (EPA, 1999), can significantly degrade the quality of water in a receiving body. Illicit discharges can enter the stormwater runoff system through either direct connections, such as wastewater systems being connected to the stormwater runoff system, or indirect connections such as infiltration into the stormwater runoff system or accidental spills that enter the stormwater runoff system through catch basins or by other means. The Phase II permit requires that a small MS4 must "develop, implement and enforce an illicit discharge detection and elimination program." (EPA, 1999) The requirements under this part of the Phase II program include (EPA, 1999):

- Create a storm sewer system map showing the location of all waters of the United States that receive discharges from outfalls
- Prohibit through an ordinance or other regulatory mechanism, to the extent allowable under State, Tribal or local law, illicit discharges into the separate storm sewer system and implement appropriate enforcement procedures and actions as needed
- Develop and implement a plan to detect and address illicit discharges, including illegal dumping, to the system
- Inform public employees, businesses and the general public of hazards associated with illegal discharges and improper disposal of waste

The Construction Site Runoff Control program requires that small MS4s "develop, implement and enforce a pollutant control program to reduce pollutants in any stormwater runoff from construction activities that result in land disturbances of 1 or more acres. Construction activities on sites disturbing less than one acre

must be included in the program if the construction activity is part of a larger common plan of development or sale that would disturb one acre or more." (EPA, 1999) The program must include:

- An ordinance or other regulatory mechanism to require erosion and sediment controls to the extent practicable and allowable under State, Tribal or local law
- Sanctions to ensure compliance (for example, non-monetary penalties, fines, bonding requirements and/or permit denials for noncompliance)
- Requirements for construction site operators to implement appropriate erosion and sediment control BMPs, such as silt fences, temporary detention ponds and diversions
- Procedures for site plan review by the small MS4 which incorporate consideration of potential water quality impacts
- Requirements to control other waste such as discarded building materials, concrete truck washout, chemicals, litter and sanitary waste at the construction site that may adversely impact water quality
- Procedures for receipt and consideration of information submitted by the public to the MS4
- Procedures for site inspection and enforcement of control measures by the small MS4

The Post-construction Stormwater Management in New Development and Redevelopment program requires that small MS4s "develop, implement and enforce a program to address stormwater runoff from new development and redevelopment projects that result in land disturbance of greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into the MS4." (EPA, 1999) The regulated MS4 will be required to:

- Develop and implement strategies which include a combination of structural and/or non-structural BMPs appropriate for the community
- Use an ordinance, or other regulatory mechanism to address post-construction runoff from new development and redevelopment projects to the extent allowable under State, Tribal or local law
- Ensure adequate long-term operation and maintenance of BMPs
- Ensure that controls are in place that would minimize water quality impacts

The term combination used in the first bullet is meant to emphasize that multiple BMPs should be considered and adopted for use in the community. A single BMP generally cannot significantly reduce pollutant loads because pollutants come from many sources within a community. The BMPs chosen should (EPA, 1999):

- Be appropriate for the local community
- Minimize water quality impacts
- Attempt to maintain pre-development runoff conditions

Non-structural BMPs are preventative actions that involve management and source controls such as (EPA, 1999):

- Policies and ordinances that provide requirements and standards to direct growth to identified areas, protect sensitive areas such as wetlands and riparian areas, maintain and/or increase open space (including a dedicated funding source for open space acquisition), provide buffers along sensitive water bodies, minimize impervious surfaces and minimize disturbance of soils and vegetation
- Policies or ordinances that encourage infill development in higher density urban areas and areas with existing storm sewer infrastructure
- Education programs for developers and the public about project designs that minimize water quality impacts
- Other measures such as minimization of the percentage of impervious area after development, use of measures to minimize directly connected impervious areas and source control measures often thought of as good housekeeping, preventative maintenance and spill prevention

EPA (EPA, 1999) recommends that small MS4 operators ensure the appropriate implementation of the structural BMPs by considering some or all of the following:

- Pre-construction review of BMP designs
- Inspections during construction to verify BMPs are built as designed
- Post-construction inspection and maintenance of BMPs
- Sanctions to ensure compliance with design, construction or operation and maintenance (O&M) requirements of the program

"To meet the third post-construction requirement (ensuring adequate long-term O&M of BMPs), EPA recommends that small MS4 operators evaluate various O&M management agreement options. The most common options are agreements between the MS4 operator and another party such as post-development landowners (e.g., homeowners' associations, office park owners, other government departments or entities) or regional authorities (e.g., flood control districts or councils of government)." (EPA, 1999) These agreements typically require the post-construction property owner to be responsible for the O&M and may include conditions which (EPA, 1999):

- Allow the MS4 operator to be reimbursed for O&M performed by the MS4 operator that is the responsibility of the property owner but is not performed
- Allow the MS4 operator to enter the property for inspection purposes
- Specify that the property owner submit periodic reports

The Pollution Prevention and Good Housekeeping for Municipal Operations program requires that small MS4s "develop and implement an operation and maintenance program that includes a training component and has the ultimate goal of preventing or reducing stormwater from municipal operations (in addition to those that constitute stormwater discharges associated with industrial activity). This program must include government employee training that addresses prevention measures pertaining to municipal operations such as: parks, golf courses, open space maintenance, fleet maintenance, new construction, land disturbance, building oversight, planning and stormwater system conveyance." (EPA, 1999) EPA (EPA, 1999) encourages operators of MS4s to consider the following in developing a program:

- Implement maintenance activities, maintenance schedules and long-term inspection procedures for structural and non-structural stormwater controls to reduce floatables and other pollutants discharged from the separate storm sewers
- Implement controls for reducing or eliminating the discharge of pollutants from streets, roads, highways, municipal parking lots, maintenance and storage yards, waste transfer stations, fleet or maintenance shops with outdoor storage areas and salt/sand storage locations and snow disposal areas operated by the MS4
- Adopt procedures for the proper disposal of waste removed form the separate storm sewer systems and areas listed above including dredge spoil, accumulated sediments, floatables and other debris
- Adopt procedures to ensure that new flood management projects are assessed for impacts on water quality and existing projects are assessed for incorporation of additional water quality protection devices or practices.

"Ultimately, the effective performance of the program measure depends on the proper maintenance of BMPs, both structural and non-structural. Without proper maintenance, BMP performance declines significantly over time. Additionally, BMP neglect may produce health and safety threats, such as structural failure leading to flooding, undesirable animal and insect breeding and odors." (EPA, 1999) Maintenance of structural BMPs could include (EPA, 1999):

- Replacing upper levels of gravel

- Dredging of detention ponds
- Repairing of retention basin outlet structure integrity

"Maintenance of non-structural BMPs could include updating educational materials periodically. The establishment of a long-term program could result in cost savings by minimizing possible damage to the system from floatables and other debris and, consequently, reducing the need for repairs." (EPA, 1999)

Current View on Maintenance of Stormwater Systems and Facilities

The primary purpose of a stormwater system is to conduct stormwater runoff away from streets and developed land to more suitable locations, such as detention/retention ponds or the nearest water body without causing damage to on-site or off-site property. This purpose is not accomplished if the system is dysfunctional - for example, if the system is blocked or has collapsed and the flow of runoff is obstructed. System failure and the resulting flooding, property damage, and threat to public health and safety can be avoided by routine preventative maintenance. In an O&M fact sheet published by EPA, preventative maintenance is defined as "the regular inspection, testing and repair of equipment and operational systems." (EPA, 1999)

Preventative maintenance of stormwater systems and facilities is a common topic of research and study within the water resources community. This is primarily due to a contradiction between conventional wisdom and reality. Conventional wisdom holds that prevention is key to saving time, effort and expense. As summarized by several studies as well as federal regulation, this assumption applies to the operation of stormwater drainage systems and facilities. The reality of the situation is that most stormwater maintenance work is done on an as-needed basis with little priority given to the preventative side of stormwater systems and facilities maintenance.

The benefits of a sound preventative maintenance program are obvious. It can save the trouble and expense of potentially costly repair and clean up projects after a system or facility failure by preventing failure

before it occurs. Proper maintenance protects property from flood damage and protects the public from uncontrolled floodwaters. Preventative maintenance can help to improve and protect receiving water quality, thus benefiting both local wildlife and human populations. In a time of budgetary constraints, it promises to reduce the amount of manpower and materials needed to correct a problem, since the problem would be detected while it is smaller and more manageable. It also fulfills the extensive maintenance requirements for the Phase II regulations. The community also benefits from the prompt repair and replacement of needed safety features such as drainage grates and protective fences as well as the pleasing aesthetics of well-maintained waterways and detention ponds.

The more commonly used stormwater systems and facilities in local Tennessee communities primarily include culverts, swales, earthen channels, catch basins and detention ponds. Recommended preventative maintenance tasks for these systems and facilities include, but are not limited to, inspection for and removal of excess debris and sediment, inspection/repair of failed man-made materials, removal of overgrown vegetation surrounding facilities, creeks and rivers, as well as detecting erosion along the banks of water bodies and taking actions to correct the damage. All of these measures are ideally to be performed on regularly scheduled intervals and after storm events to ensure proper function. "While the time during which a BMP facility performs its design function is limited (during and immediately after a storm event), it must constantly be able to do so due to the random nature of rainfall events. The maintenance required to keep a BMP fully operational at all times must therefore be performed thoroughly and on a regular basis." (Northern Virginia Planning District Commission, 1992)

On the flip side of this issue are the results of findings from surveys that have been conducted within the last decade. As a part of two different surveys (Gangaware et al, 1997 and Roenigk et al, 1992), stormwater management professionals from various local governments, in two different states, were queried as to the causes of their area's stormwater drainage problems. While the responses in both surveys indicated that there was a need for some degree of preventative maintenance, neither study found

conclusive evidence to indicate stringent preventative maintenance programs as a “fix-all” for their community’s current stormwater drainage problems.

In the1997 University of Tennessee survey of stormwater maintenance professionals, stormwater maintenance was rated only as “rarely” or “occasionally” important within 75% of the respondents’ communities. (Gangaware et al, 1997) In another study, “ . . . poor maintenance was not the most common cause of most failures in the stormwater systems. Only 19 percent of the officials who felt that the areas in their city without adequate protection attributed it to lack of maintenance.” (Roenigk et al, 1992) Other issues given higher priority for creating stormwater drainage problems include poor facility design and development within a floodplain. Another highly rated reason for stormwater drainage problems is development exceeding design capacity - which could indicate insufficient planning from the start.

“No quantitative data on the effectiveness of preventative maintenance as a BMP is available.” (EPA, 1999) This statement by EPA lends credibility to these survey results and may also indicate the need to look into other ways to reduce the burden on limited local tax revenue related to stormwater control. One idea in circulation for an alternative funding source is a stormwater utility. Very few of these programs are in place but are being studied more widely as continued urbanization leads to increased stormwater management issues and expense.

In the meantime, one other movement is being discussed as a cost-cutting measure for stormwater management. “Maintenance cannot be ignored, but many current problems can probably be avoided by planning and design improvements.” (Roenigk et al, 1992) Developing and following a more effective design, one that incorporates all of the stormwater systems and facilities with in a watershed, is designed specifically to be low maintenance, and is designed with an eye to future development, is a goal well within reach.

Documented Occurrences of Stormwater Problems Due to a Lack of Maintenance

On November 27, 1994, John S. Phipps, owner/CEO of Phipps Realty Company, contacted Metropolitan Nashville, Tennessee Department of Public Works and requested that a box culvert be cleaned out to alleviate the upstream flooding problem. Mr. Phipps's business had been located at the existing location for over 25 years and had never had a stormwater-related problem until 2.2 inches of rainfall occurred in Nashville. The combination of rainfall and the obstructions in the box culvert caused a backup of stormwater that damaged Mr. Phipps's business. The dimensions of the triple box culvert were 5.5 feet high, 16 feet wide and over 500 feet long. The result was a tremendously large project, not only due to the scale of the project, but also because the box culvert flows under Highway 70 and through two other individually owned commercial properties that have four businesses residing on them. Many issues had to be overcome before this problem could be resolved. One issue was that the liability of cleanup responsibilities was unclear, especially since the four businesses had leased the property from two individuals. In two of the four lease agreements, the businesses were required to perform maintenance of the property, while the rest of the responsibility fell upon the property owners. The next issue was finding a contractor to perform the needed maintenance, but many contractors did not want this job because it was unknown what type of debris was blocking the flow of water. Finally, one contractor accepted the job and after two years of coordination and work, the box culvert was cleaned out in a week. Six hundred tons (48 truckloads) of silt, gravel and debris were removed. (Pierce, 1998)

Many other similar problems frequently occur everyday and some of these problems, (such as Kind vs. Johnson City, 1970), are not resolved until they reach the legal system and are ruled upon or settled. In the case of Kind vs. Johnson City, the City of Johnson City constructed a concrete box in 1958 located on city property about sixty-five feet from an undeveloped piece of property. The box was built over the entrance to a cave for the purpose of channeling surface water into the cave. The city also installed a twenty-one inch pipe with a manhole covering the inlet of the pipe into the floor of the box. The manhole had three holes in it about the size of a thumb for the purpose of preventing trash and debris from entering the cave

and creating an obstruction in the cave system. There was also a manhole installed in the top of the concrete box for access and maintenance purposes. In 1963, the city improved Althea Street by constructing gutters and catch basins and paving the street. The new drainage system was piped directly into the concrete box, which receives debris and trash removal only about three times a year. The concrete box construction and Althea Street drainage improvements occurred some time before Mr. Kind's house was constructed. On the night of September 7, 1969, there was a heavy rainfall event and many witnesses testified that water was "gushing" from the manhole located on top of the concrete box. The water flowing out of the manhole flowed onto and across Mr. Kind's property causing damage. Two months after the rainfall event that spurred this suit; the city cleaned out the debris from the concrete box and removed enough trash and debris to fill a dump truck.

Preventative Maintenance Programs

Preventative maintenance programs can prevent flooding that could result in property damage, inconvenience or even loss of life. As stated by Stahre and Urbonas (Stahre and Urbonas, 1990), "if you do not plan to maintain it, do not build it". As can be perceived by this quote, maintenance of stormwater systems and facilities should be an on-going process. Well-maintained stormwater systems and facilities should be ready to convey or treat the runoff during the next storm, while poorly maintained drainage systems and facilities may not be able to function at the assumed design parameters, thus causing both on-site and downstream property damage.

Types of Activities Associated with Preventative Maintenance Programs

One of the first steps in any effective maintenance program is to perform an inventory of the existing stormwater systems and facilities. This inventory process should consist of "examining all records of complaints and previous drainage studies" (Alley, 1984) as well as "inventorying all facilities, which includes tasks such as obtaining the number of culverts," (Lock, 1990) measuring and recording

dimensions of drainage structures, entrance conditions, type, length, slope and any other relevant properties and characteristics of the stormwater drainage systems and facilities. After the conclusion of the fieldwork, this information should be gathered and entered into some type of inventory system. These inventory systems can be fairly simple such as inputting data into spreadsheets to more complicated systems such as drawing and identifying all of the stormwater systems and facilities in a Geographic Information System (GIS). Obtaining comments from area residents, such as locations of flooding problems and high water marks, can also be very important during the inventory stage, but should be verified for accuracy before the information is used. After the inventory is completed, the next step is to list "in detail all maintenance activities applied to each stormwater system and facility. This would include unpaved shoulder maintenance, housekeeping activities, stockpiling, materials handling, cleaning culverts and ditches, mowing right-of-ways and others." (Lock, 1990)

Inspections

Inspections of the urban stormwater systems and facilities are also an important step, if not the most important step, in a preventative maintenance program. Inspections should be performed at least annually to look for potential obstructions or problems with the stormwater systems and facilities. The most important step during this process is to decide when urban stormwater systems and facilities should be inspected. Most sources disagree about the frequency of inspections; for instance, Stahre and Urbonas (Stahre and Urbonas, 1990) and the American Society of Civil Engineers (ASCE) (ASCE, 1992) offer that stormwater systems and facilities should be inspected "at the beginning of each flood season, and after each significant storm". On the other hand, Pyzoha (Pyzoha, 1994) suggests that the inspections should be performed on regular intervals while being carefully balanced between available funds and the importance of the system or facility to the conveyance of stormwater runoff. The American Public Works Association (APWA) (APWA, 1981) suggests that stormwater systems and facilities should be monitored, inspected and maintained regularly following completion to assure effective operation. Debo and Reese (Debo and Reese, 1995) suggests, "stormwater inspections should be made quarterly in other than arid climates, and/or

during and after each major storm to confirm that satisfactory conditions exist, or to evaluate the need for cleanup and repair." Even though there is a disagreement about the frequency of inspections, most sources agree that the best time to inspect stormwater management facilities is during a storm event. This allows the inspector to observe, for example, the locations where stormwater systems and facilities are not performing as intended as well as other problems that might occur.

Knowing what to look for during inspection is also important. A person with a working knowledge of how stormwater systems and facilities perform should be conducting the inspections. Stahre and Urbonas (Stahre and Urbonas, 1990) and ASCE (ASCE, 1992) offer that during inspections, problems to look for are signs of erosion, excessive deposition of sediments, buildup of trash or debris or any other signs of damage. When a problem is found, it should be rectified immediately before damage has a chance to occur. Urban stormwater facilities such as detention/retention ponds should also have a well-maintained appearance for aesthetic reasons. Therefore, trash and debris removal should be performed frequently and regular mowing of the grass around the pond and within the basin should be performed. ASCE (ASCE, 1992) also recommends that for retention ponds, floating debris must also be removed from the pool surface after a storm. ASCE (ASCE, 1985 and 1992) notes that local governments should have the authority to inspect or review any private maintenance to ensure that maintenance is being provided. Based on 1980 data from 219 public agencies, APWA (APWA, 1981) rated the severity of the most prevalent maintenance problems as being weed growth, grass maintenance, sediment control, bank deterioration and mosquito control. In Appendix D on page 118 there is a copy of an owner's inspection checklist presented as Figure D-1 developed by STS Consultants Ltd. (STS Consultants Ltd., 1985) for a dam. This sample checklist could be expanded and adapted for implementation with any type of stormwater system or facility.

Record Keeping

Keeping detailed records of all inspections has proven to be just as important as performing the inspections. By keeping detailed records, comparisons can be made during field visits to determine if the properties or characteristics of the stormwater system or facility have changed. An example of this could include inspecting detention/retention pond embankments to determine if there are any problems, such as lateral and longitudinal cracks in the crest of the embankment. These cracks could result in a failure of the embankment during a storm event that could lead to property damage or more serious problems. Not only can detailed records from inspections be used to compare previous and existing conditions, but detailed records can be used to implement a planning and management process. Use of this process can reduce costs stemming from ineffective activities such as an example from the Tennessee Public Works (Lock, 1990), "several years ago a street superintendent told me that he drove his streets every day to find work for his men to do the next day." This leads to an approach that Mr. Lock (Lock, 1990) calls maintenance management, which is "a technique for managing, planning, scheduling and funding maintenance." Mr. Lock (Lock, 1990) describes maintenance management as a five-step process. The five steps are:

1. Stormwater systems and facilities are first inventoried
2. Quality standards are set
3. Annual work programs are determined
4. Scheduling is implemented
5. The work from field reports are monitored and a "score keeping" system is created to ensure that the maintenance management program is functioning properly

It is clear what is meant about the first step, an inventory of all stormwater systems and facilities must be performed before any other action is taken. The second step is described as determining "at what point of deterioration do you perform maintenance." (Lock, 1990) This is important to determine since some systems and facilities, because of their location and nature, require more maintenance and require the maintenance more frequently than other systems and facilities. This ties in closely with the third step, which is described as determining "how much of each task will be performed." (Lock, 1990)

"Implementation means scheduling and preparing work orders two weeks in advance." (Lock, 1990) The final step involves a process to constantly monitor the overall process to determine if any modifications need to be made and to ensure that the work is being performed properly and in a timely manner.

Maintenance Tasks

A document called Drainage Management (Alley, 1986), recommends, "that all ditches, streams and drainage structures be cleaned and re-shaped on a periodic basis." This is because "a variety of materials may reach the street surface, including: animal wastes, garbage, grit, oil, road salt, cinders, residual particulates resulting from auto tire and brake use and other materials." (EPA, 1977) This material that accumulates on the street surface can easily be washed into stormwater systems and facilities during a rain event. Keeping the street surfaces relatively debris and litter free is one approach to preventing these materials from entering the stormwater systems and facilities. Educating the public and establishing effective and enforceable regulations and ordinances relating to street cleanliness can prevent some of the debris and litter from reaching the street surface and stormwater conveyance systems. When debris and litter accumulates on the street surface, regularly scheduled street sweeping can be used to remove some of the material before it has a chance to enter stormwater systems and facilities. "Motorized street sweepers are designed to loosen dirt and debris from street surfaces, transport it onto a moving conveyor and deposit it temporarily in a storage hopper." (EPA, 1977) Elwyn Bembry (Bembry, 1993) states that "the typical street sweeping schedule is every day, once per week on arterials and once per month on subdivision curb and gutter streets," although, this schedule could vary depending on the community. Catch basin/inlet cleaning is another preventative maintenance task that should be included in a stormwater maintenance program. "Catch basins became standard before paved streets came into common use and were installed partly to prevent sewers becoming clogged with gravel . . ." (EPA, 1977) Catch basin inlets use a grated surface to capture debris and litter before they enter the stormwater system. The debris and litter must also be periodically removed from the grates in order for the catch basins to function properly. Pipe flushing is another technique that can be incorporated into a preventative maintenance program. A flusher truck that

uses a combination process to remove solids from the pipe systems performs this procedure. The first step of the process is to loosen the debris and litter caught in the pipe system by using a high-pressure water hose. The debris and litter are then vacuumed from the pipe system. One last preventative maintenance task is described as “routine small ditch cleaning (which) can be accomplished with a grader and larger ditches can be maintained with a back hoe.” (Alley, 1986)

One could conclude that regularly-scheduled preventative maintenance stormwater programs could be effective. However, no matter how a preventative maintenance program is established, Brett Ward (Ward, 1998) states, “a top-quality program requires four elements for success.” Even though Mr. Ward was referring to a wastewater treatment plant and collection system, his following four elements for success apply toward stormwater maintenance programs as well:

1. Personnel must be motivated to make the program work.
2. Employees need a system that’s organized to meet the system’s needs and their personal needs.
3. The system managers must provide adequate financial resources.
4. There must be a long-term commitment to make the program work – regardless of the obstacles.

Maintenance in the Design Phase

Knox County hydrologist, Mr. Chris Granju (Granju, 1999), acknowledges, "effective maintenance starts with project planning and that poor maintenance affects both downstream as well as on-site property owners". Designing stormwater facilities requires insight and forethought on how the final design will burden the owner with required maintenance. Debo and Reese (Debo and Reese, 1995) agree “full consideration must therefore be given to maintenance during the design process” and have given a list of suggestions and advice pertaining to the design process. This list consists of:

- Good storm water management facility design practices recognize that all structures require periodic maintenance inspections and repair
- Reasonable access for maintenance personnel and equipment must be provided for this necessary function

- Communications between designers and maintenance personnel are essential
- Design personnel are encouraged to contact maintenance personnel for their input on difficulties they identify in maintaining storm water management facilities
- Reports by the maintenance forces of both effective and not-effective installations aid designers in future work

Finally, Debo and Reese (Debo and Reese, 1995) offers this piece of advice, "improper maintenance of a storm water system does not just affect the system but has spill over effects of surrounding property and other infrastructure." ASCE (ASCE, 1985 and 1992) has developed a list of considerations for the design process. Some of the maintenance-related considerations include the following:

- Accessibility to stormwater facilities is important so that maintenance equipment can remove silt and debris and perform any necessary repairs
- Permanent ponds should have provisions for complete drainage for sediment removal
- Underground stormwater systems and facilities should be sized and designed to permit entrance of equipment to remove sediment
- Detention basins should be designed with sufficient depth to allow for accumulation of sediment for several years
- Wet basins should be deep enough to discourage excessive aquatic vegetation
- Careful design and placement of trash racks or fences are helpful in maintaining stormwater facilities
- Outlet structures should be designed with no moving parts to prevent mechanical failure
- Outlet structures also should be designed with openings as large as possible to reduce maintenance
- Energy dissipaters at the outlet of stormwater facilities can help reduce maintenance at the outlet of pipes

ASCE (ASCE, 1985) suggests that "the difference between a maintainable design and a design that is difficult and expensive to maintain will often also be the difference between an attractive operating facility and a neglected, degrading eyesore generating frequent public complaints." A survey (Gangaware et al, 1997) in 1997 of Tennessee technical stormwater representatives from Tennessee municipal and county stormwater offices, such as Public Works Directors and engineers, showed that 77% of all the respondents indicated designs of stormwater systems that require less maintenance would be helpful.

As can be seen from above, there are many issues involved with maintenance of stormwater systems and facilities. No matter what stormwater system or facility is designed, it will require maintenance. Maintaining stormwater systems and facilities requires some coordination and effort between the owners and community officials, but an effective maintenance program ultimately becomes highly cost effective to the community in terms of lower taxes and higher property values. Mr. Ward (Ward, 1998) probably says it best when he states "but in the long-run, doing maintenance work according to your schedule – when it's convenient for you and your workers – is far superior than doing it by chance or after a breakdown."

Chapter III. Survey Questionnaire and Summary

The purpose of the survey conducted by the Civil and Environmental Engineering Department at the University of Tennessee, Knoxville was to obtain information in order to characterize the existing stormwater-related maintenance programs for all 95 counties in Tennessee and Tennessee municipalities with a 1990 Census population of 2500 or greater. The survey questionnaire was sent to stormwater management personnel, which include, but are not limited to engineers, public works directors and highway/road superintendents. These personnel were targeted because they would provide the opinions and experiences of those who manage and direct the stormwater-related maintenance programs of communities throughout Tennessee. It is also interesting to note that these personnel represent a wide range of experiences, geographic and geologic locations and community tax bases.

The stormwater maintenance program survey questionnaire was distributed to the counties and municipalities by conventional mail and facsimiles. Individual telephone conversations were also conducted to clarify or receive responses from certain counties and municipalities. The majority of the responses were returned through the mail; however, some responses from the NPDES Phase II communities were obtained by follow-up telephone interviews.

Survey Questions

The survey questionnaire concentrated on eight topics associated with maintenance programs for stormwater systems and facilities, which include:

- Annual budgets dedicated for maintenance of stormwater systems and facilities
- Percentage of stormwater related problems due to a lack of maintenance of stormwater systems and facilities
- Priority for maintenance response of stormwater systems and facilities
- Responsible parties for performing maintenance on stormwater systems and facilities

- Number of visits made per year to privately owned stormwater handling facilities to assess the current condition
- Enforcement action taken by the community against the owners of improperly maintained stormwater handling facilities
- Most common stormwater-related maintenance problems
- Need for "maintenance-free" designs

A sample survey questionnaire can be found in Appendix A on page 78. The respondents of the survey questionnaire were asked to provide responses by selecting ranges, ranking items in order of importance and by providing detailed responses. Most questions included an area for the respondent to include any additional comments pertaining to that community's stormwater-related maintenance program.

The first question asked the respondent to indicate the total annual amount of funds spent by the community on stormwater and street maintenance. It was important to ask each community for the total amount spent on stormwater and street maintenance due to the fact that some communities include the stormwater-related maintenance expenditures in the street-related maintenance budget. Also because the same work crews commonly handle not only street-related maintenance problems but stormwater-related maintenance problems as well. This question was asked to help characterize the budgets allocated to stormwater-related maintenance activities.

The second question on the survey questionnaire asked the respondent to estimate the percentage of the stormwater and street budget that was allocated for stormwater-related maintenance only. This question was valuable in that it provided an indication of any possible budgetary restraints placed on a community that would hinder an effective stormwater-related maintenance program. It should be noted that some of the communities have different budgeting systems and some of the responses may include costs for such items such as materials, labor, equipment maintenance or any combination of the three.

The third question was asked to determine what percentage of the stormwater-related maintenance budget is used for preventative maintenance activities, such as, but not limited to street sweeping and routine catch basin cleaning, and provides valuable information to determine if preventative maintenance programs are being used to reduce the total number of stormwater-related problems in a community.

The fourth question was asked to determine what percentage of stormwater problems within a community are attributed to needed maintenance activities as opposed to urban growth, poor construction or outdated designs. If stormwater problems attributed to only needed maintenance can be reduced or eliminated, then potential costs stemming from system failure, which may cause property damage, personal injury, unnecessary hazards and delays to local commerce, can be reduced and make the community a more attractive place to live and work.

In the fifth question, the respondent was asked to rank on a scale of one (highest) to five (lowest), the community's priorities for responding to needed maintenance of stormwater systems and facilities that are located on public property.

Questions six investigates the maintenance responsibilities of stormwater systems and facilities which are located on publicly owned or privately owned land, as well as stormwater systems and facilities that extend from privately owned lands to publicly owned lands. Given that existing and future stormwater management facilities need to be adequately maintained, local governments must establish whether the private sector or they will be responsible for maintenance.

Question seven asks how often local authorities inspect stormwater facilities that are located on privately owned land to ensure that the facilities are properly maintained. This question is also associated with the previous question.

Question eight was asked because it is important for the communities to have a set enforcement policy for private owners who do not responsibly maintain the stormwater systems and facilities. If there is no enforcement policy in place, private owners sometimes do not understand the implications of not maintaining the stormwater systems and facilities and are unwilling to do so. This question provided insight on the different enforcement policies that are in place and being used to ensure that proper maintenance is provided.

Question nine provides an indication of the most common stormwater-related maintenance problems in the counties and municipalities throughout the state. These problems include, but are not limited to obstructions in pipe/culvert systems, pipe/culvert collapses, sediment and erosion problems and obstructions in open channels, such as ditchlines and creeks/streams. By devising categories for the most common stormwater-related maintenance problems, an effective maintenance protocol was devised that may be of benefit.

The tenth question provides information related to the needed increase of the current budget to improve the current stormwater-related maintenance program to minimize future problems, address recurrent problems or improve the existing stormwater systems and facilities within the community. This question will demonstrate whether or not the existing budgets dedicated to stormwater-related maintenance are adequate in the opinion of the respondent and assist in determining sources for adequate funding.

Other studies have shown that designs that require less maintenance will help ensure that stormwater systems and facilities function as they are designed. Question eleven requires the respondents to indicate what type of “maintenance-free” designs are encouraged within the jurisdiction, which provided information on the “maintenance-free” designs that are used throughout Tennessee.

The twelfth question characterizes the attitude related to stormwater utilities. This question will help determine if communities throughout Tennessee would be receptive to a stormwater utility fee. A

stormwater utility fee can provide sufficient funds for a community to address the upcoming NPDES Phase II stormwater requirements and provide a new source of funds dedicated only to a stormwater program.

A follow-up question, the thirteenth and final question, asked how the communities plan to provide funds for the NPDES Phase II mandates. This question provided information on what funding sources the counties and municipalities are considering to fund the Phase II mandates.

Summary of Findings

Of the 223 questionnaires that were sent, 54.71% of the targeted personnel responded to the questionnaire, and included 62 of the 95 counties and 60 of the 128 municipalities. Figure 3-1 provides a visual geographic distribution and coverage of the counties and municipalities who responded to the questionnaire.

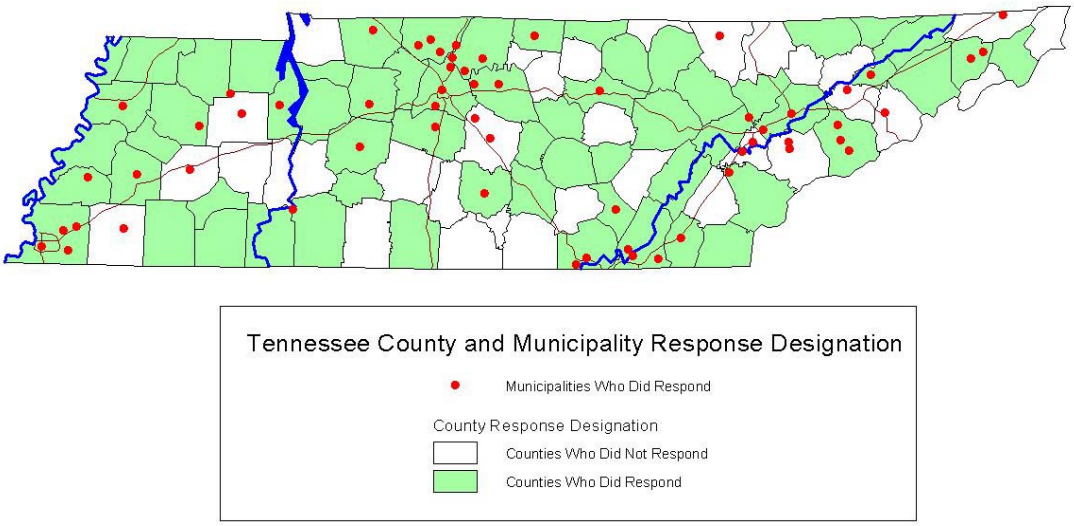


Figure 3-1: Respondents of Stormwater Maintenance Program Survey Questionnaire

As can be seen from Figure 3-1, the survey questionnaire responses show a uniform distribution of the counties and apparent concentrations of municipalities in an Eastern corridor from the Tri-Cities area; through the Knoxville and Chattanooga areas; around the Nashville Metro area; and communities in the Memphis area. Few municipalities responded from the Eastern Plateau and Southern areas of Tennessee

There three probable reasons why additional survey questionnaires were not returned and why only part of some questionnaires were answered. The first reason is that the survey questionnaire consisted of thirteen questions, which was necessary to help characterize the current stormwater maintenance programs, but may have been intimidating to some officials. Additionally, almost half of the questions were open-ended or discussion type questions that may have required considerable time to answer. Finally, due to the administrative structure of the community, some of the questions could probably not be answered by only one person.

One of the first major discoveries of the survey questionnaire was that some communities do not have a stormwater-related maintenance program or do not offer stormwater-related services. Below, the survey questionnaires are summarized in discussion format, but individual responses will not provided because respondents were told that their response would be treated with confidence and that individual answers would not be identified. Additionally, due to the nature of some of the questions and responses, some interpretation was required for categorization purposes. A summary of the questions, independent of other questions from the survey questionnaire, are presented as bar graphs in Appendix B as Figure B-1 through Figure B-24 on pages 83 through 106. A summary of the comments associated with the survey questionnaire is presented in Appendix C on pages 108 through 116.

1. Please indicate the total annual amount of funds that your community spends on ***stormwater and street maintenance.***

Of the 122 respondents, 61 county personnel and 51 municipal personnel responded to Question 1. Over

Table 3-1: Annual Stormwater and Street Maintenance Budget Based upon 1990 Population

Annual Budget Spent on Stormwater and Street Maintenance	Mean	N	Minimum	Maximum	Range	Std. Deviation	Median
$0 - $250,000	14928	52	2593	73712	71119	17099	7363
$250,001 - $500,000	21065	9	3502	41494	37992	11516	20551
$500,001 - $1,000,000	70362	15	10070	510784	500714	125946	25741
$1,000,000 - $2,000,000	76823	17	7129	826330	819201	193639	31717
Over $2,000,000	102720	19	15795	370469	354674	110261	51373
Total		112					

46% of these respondents indicated that there is only between $0-$250,000 available for stormwater and street maintenance, but no community indicated that there was $0 spent on stormwater and street maintenance. This can be seen in Figure B-1 on page 83 in Appendix B.

It was also found that the allocated budget varies with the population within a community's jurisdictional boundary. The above table (Table 3-1) provides a summary of the budget allocated for stormwater and street maintenance based upon 1990 Census population data. As can be seen from Table 3-1, as the mean and median population increases, the annual budget spent on stormwater and street maintenance increases.

To determine if there was a correlation between the population and the budget dedicated for stormwater and street maintenance, a bivariate nonparametric correlation was performed and it was found that the Spearman's rho value was 0.638 and the p-value was 0.000001. The Spearman's rho value of 0.638 indicates that there is a positive relationship between the population and the annual budget allocated for stormwater and street maintenance. The significance level or p-value is 0.000001, which indicates a very low significance level and indicates that the population and allocated budget for stormwater and street maintenance are significantly positively correlated. This provides the conclusion that as the population increases, the allocated budget increases as well. Table 3-2 on the following page provides the results of the bivariate nonparametric correlation test.

2. What percentage or known amount of the stormwater and street maintenance budget is used for ***stormwater-related maintenance****?*

Table 3-2: Bivariate Nonparametric Correlation Test

			Population, 1990	Annual Budget Allocated for Stormwater and Street Maintenance
Spearman's rho	Population, 1990	Correlation Coefficient	1.000	.638**
		Sig. (2-tailed)	.	.000001
		N	222	112
	Annual Budget Spent on Stormwater and Street Maintenance	Correlation Coefficient	.638**	1.000
		Sig. (2-tailed)	.000001	.
		N	112	112

**. Correlation is significant at the .01 level (2-tailed).

Of the 103 respondents (52 county personnel and 51 municipal personnel) who responded to Question 2, over 61% indicated that less than 20% of the annual stormwater and street budget is available for stormwater-related maintenance activities. Of the 103 respondents, 3 respondents indicated that 0% of the budget is allocated for stormwater-related maintenance; with one of communities indicating that they do not have a stormwater program. This can be seen in Figure B-2 on page 84 in Appendix B.

Out of all of the survey questionnaire respondents, 52 county personnel and 50 municipal personnel responded to Question 1 and to Question 2. The following summary table (Table 3-3) provides a detailed summary of the annual budget for stormwater and street maintenance versus the percentage of the budget spent on stormwater-related maintenance only.

As can be seen from Table 3-3, a majority (over 60%) of the respondents indicated that less than 20% of the annual budget allocated for stormwater and street maintenance is spent on stormwater-related maintenance. Likewise, only about 13% of the respondents indicated that over 40% of the stormwater and street maintenance budget is spent only on stormwater-related maintenance. This provides a conclusion that stormwater-related maintenance is not given a top priority in the communities throughout Tennessee and may indicate that more money is needed to adequately fund a stormwater management program.

Table 3-3: Summary Table for Respondents who Answered Question 1 and Question 2

City/County				Amount of Budget Spent on Stormwater-Related Maintenance					Total
				0% - 20%	21% - 40%	41% - 60%	*	81% - 100%	
County	Total Annual Funds Spent on Stormwater and Street Maintenance	$0 - $250,000	Count (n)	11	3	2		1	17
			% within Annual Budget	64.7%	17.6%	11.8%		5.9%	100%
		$250,001 - $500,000	Count (n)	2		2		1	5
			% within Annual Budget	40.0%		40.0%		20.0%	100%
		$500,001 - $1,000,000	Count (n)	5	1				6
			% within Annual Budget	83.3%	16.7%				100%
		$1,000,000 - $2,000,000	Count (n)	8	2	2			12
			% within Annual Budget	66.7%	16.7%	16.7%			100%
		Over $2,000,000	Count (n)	8	3	1			12
			% within Annual Budget	66.7%	25.0%	8.3%			100%
	Total		Count (n)	34	9	7		2	52
			% within Annual Budget	65.4%	17.3%	13.5%		3.8%	100%
City	Total Annual Funds Spent on Stormwater and Street Maintenance	$0 - $250,000	Count (n)	19	9	2			30
			% within Annual Budget	63.3%	30.0%	6.7%			100%
		$250,001 - $500,000	Count (n)	2	2				4
			% within Annual Budget	50.0%	50.0%				100%
		$500,001 - $1,000,000	Count (n)	2	4	2			8
			% within Annual Budget	25.0%	50.0%	25.0%			100%
		$1,000,000 - $2,000,000	Count (n)	2	2				4
			% within Annual Budget	50.0%	50.0%				100%
		Over $2,000,000	Count (n)	3	1				4
			% within Annual Budget	75.0%	25.0%				100%
	Total		Count (n)	28	18	4			50
			% within Annual Budget	56.0%	36.0%	8.0%			100%

* Indicates missing range due to no respondents indicating a value between 61% and 80%.

Budgetary information is the most difficult data to acquire, primarily due to the administrative structure of the counties and municipalities in Tennessee. The budgetary figures for Question 1 and Question 2 vary quite significantly, which may indicate that the lower values (i.e., $0-$250,000 and 0%-20%) represent only materials and not include other costs such as labor and costs associated with the maintenance of equipment.

The comments given on Question 2 are presented in Appendix C on page 108.

*3. What percentage split of your total **stormwater maintenance budget** best characterizes routine **preventative maintenance** (e.g. Street sweeping, catch basin/catch basin inlet cleaning, removing debris and litter from ditches, creek cleaning, etc.) versus **responsive maintenance** (e.g. Responding to drainage complaints or to emergency events)?*

Of the 107 respondents (53 county personnel and 54 municipal personnel) who responded to Question 3, over 44% indicated that less than 50% of the stormwater-related budget is spent on preventative maintenance activities. This can be seen in Figure B-3 on page 85 in Appendix B.

Ninety-four respondents (46 county personnel and 48 municipal personnel) provided responses for both Question 2 and Question 3. The following summary table (Table 3-4) provides a detailed summary of the percentage of the annual budget for stormwater and street maintenance that is spent on stormwater-related maintenance only versus the percentage split that characterizes preventative maintenance activities versus responsive maintenance activities broken out by municipalities and counties.

Budgetary information alone, however, does not necessarily reflect the status of a preventative stormwater-related maintenance program in a county or municipality. It is possible that a successful and efficient preventative stormwater-related maintenance program or designed “maintenance-free” systems and

Table 3-4: Summary Table for Respondents who Answered Question 2 and Question 3

				Preventative Versus Responsive Maintenance Activities										
City/County				0% - 100%	10% - 90%	20% - 80%	30% - 70%	40% - 60%	50% - 50%	60% - 40%	70% - 30%	80% - 20%	90% - 10% ***	Total
County	Amount of Budget Spent on Stormwater-Related Maintenance	0% - 20%	Count (n)	2	5	2		3	6	3		3	4	28
			% within Stormwater Budget	7.1%	17.9%	7.1%		10.7%	21.4%	10.7%		10.7%	14.3%	100%
		21% - 40%	Count (n)			2			3	2	2			9
			% within Stormwater Budget			22.2%			33.3%	22.2%	22.2%			100%
		41% - 60% *	Count (n)			1	1	1	3	1				7
			% within Stormwater Budget			14.3%	14.3%	14.3%	42.9%	14.3%				100%
		81% - 100%	Count (n)	1									1	2
			% within Stormwater Budget	50.0%									50.0%	100%
	Total		Count (n)	3	5	5	1	4	12	6	2	3	5	46
			% within Stormwater Budget	6.5%	10.9%	10.9%	2.2%	8.7%	26.1%	13.0%	4.3%	6.5%	10.9%	100%
City	Amount of Budget Spent on Stormwater-Related Maintenance	0% - 20%	Count (n)	2	1	2	5	1	3	4	3	3	3	27
			% within Stormwater Budget	7.4%	3.7%	7.4%	18.5%	3.7%	11.1%	14.8%	11.1%	11.1%	11.1%	100%
		21% - 40%	Count (n)		3	1	5	1	3	1	3			17
			% within Stormwater Budget		17.6%	5.9%	29.4%	5.9%	17.6%	5.9%	17.6%			100%
		41% - 60% * **	Count (n)		1					1	2			4
			% within Stormwater Budget		25.0%					25.0%	50.0%			100%
	Total		Count (n)	2	5	3	10	2	6	6	8	3	3	48
			% within Stormwater Budget	4.2%	10.4%	6.3%	20.8%	4.2%	12.5%	12.5%	16.7%	6.3%	6.3%	100%

* Indicates a missing range due to no respondents indicating a value between 61% and 80%
** Indicates a missing range due to no respondents indicating a value between 81% and 100% (City personnel only)
*** Indicates a missing range due to no respondents indicating a value between 100% and 0%

facilities may have lower expenditures and require less funding, which may give the appearance that the community is not concerned with the maintenance of stormwater systems and facilities. However, a large budgetary expenditure may indicate that the community is taking a proactive approach toward stormwater-related maintenance or it may suggest that a preventative stormwater-related maintenance program is not functioning properly and the community is wasting money and resources. To uncover what exactly is occurring within the counties and municipalities within Tennessee, it is important to determine what percentage of the stormwater-related problems in a community is attributed to a lack of maintenance of stormwater systems and facilities. Question 4 will provide additional insight into the status of stormwater maintenance programs within Tennessee.

The comments given on Question 3 are presented in Appendix C on page 109.

4. ***What percentage, do you estimate, of all stormwater problems in your community are attributed to needed maintenance*** *(obstructions in pipe and culvert systems, catch basin blockage, deposition of silt in detention ponds, obstructions at outlet control structures in detention ponds, vegetative growth in creeks, debris pileup at bridges, etc) as opposed to outdated designs, poor construction, urban growth, ordinary wear and tear or extreme event conditions?*

Of the 113 respondents (56 county personnel and 57 municipal personnel) who responded to Question 4, over 53% indicated that up to 40% of all of the stormwater problems in the community are attributed to needed maintenance as opposed to outdated designs, poor construction, urban growth, ordinary wear and tear or extreme event conditions. Likewise, over 77% of the respondents indicated that up to 60% of all stormwater problems in the community are attributed to needed maintenance as opposed to outdated designs, poor construction, urban growth, ordinary wear and tear or extreme event conditions. This can be seen in Figure B-4 on page 86 in Appendix B.

One hundred three respondents (51 county personnel and 52 municipal personnel) answered both Question 3 and Question 4. While examining the responses, it was found that counties who spent less

than 50% of the budget dedicated to stormwater-related maintenance activities on preventative maintenance activities had a higher percentage of stormwater problems attributed to needed maintenance than those counties who spent more than 50% of the budget dedicated to stormwater-related maintenance activities on preventative maintenance activities. This may suggest that a preventative maintenance program may help reduce the number of stormwater-related problems attributed to needed maintenance. Some counties who spend more than 50% of the stormwater-related budget on preventative activities have a greater number of other stormwater-related problems such as urban growth, outdated designs or poor construction of stormwater systems and facilities. This could suggest that some counties have not correctly implemented a preventative maintenance program and may be needlessly wasting resources.

In contrast, the municipalities who spent less than 50% of the budget dedicated to stormwater-related maintenance activities on preventative maintenance activities had a lower percentage of stormwater problems attributed to needed maintenance than those municipalities who spent more than 50% of the budget dedicated to stormwater-related maintenance activities on preventative maintenance activities. This may suggest that (1) a preventative maintenance program may not reduce the number of stormwater-related problems that are attributed to needed maintenance, (2) preventative maintenance programs have just been implemented and it is too early to determine if they are effective, or that (3) the preventative maintenance program is not functioning correctly due to any number of factors, such as inadequate scheduling of preventative maintenance activities or improper procedures carried out by the maintenance workers.

An additional test, such as a Pearson Chi-Square test, will be required to determine if the differences between the counties and municipalities are meaningful or if the responses were due to chance.

The following summary table (Table 3-5) provides a detailed comparison of the responses to Question 3 and Question 4.

Table 3-5: Summary Table for Respondents who Answered Question 3 and Question 4

				Percentage of Stormwater Problems Attributed to Needed Maintenance		
City/County				0-40%	41-100%	Total
County	Percentage of Stormwater Related Budget Used for Preventative Maintenance Activities	0-49%	Count (n)	8	14	22
			% within Percentage of Stormwater Related Budget Used for Preventative Maintenance Activities	36.4%	63.6%	100%
		50-100%	Count (n)	17	12	29
			% within Percentage of Stormwater Related Budget Used for Preventative Maintenance Activities	58.6%	41.4%	100%
	Total		Count (n)	25	26	51
			% within Percentage of Stormwater Related Budget Used for Preventative Maintenance Activities	49.0%	51.0%	100%
City	Percentage of Stormwater Related Budget Used for Preventative Maintenance Activities	0-49%	Count (n)	14	9	23
			% within Percentage of Stormwater Related Budget Used for Preventative Maintenance Activities	60.9%	39.1%	100%
		50-100%	Count (n)	16	13	29
			% within Percentage of Stormwater Related Budget Used for Preventative Maintenance Activities	55.2%	44.8%	100%
	Total		Count (n)	30	22	52
			% within Percentage of Stormwater Related Budget Used for Preventative Maintenance Activities	57.7%	42.3%	100%

A Pearson Chi-Square test was performed on Question 3 and Question 4 to test the null hypothesis that the percentage of the stormwater-related budget used for preventative maintenance activities and the percentage of the stormwater problems attributed to needed maintenance in Table 3-5 above are independent of one another. Rejecting the null hypothesis of this test will suggest that a preventative maintenance program can help reduce the number of stormwater problems that are attributed to needed maintenance within a community. A low significance value (typically below 0.05) would indicate that there might be some relationship between the two variables in Table 3-5 for the counties and municipalities within Tennessee.

For the counties located within Tennessee a χ^2 value of 2.480 and a p-value of 0.115 were calculated. Therefore, it has been concluded that the null hypothesis that the row and column variables are independent cannot be rejected.

Likewise, for the municipalities located within Tennessee a χ^2 value of 0.171 and a p-value of 0.680 were calculated, so it has been concluded that the null hypothesis that the row and column variables are independent cannot be rejected.

In conclusion, the Pearson Chi-Square test suggests that a preventative maintenance program does not seem to significantly reduce the perceived number of stormwater problems that are attributed to needed maintenance within a community. The results of the Chi-Square test can be seen in Table 3-6 below.

Table 3-6: Chi-Square Test Between Question 3 and Question 4

City/County		Value	df	p-value, 1-sided
County	Pearson Chi-Square	2.480	1	.115
	N of Valid Cases	51		
City	Pearson Chi-Square	.171	1	.680
	N of Valid Cases	52		

The comments given on Question 4 are presented in Appendix C on page 110.

5. ***Please rank the following list of items from 1 (highest) to 5 (lowest) according to your community's priorities*** *for maintenance response of stormwater systems and facilities that are located on public property.*

_____ *Routine scheduling of maintenance (e.g. Street sweeping, catch basin/catch basin-inlet cleaning, removing debris and litter from ditches, etc.)*
_____ *On a complaint basis*
_____ *After significant rain events*
_____ *Legal basis or court ordered*
_____ *Other* _____

By examining the responses to Question 5, 99 respondents provided a response for the highest priority for maintenance response of stormwater systems and facilities located on public property. Of the 45 county personnel and 54 municipal personnel, over 34% indicated that routine scheduling of stormwater maintenance activities was the top priority. Over 35% of the respondents indicated that maintenance was performed on a complaint basis, while over 24% of the respondents indicated that maintenance was performed after significant rain events and only over 6% indicated that maintenance was performed due to a legal basis or a court order.

The responses to Question 5 can be seen clearly in Figure B-5 through Figure B-8 on pages 87 through 90 in Appendix B. It should be noted that Figure B-5 through Figure B-8 have been created based on the answers provided to maintenance response:

- Performed on a Routine Basis
- Performed on a Complaint Basis
- Occurring After Significant Rain Events
- Attributed to a Legal Order

Eighty-six respondents (39 county personnel and 47 municipal personnel) provided responses to both Question 4 and Question 5. While examining the responses, it was found that while the row percentages (Proactive Programs versus Reactive Programs) for the following 2 X 2 table (Table 3-7) were about the same for both counties and municipalities, the counts for the proactive programs were much lower than the counts for the reactive programs.

By performing a Pearson Chi-Square test on the above table, it can be determined if the null hypothesis, the type of maintenance program (Proactive Program or Reactive Program) and the percentage of the stormwater problems attributed to needed maintenance are independent, should be accepted or rejected. By rejecting the null hypothesis, it could be concluded that a proactive maintenance program will provide a greater benefit for a community by reducing the number of stormwater problems attributed to needed maintenance than a reactive program. After performing the Chi-Square test, it was found that two cells had observed counts less than expected counts. To resolve this problem, the county and municipal responses were collapsed down to one group of responses and the result was Table 3-8.

The χ^2 value was calculated to be 0.017 and the associated p-value was 0.898, which suggests that the null hypothesis should not be rejected. Therefore, it can be concluded that a proactive maintenance program does not seem to provide a greater benefit for a community than a reactive program. It is interesting to note that there are 10 communities who have a proactive program, yet have a large percentage of stormwater problems attributed to needed maintenance. Six of these 10 communities indicated that there was less that $250,000 allocated for stormwater and street maintenance. Three of the 6 communities also indicated that 50% or more of their budget allocated for stormwater-related maintenance was spent only on preventative maintenance programs. It can be concluded that these communities who have a proactive program, yet have a large percentage of stormwater problems attributed to needed maintenance, fall into this category. This is due to a lack of funds dedicated toward a stormwater program and as a result the communities do not have the resources to adequately maintain stormwater systems and facilities. Table 3-9 provides the results of the Chi-Square test.

Table 3-7: Summary Table for Respondents who Answered Question 4 and Question 5

City/County				Percentage of Stormwater Problems Attributed to Needed Maintenance		Total
				0-40%	41-100%	
County	Complaint or Legal Basis Ranked as Either First or Second Priority for Maintenance Response of Stormwater Systems and Facilities	Other Priorities, (Proactive Programs)	Count (n)	3	6	9
			% within Complaint or Legal Basis	33.3%	66.7%	100%
		Complaint or Legal Priority, (Reactive Programs)	Count (n)	16	14	30
			% within Complaint or Legal Basis	53.3%	46.7%	100%
	Total		Count (n)	19	20	39
			% within Complaint or Legal Basis	48.7%	51.3%	100%
City	Complaint or Legal Basis Ranked as Either First or Second Priority for Maintenance Response of Stormwater Systems and Facilities	Other Priorities, (Proactive Programs)	Count (n)	8	4	12
			% within Complaint or Legal Basis	66.7%	33.3%	100%
		Complaint or Legal Priority, (Reactive Programs)	Count (n)	17	18	35
			% within Complaint or Legal Basis	48.6%	51.4%	100%
	Total		Count (n)	25	22	47
			% within Complaint or Legal Basis	53.2%	46.8%	100%

Table 3-8: Collapsed Summary Table for Responses Given to Question 4 and Question 5

			Percentage of Stormwater Problems Attributed to Needed Maintenance		
			0-40%	41-100%	Total
Cities/Counties who Ranked Complaint Basis or Legal Basis as Either Their First or Second Priority for Maintenance Response of Stormwater Systems and Facilities	Other Priorities (Proactive Programs)	Count (n)	11	10	21
		% within Complaint Basis or Legal Basis	52.4%	47.6%	100%
	Complaint or Legal Priority (Reactive Programs)	Count (n)	33	32	65
		% within Complaint Basis or Legal Basis	50.8%	49.2%	100%
Total		Count (n)	44	42	86
		% within Complaint Basis or Legal Basis	51.2%	48.8%	100%

Table 3-9: Chi-Square Test Between Question 4 and Question 5

	Value	df	p-value, 1-sided
Pearson Chi-Square	.017	1	.898
N of Valid Cases	86		

The comments given on Question 5 are presented in Appendix C on page 111.

6. ***Who is generally responsible, for maintaining stormwater systems and facilities*** *that are located on* ***each*** *of the following properties? (Check (Ö) one for each item)*

1. Systems/facilities located on public property
____ *City/County Government*
____ *Stormwater Utility*
____ *Adjacent Property Owner*
____ *Other* _____

2. Systems/facilities located on private property
____ *City/County Government*
____ *Stormwater Utility*
____ *Adjacent Property Owner*
____ *Other* _____

3. *Systems/facilities (i.e. culverts, creeks, etc.) located on private property but extending onto public property*

____ *City/County Government*
____ *Stormwater Utility*
____ *Adjacent Property Owner*
____ *Other* _____

Of the 98 respondents (50 county personnel and 48 municipal personnel) who responded to the first part of Question 6, over 95% indicated that the City/County government is responsible for maintaining stormwater systems and facilities that are located on public property.

Of the 95 respondents (47 county personnel and 48 municipal personnel) who responded to the second part of Question 6, over 85% indicated that the adjacent property owner is responsible for maintaining stormwater systems and facilities that are located on private property.

Of the 96 respondents (48 county personnel and 48 municipal personnel) who responded to the third part of Question 6, over 43% indicated that the City/County government is responsible for maintaining systems and facilities located on private property, but extending onto public property. Over 31% indicated that the adjacent property owner was responsible and 25% indicated that the City/County government and the adjacent property owner would work together.

This can be seen in Figure B-9 through Figure B-11 on pages 91 through 93 in Appendix B.

The comments given on Question 6 are presented in Appendix C on page 112.

7. ***How many times a year do you make routine visits to private stormwater handling facilities*** *(such as subdivision detention ponds, etc) to assess their needed maintenance and report your findings to the responsible party?*

Eighty-three respondents (41 county personnel and 42 municipal personnel) responded to Question and over 91% of the respondents indicated that less than 10 visits per year are made to private stormwater handling facilities. Of the 76 respondents who indicated that less than 10 visits per year are made to private stormwater handling facilities, 63 respondents indicated that less than 5 visits per year are made to private stormwater handling facilities. Forty-five of the 63 respondents indicated that 0 visits per year are made to private stormwater handling facilities. This can be seen in Figure B-12 on page 94 in Appendix B.

This likely means that either the communities do not have sufficient man power to provide inspections for private stormwater handling facilities or that it is solely the owner of the stormwater handling facility who is responsible for performing the needed maintenance of the private stormwater handling facilities.

The comments given on Question 7 are presented in Appendix C on page 113.

8. ***What happens when private owners do not responsibly maintain their stormwater facilities*** *(i.e. What enforcement action, if any, is taken by the community)?*

Eighty-four respondents (44 county personnel and 40 municipal personnel) provided a response to this question. There were six basic categories that these responses fell into. Over 41% of the respondents indicated that no enforcement action was taken against the private owners of stormwater facilities who failed to responsibly maintain these facilities. Over 26% indicated that some type of legal action was pursued against the private owners, over 16% indicated that the owner was just contacted and asked to take corrective action for the facilities, over 5% indicated that the City/County government would perform the needed maintenance and not bill the owner, while the same percentage of respondents indicated that the City/County government would perform the needed maintenance and bill the owner. The rest of the respondents indicated that the Tennessee Department of Environment and Conservation (TDEC) is contacted and asked to handle the situation. This can be seen in Figure B-13 on page 95 in Appendix B.

9. ***Please prioritize from 1(high) to 5(low) the top five-stormwater maintenance problems*** *in your community: (e.g. Obstructions in pipe and culvert systems, pipe and culvert collapses, deposition of silt in detention ponds, obstructions at outlet control structures in detention ponds, obstructions and vegetative growth along creeks, catch basin blockage, debris at bridges, etc.)*

The responses and the number of responses in each category varied greatly, but the responses have been grouped into seven different general categories, which include:

1. Pipe/Culvert Obstructions, Including Obstructions due to Sediment Deposition
2. Pipe/Culvert Collapses or Damage
3. Ditchline Obstructions, Including Erosion and Sediment Deposition Problems
4. Obstructions at Bridges
5. Creek/Stream Related Problems, Including Vegetation Overgrowth and Erosion and Sediment Deposition Problems
6. Obstructions in Catch Basins, Including Obstructions due to Sediment Deposition
7. Other

It is interesting to note that of the 393 total number of responses to this question, over 40% of the respondents placed some priority on either pipe/culvert obstructions or pipe/culvert damages. Also, only five stormwater-related maintenance problems were asked for, but one community provided six different stormwater-related problems within the community.

The responses to this question can be seen in Figure B-14 through Figure B-20 on pages 96 through 102 in Appendix B.

The comments given on Question 9 are presented on page 114 in Appendix C.

10. ***If possible, estimate the percentage increase of the current budget needed to improve the current stormwater maintenance program to minimize*** *future problems, address recurrent problems or to improve the existing stormwater systems and facilities under your jurisdiction.*

Eighty-four respondents (42 county personnel and 42 municipal personnel) provided a response to this question. Over 46% of the respondents indicated that they needed less than a 20% increase in the overall stormwater budget to minimize future problems, address recurrent problems or to improve the existing stormwater problems. However, over 28% of the respondents indicated that they needed more than a 60% increase in the amount for stormwater maintenance that they are currently receiving.

There are two possible reasons for why over 46% of the respondents indicated that they needed less than a 20% increase in the overall stormwater budget to minimize future problems, address recurrent problems or to improve the existing stormwater problems. The first is that the respondents may not perceive any serious stormwater-related maintenance problems within their community and that they feel the current funding is adequate to handle these problems. The second is that while the question was to estimate the needed percentage increase in the overall stormwater budget, some of the respondents may have indicated the percentage increase that has been allocated for the next year's budget.

The responses to this question can be seen in Figure B-21 on page 103 of Appendix B.

By examining the responses provided by those communities that responded to both Question 5 and Question 10, over 13% of 68 respondents indicated that over a 40% increase is needed to the current budget to fund a proactive maintenance program as seen in following summary table (Table 3-10).

By performing a Pearson Chi-Square test on the above table, it can be determined if the null hypothesis, the type of maintenance program (Proactive Program or Reactive Program) and the needed increase in the

Table 3-10: Summary Table for Respondents who Answered Question 5 and Question 10

City/County				Needed Increase in Current Budget: Cities/Counties who need less than a 40% increase	Needed Increase in Current Budget: Cities/Counties who need more than a 41% increase	Total
County	Complaint Basis or Legal Basis Ranked as Either First or Second Priority for Maintenance Response of Stormwater Systems and Facilities	Other priorities (Proactive Programs)	Count (n)	5	3	8
			% within Complaint Basis or Legal Basis Ranked as Either First or Second Priority for Maintenance Response	62.5%	37.5%	100%
		Complaint or legal priority (Reactive Programs	Count (n)	16	7	23
			% within Complaint Basis or Legal Basis Ranked as Either First or Second Priority for Maintenance Response	69.6%	30.4%	100%
	Total		Count (n)	21	10	31
			% within Complaint Basis or Legal Basis Ranked as Either First or Second Priority for Maintenance Response	67.7%	32.3%	100%
City	Complaint Basis or Legal Basis Ranked as Either First or Second Priority for Maintenance Response of Stormwater Systems and Facilities	Other priorities (Proactive Programs)	Count (n)	4	6	10
			% within Complaint Basis or Legal Basis Ranked as Either First or Second Priority for Maintenance Response	40.0%	60.0%	100%
		Complaint or legal priority (Reactive Programs	Count (n)	12	15	27
			% within Complaint Basis or Legal Basis Ranked as Either First or Second Priority for Maintenance Response	44.4%	55.6%	100%
	Total		Count (n)	16	21	37
			% within Complaint Basis or Legal Basis Ranked as Either First or Second Priority for Maintenance Response	43.2%	56.8%	100%

Table 3-11: Collapsed Summary Table for Responses Given to Question 5 and Question 10

			Needed Increase in Current Budget		
			Cities/Counties who need less than a 40% increase	Cities/Counties who need more than a 41% increase	Total
Complaint Basis or Legal Basis Ranked as Either First or Second Priority for Maintenance Response of Stormwater Systems and Facilities	Other priorities (Proactive Programs)	Count (n)	9	9	18
		% within Complaint Basis or Legal Basis Ranked as Either First or Second Priority for Maintenance Response	50.0%	50.0%	100%
	Complaint or legal priority (Reactive Programs)	Count (n)	28	22	50
		% within Complaint Basis or Legal Basis Ranked as Either First or Second Priority for Maintenance Response	56.0%	44.0%	100%
Total		Count (n)	37	31	68
		% within Complaint Basis or Legal Basis Ranked as Either First or Second Priority for Maintenance Response	54.4%	45.6%	100%

current budget are independent, should be accepted, or should be rejected. By rejecting the null hypothesis, it could be concluded that the type of maintenance program is related to the needed increase in the current budget. After performing the Chi-Square test, it was found that two cells had observed counts less than expected counts. To resolve this problem, the county and municipal responses were collapsed down to one group of responses and the result was Table 3-11 above.

The χ^2 value was calculated to be 0.192 and the associated p-value was 0.661, which suggests that the null hypothesis should not be rejected. Therefore, it can be concluded that a preventative maintenance program is not related to the needed increase in the current budget. Table 3-12 on the following page provides the results of the Chi-Square test.

The comments given on Question 10 are presented in Appendix C on page 115.

Table 3-12: Chi-Square Test Between Question 5 and Question 10 for the Table 3-11

	Value	df	p-value, 1-sided
Pearson Chi-Square	.192	1	.661
N of Valid Cases	68		

11. Does your community encourage the use of "maintenance-free stormwater management" designs within your jurisdiction and, if so, what types of designs are used?

Ninety-two respondents (46 county personnel and 46 municipal personnel) responded to this question and the responses fell within four categories. Over 69% of the respondents indicated that "maintenance-free" stormwater designs are not being encouraged within the community, while only over 21% indicated that "maintenance-free" designs are being encouraged. However, over 4% of the respondents indicated that this question is not applicable to the community and over 4% of the respondents asked the question, "What are "maintenance-free" designs?"

The responses to this question can be seen in Figure B-22 on page 104 in Appendix B.

The comments and types of designs given on Question 11 are presented in Appendix C on page 116.

*12. **What are your feelings about requiring a stormwater utility fee** from every resident and business to make improvements and provide more maintenance to the stormwater facilities? How receptive would your community officials be to this idea?*

Since a stormwater utility fee would have to be passed by the community officials, it is important to examine how community officials would respond to a stormwater utility fee. Of the 95 respondents (49 county personnel and 46 municipal personnel) over 78% of the respondents felt that community officials

would not be receptive to a stormwater utility fee, while only about 3% felt that the community officials would be receptive to a stormwater utility fee and only about 3% felt that the community officials might be receptive to a stormwater utility fee. Over 5% of the respondents did not know if the community officials would be receptive and over 9% responded that a stormwater utility fee would not be applicable to the situation.

The responses to this question can be seen in Figure B-23 on page 105 in Appendix B.

13. If your community must meet the upcoming NPDES Phase II stormwater requirements, how does your community plan to provide funds for these mandates?

Of the 91 respondents (46 county personnel and 45 municipal personnel) over 47% had no idea how they would fund the NPDES Phase II mandates, while over 25% indicated that a budget/tax increase would be needed. Over 5% said that a stormwater utility fee would be used and about 4% said funds would have to come from some other source. Over 13% said that this was not applicable to the community, while about 4% did not know what the NPDES Phase II stormwater regulations were.

The responses to this question can be seen in Figure B-24 on page 106 in Appendix B.

Chapter IV. Summary Discussion, Conclusions and Recommendations

Survey Trends/Generalizations

By reviewing the survey questionnaire results from the 122 responding counties and municipalities, a fairly representative characterization of stormwater maintenance programs within the State of Tennessee can be defined. It has been found that:

- As can be expected, as the population within a community's jurisdictional boundary increases, the allocated budget for stormwater and street maintenance increases as well
- The results of the survey questionnaire appear to suggest that a preventative maintenance program does not seem to significantly reduce the perceived number of stormwater problems that are attributed to needed maintenance within a community
- Either communities do not have sufficient manpower to provide needed inspections for private stormwater handling facilities or the communities require the owner of the stormwater handling facility to perform the needed inspections and maintenance of the private stormwater handling facilities
- Either respondents do not perceive any serious stormwater-related maintenance problems within their community and that they feel the current funding is adequate to handle these problems or some of the respondents may have anticipated the percentage increase that has been allocated for the next year's budget

Stormwater Management Program

Stormwater systems and facilities should be maintained as the designer intended to convey stormwater runoff and to provide stormwater detention/retention to attenuate peak flows and improve water quality. A stormwater management program requires several key components in order to provide maintenance to ensure that stormwater systems and facilities function properly. These key components may include, but are not limited to (APWA, 2000):

- Administrative and planning program
- Regulations, ordinances or policies pertaining to stormwater

- A design review and permitting process for new development or redevelopment
- An inspection and enforcement program to ensure compliance
- A stormwater system and facility inventory
- An O&M program
- A capital improvement program
- An employee training program for recognizing existing and potential problems
- A public education and awareness program

An administrative and planning program is necessary to develop the stormwater management program, allocate resources and personnel, develop any regulations, ordinances or policies that are needed and to ensure overall performance of the stormwater management program. The regulations, ordinances and policies should specify requirements for new development and redevelopment, include clearly defined stormwater-related services that are provided and should include enforcement actions to ensure compliance. A design review and permitting process is needed to ensure that any new development or redevelopment adhere to the local regulations, ordinances and policies pertaining to not only stormwater runoff requirements, but also construction and post-development requirements. A capital improvement program is needed to provide services that extend beyond normal maintenance and include, but are not limited to activities such as retrofitting, replacement and upgrading stormwater systems and facilities.

An O&M program is key in ensuring that stormwater systems and facilities function as intended throughout their lifespan. An employee-training program is needed to ensure that the maintenance personnel are aware of the elements of stormwater systems and facilities, how stormwater systems and facilities operate and what is needed to keep the systems and facilities functioning properly.

A public education program is needed to inform individuals about how their actions affect stormwater systems and facilities and how their actions can affect stormwater pollution. Individuals and homeowners must also be informed of their responsibilities associated with the maintenance of stormwater systems and

facilities that are located on their property and the consequences of not providing adequate maintenance to ensure continued performance of these systems and facilities.

An O&M program includes activities such as, but not limited to (APWA, 2000):

- Creating and maintaining an inventory of all stormwater systems and facilities
- Performing routine inspections of stormwater systems and facilities
- Creating and keeping records of all inspections immediately after an inspection is complete
- Cleaning catch basins, pipes and culverts
- Removing sediment from ditchlines to restore the original carrying capacity
- Controlling, but not eliminating vegetation in ditchlines and other open channels
- Performing street sweeping to remove pollutants, litter and debris from roadways
- Repairing and replacing damaged components of a stormwater systems or facility
- Performing maintenance associated with publicly maintained detention ponds
- Providing training for the operations and maintenance personnel
- Reviewing the O&M program periodically to update and revise procedures as necessary

By having a complete inventory of all stormwater systems and facilities, the maintenance personnel will be able to locate the systems and facilities quickly, which will make the O&M program more productive. The inventory "may also aid in scheduling and planning the inspection and maintenance" (EPA, 1999) of the stormwater systems and facilities.

Inspections are the key to the effective maintenance of stormwater systems and facilities. Advantages to inspections include that they (1) do not require much time or money until the actual maintenance is performed, (2) allow for early detection of potential problems and (3) can be used to optimize a maintenance frequency. By determining the optimal maintenance frequency, a stormwater management program could reduce the number of citizen complaints, prevent nuisance flooding and other problems associated with needed maintenance and reduce the time and money spent as a result of stormwater

maintenance-related problems. Inspection checklists can be created for any type of stormwater system and facility to aid personnel and homeowners in the inspection process. A single example checklist (Figure E-1) is shown for a detention pond and can be seen on page 120 of Appendix E.

Recording keeping is similar to inspections in that there is very little cost associated with either activity except for a small investment of time. A great deal of information can be obtained from inspections and records that can help determine the frequency that stormwater systems and facilities require maintenance. The record keeping component of an O&M program should document all of the information obtained during an inspection such as, but not limited to "when the system was inspected, and, if applicable, what maintenance action was taken, including the equipment used and the personnel involved." (EPA, 1999)

"In-house employee training programs are established to teach employees about storm water management, potential sources of contaminants, and BMPs." (EPA, 1999) The O&M program also should include a maintenance personnel-training program that has training goals, procedures and schedules. The training program should inform the maintenance personnel about stormwater management, potential sources of contaminants, BMPs, SWPPPs, why stormwater systems and facilities are necessary, how the systems and facilities work and what maintenance activities are required to keep stormwater systems and facilities functioning properly. Employee training programs are easy to implement and do not have a high cost associated with them. The program can be standardized, repeated as necessary and is flexible enough so that it can be easily changed as the stormwater management program changes. EPA (EPA, 1999) states that there are obstacles that must be overcome in order to implement a successful employee-training program and include:

- Lack of commitment from senior management
- Lack of employee motivation
- Lack of incentive to become involved in BMP implementation

EPA (EPA, 1999) also offers that there are specific design criteria for implementing an employee training program and includes:

- Ensuring strong commitment and periodic input from senior management
- Communicating frequently to ensure adequate understanding of SWPPP goals and objectives
- Utilizing experience from past spills to prevent future spills
- Making employees aware of BMP monitoring and spill reporting procedures
- Developing operating manuals and standard procedures

Budget

The results of the survey questionnaire have yielded some interesting results. It was found that three communities do not even have a stormwater-related maintenance program or do not offer stormwater-related services. Almost half of 122 respondents indicated that even though they have budgeted for stormwater and street maintenance, only between $0 and $250,000 is available. Over half of 103 respondents also indicated that less than 20% of the stormwater and street maintenance budget is spent on stormwater-related maintenance activities. The survey questionnaire results show that there is very little money and resources available for maintaining stormwater systems and facilities. It should be noted that more funds should be available for maintaining stormwater systems and facilities, since it was found that over 77% of 113 respondents indicated that up to 60% of all stormwater problems within their community are attributed to needed maintenance as opposed to outdated designs, poor construction, urban growth, ordinary wear and tear or extreme event conditions.

The survey responses appear to suggest that a preventative maintenance program does not seem to significantly reduce the perceived number of stormwater problems in a community that are attributed to needed maintenance. This goes against all intuition considering the old proverb of an ounce of prevention is worth a pound of cure. This could indicate that there are insufficient funds available for a preventative maintenance program in some locations where the stormwater problems are so overwhelming that a little maintenance money will not solve the stormwater problems. One respondent presented an interesting point with the statement of “Budget constraints do not allow a highly proactive program for maintenance.”

Eighty-four respondents indicated that some increase in the overall stormwater maintenance budget was needed to minimize future problems, address recurrent problems or to improve the existing stormwater problems. Almost 30% of these respondents indicated that they needed more than a 60% increase in the current amount for stormwater maintenance. Dedicated funding for a stormwater program is one of the most, if not the most, important aspects of an effective stormwater program. Currently, most stormwater programs are funded from a general budget allowance, which can change from year to year. This can really impact a stormwater program, especially if there has been a few years of moderate storm events and the funding for a stormwater program starts being reduced. Most citizens only realize the benefit of having a stormwater program during and after a rainfall event. Therefore, stormwater programs must have a stable funding source for the capital improvement and maintenance programs in order to prepare the stormwater systems and facilities for the next rainfall event, regardless of how often an event occurs.

Funding

Not only is a stable funding source required for a stormwater program to prepare the stormwater systems and facilities for the next rainfall event, but the Final Phase II Stormwater Regulations must also be accommodated. The regulations state that the NPDES permitting authority will issue general permits for Phase II-designated small MS4s and small construction activity by December 9, 2002. The operators of Phase II "automatically" designated regulated small MS4s and small construction activity must obtain permit coverage within 90 days of permit issuance, which will be March 10, 2003. Over 47% of 91 respondents indicated that they had no idea how the community would fund the NPDES Phase II mandates. Twenty-five percent indicated that a budget/tax increase would be needed, but the problem with a budget/tax increase is that the stormwater funding will come from a general fund, which is not necessarily the most stable funding source. Four percent of the respondents also indicated that they did not know what the Phase II stormwater regulations were.

Stormwater Utility

A stormwater utility fee is one way to establish a stable funding source that is dedicated for stormwater programs only. However, over 78% of 95 respondents indicated that the community officials would not be receptive to a stormwater utility fee. About 5% of the respondents indicated that they did not know if the community officials would be receptive and another 3% indicated that community officials might be receptive. A report in 1997 indicated that the "two most significant barriers to stormwater management in Tennessee communities are concerns over funding and limited staff/resources." (Gangaware et al, 1997)

Stormwater management programs require an adequate source of funding and currently most counties and municipalities throughout Tennessee are relying on a percentage of the general budget to fund their stormwater management programs. The results from the survey questionnaire appear to indicate that many communities in Tennessee do not have adequate resources to properly fund their stormwater management programs and with the new Phase II stormwater regulations, there will be an additional strain placed upon the community in order to comply with the Federal mandates. A stormwater utility is "a dedicated funding source or "stand alone" service unit within the city government which generates revenues through fees for services" (EPA, 1994) and can "provide a stable and reliable method of financing storm water management programs." (EPA, 1994) The idea behind a stormwater utility is that "'users' should pay for storm water programs to the extent that they contribute to the problem. The term 'users' in this case, includes property owners, particularly property owners that have impervious surfaces on their property." (APWA, 2000)

Stormwater utility charges are usually assessed either on a monthly basis or as an annual fee based upon the amount of impervious area on a property. "A base rate is set for each household based on the average amount of impervious surface (known as equivalent residential units (ERUs)). A fee is then developed in association with this ERU." (APWA, 2000) Households are typically assessed the fee for one ERU, however, commercial and industrial property owners are charged based on the number of ERUs calculated from the measurement of the impervious surfaces located on their lot. The household ERU fees "generally

range from $1.00 to $5.00 per month." (Smoot et al, 1999) "Some communities are evaluating adding a water quality component to their utility fee rate formula. This quality factor would allow communities to have users pay for not only the quantity of storm water that they contribute, but also the quality." (APWA, 2000) Since the utility fee is a fee and not a tax, schools and churches are not exempt from paying the fee.

The City of Chattanooga, TN has established a stormwater utility and currently the annual cost of residential units for the stormwater utility fee ranges from $24.00 to $36.00 per year depending upon the lot size. While there is no information available as to the effectiveness of Chattanooga's utility fee as it pertains to maintenance of stormwater systems and facilities, Chattanooga has implemented a preventative maintenance program. Tom Scott, the manager of the Stormwater Management Division, has been quoted as saying, "We realized the need to better maintain the drainage system" and "It makes little sense to construct new catch basins or other types of structures to alleviate flooding problems, if there is no routine maintenance program to keep them clean." (Stormwater Management Division, 1998) The preventative maintenance program will "include the cleaning and continual maintenance of hundreds of miles of existing ditches and drainpipes, and 5700 catch basins. It is projected that this continual upkeep of existing structures will eliminate 30 to 40 percent of the drainage problems in low-lying areas." (Stormwater Management Division, 1998)

Stormwater utility credits can be implemented in a stormwater utility fee structure. A credit is usually offered to those property owners who implement certain BMPs that do not only represent what is required but go above and beyond what is required. If a community wishes to implement a stormwater utility credit program, the community must establish strict policies and guidelines pertaining to the stormwater utility credits. "A cost-benefit analysis should be performed to ensure that it is in the best interest of the municipality to grant the credit." (APWA, 2000)

Advantages of a stormwater utility include (APWA, 2000):

- A steady funding mechanism is dedicated to storm water management

- Fees can be based on the amount of contributing impervious surface on the property, which is a more equitable means of charging property owners than a flat fee
- Financial incentives can be used to encourage businesses and institutions to implement storm water BMPs
- Utilities tend to run more efficiently (more like a business)
- Implementing a storm water fee is often more appealing politically than imposing a new tax or raising property taxes

The challenges associated with stormwater utilities include (APWA, 2000):

- Some residents, businesses or institutions may resist paying the fee
- The idea may face political opposition
- Once rates are in place, it may be difficult to secure additional funding
- Enabling legislation is often required
- It may be difficult and/or time-consuming to devise an equitable rate structure, and to develop a database with required information, such as amount of impervious surface
- A billing system will be needed

Alternate Funding

Stormwater utility fees are not the only source of funding available for stormwater management programs.

The following options can also be used to fund a stormwater management program (APWA, 2000):

- Debt Financing
- Federal, State or Regional Grants and Loans
- Special Assessments
- Local Improvement Districts (LIDs)
- General Fund
- Plan Review and Inspection Fees
- Fee-in-Lieu of On-Site Construction
- Developer Participation

- System Development Fees/Connection Charges
- Combination Approaches

Determining what funding source or combination of funding sources that is most appropriate for the local stormwater management program depends on a number of criteria (APWA, 2000):

- Political Acceptance
- Fairness and Equity
- Administrative Simplicity
- Feasibility of Implementation
- Legal Defensibility
- Revenue Generating Capacity
- Dedicated Funding Source

The American Public Works Association (APWA, 2000) created a funding source evaluation matrix to outline the pros and cons of the above funding source options, which can be seen as Table 4-1 on the following page.

Responsibility

As was expected, most of the respondents indicated that the City/County government is responsible for maintaining stormwater systems and facilities that are located on public property and that the adjacent property owner is responsible for maintaining stormwater systems and facilities that are located on private property. However, it was found that almost half of the respondents indicated that the City/County government is responsible for maintaining systems and facilities that are located on private property, but extending onto public property. Another quarter of the respondents indicated that the adjacent property owner was responsible, but the other quarter of the respondents indicated that the City/County government and the adjacent property owner would work together to resolve the problem. Some of the respondents did

Table 4-1: Funding Source Evaluation Matrix (APWA, 2000)

Funding Source	Political Acceptance	Equity	Feasibility of Implementation	Ease of Administration	Legally Defensible	Revenue Capacity	Dedicated Funding Source
Debt Financing	Political will needed to implement dedicated funding	System paid for as it depreciates	Must have rates to support revenue bonds	Paid through rates &/or connection charges	Debt ceiling for G.O. debt, covenants for revenue bonds	Used for capital only	Dedicated funding source in place for revenue bonds
State/Federal Grants & Loans	Less risky to accept grants		Highly competitive process	Careful tracking	Meet terms of grant/loan scope	Used only for qualifying projects	Not a dedicated source
Utility Rates	Requires political will to implement new charge	Fees for services	Administrative billing support	Depends on rate structure	Verify that it is allowed in State Statute	Used for operating &/or capital	Dedicated funding source
Assessments	Requires political will to implement new assessment; may conflict with property tax LIDs	May be unrelated to cost of service	Administrative billing support	Not difficult	Allowed	Used for operating & capital	Dedicated funding source
LIDs	Must be approved by area served	Assigns costs of facilities to benefiting areas	May be cumbersome to initiate	May be cumbersome to track	Allowed	Used for specific capital project only	Dedicated to specific projects only
General Fund/Street Fund	Difficult to allocate revenue to conflicting needs in fund	May be unrelated to cost of service	Not difficult; political will	Not difficult	Allowed	Available for operating & capital	Not a dedicated source; subject to changing priorities
Plan Review & Inspection Fees	Less risky to charge fees for plan review	Recovery of cost of direct services	Not difficult; requires isolation and fee calculation	Not difficult	Allowed	Used for specific operating activities only	Dedicated to specific operating activities
Fees-in-Lieu of Construction	Less risky if stormwater ordinance is in place and requires on-site facilities	Meet development requirements	Need stormwater ordinance requiring on-site facilities	Fee paid at time of development	Allowed	Used for specific capital projects only; growth dependent	Dedicated to specific projects only
Developer Participation	Difficult to get developer to pay for infrastructure	Mitigate direct impacts of development	Negotiation	Not difficult	Allowed	Used for specific capital projects only	Not a fund source, but a capital project contribution
System Development Fees/Connection Charges	Requires political will to assess new fee on development	Add equity between existing and future customers	May be opposed by developers	Fee paid at time of development	Verify that it is allowed in State Statute	Used for capital only; usually partial funding; growth dependent	Dedicated to stormwater capital projects only
Local Gas Tax	Requires political will, particularly where taxes are high	Justified; autos and roads contribute to water quality problems	Not difficult	Not difficult	May require State legislation	Depends on amount of tax and amount dedicated stormwater programs	Dedicated to environmental programs, portion could be for stormwater programs

provide comments relating to this situation and they indicated that they either performed a site-by-site analysis, only maintained the portion of the system or facility located on the public property or performed the maintenance if damage is occurring to the public property.

Local governments must make a policy decision about who is responsible for maintaining the stormwater systems and facilities that are located on private property, but extending onto public property. A decision must also be made about the stormwater systems and facilities that are located on public property, but extending onto private property. There are basically three options that local governments can select from.

The first option is that the local government will only be responsible for maintaining the stormwater systems and facilities located on public property. The adjacent property owner or a homeowner's association will be responsible for maintaining the systems and facilities located on private property.

The second option is that the local government will only be responsible for maintaining the stormwater systems and facilities located on public property and the private systems and facilities that accept stormwater runoff from the public system. The systems and facilities located on private property that do not accept stormwater runoff from the public system would be the responsibility of the adjacent property owner or a homeowner's association.

The third option would be that the local government would be responsible for maintaining all of the stormwater systems and facilities located on both public and private property. This option should not be chosen unless the community has an adequate source of funding, such as a stormwater utility, that would be able to provide the resources needed to maintain all of the stormwater systems and facilities located within their jurisdiction.

A report from the Water Resources Research Institute of the University of North Carolina provided guidance concerning this issue as well. The report "recommended that the division of responsibilities

should depend on the type and scale of the facilities. Larger and regional facilities should be completely a public responsibility while structures serving small sites and individual subdivisions should be privately designed, financed, and constructed but then dedicated to the public for maintenance and improvements." (Roenigk et al, 1992) The report also suggested "the division should also be based on land use type with commercial and industrial sites being a private responsibility but residential sites a public charge." (Roenigk et al, 1992)

Regardless of which option is chosen, the local government must clearly define the level of extent their stormwater services provide and must distribute this information to adjacent property owners and homeowner's associations. Most property owners and homeowner's associations are not aware of their responsibilities, which is why a maintenance agreement should be required for any new development or redevelopment as part of the design review and permitting process.

It was also found that while the City/County governments could provide resources to perform maintenance on stormwater systems or facilities that are located on private property, but extending onto public property, almost all of the respondents indicated that less than 10 visits are made to privately owned stormwater handling facilities. This provides the conclusion that either the communities do not have the resources to provide inspections or that they rely on the owner of the facility to provide the inspections. To assist the owner in making inspections of stormwater systems and facilities, communities may wish to create an inspection checklist for the most common stormwater systems and facilities located within their jurisdictional boundary and distribute these checklists to the owners of stormwater systems and facilities.

It was also found that when the private owners fail to responsibly maintain these facilities, almost half of the respondents indicated that no enforcement action was taken against the owner. However, a quarter of the respondents did indicate that some type of legal action, such as a fine or a notice of violation, was issued to the owner. Over 16% of the respondents did indicate that the owner was contacted and asked to perform the needed maintenance, but there was little else the community could do. The rest of the

communities either asked TDEC to handle the situation, perform the needed maintenance, but not bill the owner, or perform the needed maintenance, but bill the owner. If the local government requires that adjacent property owners or homeowner's associations be responsible for maintaining any stormwater systems or facilities, the local government must make another policy decision about the enforcement action they will take if the adjacent property owners or homeowner's associations fail to properly maintain stormwater systems and facilities in order to ensure that the systems and facilities continue to receive any needed maintenance.

Use of Stormwater Maintenance Protocols

Question 9 of the survey questionnaire was asked to provide an indication of the most common stormwater-related maintenance problems in the counties and municipalities throughout the State. These problems include, but are not limited to obstructions in pipe/culvert systems, pipe/culvert collapses, sediment and erosion problems and obstructions in open channels, such as ditchlines and creeks/streams. By devising categories for the most common stormwater-related maintenance problems, effective maintenance protocols for certain categories were devised and may be of benefit. An additional protocol was established for detention ponds as well since some of the respondents indicated that detention ponds are also a stormwater-related maintenance problem. These protocols can be found in Appendix F as Table F-1 through Table F-5 on page 123 through page 127.

Not only can maintenance protocols be used to improve the conditions of stormwater systems and facilities, planning for maintenance in the design phase of a project can help reduce the amount and frequency a stormwater system or facility requires to function properly. It was found that almost 70% of 92 respondents indicated that "maintenance-free" designs are not being encouraged within their community. This alarming percentage only reinforces the demand for a properly functioning stormwater program.

Maintenance Considerations in the Design Phase

A report written by the Northern Virginia Planning District suggests, "designing BMPs to minimize maintenance needs is the most effective way to reduce the effort needed for maintenance." (Northern Virginia Planning District Commission, 1992) By designing stormwater systems and facilities to be as "maintenance-free" as possible and by assuming that any constructed systems and facilities will not receive any maintenance at all, there could be less of a physical and fiscal burden placed upon private owners and local governments. One report found that there was inadequate maintenance access for stormwater facilities and the "most common problems were fencing with limited gate access, facilities located in wooded areas, and devices located too close to structures." (Roenigk et al, 1992) It was also found that "embankments were too steep for mechanical mower maintenance at one-third of detention basins and about eleven percent of the vegetative channel segments. Many of the overgrowth problems existed at detention basins that were clearly too steep for mechanical mower use. Thus, while steeper detention embankments (and deeper basins) preserve more lot area for development, such designs may lead to long term problems by making maintenance more difficult." (Roenigk et al, 1992) Other design considerations include (Northern Virginia Planning District Commission, 1992):

- Multiple orifice outlets (however debris that could pass through a larger single orifice could clog smaller multiple orifices)
- Gravel jackets around an orifice (however the gravel jacket could become clogged and require that heavy equipment be brought it to rectify the problem)
- Trash racks can be used to trap debris before it can reach the outlet device (however the trash rack openings could become clogged and trash racks can provide a false sense of security, which could lead to less frequent inspections than those facilities without trash racks)
- Use of low flow channels
- Use of reinforced concrete instead of corrugated metal for all of the facility's piping, barrels and risers for greater longevity
- An on-site disposal area for sediment removed from the facility or allowing for extra storage within the facility

Some suggestions for improving design and management of stormwater facilities in relation to maintenance include (Roenigk et al, 1992):

- Evaluate each component in the system for compatibility with a) other system components, b) site characteristics, and c) anticipated upstream development
- Establish standards that take into account long-term maintenance costs
- Inspect construction sites regularly during installation for quality assurance
- Accept only designs certified by professional engineers
- Systematically re-evaluate design and design criteria for future improvement
- Design systems to be visually attractive or serve as recreational facilities to encourage support for and attention to maintenance
- Keep maps of systems on file by watershed and update regularly
- Require maintenance manuals as part of facility design
- Require bypasses for storms larger than the design storm
- Increase minimum design standards to automatically accommodate new development

Other/Further Research

While much work has been done to characterize current stormwater-related maintenance programs in Tennessee, future studies would be beneficial to expand the knowledge base pertaining to the specific benefits of a preventative maintenance program. Additional research should be conducted in the following areas:

- With the exception, perhaps, of sediment-laden runoff, water *quality* problems are generally less obvious to the public and to many public officials than stormwater *quantity* problems, further research needs to be conducted to determine to what extent the stormwater system and facility maintenance protocols need to be upgraded to include water quality protection standards
- Further research is needed in order to determine what the expected long-term frequency and costs of maintenance for stormwater systems and facilities should be in order to prevent system and facility failure due to a lack of maintenance
- Determining how to assess the overall effectiveness of a preventative maintenance program versus a responsive maintenance program in order to decide if preventative maintenance programs actually save money, time and resources over a long period of time
- A general policy for the stormwater BMP design review and permitting process is needed for the counties and municipalities in the State of Tennessee who do not have a design review and permitting process in place

- Determining what the reasons and goals for maintenance response, such as, but not limited to nuisance flooding, property damage, poor water quality or loss of life, would provide an indication of how serious a lack of maintenance is within Tennessee

- The actual dollar amounts that local governments use for stormwater-related maintenance activities is needed to help characterize the existing maintenance programs in the State

- It would be useful to know what policies, regulations, enforcement actions and ordinances pertaining to maintenance of stormwater systems and facilities are the most effective within Tennessee

- A design for the most effective combination of inspections, regularly scheduled maintenance and response based maintenance is needed

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Appendices

Appendix A

Stormwater Maintenance Program Survey Questionnaire

University of Tennessee
Stormwater Maintenance Program Survey

Send to:
Jacob Chandler
University of Tennessee
64C Perkins Hall
Knoxville, TN 37996-2010

Question 1 – Please indicate the total annual amount of funds that your community spends on **stormwater and street maintenance.**

_____A. $0 - $250,000
_____B. $250,001 - $500,000
_____C. $500,001 - $1,000,000
_____D. $1,000,001 - $2,000,000
_____E. Over $2,000,000
_____F. _____(Actual amount, if known)

Question 2 – What percentage or known amount of the stormwater and street maintenance budget is used for **stormwater-related maintenance**?
_____% or $_____

Comments:_____
_____

Question 3 – What percentage split of your total **stormwater maintenance budget** best characterizes routine **preventative maintenance** (e.g. Street sweeping, catch basin/catch basin inlet cleaning, removing debris and litter from ditches, creek cleaning, etc.) versus **responsive maintenance** (e.g. Responding to drainage complaints or to emergency events)? (Check (√)? one)

Preventative-Responsive	Preventative-Responsive	Preventative-Responsive
____0 – 100 %	____40 – 60 %	____ 80 – 20 %
____10 – 90 %	____50 – 50 %	____ 90 – 10 %
____20 – 80 %	____60 – 40 %	____ 100 – 0 %
____30 – 70 %	____70 – 30 %	

Comments:_____
_____

Question 4 – **What percentage, do you estimate, of all stormwater problems in your community are attributed to needed maintenance** (obstructions in pipe and culvert systems, catch basin blockage, deposition of silt in detention ponds, obstructions at outlet control structures in detention ponds, vegetative growth in creeks, debris pileup at bridges, etc) as opposed to outdated designs, poor construction, urban growth, ordinary wear and tear or extreme event conditions?
_____%

Comments:_____
_____

<u>Question 5</u> – **Please rank the following list of items from 1 (highest) to 5 (lowest) according to your community's priorities** for maintenance response of stormwater systems and facilities that are located on public property.

_____ Routine scheduling of maintenance (e.g. Street sweeping, catch basin/catch basin-inlet cleaning, removing debris and litter from ditches, etc.)
_____ On a complaint basis
_____ After significant rain events
_____ Legal basis or court ordered
_____ Other _____

Comments:_____
_____

<u>Question 6</u> – **Who is generally responsible, for maintaining stormwater systems and facilities** that are located on **each** of the following properties? (Check (√)? one for each item)

1. Systems/facilities located on public property
____ City/County Government
____ Stormwater Utility
____ Adjacent Property Owner
____ Other _____

2. Systems/facilities located on private property
____ City/County Government
____ Stormwater Utility
____ Adjacent Property Owner
____ Other _____

3. Systems/facilities (i.e. culverts, creeks, etc.) located on private property but extending onto public property
____ City/County Government
____ Stormwater Utility
____ Adjacent Property Owner
____ Other _____

Comments:_____
_____

<u>Question 7</u> – **How many times a year do you make routine visits to private stormwater handling facilities** (such as subdivision detention ponds, etc) to assess their needed maintenance and report your findings to the responsible party? _____

Comments:_____
_____

<u>Question 8</u> - **What happens when private owners do not responsibly maintain their stormwater facilities** (i.e. What enforcement action, if any, is taken by the community)?

_____
_____
_____

<u>Question 9</u> – **Please prioritize from 1(high) to 5(low) the top five-stormwater maintenance problems** in your community: (e.g. Obstructions in pipe and culvert systems, pipe and culvert collapses, deposition of silt in detention ponds, obstructions at outlet control structures in detention ponds, obstructions and vegetative growth along creeks, catch basin blockage, debris at bridges, etc.)

1. _____
2. _____
3. _____
4. _____
5. _____

Comments:_____
_____

<u>Question 10</u> - **If possible, estimate the percentage increase of the current budget needed to improve the current stormwater maintenance program to minimize** future problems, address recurrent problems or to improve the existing stormwater systems and facilities under your jurisdiction.
_____

Comments:_____
_____

<u>Question 11</u> – Does your community encourage the use of "maintenance-free stormwater management" designs within your jurisdiction and, if so, what types of designs are used?
_____
_____
_____

<u>Question 12</u> - **What are your feelings about requiring a stormwater utility fee** from every resident and business to make improvements and provide more maintenance to the stormwater facilities? How receptive would your community officials be to this idea?
_____
_____
_____

<u>Question 13</u> – If your community must meet the upcoming NPDES Phase II stormwater requirements, how does your community plan to provide funds for these mandates?
_____
_____
_____

When you return your survey, please include a copy of applicable parts of any ordinances, regulations or policy pertaining to stormwater maintenance issues such as what is the property owners' and the municipality's responsibility for maintenance of stormwater systems and facilities.

_____
Name of Respondent
_____
Title
Telephone #: _____
Email: _____
Fax: _____

Appendix B

Survey Questionnaire Summary Bar Graphs

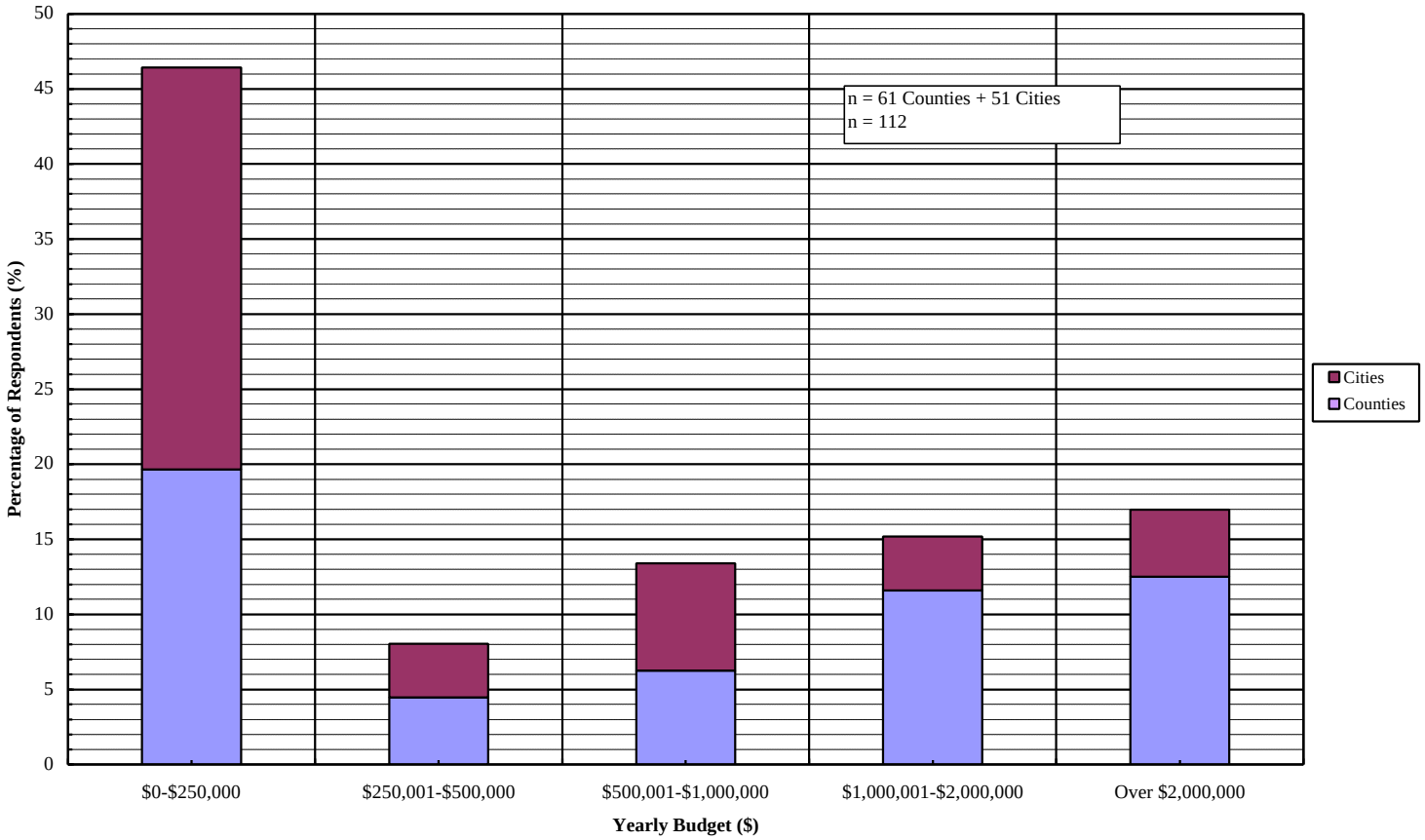


Figure B-1: Yearly Budget for Stormwater and Street Maintenance

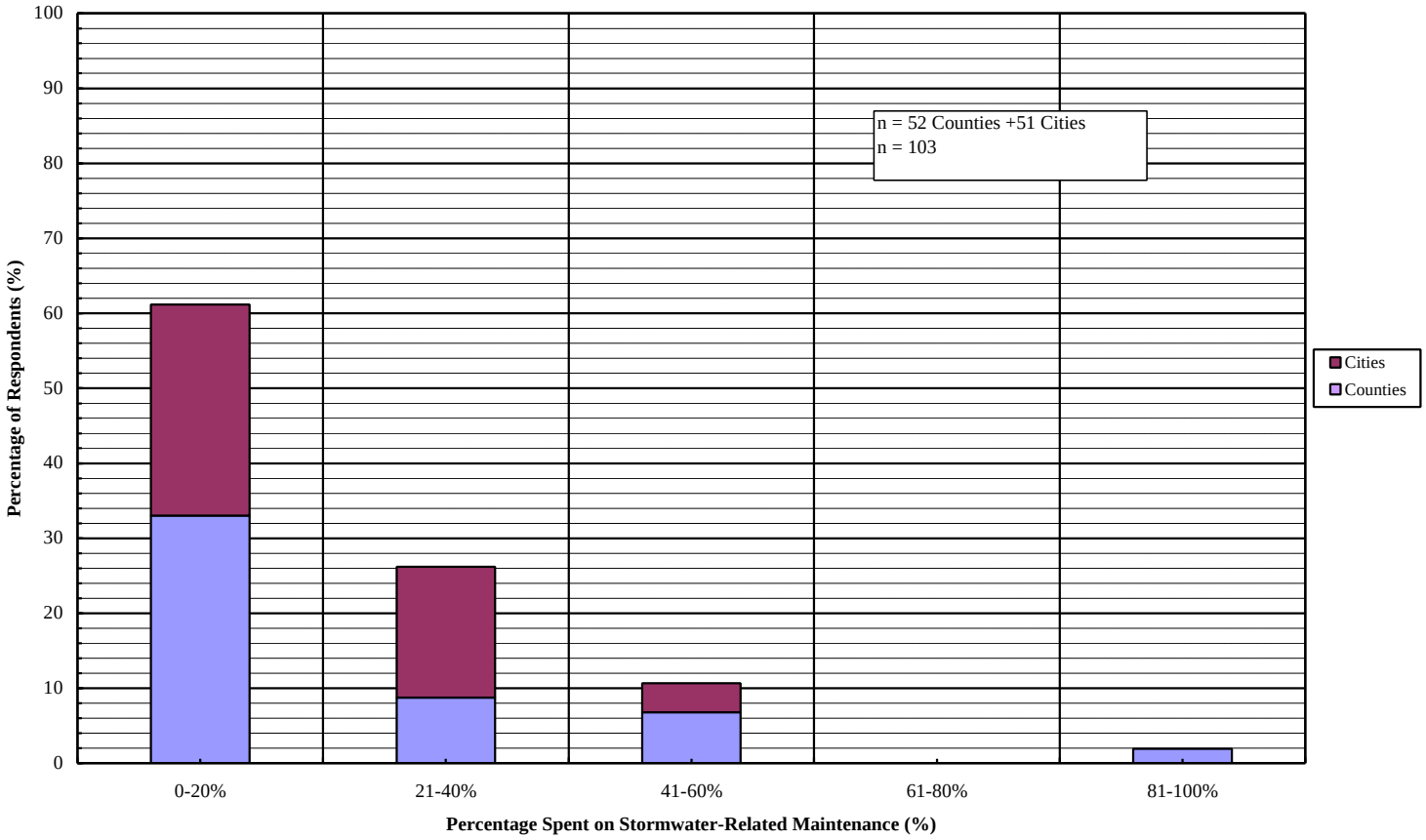


Figure B-2: Percentage of Yearly Budget Spent on Stormwater-Related Maintenance

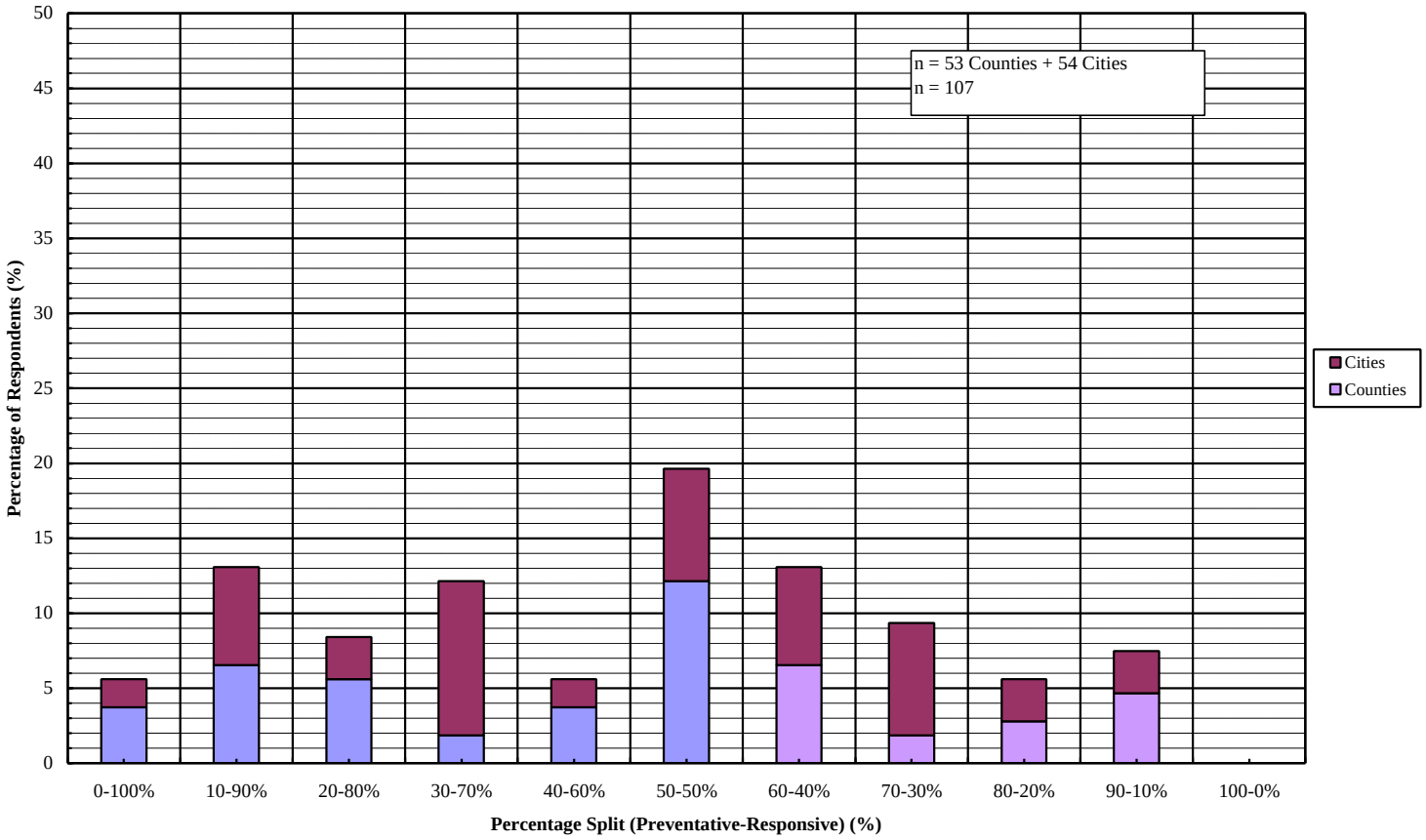


Figure B-3: Percentage Split of Stormwater-Related Maintenance Budget

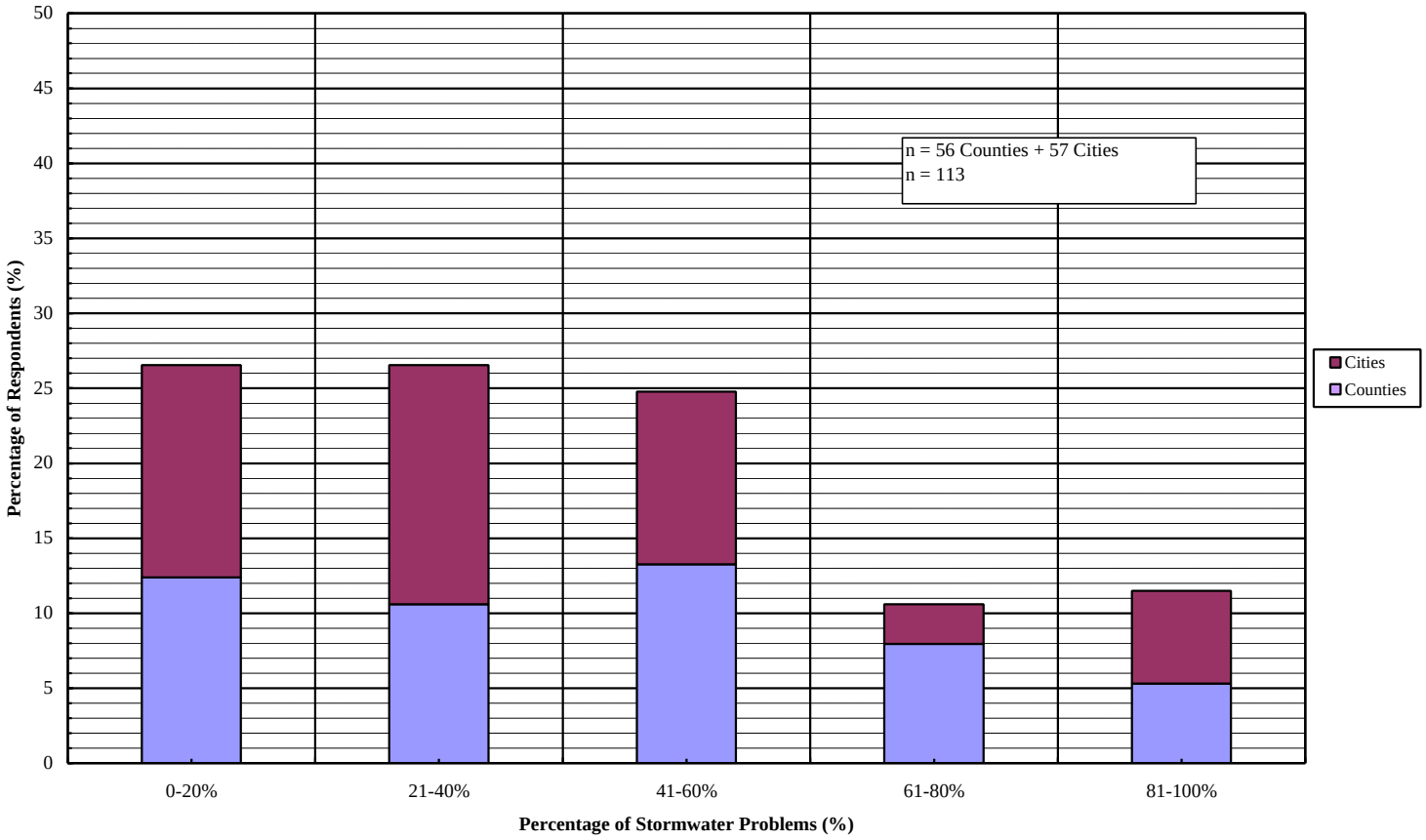


Figure B-4: Percentage of Stormwater Problems Attributed to a Lack of Maintenance

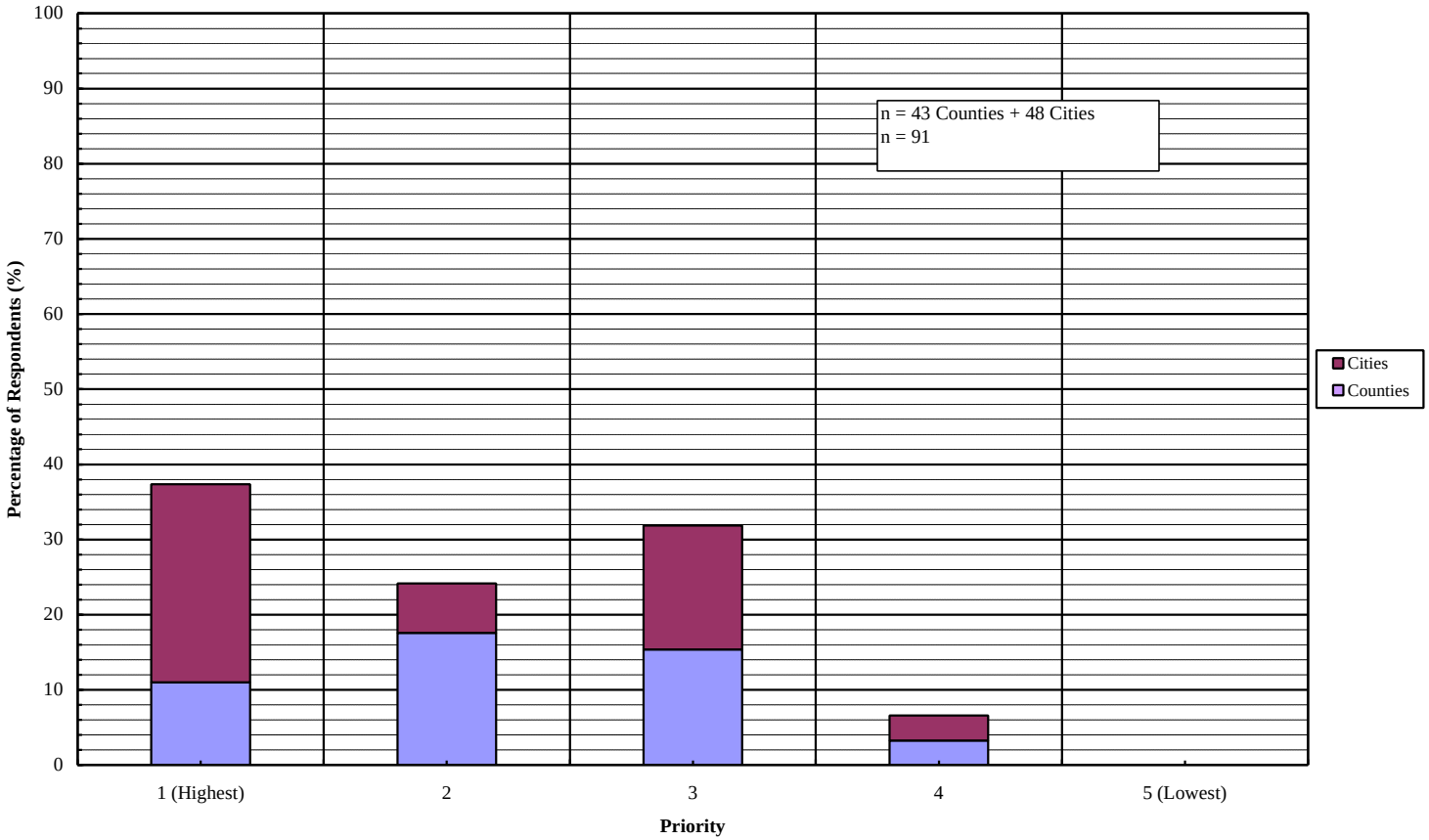


Figure B-5: Priority Ranking for Maintenance Response Performed on a Routine Basis

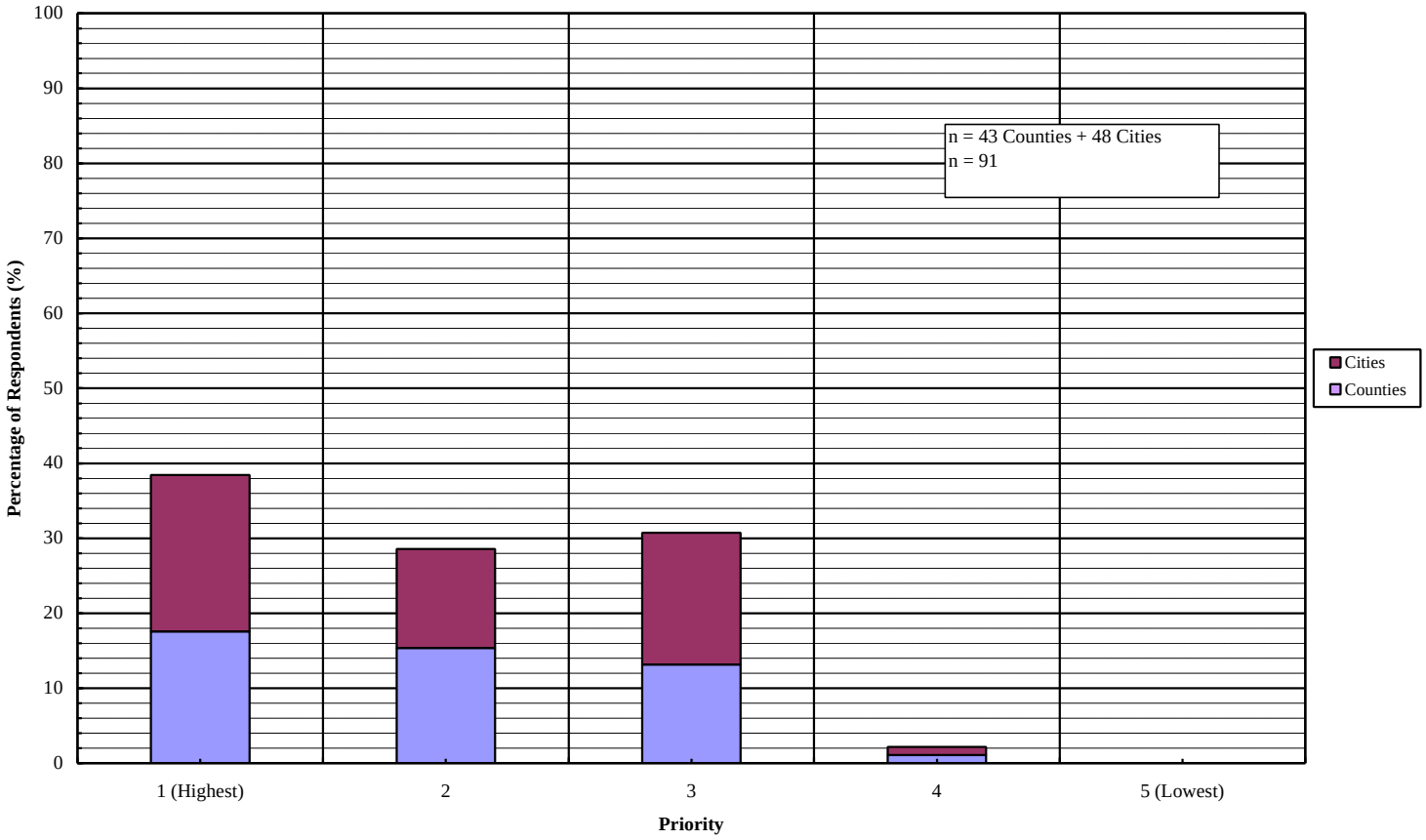


Figure B-6: Priority Ranking for Maintenance Response Performed on a Complaint Basis

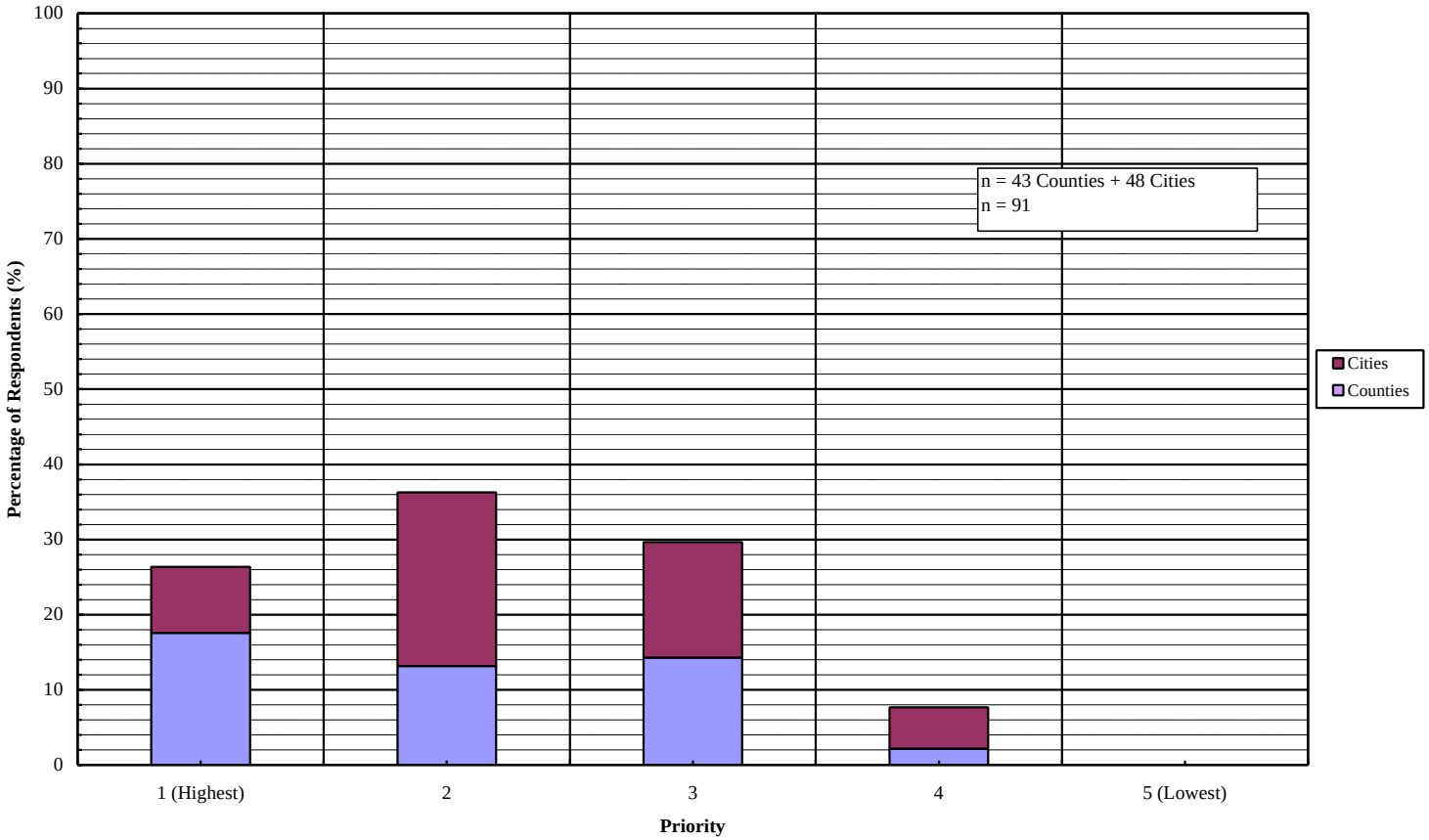


Figure B-7: Priority Ranking for Maintenance Response Occurring After Significant Rain Events

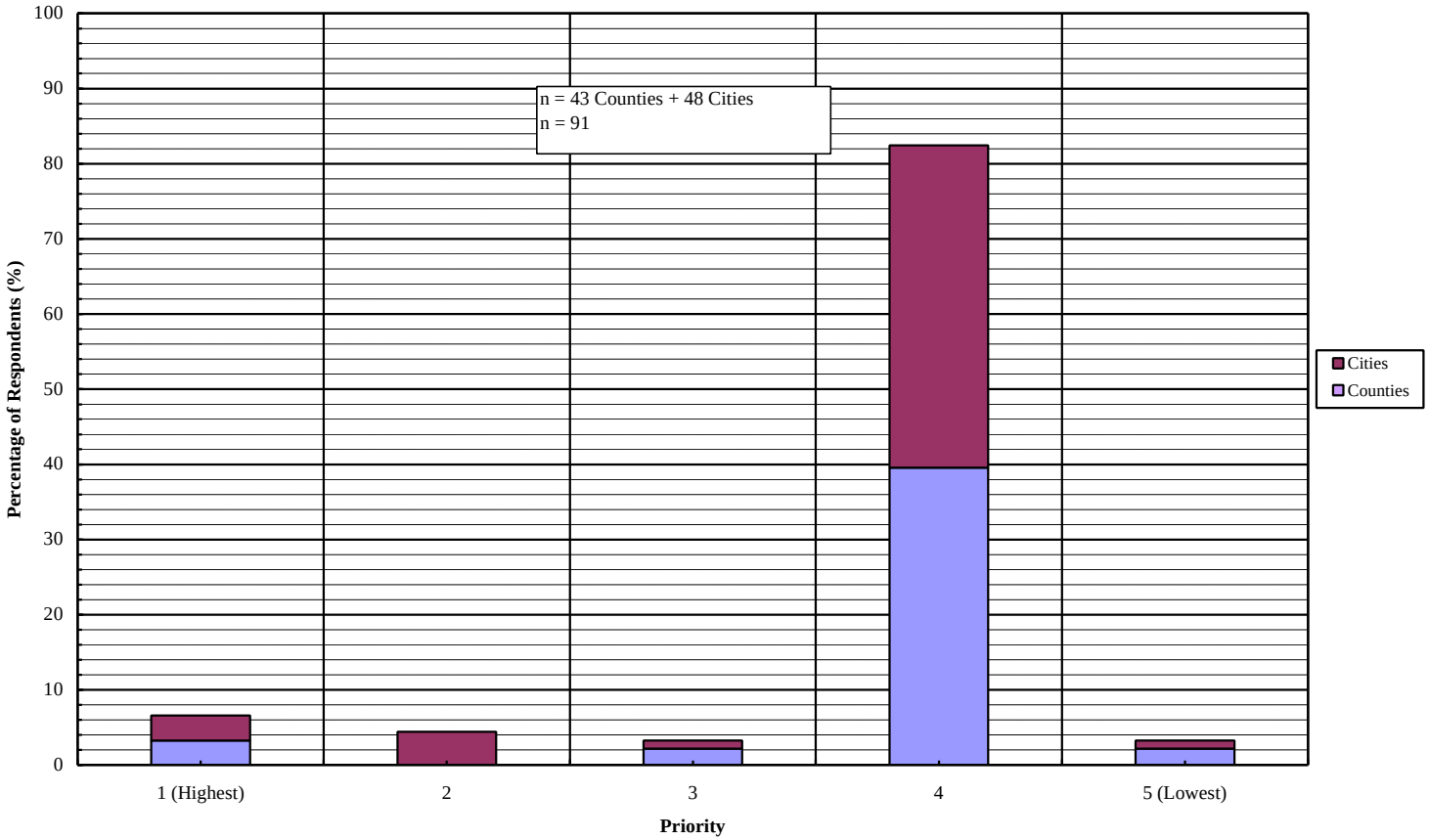


Figure B-8: Priority Ranking for Maintenance Response Attributed to a Legal Order

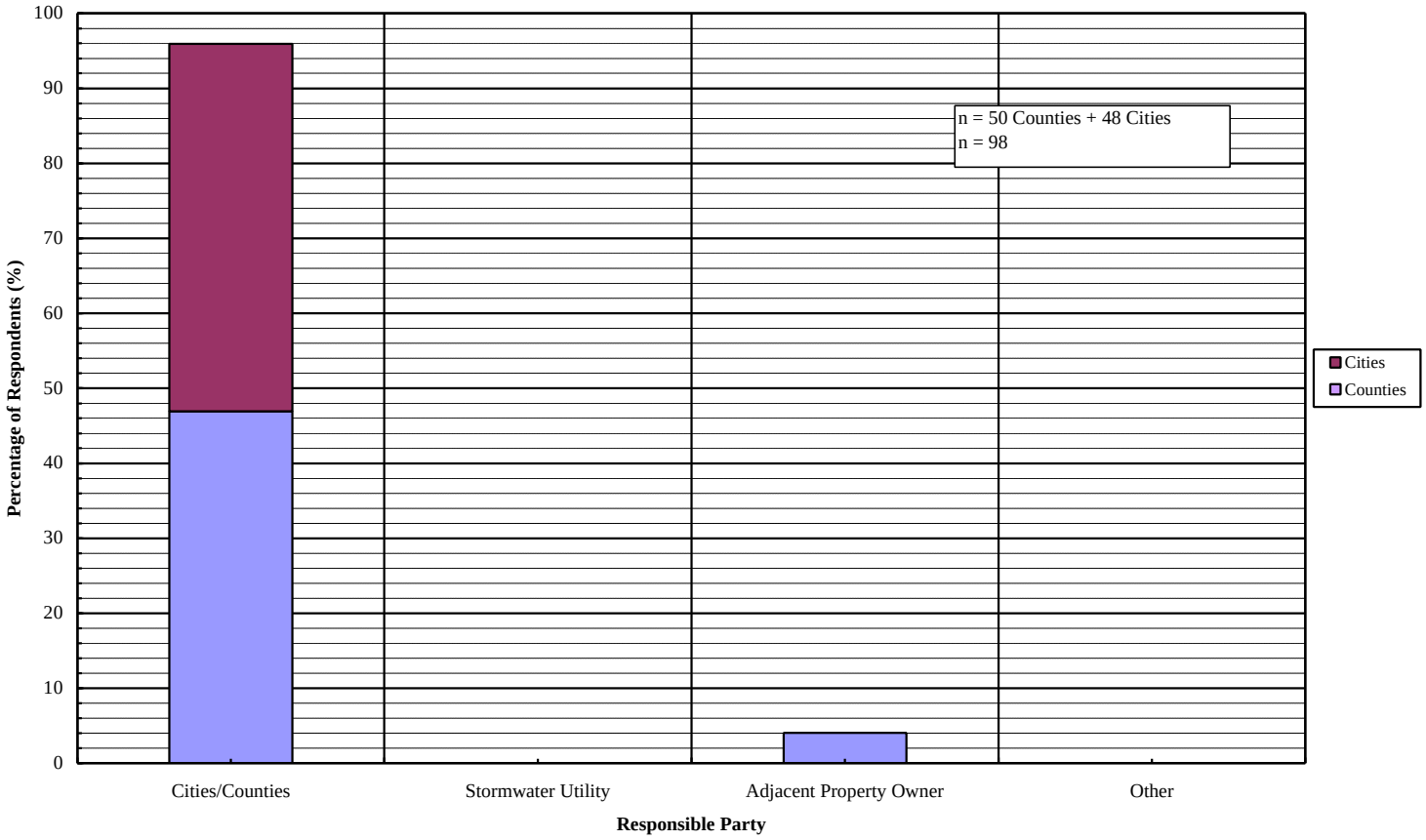


Figure B-9: Maintenance Responsibility for Stormwater Systems/Facilities Located on Public Property

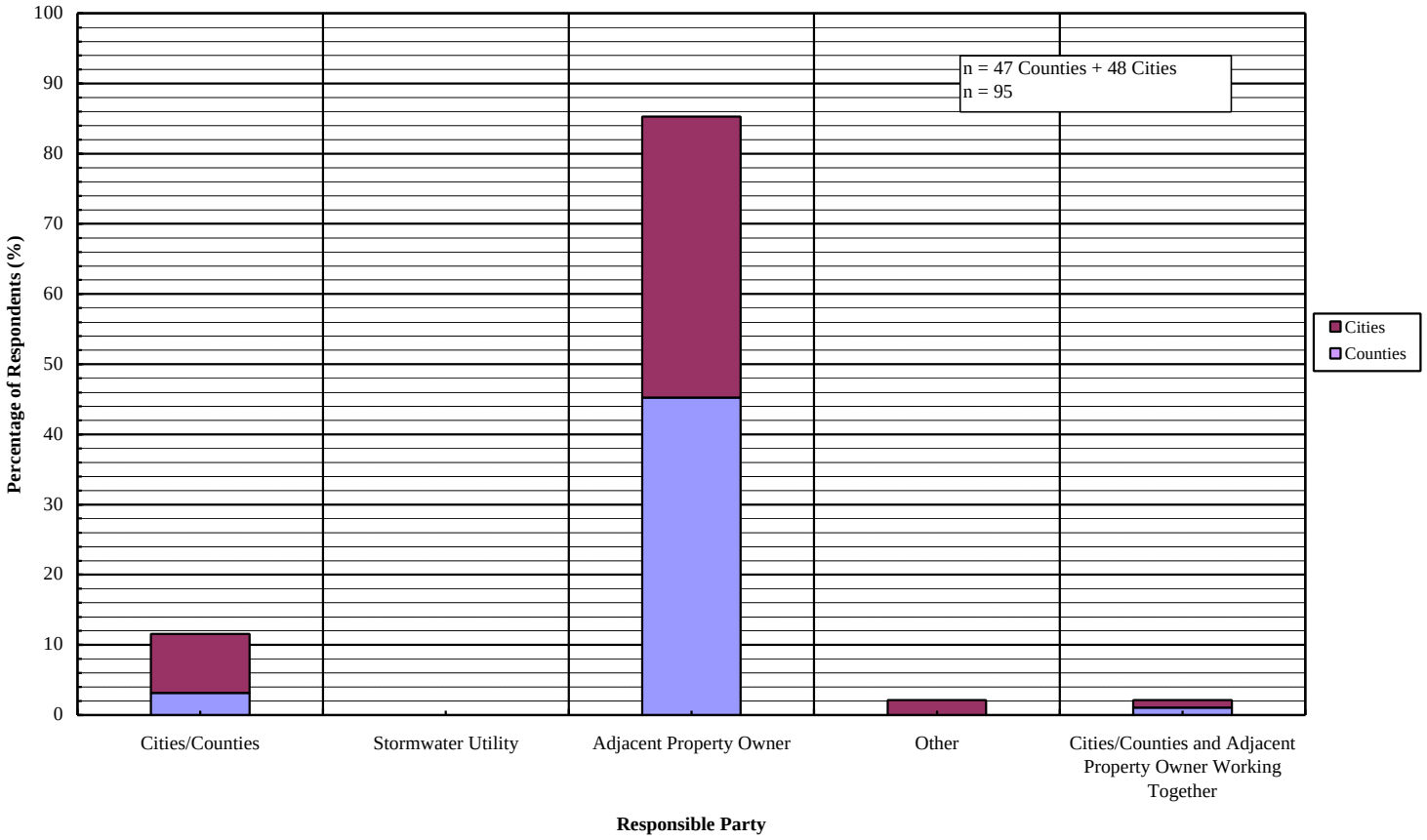


Figure B-10: Maintenance Responsibility for Stormwater Systems/Facilities Located on Private Property

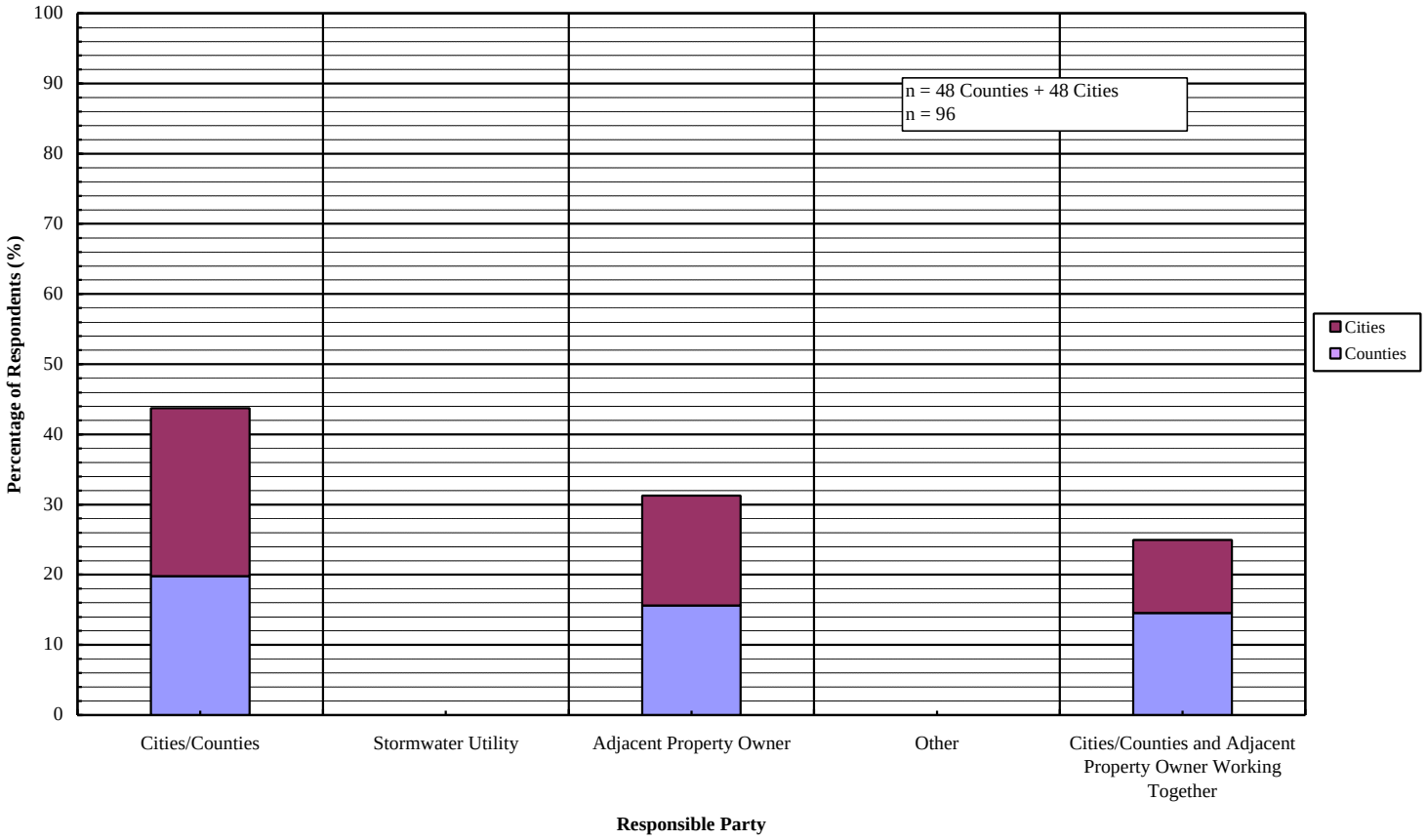


Figure B-11: Maintenance Responsibility for Conveyances Extending from Private Property to Public Property

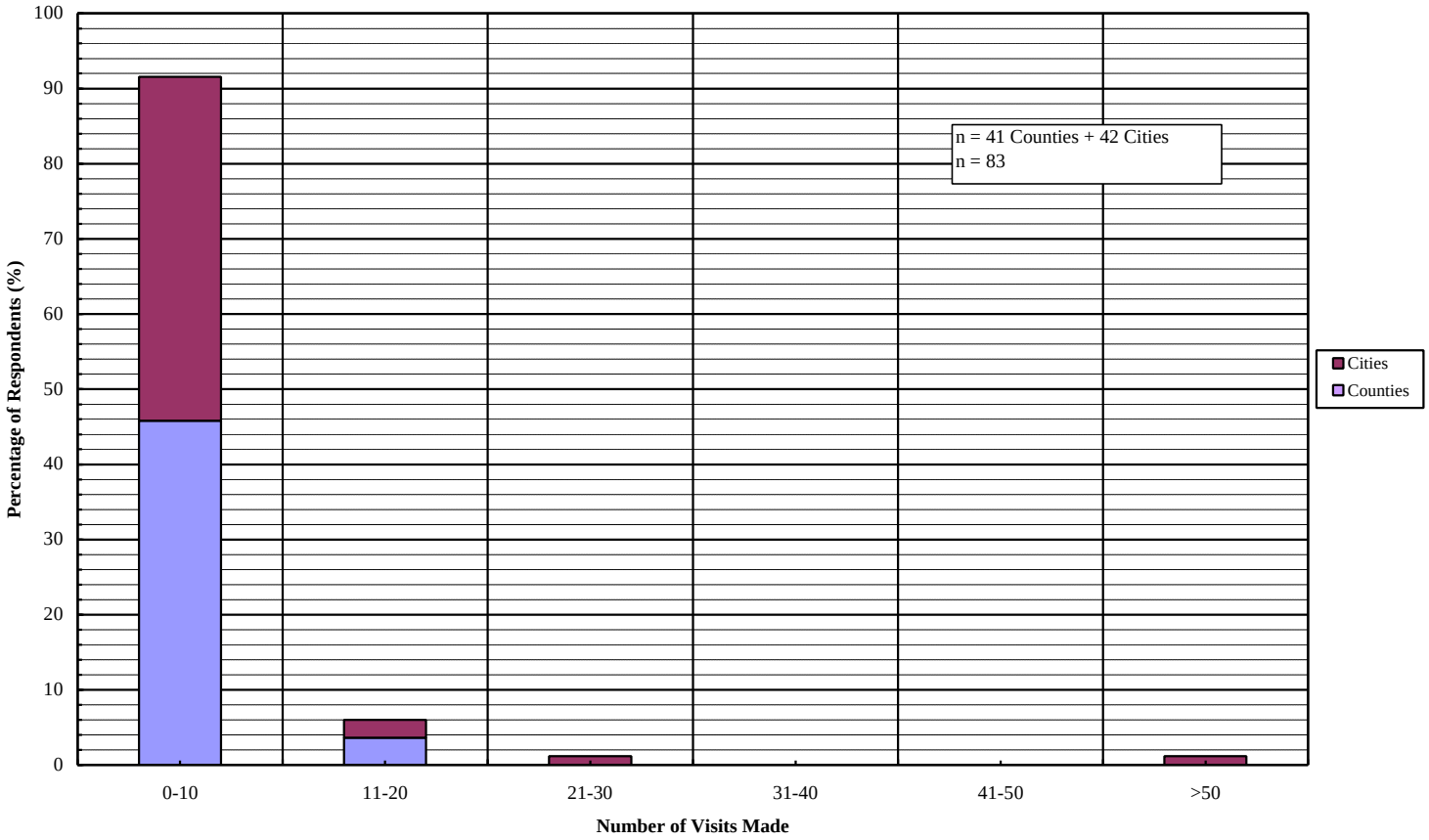


Figure B-12: Number of Visits Made Per Year to Private Stormwater Handling Facilities

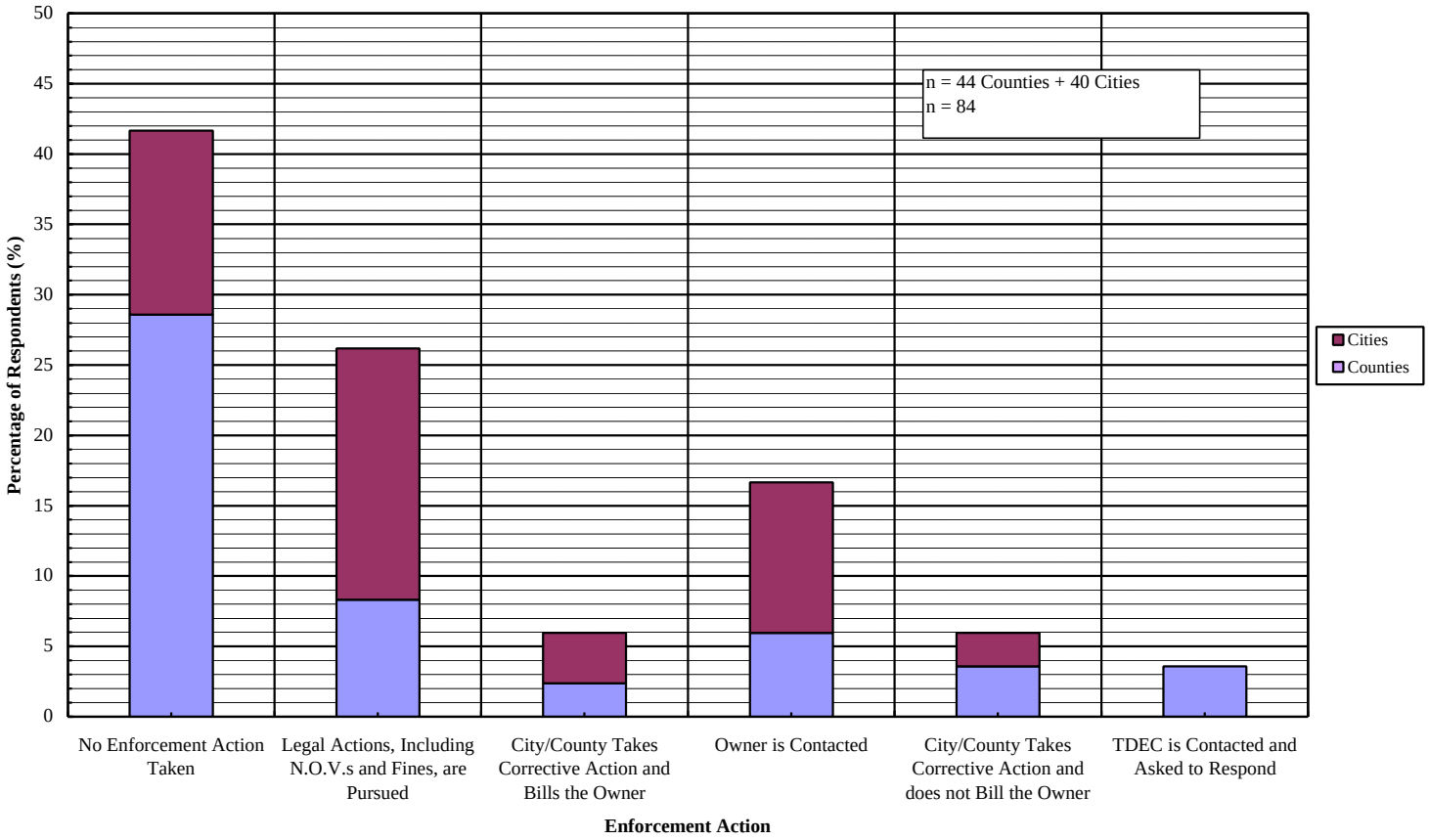


Figure B-13: Enforcement Taken by Local Government when Private Stormwater Facilities are not Maintained

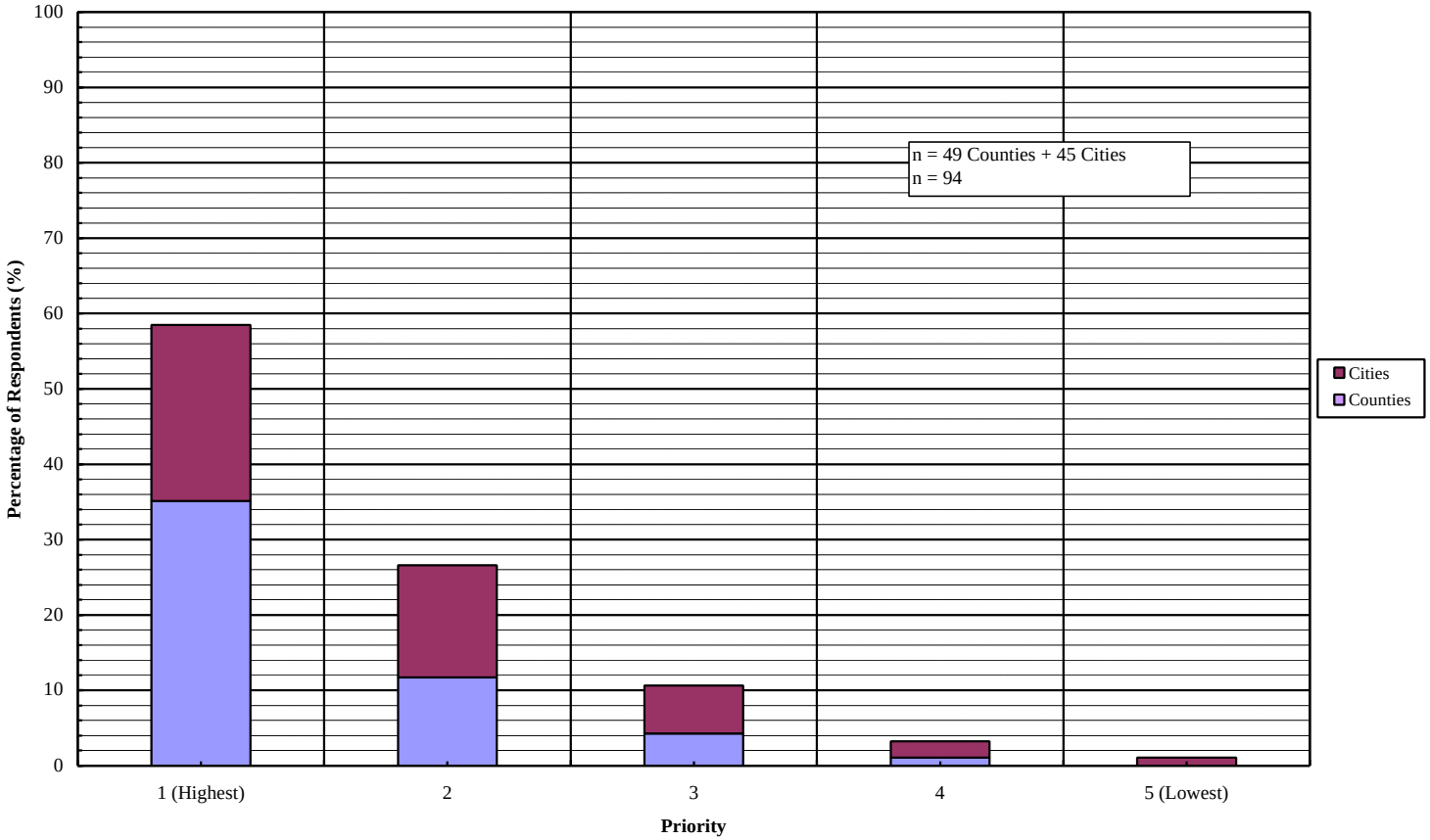


Figure B-14: Priority Ranking for Stormwater Maintenance Problems Attributed to Pipe/Culvert Obstructions, Including Obstructions Attributed to Sediment Deposition Problems

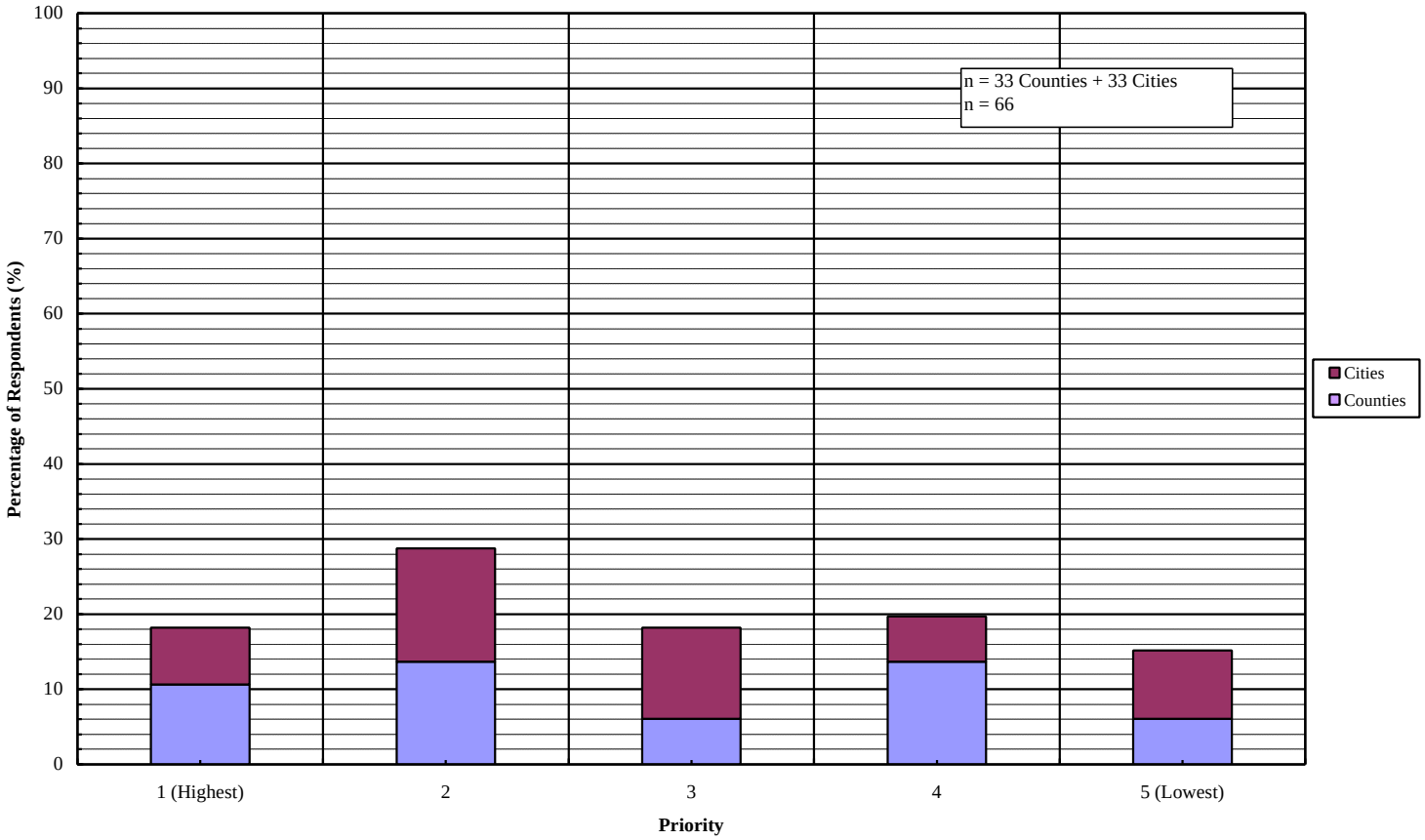


Figure B-15: Priority Ranking for Stormwater Maintenance Problems Attributed to Pipe/Culvert Collapses/Damage

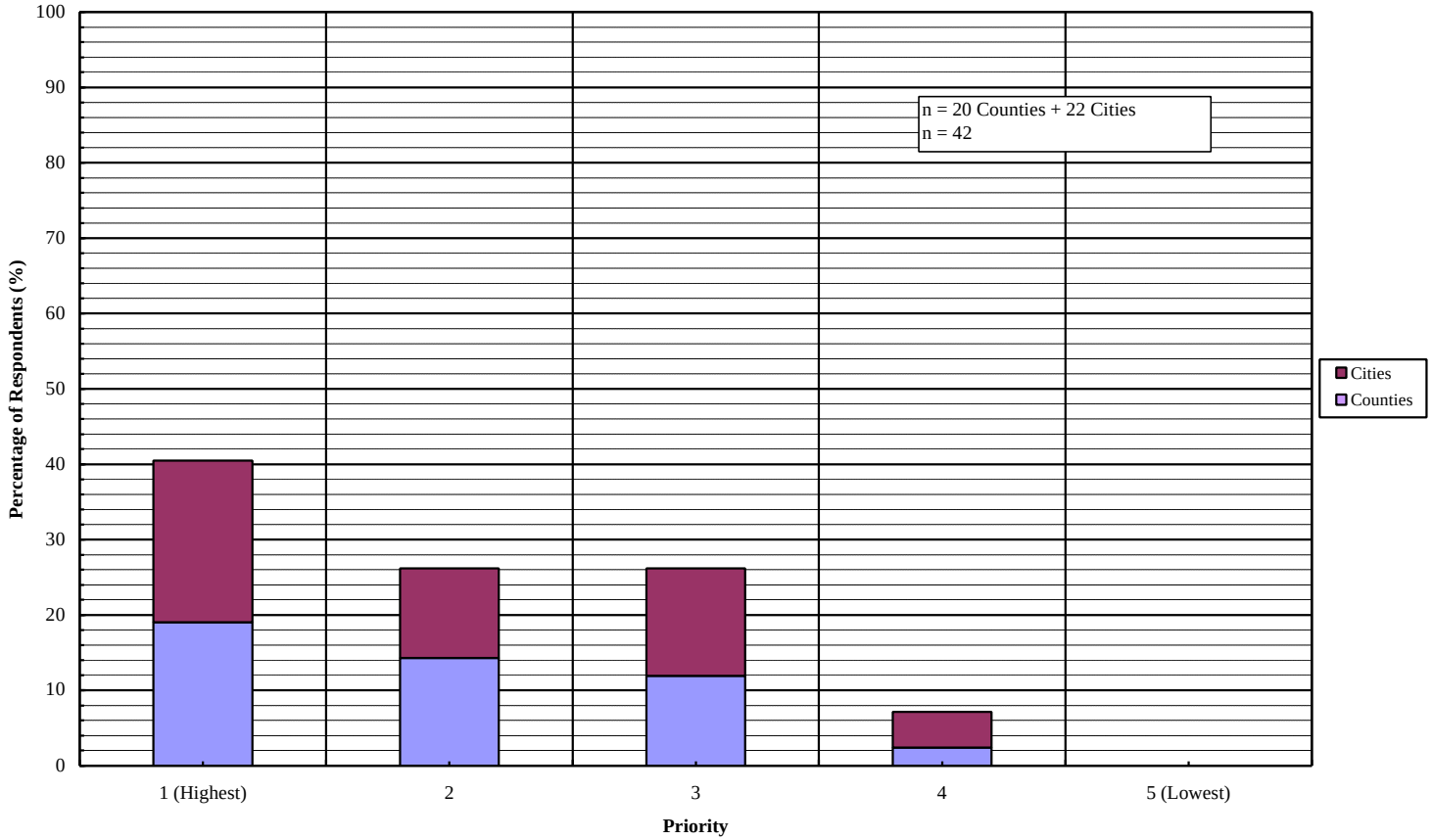


Figure B-16: Priority Ranking for Stormwater Maintenance Problems Attributed to Ditchline Obstructions, Including Erosion and Sediment Deposition Problems

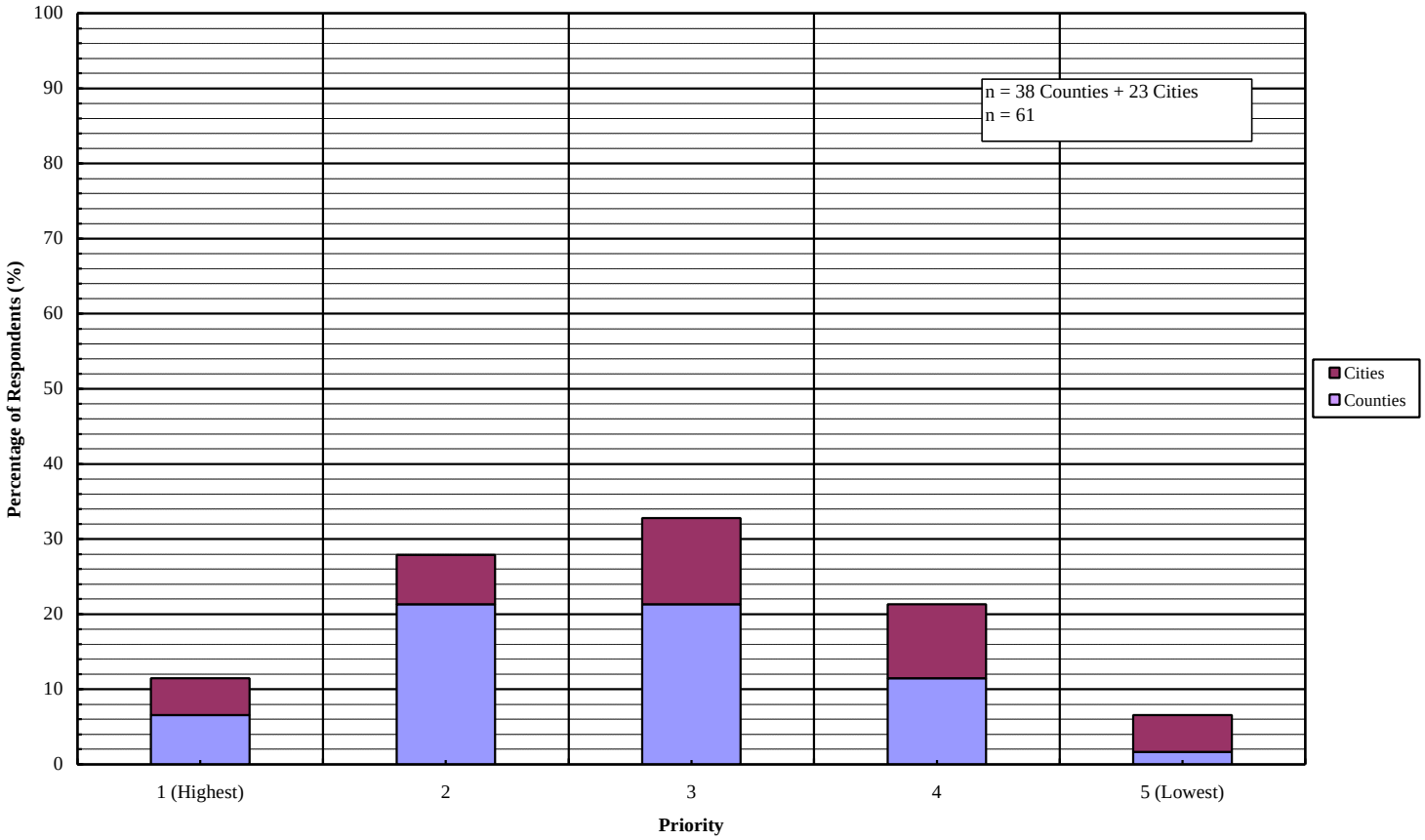


Figure B-17: Priority Ranking for Stormwater Maintenance Problems Attributed to Obstructions at Bridges

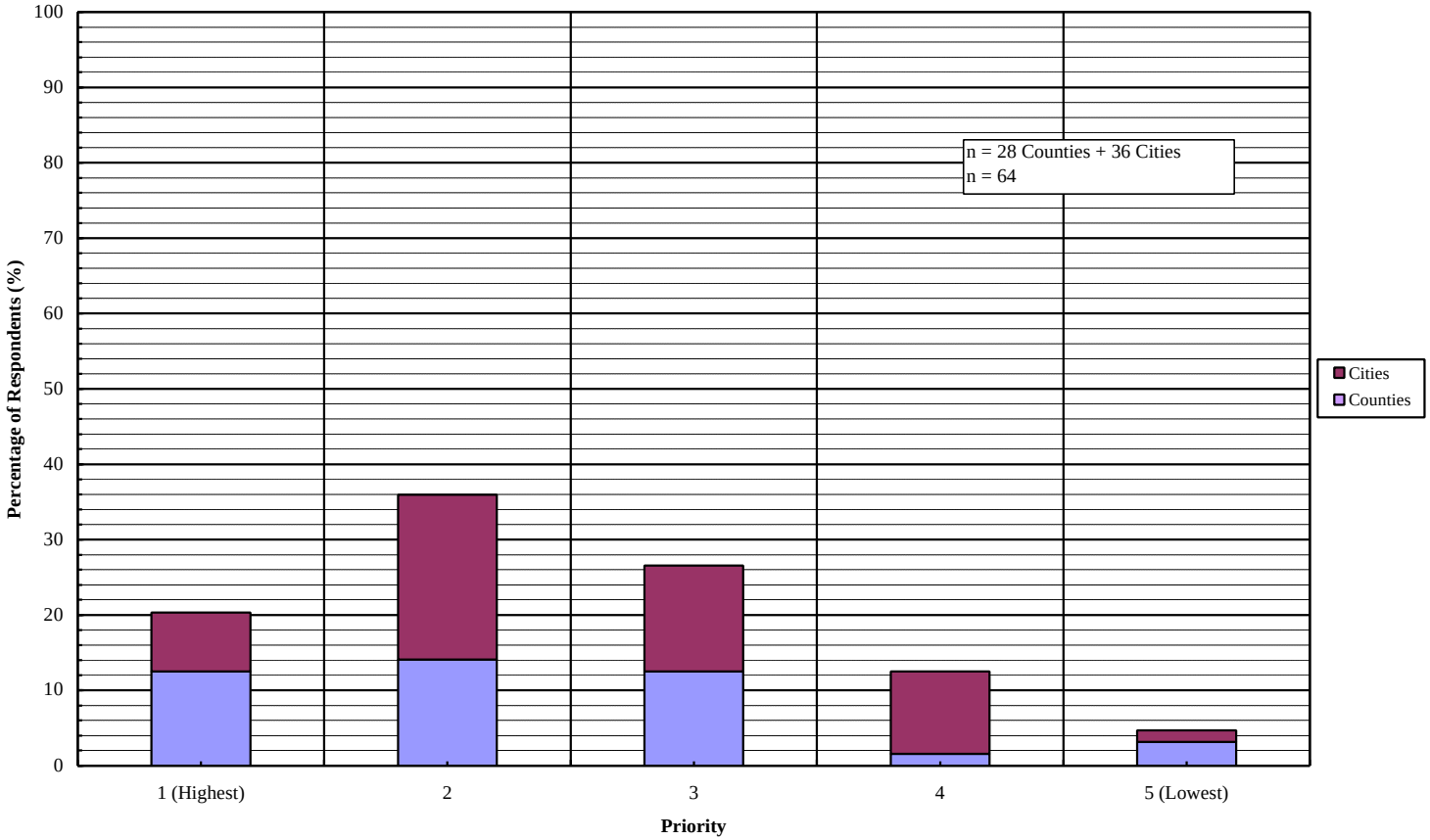


Figure B-18: Priority Ranking for Stormwater Maintenance Problems Attributed to Creek/Stream Related Problems, Including Vegetation Overgrowth and Erosion and Sediment Deposition Problems

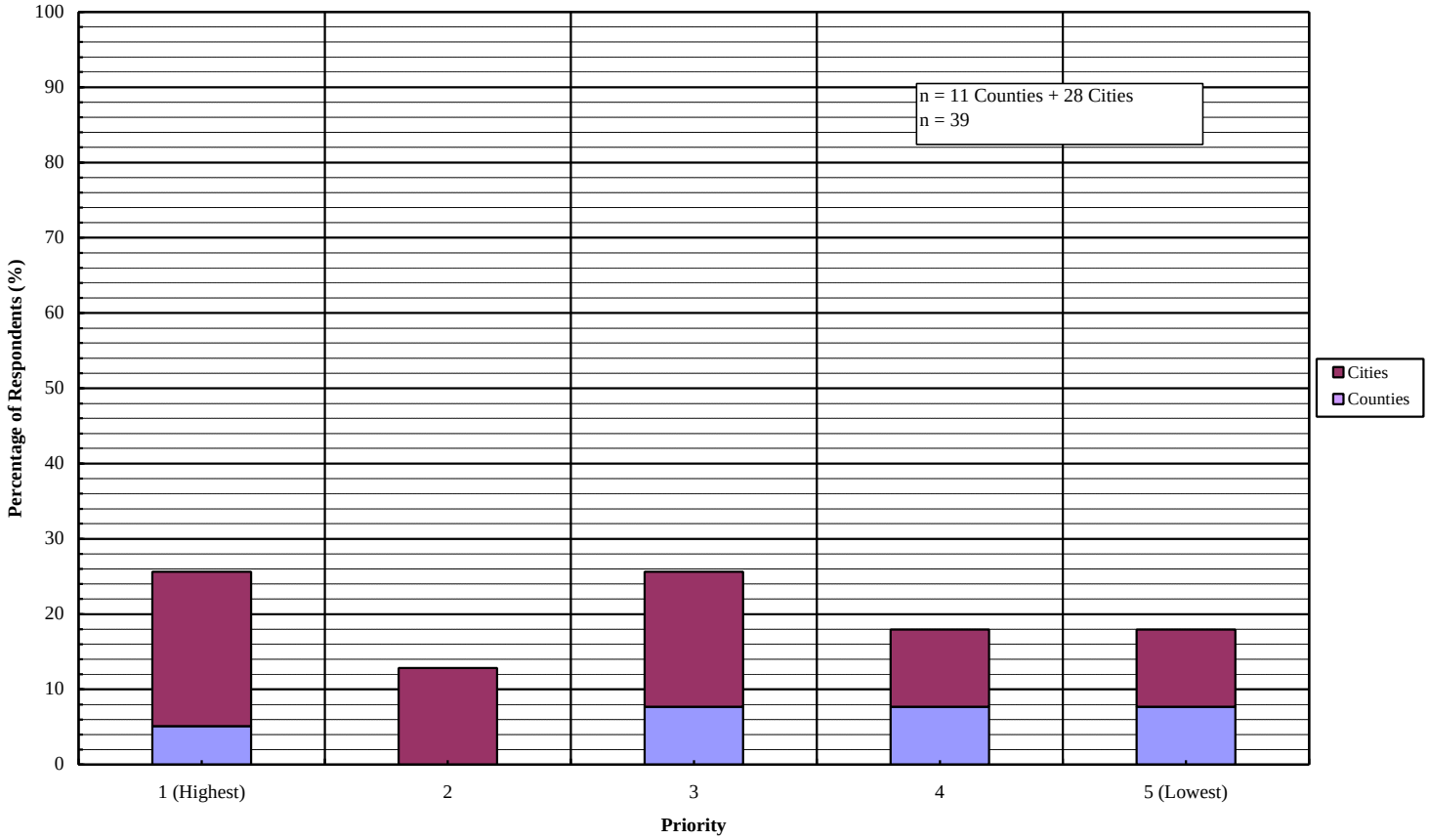


Figure B-19: Priority Ranking for Stormwater Maintenance Problems Attributed to the Obstructions of Catch Basins, Including Obstructions Attributed to Sediment Deposition Problems

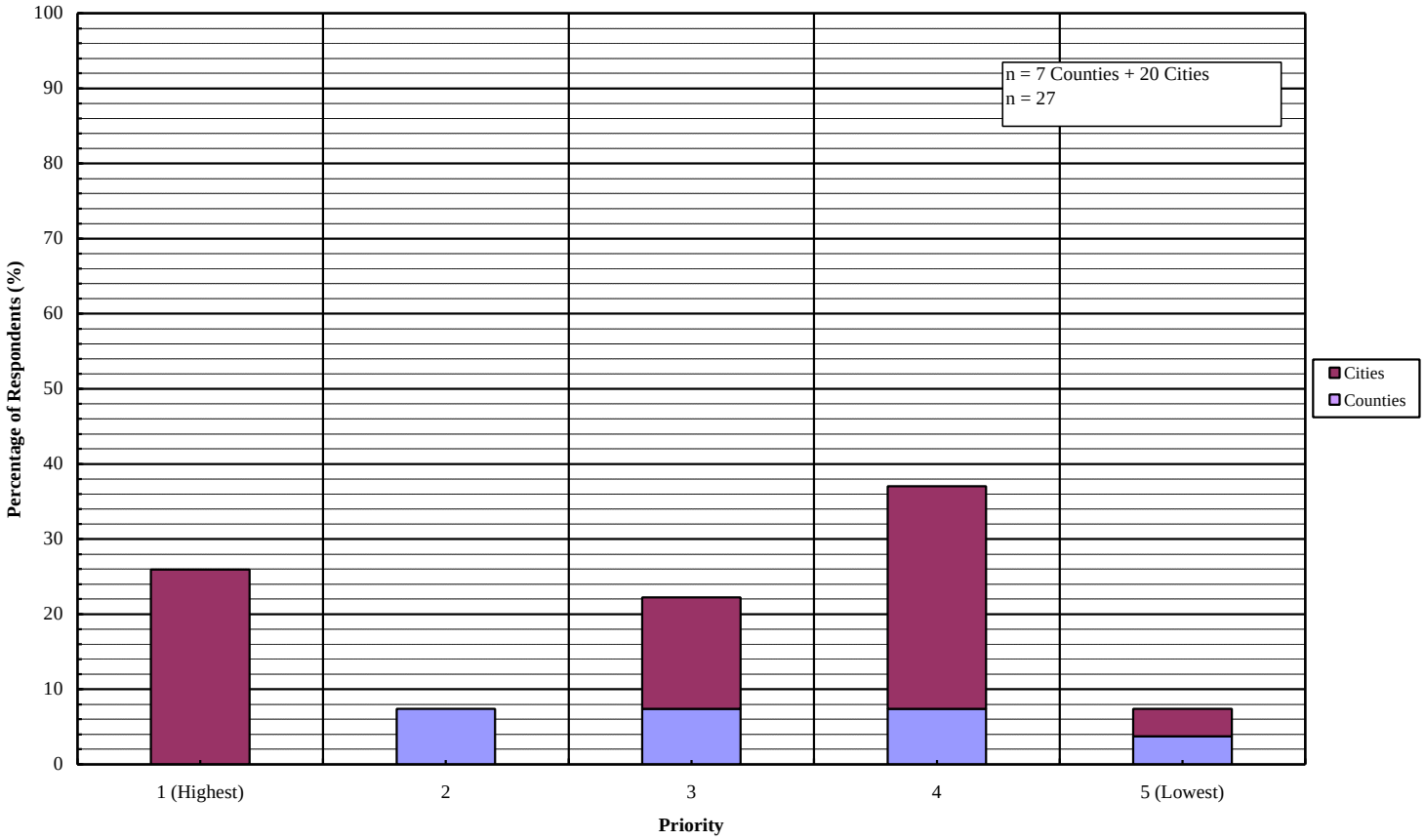


Figure B-20: Priority Ranking for Other Reported Stormwater-Related Maintenance Problems

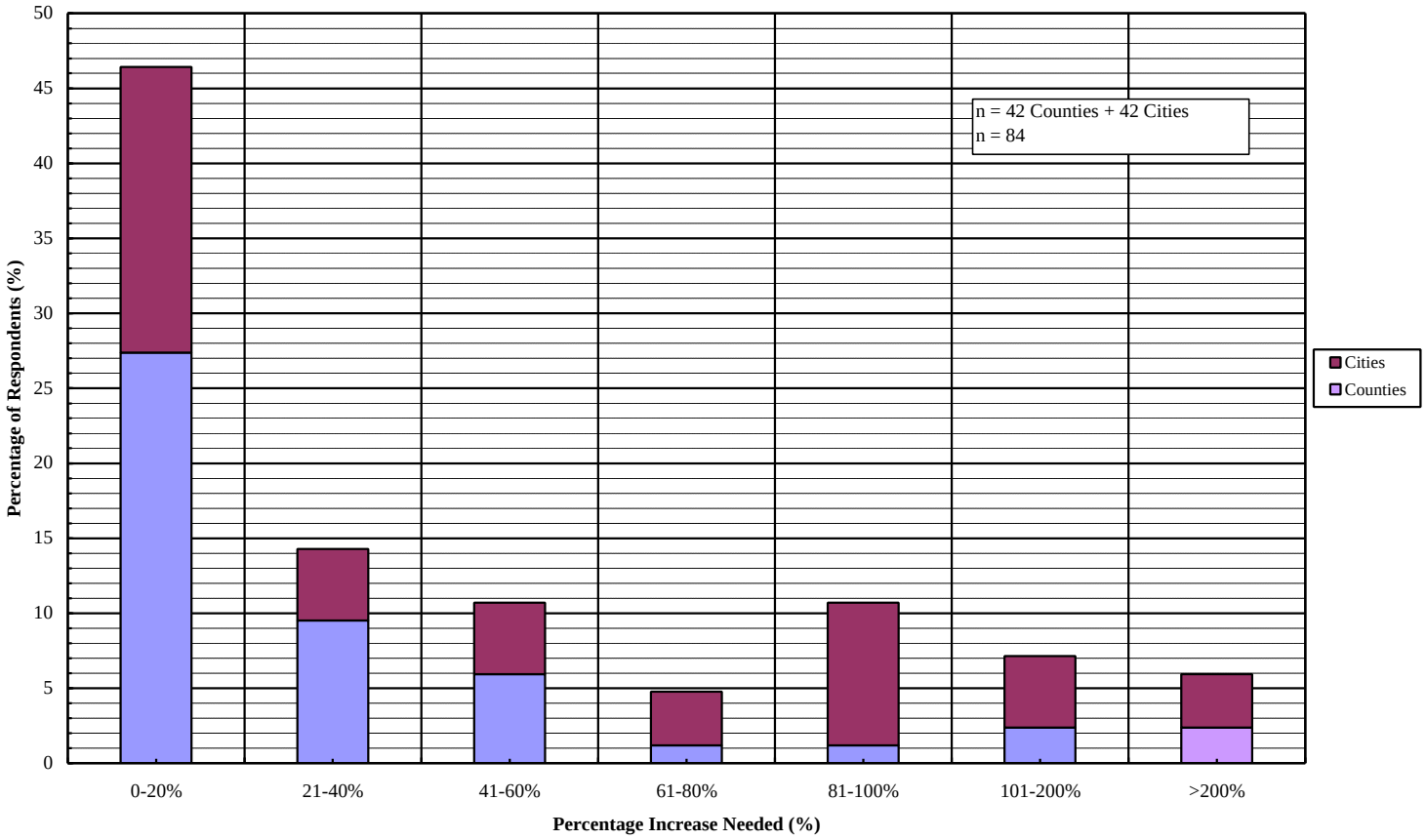


Figure B-21: Needed Percentage Increase in Yearly Budget

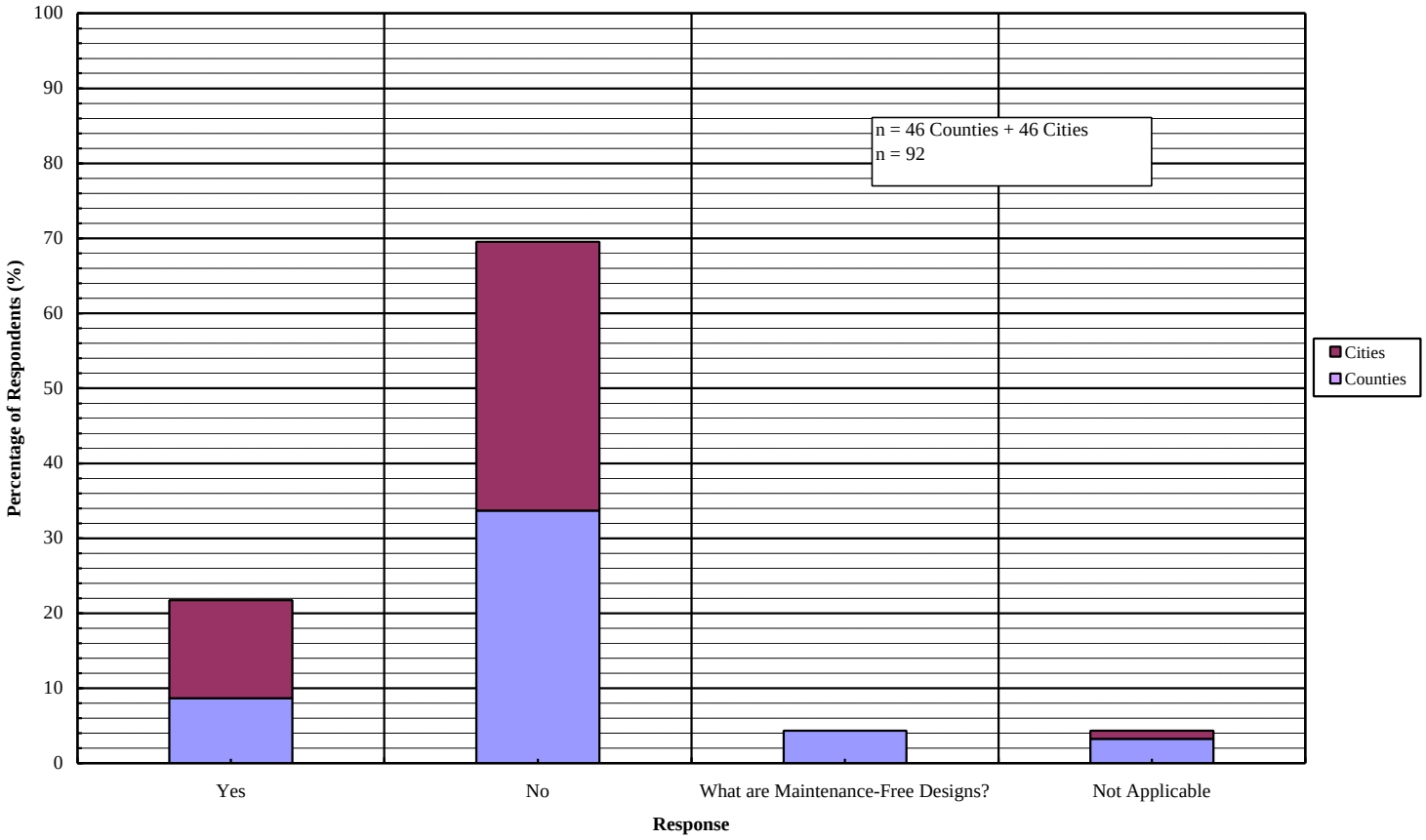


Figure B-22: Are "Maintenance-Free" Designs Encouraged?

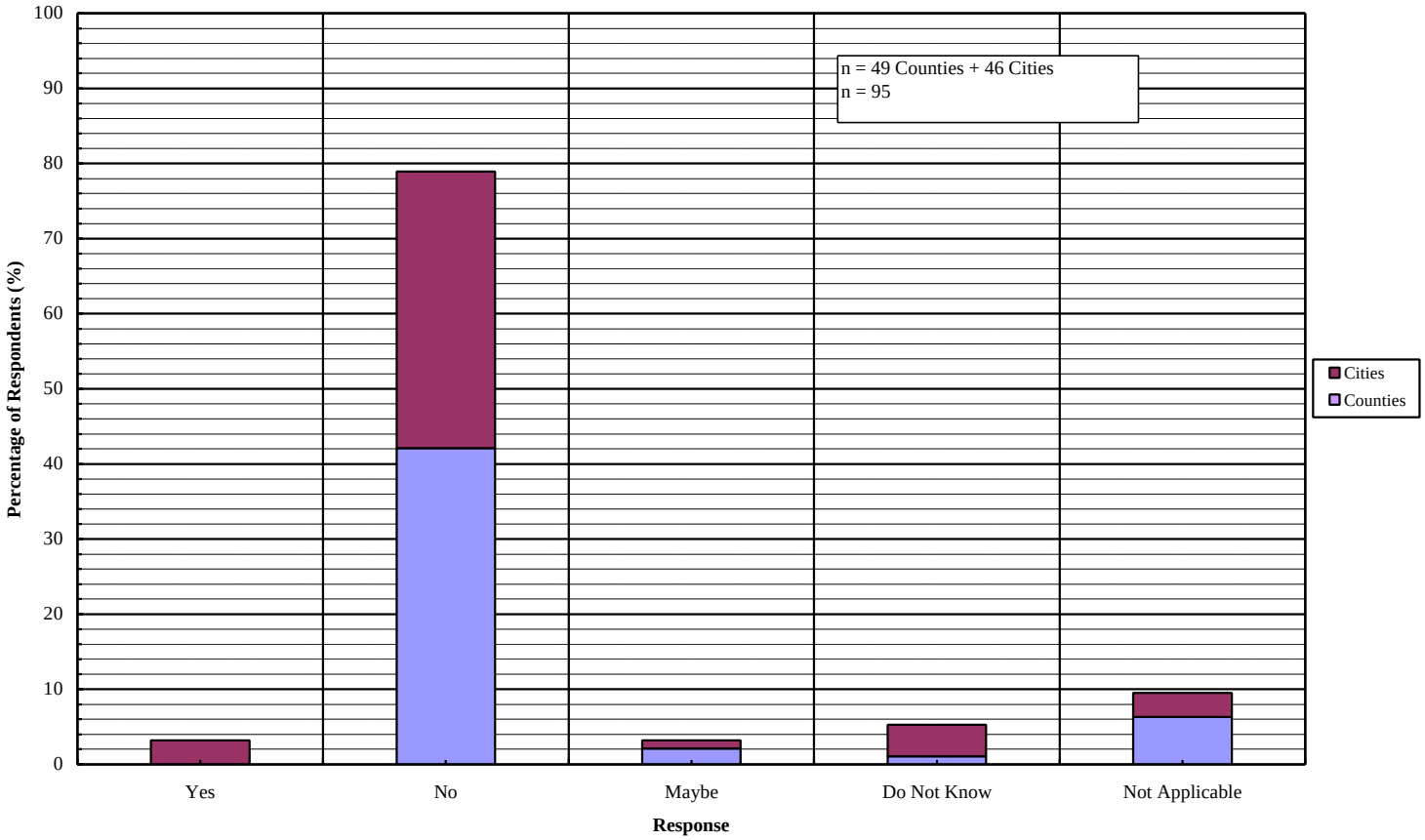


Figure B-23: Would Community Officials be Receptive to a Stormwater Utility Fee?

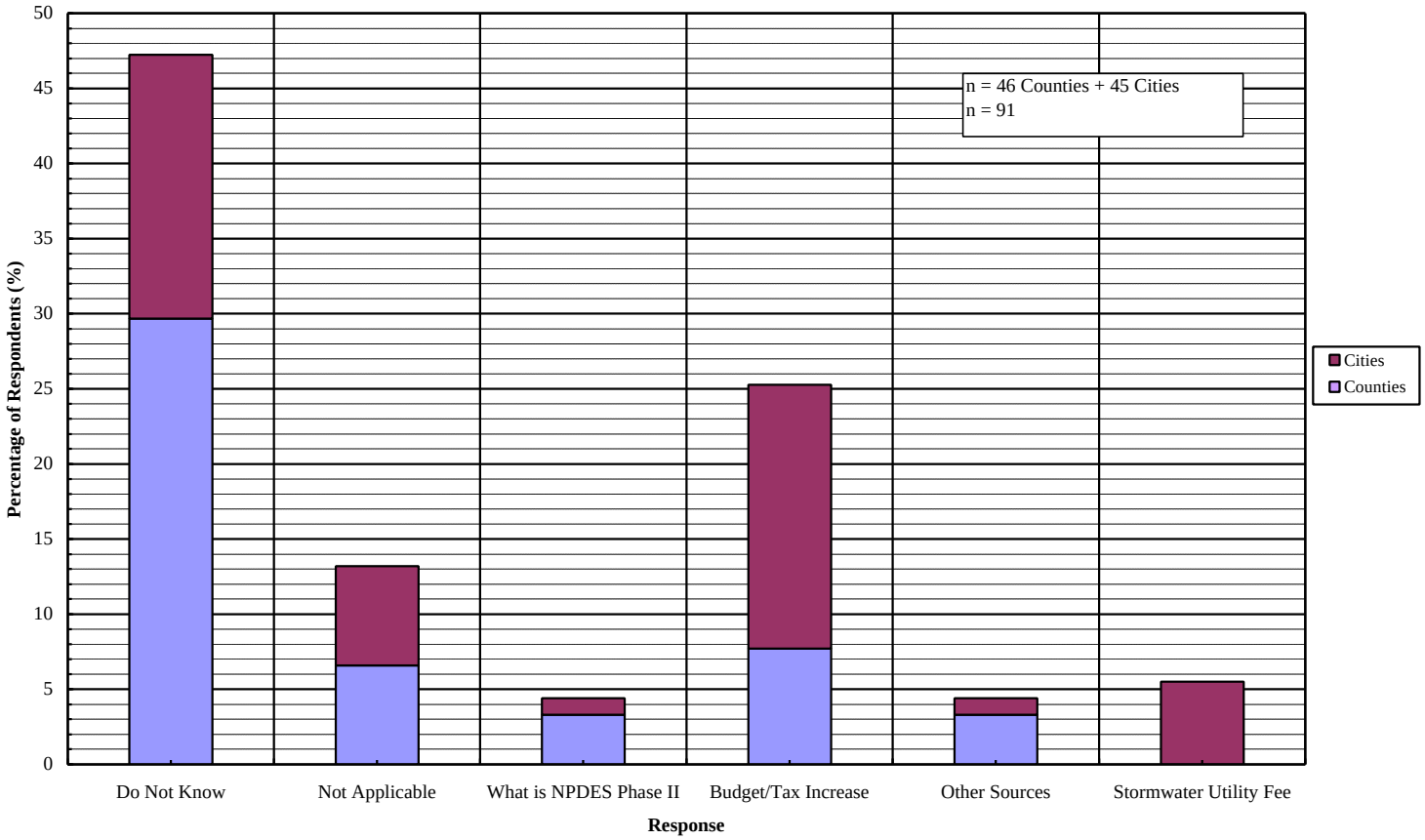


Figure B-24: How Local Governments Plan to Fund the NPDES Phase II Mandates

Appendix C

Comments from Stormwater Maintenance Program Survey Questionnaire

The comments associated with Question 2 were:

- The Street Maintenance Department is only responsible for the County roads
- Our County has steep mountainous terrain that is prone to flash flooding and we try to design all culverts and bridges for 100-year/24-hour events
- $800,000 was spent in an exceptional year to replace washed out bridges, unsafe bridges and tiles throughout the entire County
- This estimation includes bridges and culverts (new and repaired) with some allowance for ditching and channel lining, however no equipment maintenance or overhead/support is included
- This depends on how many storms we have and how bad the storms are
- This is for re-establishing ditchlines, cleaning debris from under bridges and mowing of vegetation
- This includes labor and materials
- The Highway Department performs a great deal of ditch work each year and installs drain pipes, however heavy rains can still cause flooding and drainage problems along bridges and pipes
- This is estimated on $1,712,000 total street/drainage budget
- This is for materials only, our work crews are teamed together such that labor costs for all types of maintenance are mingled together
- The City has just initiated a stormwater management program to identify needs and corrective actions
- Developers expend much more in site drainage, retention, etc
- This varies from year to year (2 respondents)
- I have requested $20,000 for the next budget year to be used just for stormwater
- We are a new town and have no sewer or stormwater services
- We do very little work in this area

The comments associated with Question 3 were:

- We are still replacing culverts/ditches which were undersized in the past and I have been in office about 3.5 years
- The County Highway Department performs regular preventative maintenance on bridges and ditches and culverts are usually left in place until failure or problems occur, although they are inspected regularly
- When there is a creek or culvert located on private property, the property owner is responsible for the portion located on their property
- Budget constraints do not allow a highly proactive program for maintenance
- We already have a preventative maintenance program
- This varies from year to year

The comments associated with Question 4 were:

- Loggers create problems because the silt runs from clear cut areas and the telephone company stops up ditchlines when they bury cables
- We have over 1000 miles of County roads to maintain and the accumulation of leaves and trash is a big problem
- Most of the stormwater problems are due to unwise development, which occurred before stormwater regulations were adopted in 1979
- Tiles and bridges become obstructed by tree branches and debris
- The problems that usually show up in extreme flooding events are associated with accompanying drift and erosion/siltation problems
- The County's geography consists of hills, hollows, metal tiles, wooden bridges and no watershed program, so when we have heavy rainfall, we have damage to our roadways and have to repair them
- The rural roads have more travel and homes now, so therefore more water runs off. Also leaves from trees cause major problems during the fall of the year because people rake their leaves into the County roadway ditches, which causes drain pipes to stop up
- 40% of the problems come from inadequate design and another 40% comes from urban growth
- The main problems are siltation and reduced flow rates in ditches from vegetation and debris
- We are currently working with the Army Corps of Engineers to remedy a "big" problem with the main creek that traverses the City
- Most problems are caused by leaves and silt in pipes and ditches
- Many problems are due to outdated designs
- About 50% of our drainage system is outdated
- All of the stormwater costs are related to road maintenance

The comments associated with Question 5 were:

- Legal basis or court ordered has never occurred
- On priority setting, we really mobilize after significant rains, find most of the major problems ourselves, follow up on complaints and then return to a regular schedule
- All stormwater problems are top priority

The comments associated with Question 6 were:

- The second question depends if the system extends from public property onto the property owner
- On the second question, the Public Works Department often assists the property owners.
- On the third question, the County/City only maintains the road frontage, while the property owner maintains the rest
- The third question falls into a gray area and depends on a site by site analysis (3 respondents)
- We on occasion perform adjacent ditch work with the property owner's approval, but most situations are left up to the property owner
- For the third question, the County will maintain only the portion located on County property
- For the third question, any maintenance activities will only be performed under emergency situation such as structural flooding
- If there is a problem existing on private property and is or may cause a problem on public property, the County works with the property owner to correct and prevent future problems
- The third question depends if there is an easement

The comments associated with Question 7 were:

- The County responsibilities only cover County roads
- There are no stormwater handling facilities located within our jurisdiction (5 respondents)
- This is never done as a routine, stormwater handling facilities are only visited when a complaint or request is received (11 respondents)
- We have area supervisors who are assigned districts in which they are responsible for
- The ordinance to allow this inspection and to force compliance is in the final draft stage
- The City requires an easement be platted around the outlet control structures and outfall piping, therefore the City maintains these structures
- The Public Works Department is responsible for maintenance of these structures and there has not been routine inspections in the past, however routine inspections are planned in this coming fiscal year
- The visits are only made when problems are observed from a “windshield” survey and the adjacent property owner is the responsible party
- Detention requirements have only been implemented recently, so there are very few facilities in place and the Public Works Department attempts to inspect these a couple of times per year
- The City maintains the subdivision stormwater handling facilities
- The City will check these facilities about four times a year to determine if there is any maintenance that is required

The comments associated with Question 9 were:

- The creek and stream banks are becoming highly vegetated and forested, while the water flowing through the creeks and streams are transporting trash and debris (2 respondents)
- Environmental handcuffs have hampered many of our efforts
- Erosion control of construction sites and failed clean up activities are a major problem
- Our biggest problem is that drainage banks and shoulders are higher than the roads
- All of the stormwater related maintenance problems from the question are a high priority
- Lack of enough detention ponds could be more of a problem in the future with more development unless we can make sure new development has plenty of detention ponds

The comments associated with Question 10 were:

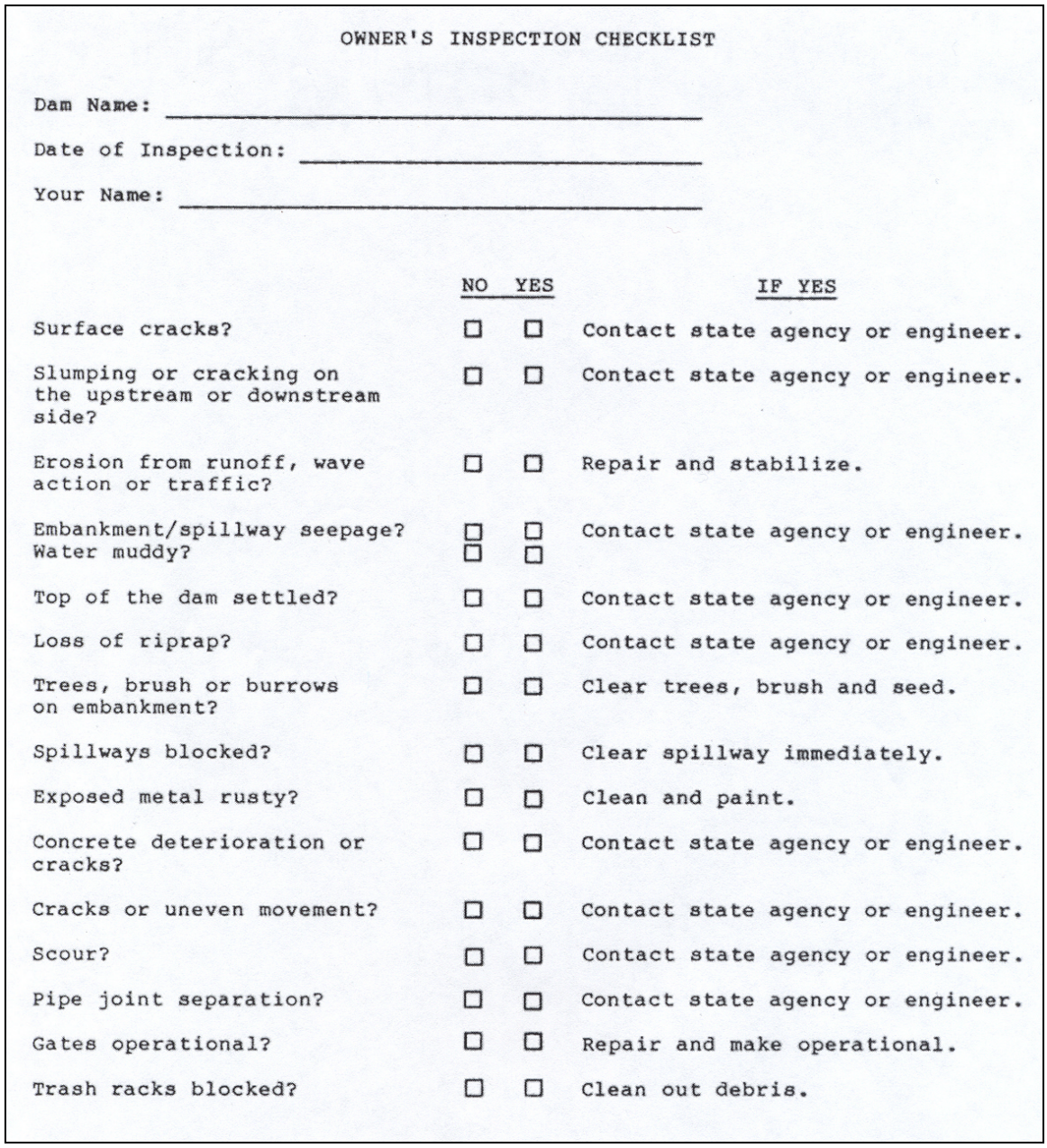
- We need concrete culverts to prevent culverts from washing away and collapsing
- Our budget is spread over paving, gravel, signs, equipment, etc., which results in a minimal amount for preventative maintenance
- We would like to have 100% matching funds from the Federal government to open stream channels like they did on the Mississippi Delta
- We could use at least three times the current amount for rip-rap, concrete structures, sodding or matting and concrete or aluminum culverts
- We need full time staff members, etc.
- We do not have that many problems
- This amount is not considering what will be needed for Phase II
- We will budget the same amount for stormwater maintenance as the previous year
- The current level of funding is adequate for manpower to perform the necessary work
- We need much more that what we get from the State
- We have just begun a process to assess this issue
- A 25% increase would suffice, however, Phase II of the NPDES will likely require the current budget of $60,000 to double
- The current budget is adequate, although some minor increases will be needed to comply with the Phase II mandates
- A comprehensive system would have to be developed for our City, which would be thousands of times greater than the current spending
- This will be what percentage increase we will possibly get for next years budget

The comments associated with Question 11 were:

- In my capacity as Road Superintendent and with my seat on the county wide planning commission, I require all new construction in subdivisions and the resulting connections with the County road system to be as near "maintenance-free" as possible
- Grass swales and buffer areas
- Detention ponds on private property
- We have regulations for builders of subdivisions
- We encourage using rip-rap at curb cuts and other areas where needed
- We have catch basins and retention ponds
- The design is approved by the Planning Commissioner and the County Engineer
- Not only is a maintenance agreement required for detention/retention ponds, trash racks are required for water quality orifices and energy dissipaters are required when necessary
- We prefer open grassed swales to piping and encourage slowing runoff down and allowing for infiltration
- We do encourage “maintenance-free” designs, but we do not know of anything that is actually “maintenance-free”
- This is no such thing as a “maintenance-free” design, stormwater management is an ongoing project
- We encourage retention ponds
- I have designed numerous systems for both “maintenance-free” and maximum flow with obstructions
- We encourage detention ponds and cement lined ditches
- Due to the steep topography, sound engineering practices must be used and there are numerous designs used here

Appendix D

Owner's Inspection Checklist for a Dam



OWNER'S INSPECTION CHECKLIST

Dam Name: _____

Date of Inspection: _____

Your Name: _____

	NO	YES	IF YES
Surface cracks?	☐	☐	Contact state agency or engineer.
Slumping or cracking on the upstream or downstream side?	☐	☐	Contact state agency or engineer.
Erosion from runoff, wave action or traffic?	☐	☐	Repair and stabilize.
Embankment/spillway seepage?	☐	☐	Contact state agency or engineer.
Water muddy?	☐	☐	
Top of the dam settled?	☐	☐	Contact state agency or engineer.
Loss of riprap?	☐	☐	Contact state agency or engineer.
Trees, brush or burrows on embankment?	☐	☐	Clear trees, brush and seed.
Spillways blocked?	☐	☐	Clear spillway immediately.
Exposed metal rusty?	☐	☐	Clean and paint.
Concrete deterioration or cracks?	☐	☐	Contact state agency or engineer.
Cracks or uneven movement?	☐	☐	Contact state agency or engineer.
Scour?	☐	☐	Contact state agency or engineer.
Pipe joint separation?	☐	☐	Contact state agency or engineer.
Gates operational?	☐	☐	Repair and make operational.
Trash racks blocked?	☐	☐	Clean out debris.

Figure D-1: Inspection Checklist for a Dam (STS Consultants Ltd., 1985)

Appendix E

Inspection Checklist for a Detention Pond

Detention Pond Inspection Checklist

Location of Detention Pond: _____

Date of Inspection: _____

Name of Inspector: _____

A yes answer to any of these items should result in corrective action or a call to a professional inspector or engineer.

	Yes	No	N/A	Comments
1. Does the earthen dam's embankment slopes, side slopes or crest show signs of settling, cracking, bulging or other structural deterioration?	___	___	___	
2. Is there embankment seepage or seepage around or under the spillway? Is the water muddy?	___	___	___	
3. Are trees or brush present on the embankment?	___	___	___	
4. Are animal burrows present in the embankment?	___	___	___	
5. Do the embankments show signs of significant erosion?	___	___	___	
6. Does the emergency spillway show signs of significant erosion?	___	___	___	
7. Do the side slopes show signs of significant erosion?	___	___	___	
8. Do the inlet or outlet structures show signs of significant erosion?	___	___	___	
9. Does the channelway show signs of significant erosion?	___	___	___	
10. Is there debris or other obstructions blocking the principal outlet or emergency spillway?	___	___	___	
11. Is the outlet pipe damaged or otherwise not functioning properly?	___	___	___	
12. Is there debris or silt clogging the extended detention outlet control?	___	___	___	
13. Is there debris or other obstructions affecting the performance of trash racks or anti-vortex devices?	___	___	___	
14. Is there sufficient sediment accumulation that needs to be removed from the pond?	___	___	___	
15. Do grassed areas require mowing and/or are clippings building up?	___	___	___	
16. Is there water standing in inappropriate areas?	___	___	___	
17. Are there signs of vandalism, especially around and inside the principal outlet, which would impair the safe and effective operation of the pond? This includes the use of the pond area for neighborhood trash and yard waste or filling the pond area in by adjacent homeowners.	___	___	___	
18. Do the fence, gate, lock or any other safety devices need repair?	___	___	___	

Figure E-1: Inspection Checklist for a Detention Pond

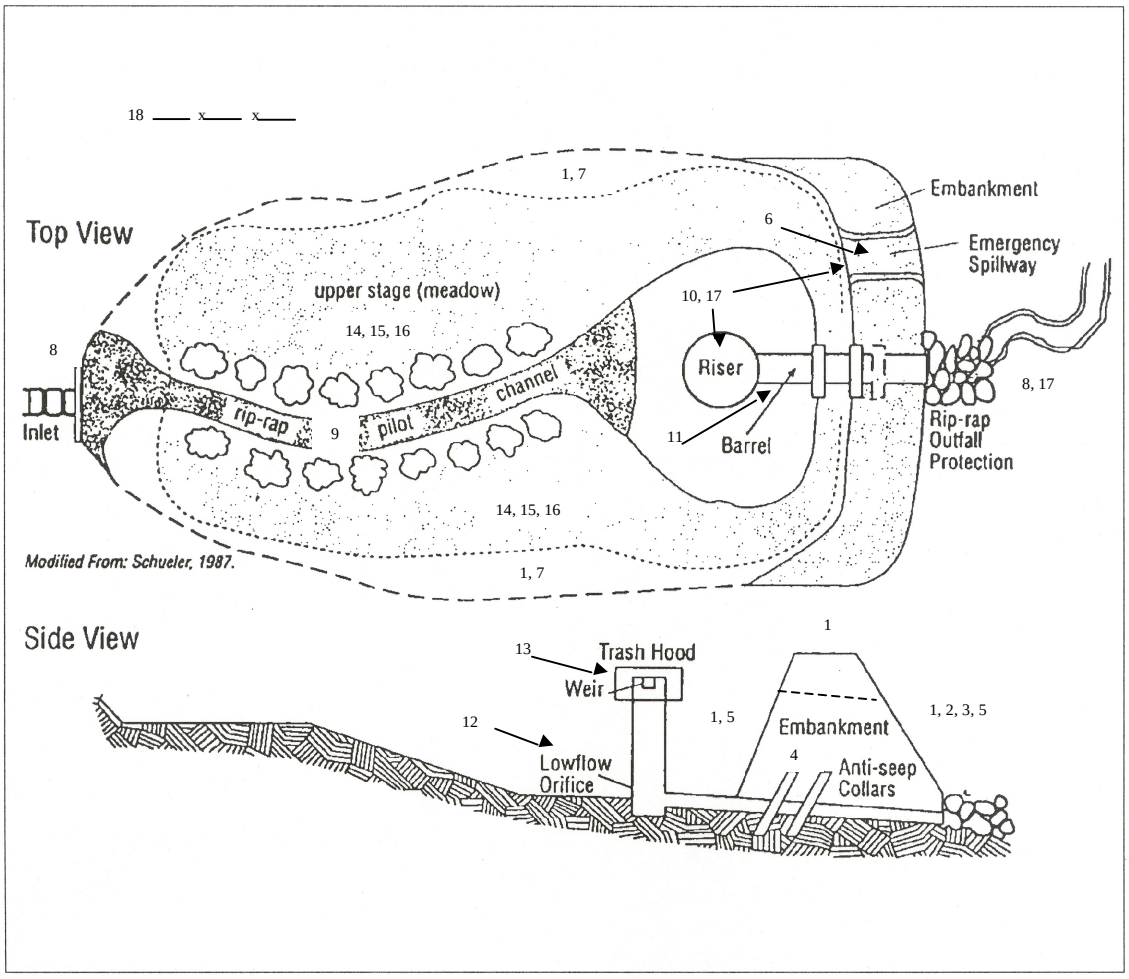


Figure E-2: Detention Pond Schematic for the Inspection Checklist (Gesier, 2000)

Appendix F

Stormwater Maintenance Protocols

Table F-1: Detention Pond Maintenance Protocol

Problem Areas	Hydraulic/Other Effect(s)	Possible Cause(s)	Corrective Action(s)
Storage volume is inadequate	• Dam overtopping • Inadequate stormwater control • Possible dam failure • Downstream Flooding	• Excessive sediment from watershed • Dam settlement • Deliberate filling by property owner • Inadequate engineering design • Inadequate construction	• Periodic inspections and inspections after major storm events • As-built inspections • Regular maintenance • Effective erosion and sediment control management • Raise the dam height • Allow for settling and sediment in design • Require qualified professional engineer and contractor in the design/build phase
Actual dam height lower than design height	• Dam overtopping • Possible dam failure • Inadequate stormwater control • Increased downstream flooding	• Dam settlement • Dam not built as designed • Dam crest eroded	• Periodic inspections • As-built inspections • Raise dam height • Erosion management • Require qualified professional engineer and contractor in the design/build phase
Partially- or completely-clogged: outlet control, principal riser or emergency spillway	• Dam overtopping • Possible dam failure • Pond remains full for next storm • Inadequate stormwater control • Increased downstream flooding	• Inadequate maintenance • Excessive litter or sediment from watershed • Pond is overgrown • Vandalism	• Periodic inspections and inspections after major storm events • Regular maintenance • Effective litter and erosion management • Trash racks • Citizen cleanup and education programs • Install fencing, gates, locks and signs
Muddy seepage or discharge: downstream toe, drain pipe or embankment	• Possible dam failure • Excess sediment deposited downstream • Property damage • Embankment collapse	• Inadequate mowing schedule • Trees roots located in embankment • Animal burrows in embankment • Erosion of embankment slopes, side slopes, inlet or outlet areas, channelway, emergency spillway • Poorly compacted embankment • Internal erosion or piping	• Periodic inspections of downstream toe, embankment and outlet area • Animal control • Tree and vegetation control • Any embankment work requires qualified professional engineer • Anti-seep collars for drain pipe
Vandalism	• Pond remains full for next storm • Dam overtopping • Possible dam failure • Increased downstream flooding • Inadequate stormwater control	• Primary outlet structure blocked or damaged • Inlets, outlets or spillways clogged	• Regular inspections • Install fencing, gates, locks and signs • Neighborhood Watches

Adapted from (Tschantz, 2000)

Table F-2: Pipe/Culvert Maintenance Protocol

Problem Areas	Hydraulic/Other Effect(s)	Possible Cause(s)	Corrective Action(s)
Partially- or completely-clogged pipe/culvert, including damaged inlets and outlets	• Flow capacity reduced • Local flooding • Damage to local property • Hazardous street flooding • Mosquito breeding area	• Blockage due to debris, tree roots, litter or silt • Blockage due to a collapse • Joint misalignment and separation • Pipe/culvert deterioration • Vehicular traffic running over inlet and outlet ends of pipe/culvert • Inadequate slope of pipe/culvert or ditchline	• Periodic inspections • Regular maintenance • Street sweeping • Lining inserts • Effective litter and erosion management • Trash racks • Protected inlet and outlet ends • Seal joints or defects in pipe/culvert • Kill tree roots with chemicals or physically remove tree roots • Use reinforced concrete instead of corrugated metal • Check slope of pipe/culvert or ditchline • Citizen roadside cleanups
Sunken areas or depressions above pipe/culvert	• Local flooding • Damage to local property • Hazardous street flooding	• Possible collapse or damage in pipe/culvert • Pipe/culvert settlement • Joint misalignment • Pipe/culvert deterioration • Inadequate bed material • Inadequate fill over pipe/culvert	• Periodic inspections • Regular maintenance • Use reinforced concrete instead of corrugated metal • Repair or replace defective pipe/culvert • Seal joints or defects in pipe/culvert • Require a qualified professional engineer for design

Table F-3: Catch Basin Maintenance Protocol

Problem Areas	Hydraulic/Other Effect(s)	Possible Cause(s)	Corrective Action(s)
Standing water in catch basin	• Flow capacity may be reduced • Mosquito breeding area	• Downstream pipe system may be blocked • Outlet entrance may be blocked with debris, litter or silt	• Periodic inspections and inspections after major storm event • Regular maintenance • Effective litter and erosion management • Regular street sweeping • Citizen cleanup and education programs
Runoff unable to enter catch basin	• Runoff ponds in street creating hazard • Possible property damage • Possible hydroplaning • Pedestrian inconveniences	• Catch basin may be filled with debris, litter or silt • Grate may be blocked with debris and litter • Ineffective catch basin capacity • Asphalt pave over • Inadequate design elevation	• Periodic inspections • Regular maintenance • Effective litter management • Regular street sweeping • Redesign and replace catch basin • Citizen cleanup and education programs
Damage to grate and/or curb iron	• Runoff ponds in street creating hazard • Possible damage to vehicles • Hazard to pedestrians, children and bicycles	• Vehicle has damaged grate and/or curb iron • Maintenance and inspection oversight • Deterioration	• Periodic inspections • Repair or replace grate and/or curb iron

Table F-4: Open Channel Maintenance Protocol

Problem Areas	Hydraulic/Other Effect(s)	Possible Cause(s)	Corrective Action(s)
Excessive vegetation overgrowth	• Increased flow resistance • Decreased flow rates • Increased flood heights • Can cause possible channel obstructions • Out of bank flooding and property damage	• Growth of non-native vegetation • Inadequate stream bed and bank maintenance	• Periodic inspections • Regular maintenance • Selective use of herbicides (check regulations)
Eroding banks and channel bottoms	• Bank undercutting • Erosion problems • Sediment deposition in channel	• Loss of stream bank erosion control • Channel dredging • Loss of protective vegetation/rip-rap • Major flooding events	• Periodic inspections • Regular maintenance • Restore erosion control • Slope back banks • Restore protective vegetation/rip-rap
Obstructions caused by litter and debris	• Reduced flow capacity • Increased flood heights • Out of bank flooding and property damage • Aesthetic needs	• Uncontrolled litter or sediment from watershed • Deliberate floodway or floodplain filling	• Periodic inspections • Regular maintenance • Effective litter and erosion management • Effective floodway and floodplain regulations • Citizen cleanup and education programs
Sediment deposition	• Reduced flow capacity • Increased flood heights • Out of bank flooding and property damage • Change in channel characteristics • Destabilizes stream habitat and aquatic life	• Lack of erosion and sediment control upstream in watershed • Loss of protective vegetation/rip-rap • Upstream channel dredging • Local construction by riparian owners, utilities and local government	• Periodic inspections • Regular maintenance • Restore erosion control • Slope back stream banks • Restore protective vegetation/rip-rap • Effective construction regulations • Dredging and channel cleaning (Follow appropriate regulations)

Table F-5: Bridge Obstruction Maintenance Protocol

Problem Areas	Hydraulic/Other Effect(s)	Possible Cause(s)	Corrective Action(s)
Obstructions at bridge openings	• Reduced channel capacity • Increased backwater flood heights • Concentrated flows may cause erosion of embankments and under pier footings • Bridge overtopping • Local traffic hazards • Property damage	• Excessive sediment buildup • Inadequate design and construction • Inadequate maintenance • Excessive trash and debris buildup • Increased upstream development causes increased frequency and levels of flow • Uncontrolled utility construction	• Periodic inspections • As-built inspections • Regular maintenance • Effective litter and erosion management • Citizen cleanup and education programs • Require a qualified professional engineer and contractor • Reroute utility lines around bridge openings
Local scouring and erosion of embankments and under pier footings	• Erodes bed material around footing and banks • Possible pier and bridge failure condition	• Excessive litter or sediment from watershed • Excessive and concentrated water velocities • Inadequate designs • Inadequate construction • Inadequate maintenance	• Periodic inspections and inspections after major flood events • Regular maintenance • Reassess and replace bridge design • Effective litter and erosion management • Citizen cleanup and education programs • Rip-rap to stabilize footers • Require qualified professional engineer

Vita

Jacob Shea Chandler was born in Kingsport, Tennessee on July 24, 1976. He graduated from high school in June 1994 and entered the University of Tennessee, Knoxville in the fall of 1994. He graduated in May 1999 with a Bachelor of Science degree in Civil Engineering. He then entered the Environmental Engineering graduate program at the University of Tennessee, Knoxville in the summer of 1999.

Mr. Chandler worked part-time throughout much of his college career for the City of Knoxville, Tennessee Engineering Department in the Stormwater Management Department. He began employment at the University of Tennessee, Knoxville as a Graduate Teaching Assistant as a hydraulics (CE 390) lab instructor, computer lab monitor and finally a computer lab manager.