ABSTRACT

PROTECTION OF THE NEW YORK CITY WATER SUPPLY LAND DEVELOPMENT THREATS AND THE PROGRAMS TO CONTROL THEM

by
Werner Mueller

The Surface Water Treatment Rule under the Safe Drinking Water Act requires that all surface water sources used for drinking water must be filtered, unless the purveyor can demonstrate that the water is of such high quality that filtration is not required. The New York City Department of Environmental Protection (DEP) operates the New York City water supply system and is taking actions to ensure that the water supplied from the Catskill – Delaware system remains of high enough quality to maintain an avoidance of filtration determination granted by the Environmental Protection Agency (EPA). New watershed rules and regulations have been adopted to govern land development activities, and to address pollutants that may be carried into the water supply system with storm water runoff from new impervious surfaces.

This paper presents an overview of the pollution threats presented by new land development, outlines the evolution of the regulatory requirements controlling storm water management, and attempts an assessment of the effectiveness of the current regulatory initiatives. A land development scoring system is proposed to measure the rate of storm water management implementation and the impacts of the new regulations. The result of the research demonstrates that insufficient time has passed since the adoption of the watershed rules and regulations to allow a proper measure of their effectiveness. Finally, the land development scoring system is proposed as a simplified method for use by the DEP in monitoring the effect of the regulations as future land development activities take place.

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by
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To Lisa, Rae and Lee for providing continual inspiration

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TABLE OF CONTENTS

Chapter **Page**

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Purpose

Much of the New York City water supply originates in rural areas located north and west of the City. The water supply watershed west of the Hudson is known as the Catskill-Delaware system. Water supplied from this system is currently unfiltered and has come under the scrutiny of the EPA. The Surface Water Treatment Rule under the Safe Drinking Water Act requires that all surface water sources used for drinking water must be filtered, unless the purveyor can demonstrate that the water is of such high quality that filtration is not required. The New York City Department of Environmental Protection (DEP) operates the City water supply system and is taking actions to ensure that the water supplied from the Catskill – Delaware system remains of high enough quality to maintain an avoidance of filtration determination granted by the Environmental Protection Agency (EPA). As part of this initiative, the New York City DEP has entered into a watershed agreement with local communities located within the Catskill – Delaware watershed. This agreement incorporates new watershed protection rules and regulations. An integral part of these rules regulate land development activities to address pollutants that may be carried into the water supply system with storm water runoff from new impervious surfaces.

The research undertaken herein presents an overview of the pollution threats presented by new land development, outlines the evolution of the regulatory requirements controlling storm water management, and attempts an assessment of the effectiveness of the current regulatory initiatives. The New York State permit requirements in conjunction with the New York City Watershed Rules and Regulations are examined to determine how they bring about change in storm water management practices incorporated into new land developments. The analysis compares between two time periods, before and after the adoption of the Watershed Rules and Regulations. A land development scoring system is proposed to measure the rate of storm water management implementation, and how the new regulations have impacted that rate.

1.2 The New York City Watershed

In the year of 1832, human waste filtering into Manhattan's groundwater contaminated the City's only supply of drinking water. This contamination resulted in the deaths of over 3,500 residents (New York Times, Aug. 31, 1997) and forced legislators to acknowledge the need to develop a source of plentiful clean drinking water to protect the City's resident and to ensure future growth. Two years after the epidemic, the State Legislature granted the City the right to condemn land and obtain water rights in rural regions to the north. By 1836, the first aqueduct and the Croton Dam were being constructed, becoming operational by 1842. During the ensuing decades, the City routinely condemned homes, farms and entire villages to make way for dams and reservoirs, creating the Catskill and Delaware Systems. The City has maintained a complicated network of reservoirs and aqueducts for over 15 years to provide residents with what many consider to be one of the best water sources for a large city. This network provides 1.4 billion gallons of drinking water every day from a network of 19 reservoirs in a 1,969 square mile watershed that extends 125 miles north and west.

Increasing incidences of giardiasis nationwide amongst people consuming surface waters has raised concerns over the purity of previously unsuspected water sources. Giardiasis is caused by ingestion of a protozoan, *Giardia Lamblia*, found in the fecal discharge of infected animals including humans (Okun, Craun, Edzwald, Gilbert, Rose, March 1997). In response to increasing incidences of the infection, the EPA promulgated The Surface Water Treatment Rule (SWTR) in 1989 in an amendment to the 1986 Safe Drinking Water Act. The SWTR requires that all surface water sources be filtered. However, a water purveyor can gain an "avoidance of filtration" ruling if the source is of high quality and is adequately protected, specified turbidity and fecal coliform levels are not exceeded, adequate disinfection is provided, and no outbreaks of waterborne diseases have occurred.

Currently the City does not filter the drinking water that it delivers to its 1.4 billion customers. The purity of the water is dependent upon the quality of the source. The only treatment consists of chlorine applied at the effluent chamber and at shaft 18 of the Catskill and Delaware Water Supply System (Okun). Meanwhile, City reservoirs are under pressure from pollutants including runoff from dairy farms, dumped sewage, leaking septic systems, wastewater treatment plant discharges, and runoff from developed areas. Under the SWTR, New York City has agreed to provide filtration for the older Croton System which is suffering under the greatest pollution threats. However, according to the DEP, the Catskill – Delaware system represents a high quality source. DEP has estimated that filtration of the Catskill - Delaware would require construction of the world's largest filtration facility having an estimated construction cost of $5 billion and annual operating costs of $300 million. Under the SWTR, the City is required to filter its Catskill - Delaware Supply unless it can meet criteria established by the EPA to avoid filtration.

In response to requests by the New York Department of Environmental Protection (DEP), the EPA announced an interim decision on January 19, 1993 granting New York City permission to avoid filtration until December 31, 1993. By meeting a list of some 70 conditions set forth at that time by the EPA, New York's avoidance of filtration was extended to December 31, 1996. With the November 2, 1995 adoption of a watershed agreement that united the watershed communities, New York City, New York State, the EPA, and environmentalists in support of an enhanced watershed protection program, the EPA once again extended the avoidance of filtration determination to December 31, 1999. With the formal signing of the agreement on January 21, 1997, the avoidance of filtration determination was extended to December 31, 2002

1.3 The Watershed Agreement

The Watershed Memorandum of Agreement signed on January 21, 1997, unites the watershed communities, New York City, New York State, the EPA and environmentalists in support of a comprehensive watershed protection program for the New York City drinking water supply. The watershed agreement represents a breakthrough between the City and the watershed communities. The historic imposition of watershed controls and the condemnation of private lands during the development City's water supply system had created an atmosphere of confrontation between the City and upstate communities.

This atmosphere of opposition allowed the quality of the New York City water supply to degrade while the City and watershed communities bickered over who had the right to control the ultimate disposition of watershed lands. The point of controversy was most often based on community concerns that controls implemented by the City would restrict economic development of the region. The watershed agreement addresses these concerns and represents a compromise that depends on cooperation between all involved parties. However, many detractors of the agreement believe that the compromise does not adequately protect water quality. They believe that the agreement provides too many loopholes, allowing the continuing development of watershed lands, ultimately resulting in a degraded water supply and the need for the construction of a filtration plant.

The watershed agreement defines three principal elements of a watershed protection program which include:

- Land Acquisition and Stewardship Programs,
- Watershed Protection and Partnership Programs, and
- Watershed Regulations

The Land Acquisition Program implemented under a permit issued by the State of New York Department of Environmental Conservation (NYSDEC) enables the City to purchase land or conservation easements on undeveloped areas near reservoirs, wetlands, or watercourses. The City anticipates spending \$250 million within the Catskill – Delaware system using a voluntary system that avoids condemnation, and includes consultation with the watershed communities to ensure that the interests of watershed towns and villages are considered.

The Watershed Protection Partnership promotes and institutionalizes cooperation and planning through the creation of the Watershed Protection and Partnership Council, the Catskill Watershed Corporation, and the Catskill Fund for the Future. The Watershed Protection and Partnership Council serves as a regional forum for the discussion and review of water quality concerns and related watershed issues. The Catskill Watershed Corporation is a locally based non-profit organization that administers the funds committed by the City for the enhancement of water quality and economic development programs west of the Hudson. In conjunction with the State Environmental Facilities Corporation, the Catskill Watershed Corporation will manage the Catskill Fund for the Future which will be used as an economic development bank issuing loans to support responsible, environmentally sensitive projects in the west Hudson watershed.

The Watershed Regulations are the third principle element of the watershed agreement and will replace antiquated regulations over 44 years old. The new regulations attempt to improve the protection of the water supply while permitting responsible development in existing population centers. These new regulations establish standards for the design, construction and operation of wastewater treatment plants, set design standards and setbacks for septic systems, and require the implementation of storm water control measures for a variety of commercial, residential, institutional and industrial projects.

The quality of the drinking water supplied to the City and upstate communities which draw from the New York City water supply depends on the quality of the source waters which feed the reservoirs. Both the source waters and the reservoirs are vulnerable to degradation and contamination from various sources and activities. The potential sources of degradation and contamination are outlined in section 18-12(a) of the new watershed regulations, which were adopted in principal as an integral component of the Watershed Agreement. These potential sources of degradation due to human activities include:

- Wastewater discharges to surface water and groundwater:
- Urban, suburban, rural, mining, silvicultural and agricultural land use practices that result in non-point source runoff of pollution and/or in adverse changes in the natural rate at which water flows into and through a delineated drainage basin: and
- Improper use, handling, storage, transport and / or disposal of substances including but not limited to, hazardous substances, radioactive materials, pesticides, fertilizers, winter highway maintenance materials, solid wastes, and animal wastes.

1.4 Land Developments Threaten the New York City Water Supply

The Catskill - Delaware watersheds are relatively sparsely developed with populations ranging from a low of approximately 14 people per square mile in the Neversink drainage basin to a high of approximately 51 people per square mile in the Ashokan basin. Altogether, the City owns approximately 6 percent of the land area inside the Catskill-Delaware watershed and another 20 percent is protected as part of State owned forest preserve. However, this leaves approximately 75 percent of the watershed land area subject to human land use which may degrade the quality of the water entering the source streams and reservoirs. This study focuses on one of the potential sources of water quality degradation. Specifically, the impacts and controls on storm water runoff from new land development activities will be examined.

As land is converted from open, forested, and natural areas to residential, commercial, and industrial developments, the amount of paved and built over land surfaces increases drastically. The elimination of natural or vegetated areas where rainfall can infiltrate into the ground causes hydrologic changes which also tend to increase the levels of pollution associated with storm water runoff. As the rainfall which leaves a site increases, it also washes off pollutants which accumulate on impervious areas during dry periods (Schueler, 1991). Accumulated pollutants are dissolved into or carried away by the rainfall runoff and can subsequently be transported into the watershed. Runoff traveling through gutters, catch basins, sewer systems, and drainage channels may in turn scour and entrain additional accumulated pollutants which were deposited by previous storm events. Ultimately, this mix of storm water runoff and its load of pollutants is discharged to surface waters potentially causing the degradation of the water supply reservoirs and source streams.

The City has taken great care to protect upland reservoirs and their shorelines, but human land use in the watersheds has had significant negative impacts. The five impounding reservoirs in the Catskill – Delaware system include the Cannonsville, Neversink, Papacton, Rondout, and Schoharie. These impoundment reservoirs provide multiple months of detention usually resulting in high quality water being delivered to the Kensico, the source reservoir feeding the distribution system. At times the Kensico has experienced water quality problems requiring that it be taken off line and that the West Branch Rondout, and Ashokan be used as source reservoirs. However, these reservoirs have also experienced water quality problems including bacterial and turbidity spikes, and algal blooms. Many of these water quality problems can be partly traced to the impacts of land development.

1.5 EPA, DEC and DEP Recognize Storm Water Runoff Threat

Many studies show that runoff from land developments typically contains significant quantities of the same general types of pollutants that are found in wastewater and industrial discharges. These pollutants include heavy metals (e.g., chromium, cadmium, copper, lead, nickel, zinc), pesticides, herbicides, nitrogen, phosphorous, and organic compounds such as fuels, waste oils, solvents, lubricants, and grease (EPA, 1991). In response to the notable degradation of our nation's surface waters, the 86^{th} United States Congress passed significant amendments to the Federal Water Pollution Control Act (commonly referred to as the Clean Water Act). These amendments passed in 1987 expand the prohibitions governing the discharge of any pollutant to the waters of the United States, unless the discharge is authorized by a National Pollution Discharge Elimination System (NPDES) permit. Prior to the passage of the amendments, efforts under NPDES focused on the reduction of pollutant discharges from easily identified sources associated with industrial process wastewater and municipal sewage. The Act amendments provide for a greater focus on pollutants associated with storm water runoff, including runoff from impervious areas associated with land development.

Traditionally, runoff from land development activities was considered as a diffuse source, or, non-point source of pollution. However, much of this runoff is discharged to surface waters through storm sewers or other manmade conveyances defined as point sources under the Clean Water Act, and are therefore legally subject to the NPDES program. In 1987, Congress revised the Clean Water Act by adding Section 402(p) to address storm water discharges from point sources. The Clean Water Act as amended in 1987 mandates that NPDES permits be required for discharges composed entirely of storm water when the following conditions apply:

- The discharge has been permitted prior to February 4, 1987 (in which case the operator is required to maintain the existing permit)
- The discharge is associated with industrial activity
- The discharge is from a large (population greater than 250,000) or medium (population greater than 100,000 but less than 250,000) municipal separate storm sewer system.
- The permitting authority determines that the discharge contributes to a violation of water quality standards or is a significant contributor of pollutants to waters of the Untied States (EPA, 1991).

In response to the Act, the EPA published permit application requirements on November 16, 1990 (55 FR 47990), and ensuing regulations which are primarily contained within Section 122.26 of Section 40 of the Code of Federal Regulations. The regulations governing discharges from industrial activities are of special interest for this investigation.

Section 122.26 of Section 40 of the Code of Federal Regulations formally establishes the definition of storm water discharges associated with industrial types of activity. Using Standard Industrial Classification Codes, the regulations encompass storm water discharges from activities ranging from Dairy Product Processing to Explosives Manufacturing. The regulations also incorporate storm water discharges from hazardous

hazardous waste facilities, recycling facilities, steam electric power generating facilities, transportation facilities, treatment works treating domestic sewage, and *construction activities* (EPA, 1991).

Provisions of the Clean Water Act allow States to request EPA authorization to administer the NPDES program. The State of New York is designated as a NPDES-delegated State and administers the pollution reduction program through the State Pollutant Discharge Elimination System (SPDES). In accordance with permit administration options provided by the EPA, the State of New York chose to apply for a general permit to cover construction activities disturbing areas greater than five acres. The New York State general permit approved by the EPA for NPDES coverage is effective from August 1, 1993 to August 1, 1998, and has been extended pending the adoption of new permit requirements. The permit language adopted by New York is more specific and direct than the permit language outlined by the EPA. The permit language adopted by the EPA states, "Structural (storm water management) measures should be placed to the degree attainable". However, the New York general permit language states that, "Storm Water Management controls shall conform to and be implemented in a manner consistent with the technical standards set forth in Appendix D. Where conformance with Appendix D is not attainable, the operator shall describe what practices will be implemented together with an explanation as to why conformance with Appendix D cannot be achieved." (NYSDEC, 1993) Appendix D is attached to the general permit and it outlines extensive storm water management guidelines for the post construction period on new site developments. Included are water quality management guidelines which incorporate the control of the first flush which carries most runoff related contaminants, control of thermal discharges, and a hierarchy of methods for managing storm water quality. Clearly the transition from the pre general permit era, without a formalized program, to a post general permit time period, using permit language more stringent then required by the NPDES regulations, should result in a significant increase in the use of structural best management practices.

To qualify for an avoidance of filtration ruling from the EPA, New York City needed to recognize the pollution threat presented by land development activities. The watershed rules and regulations adopted as part of the watershed agreement implement an even greater degree of control over storm water runoff than the general permit enforced by the State. The new watershed rules and regulations include guidelines for development of Stormwater Pollution Prevention Plans and extend requirements adopted within the State General Permit to other construction activities within the watershed.

Section 18-39(b)(3) of the watershed regulations require that Stormwater Pollution Prevention Plans(SWPPP's) be prepared in accordance with the State general permit for the following activities:

- Plans for development or sale of land that will result in the disturbance of five or more acres of land as described in General Permit No. GP-93-06,
- Construction of a subdivision,
- Construction of a new industrial, municipal, commercial, or multi-family residential project that will result in creation of an impervious surface totaling over 40,000 square feet in size,
- A land clearing or land grading project, involving two or more acres, located at least in part within the limiting distance of 100 feet of a watercourse or wetland, or within

the limiting distance of 300 feet of a reservoir stem or controlled lake or a slope exceeding 15 percent,

- Construction of a new solid waste management facility or alteration or modification of an existing solid waste management facility within 300 feet of a watercourse or wetland or 500 feet of a reservoir, reservoir stem, or controlled lake,
- Construction of a gas station,
- Construction of an impervious surface for a new road (limitations defined in section 18-39(a)(6) of the new regulations,
- Construction of an impervious surface in the West of Hudson watershed within a village, hamlet, village extension, or are zoned for commercial or industrial uses (limitations defined in section 18-39(a)(8) of the new regulations.),
- Up to a 25 percent expansion of an existing impervious surface at an existing commercial or industrial facility which is within the limiting distance of 100 feet of a watercourse or wetland (limitations defined in section 18-39(a)(4)(iii) of the new regulations)

Specific sections of the adopted regulations encourage the installation of measures during the construction process to control pollutants in storm water discharges that will occur after construction operations have been completed.

CHAPTER 2

HYPOTHESIS

Clearly the EPA, State of New York, the DEP and the watershed communities have recognized that land development activities present a threat to the quality of the drinking water supply. The 1987 Clean Water Act Amendments, and the resulting regulations promulgated by the Environmental Protection Agency, the New York Department of Environmental Conservation and the New York City Department of Environmental Protection, represent an ambitious program to identify, permit, and control the quality of point sources of storm water runoff from human land development.

The Storm water controls specified in the New York State general permit and the newly adopted watershed rules and regulations are relatively clear, and more stringent than the NPDES language promulgated by the EPA. The use of new watershed regulations as the enforcement tool for storm water management on specified construction activities within the water supply watershed should result in a significant increase in the use of structural best management practices, and therefore an improvement in water quality. This study attempts to measure the rate of best management use in relation to the adoption of the watershed rules and regulations. This measure will be performed through an examination of land development activities between two time periods, prior to the adoption of the watershed rules and regulations and subsequent to their adoption. A simplified method to measure the rate of best management practice implementation is proposed through the use of a land development scoring system.

CHAPTER 3

BACKGROUND

In recent years, a significant body of research has investigated the levels of increased storm water runoff pollution that are associated with the human alteration of landform. Associated with this research, is a growing sophistication in the use of storm water management techniques for the control of the quality of storm water runoff from developed sites.

3.1 Pollutants Associated with Storm Water Runoff

A comprehensive study of storm water runoff from residential, commercial and light industrial areas throughout the United States was conducted under the EPA's Nationwide Urban Runoff Program (EPA, 1983) from 1978 to 1983. The results of this study contains a large data base of pollutant concentrations and loads emanating from various land uses measured under various storm events. Other data bases of storm water pollutant loads and concentrations are documented in EPA's Handbook on Urban Runoff Pollution Prevention and Control Planning. These databases include Driver and Tasker (1990); Tasker and Driver (1988); and other EPA studies dated, 1974, 1977, 1982a, 1990. (EPA, 1993)

The impacts on our nations water resources caused by land development are the subject of extensive study ranging from the development of simulation models to predict pollutant loads, to models to predict impacts on receiving waters. The extent of research on this subject is too expansive to document here, but a general overview of the known problems associated with land development, and how they may be controlled will be introduced to establish the context of the proposed investigation.

EPA's Handbook on Urban Runoff Pollution Prevention and Control Planning (EPA, 1993), and the Manual for Controlling Urban Runoff developed by the Washington Council of Governments (Schueler, 1991) classify water quality impacts associated with land development into a number of general categories. These pollutant categories consist of sediments, nutrients, oxygen demand, oil and grease, toxic substances, chlorides, and thermal impacts. Following is a brief description of each.

- **Sediments**

Sediment is made up of particulate matter that becomes entrained in storm water runoff and then settles and fills the bottoms of ditches, streams, lakes, rivers, and wetlands. High sediment loads cause many adverse impacts including increased turbidity, reduced light penetration, clogging of fish gills and filters of invertebrates, smothering of the benthic community, and changes in bottom substrates. Sediment is also and efficient carrier of toxicant and trace metals. Though the greatest sediment loads are experienced during construction, increased runoff from uncontrolled development carries high rates of sediment also.

- **Nutrients**

Excess levels of phosphorous and nitrogen in urban runoff lead to unwanted algae blooms in receiving waters. Studies indicate that nutrients in urban runoff are present in soluble forms that are readily taken up by algae. As a result, receiving waters run the risk of developing eutrophic conditions including: surface algal scums, water discoloration, strong odors, and depressed oxygen levels and release of toxins as the algae bloom decomposes. High nutrient levels also promote the growth of dense algal mats that attach to and alter the composition of shallow unshaded stream bottoms. Generally, nutrient export is generated from land developments with the greatest impervious areas with the exception of golf courses, cemeteries and other intensively landscaped areas, which are subject to high fertilizer inputs.

- **Oxygen Demand**

Decomposition by microorganisms depletes oxygen levels in water bodies. Organic enrichment can occur from pollutants that accumulate on impervious surfaces and are subsequently washed off during rainfall events. These can include pet droppings, vegetative matter, litter and debris. A sudden release of oxygen demanding substances into a water body can result in total oxygen depletion and fish kills.

- **Oil and Grease**

The major source of hydrocarbons in urban runoff is the result of leaking crankcase oil and other lubricants from automobiles. Particularly high hydrocarbon runoffs are generated by parking lots, roads, and service stations. Illegal disposal of waste oil has also been a notable source. Hydrocarbons are lighter than water and are initially found in the form of a rainbow colored film on the water's surface. However, hydrocarbons ultimately attach to sediments and settle out, tending to rapidly accumulate in bottom sediments of lakes and estuaries where they may persist and cause adverse impacts on benthic organisms.

- **Toxic Pollutants**

Toxic pollutants include metals and organic chemicals. Heavy metals in runoff can result from sources as diffuse as the breakdown of galvanized and chrome plated products, vehicle exhaust residue, and deicing agents. Potential sources of organics and metals other than hydrocarbon noted above include paint thinners, wood preservatives and pesticides. These compounds are toxic to aquatic organisms and can bioaccumulate in fish and shellfish, potentially causing toxic affects in humans who consume this food.

- **Chlorides**

Chlorides are introduced into surface waters as the result of the application of salts to remove ice and snow from roads, parking lots, and sidewalks. Due to its extreme solubility, almost all chlorides applied for snow removal end up in surface or ground waters. High chloride concentrations can affect the taste of drinking water supplies and can have a toxic affect on freshwater aquatic organisms and plants that do not have a high tolerance level.

- **Thermal Impacts**

Elevated water temperatures in storm water runoff from an urbanized landscape are a particular concern during summer. Heat can be imparted to rainfall runoff by impervious surfaces. Fewer trees also results in less shade to ground cover and stream channels.

Elevated water temperatures can have significant effects on species that are adapted to a cold water environment. A rise in water temperature of just a few degrees can reduce or eliminate sensitive stream insects such as stone and mayflies, and fish species such as trout. Thermal impacts are particularly problematic for piedmont streams that straddle geographic regions between cold water streams and warm water streams.

3.2 Reducing the Pollution Threat through Best Management Practices

Pollution problems due to rainfall runoff are more difficult to control than steady state dry weather point discharges because of the intermittent and variable nature of rainfall runoff and the large variety of pollutant types. The expense of constructing facilities to collect and treat storm water can be prohibitive. Therefore, the treatment of storm water focuses on the use of least cost options including non-structural and low cost structural controls. These methods are known as Best Management Practices or BMP's. Nonstructural BMP's include regulations that prevent pollution problems by controlling land development and land use. Low cost structural BMP's include the use of facilities that either settle or filter pollutants, or encourage uptake of pollutants by vegetation.

Comprehensive plans that address runoff pollution prevention rely on both non-structural and structural practices. Non-structural controls are generally applied to new land development and are used to limit both the quantity of runoff as well as its pollutant load. Non-structural controls typically implemented by municipalities include: land use regulations such as zoning ordinances, subdivision regulations, site plan review procedures, and natural resource protection; comprehensive runoff control regulations, and land acquisition. Structural runoff pollution control practices can be subdivided into several categories including detention facilities, infiltration facilities, vegetative practices, filtration practices, and water quality inlets. Following is a concise description of the various structural Best Management Practices that are used for the control of pollutants in storm water runoff (EPA,1993 and Schueler, 1991):

- **Detention Facilities**

Detention facilities are one of the most common structural methods used to control urban runoff and reduce pollutant loads. Detention facilities used originally to reduce rates of runoff from newly created impervious areas, also have beneficial impacts on runoff pollutants. Pollutant removal is primarily achieved through the settling of solids. Detention facilities are therefore most efficient in removing solids and the pollutants that typically adhere to solids, and are less effective at removing dissolved pollutants. Detention facilities that are effective in the removal of pollutants can be divided into three categories; extended dry detention ponds, wet ponds, and constructed wetlands.

Extended Dry Detention Ponds - These ponds generally consist of topographical depressions which are normally dry, but designed to capture and contain rainfall runoff for an extended time period. These ponds are usually designed for a certain detention time for a given design storm (e.g., 1 year 24 hour storm released over a minimum of a 24 hour time period). Constraints on the use of these ponds include relatively high maintenance costs and large land area requirements which make them impractical for incorporation into old developments and cause owners of new developments to hesitate due to land areas lost to development. Other physical constrains include topography and depth to bedrock. Some ponds include vegetated strips, which increase pollutant removal through filtering and biological uptake. Overall the pollutant removal efficiencies of dry ponds has been shown to be less than that of wet ponds and constructed wetlands.

Wet Ponds - Wet ponds are similar to extended dry detention ponds with the exception that a permanent pool of water is maintained. Depending on the size of the permanent pool in relation to runoff produced from the contributing watershed, wet ponds remove pollutants through both settling and biological uptake. As with extended detention basins, wet ponds require maintenance and periodic removal of accumulated sediments. Practical limitations make these types of ponds unsuitable for areas with porous soils or low ground water levels since the water elevation of the low pool cannot be maintained. Well designed wet ponds include native emergent aquatic plant species which can remove dissolved pollutants such as nutrients.

Constructed Wetlands - Constructed wetlands are effective in the removal of many urban storm water pollutants. These facilities remove pollutants through a series of mechanisms including sedimentation, filtration, absorption, microbial decomposition, and vegetative uptake. Practical limitations on the use of these facilities include a lack of generally accepted design criteria, need for regular maintenance, requirement for large areas of undeveloped land, and need for proper soil and ground water conditions.

- **Infiltration Facilities**

Unlike detention facilities, which capture runoff and release it to surface waters, infiltration facilities permanently capture runoff so that it soaks into the ground. These facilities achieve pollutant removal through infiltration, which eliminates or lowers surface runoff volumes reaching water bodies. However, since the infiltrated flow can travel through the ground water and still be released to surface water, dissolved pollutants could be reintroduced with minimal removal. Infiltration facilities can be divided into three categories including infiltration basins, infiltration trenches/dry wells, and porous pavement.

Infiltration Basins - Infiltration ponds are similar to dry detention ponds with the exception that there is only an emergency spillway and no standard outlet structure. Therefore, all flow entering an infiltration basin is retained and allowed to soak into the soil. Limitations include regular maintenance needs, relatively large land area requirements, need for suitable soils usually consisting of sands and loams, and low ground water tables usually two to four feet below the bottom of the basin. Infiltration basins are particularly effective in removing bacteria, suspended solids, insoluble nutrients, oil and grease and floating wastes. They are less effective in removing dissolved nutrients, some toxic pollutants and chlorides.

Infiltration Trenches / Dry Wells - These facilities are built below ground and force runoff into the soil to recharge groundwater and remove pollutants. Infiltration trenches are usually placed at the base of a mild vegetated slope and consist of a trench having a minimum depth of three feet which is filled with washed stone and enveloped in filter fabric. Storm water runoff is directed over the vegetated slope and into the top of the infiltration trench through a pervious stone layer. Subsurface infiltration dry well systems generally consist of precast concrete structures with holes in the sides and bottoms surrounded by 2 to 4 feet of washed stone. Storm water is generally piped into these systems so that infiltration can take place. If located throughout the drainage systems, infiltration trenches and dry wells have manageable land area requirements. However, their placement is dependent on the suitability of the soil and the depth to groundwater. Pollutant removals are similar to that of infiltration basins.

Porous Pavement- Generally paved areas are impervious to runoff. However, porous pavement consists of uniformly graded aggregates and allows water to flow through and into a designed underground gravel bed. Since significant pollutants are the result of runoff from impervious surfaces, porous pavements have a generally high pollutant capture rate. Porous pavements can remove significant quantities of soluble and particulate pollutants. Practical limitations include high maintenance requirements to keep the surface free of coarse particles which could clog the pavement, and a high cost for initial construction and repair.

- **Vegetative Practices**

Vegetative practices in land development increases the area of vegetation, which promotes infiltration and capture of solids. These practices generally provide low to moderate pollutant removals and can be used in tandem as pretreatment for solids removal prior to storm water treatment by other methods. The two major types of vegetative practices include grassed swales and filter strips.

Grassed Swales - Grassed swales are channels that are lined with vegetation and replace conventional catch basin and pipe network systems used to transport runoff to surface waters. Storm water runs through these swales, reducing runoff velocity, and promoting the removal of suspended solids. Uses are limited to low slope areas where soils are not easily eroded.

Filter Strips - Filter strips are similar to grass swales with the exception that runoff is directed perpendicular to the strip and is evenly distributed in sheet flow. The effectiveness of filter strips is dependent on their length, size, slope, and soil permeability. Maintenance requirements for these strips can be low if they are large enough to be left on their own to create a natural filter. Slope is the major limitation on the use of filter strips. They operate the best when placed on flat areas in permeable soils. Pollutant removal is primarily achieved through infiltration and filtering. These strips are generally good at removing solids, organic material, and some trace metals, but are less effective at removal of dissolved pollutants.

- **Filtration Practices**

Filtration practices provide runoff treatment through settling and filtering using special layers of sand or other filtration materials. Flow enters the filtration structure and is filtered through the media to an under drain that discharges to surface water. Filtration practices currently in use consist of two different types.

Filtration basins - These systems resemble detention basins in that they require a topographical depression in which to store runoff. Once stored the runoff percolates through the filter media it is collected in perforated pipes. These facilities are in limited use, and therefore may not be considered a proven technology. One of the major questions concerns the effects of cold temperature and freezing conditions on the operation of these systems. Limitations include large land area requirements and the need for low ground water tables. Thought untested, pollutant removal is believed to be achieved by trapping of solids and organic matter by the filter media.

Sand Filters - Sand filters are similar to filtration basins, but can be built underground to reduce the amount of land required. These systems consist of a catch basin and a filtration chamber filled with sand. Runoff first enters the catch basin where heavy solids and debris is captured. Overflow is directed to the filtration chamber where the runoff is passed through the filter media. Maintenance requirements are relatively low and consist of periodically removing debris from the catch basin and accumulated sediment from the top layer of sand. Because of their limited size, sand filters can be used for pretreatment or in small watersheds but cannot be used solely to treat large watershed areas.

- **Water Quality Inlets**

Water quality inlets, which are also known as oil and grit separators, provide treatment through a series of settling chambers and separation baffles. These systems have been in use for years, but have limited expected removal rates, and are therefore more effective as pretreatment structures to other BMP's. Limitations are similar to the limitations for sand filters and their effectiveness is dependent on runoff detention times.

3.3 Pollutant Removal Rates Associated with Best Management Practices

The pollutant removal rate of a BMP is based on the removal mechanisms that it uses, the amount of runoff that it treats, and the nature of the pollutant that is being removed. Table 1 illustrates the removal capabilities of various BMP options. These rates are inferred from field performance monitoring, laboratory experiments, modeling analyses, and theoretical considerations. The anticipated removal rates shown here are based on tables presented in referenced literature, and in particular, EPA's Handbook on Urban Runoff Pollution Prevention and Control Planning (EPA,1993), and Washington Council of Government's Manual for the Planning and Designing Urban BMP's (Schueler, 1991).

Table 1 - Typical Pollutant Removal Levels

BMP	Suspended Sediment	Total Phosphorous	Total Nitrogen	Oxygen Demand	Trace Metals	Bacteria
Detention Facilities						
Extended Det. Dry Ponds	40-60%	20-40%	20-40%	40-60%	20-40%	0-20%
Wet Ponds	60-80%	40-60%	40-60%	40-60%	60-80%	0-20%
Constructed Wetlands	60-80%	20-40%	0-20%	40-60%	60-80%	0-20%
Infiltration Facilities						
Infiltration Basins	60-80%	60-80%	60-80%	60-80%	60-80%	60-80%
Infil. Trenches / Dry Wells	60-80%	20-40%	60-80%	60-80%	60-80%	60-80%
Porous Pavement	60-80%	40-60%	80- 100%	60-80%	80-100%	60-80%
Vegetative Practices						
Grassed Swales	40-60%	20-40%	20-40%	0-20%	20-40%	0-20%
Filter Strips	60-80%	60-80%	60-80%	40-60%	40-60%	0-20%
Filtration Practices						
Filtration Basins	60-80%	60-80%	0-20%	60-80%	60-80%	0-20%
Sand Filters	80-100%	0-20%	20-40%	60-80%	60-80%	0-20%
Other Practices						
Water Quality Inlets	20-40%	0-20%	0-20%	0-20%	0-20%	0-20%

CHAPTER 4

METHODOLOGY

Extensive literature exists on pollutants generated by land development activities and the associated best management practices that can be used to limit their impacts. In addition, there are policy and legislative initiatives that have been undertaken and examined for how they impact the use of known technology to control pollutants. This is especially true for a number of estuaries and lakes that have received national attention including the Chesapeake Bay (Lindsey, 1991), the Narragansett Bay (Meyers, 1989), and the Great Lakes (Kaufman, 1995). However, to date there has been no significant research on how the 1987 Clean Water Act Amendments and the subsequent NPDES regulations adopted by the EPA, the general permit developed by the NYSDEC, and specifically the watershed rules and regulations have impacted the use of structural BMP's. The methodology proposed herein provides a mechanism for measuring the impact of the policy initiatives associated with the New York City water supply.

4.1 Study Area or Population

The transition from a total lack of formal regulatory requirements, to the 1991 adoption of the SPDES General Permit governing storm water discharges from sites disturbing greater than five acres created a new climate under which land development activities take place. Even stricter watershed rules and regulations requiring the development of a storm water pollution prevention plan for many significant land development activities, should result in a significant increase in the implementation of best management practices.

A measure of the effectiveness of the watershed rules and regulations can be based on a sample of land development sites within the drainage basin of one selected water supply reservoir. A reservoir selected on the basis of volume of construction activity would provide a representative sample, and moderate to high level of construction activity would ensure an adequate number of sampling sites constructed before and after passage of watershed regulations. All construction sites that include clearing, grading, and excavation activities would be considered for inclusion in the sample. Residential, commercial, public and industrial development sites would be considered since the best management practices can be equally incorporated into all types of site improvements.

4.2 Variable Identification

Table 2 provides a summary of the variables proposed for study and a concise synopsis of the variable definition. The table is followed by a more in depth description of each variable and the logic behind its use.

Table 2 – Variable Definition

Variable	**Definition**
LDS – Land Development Score	A measurement of the degree to which a land development has incorporated storm water management measures to reduce post construction pollution.
Watershed	A record of which reservoir watershed a site is located within.
EIS Year	Year that the Environmental Impact Statement and SWPPP or storm water management plan was developed.
BMP Practices	A record of the type and number of different Best Management Practices used on a site to control pollutants in post construction storm water runoff
SWPP	A record of whether a Storm Water Pollution Prevention Plan has been developed for a sampled site.
Regulatory Control	A record of which agency has primary review responsibility
Development Type	A record of the type of land development project that is being sampled (e.g. Residential, Commercial, Public, Industrial, etc.)
Acreage	The total acres of disturbance encompassed by the sampled land development.

- **Land Development Score**

The effective implementation of Best Management Practices to control storm water runoff pollution will be determined by the use of a proposed Land Development Scoring System. This scoring system is based on the pollutant removal efficiencies of the previously identified BMP's and is weighted for the percentage of a site which is treated by a BMP. The land development scoring system is developed as follows.

A weighted "pollutant removal value" is developed for each BMP using the major pollutant constituents documented in the literature, and the removal efficiency of each

BMP. The major pollutant constituents consist of sediments, nutrients, oxygen demand and bacteria. The degree of pollutant removal was considered high (Schueler, 1991) if the anticipated removal rate ranged from 80 - 100%, and the BMP was given a grade of 5 for that constituent. The removal rate was considered low if it ranged from 0 - 20% and the BMP was given a grade of 1. Values of 4 to 2 were assigned to gradations in between the high and low values. The cumulative score of removal rates for the major storm water pollutants results in a weighted "pollutant removal value" for each BMP. The development of these removal values is illustrated on table 3.

Table 3 – BMP Pollutant Removal Values

BMP	Suspended Sediment	Total Phosphorous	Total Nitrogen	Oxygen Demand	Trace Metals	Bacteria	Pollutant Removal Value
Percent Removal Ranking Weight	X 1.0	X 1.0	X 1.0	X 1.0	X 1.0	X 1.0	
Detention	**Facilities**						
Extended Det. Dry Ponds	40-60% ❸	20-40% ❷	20-40% ❷	40-60% ❸	20-40% ❷	0-20% ❶	*13*
Wet Ponds	60-80% ❹	40-60% ❸	40-60% ❸	40-60% ❸	60-80% ❹	0-20% ❶	*18*
Constructed Wetlands	60-80% ❹	20-40% ❷	0-20% ❶	40-60% ❸	60-80% ❹	0-20% ❶	*15*
Infiltration	**Facilities**						
Infiltration Basins	60-80% ❹	60-80% ❹	60-80% ❹	60-80% ❹	60-80% ❹	60-80% ❹	*24*
Infil. Trenches / Dry Wells	60-80% ❹	20-40% ❷	60-80% ❹	60-80% ❹	60-80% ❹	60-80% ❹	*22*
Porous Pavement	60-80% ❹	40-60% ❸	80-100% ❺	60-80% ❹	80-100% ❺	60-80% ❹	*25*

Table 3 (continued) – BMP Pollutant Removal Levels

BMP	Suspended Sediment	Total Phosphorous	Total Nitrogen	Oxygen Demand	Trace Metals	Bacteria	Pollutant Removal Value
Percent Removal Ranking Weight	X 1.0	X 0.5	X 0.5	X 1.0	X 1.0	X 1.0	
Vegetative	**Practices**						
Grassed Swales	40-60% ❸	20-40% ❷	20-40% ❷	0-20% ❶	20-40% ❷	0-20% ❶	*11*
Filter Strips	60-80% ❹	60-80% ❹	60-80% ❹	40-60% ❸	40-60% ❸	0-20% ❶	*19*
Filtration	**Practices**						
Filtration Basins	60-80% ❹	60-80% ❹	0-20% ❶	60-80% ❹	60-80% ❹	0-20% ❶	*18*
Sand Filters	80-100% ❺	0-20% ❶	20-40% ❷	60-80% ❹	60-80% ❹	0-20% ❶	*17*
Other	**Practices**						
Water Quality Inlets	20-40% ❷	0-20% ❶	0-20% ❶	0-20% ❶	0-20% ❶	0-20% ❶	*7*

The use of Best Management Practices (BMP's) are only effective if they capture storm water runoff from a developed site, and if they treat a large percentage of the site development. The "pollutant removal value "(PRV) for each BMP is weighted based on the percentage of the site treated by the BMP. If an entire site is treated by a more effective BMP such as infiltration basin (PRV = 21) it would have a higher Land Development Score than if an entire site were treated by water quality inlets (PRV = 7). Likewise, if a site is treated with a group of more efficient BMP's, it would score higher than a site treated with less efficient BMP's. The percentage of a site being treated by BMP's would also influence the score as would the use of BMP's in tandem such as filter strips leading to detention basins. The Land Development Score will not provide an absolute measure of BMP use, but it will allow a comparison between land developments to determine if there are positive trends in BMP implementation. The worksheet that would be used to score a site is demonstrated in table 4.

Table 4 - BMP Ranking and Land Development Scoring

BMP	Ranking Score		Percent of Site Treated		Site Score
Porous Pavement	25	x	-------	=	---------
Infiltration Basin	24	x	-------	=	---------
Infiltration Trenches	22	x	-------	=	---------
Filter Strips	19	x	-------	=	---------
Wet Ponds	18	x	-------	=	---------
Filtration Basins	18	x	-------	=	---------
Sand Filters	17	x	-------	=	---------
Constructed Wetland	15	x	-------	=	---------
Extended Dry Detention Pond	13	x	-------	=	---------
Grassed Swales	11	x	-------	=	---------
Water Quality Inlets	7	x	-------	=	---------
			Total Land Development Score (LDS)	=	------------

Following is a full description of the independent variables which could be used to determine the validity of any relationship between the adoption of the watershed rules and regulations and the implementation of storm water BMP's.

- **Watershed**

A record of which New York City Reservoir Watershed the site is located within. The record of this variable will allow a determination of whether the reservoir receiving storm water runoff from a subject site has a bearing on the degree of BMP's utilized.

- **EIS Year**

A measure of the year an Environmental Impact Statement was developed for the sampled site. Since each site within the watershed of a New York City water supply reservoir has the potential to have a significant environmental impact, the site will be the subject of an EIS as required by the New York State Environmental Quality Review Act (SEQRA). As part of an EIS, a measure of impacts to surface water resources is required. This impact is normally determined through a comparison of pre and post development runoff characteristics documented within a storm water management plan or SWPPP. The land development score will be measured against the EIS Year to determine if the adoption of the New York State general permit and the watershed rules and regulations have had an effect on BMP implementation. A positive trend would show higher land scores after permit and regulation adoption. A negative trend would be indicated by flat or lower land development scores.

- **BMP Practices**

Record of the types and number of different BMP's used on a sampled land development site. Major BMP groups will be categorized as:

- Detention Facilities
- Infiltration Facilities
- Filtration Practices
- Vegetative Practices
- Water Quality Inlets

The record of BMP types will allow cross examination with the total land development score. One would suspect that the higher land development scores would be associated with use of the more effective BMP's, and the use of number of different types of BMP's.

- **SWPPP**

This variable will serve as an indicator of whether a Storm Water Pollution Prevention Plan has been developed. A positive indication will affirm that a plan complying, at minimum with the New York State general permit has been developed. A negative indication will be given if no plan has been developed, or if the Storm Water Pollution Prevention Plan does not comply with the requirements outlined in the State general permit.

- **Regulatory Control**

This variable will provide a record of the agency which has jurisdiction over a site's storm water management or Storm Water Pollution Prevention Plan. The primary assumption is that the NY City Department of Environmental Protection will exert the greatest effort in reviewing SWPPP due to their direct responsibility to ensure adequate safe guards for the New York City water supply. The second most detailed review would be expected to come from the NY Department of Environmental Conservation who is responsible for enforcing the general permit requirements to maintain statutory control over Federal National Pollution Discharge Elimination System (NPDES) permitting requirements. Other agencies that might review SWPPP's include local or County planning boards and health departments. The accuracy and detail of reviews by regulatory authorities other than the DEP or the NYSDEC are greatly variable and dependent on the expertise and thoroughness of regulatory agency. For this reason, one would suspect that local reviews would have the lowest level of consistency.

- **Development Type**

The site development type will be recorded to relate the level of BMP adoption to the type of land development constructed. Land development types will be broken down into the following categories:

- Residential
- Commercial
- Public
- Industrial

- **Acreage**

A record of the total acreage of disturbed land area associated with the construction of a site development. A record of this value will allow an examination of BMP trends in relation to development size.

4.3 Method of Measurement

Table 5 provides a summary of the methods utilized to measure each variable defining characteristics of watershed activities in relation to the Land Development Score.

Table 5 - Method of Variable Measurement

Variable	**Method Of Measurement**
LDS – Land Development Score	Storm Water Pollution Prevention Plans developed for sites regulated by the new watershed rules and regulations will be examined in the offices of the DEP where they are on file. Land development sites not on file with the DEP, or not under DEP jurisdiction will be examined through a review of Environmental Impact Statements located in public libraries. The measurement of the LDS variable will primarily consist of a record of BMP's incorporated into each development for post construction runoff pollution control. The use of each BMP will be noted and an estimate of the percentage of the development site being treated by each BMP will be made.
Watershed	The name of the New York City reservoir watershed within which the site resides will be recorded from the EIS.
EIS Year	The year of the EIS development will be recorded from the EIS being reviewed.

Table 5 (continued) - Method of Variable Measurement

Variable	Method of Measurement
BMP Practices	A record of the types of Best Management Practices used on a site to control pollutants in post construction storm water runoff will be recorded based on EIS and plan review.
Regulatory Control	A record of the agencies having jurisdiction over Storm Water Pollution Prevention Plans or storm water management plans will be recorded based on EIS and plan review.
SWPP	A record of whether a site development has a Storm Water Pollution Plan addressing storm water runoff will be recorded based on EIS review
Site Type	The record of the type of land development project (e.g. Residential, Commercial, etc.) will be based on information gathered from EIS and plan review.
Acreage	The total acreage disturbed by the land development will be recorded from land development plans.

4.4 Sampling Procedure

The sample population targeted by the study consists of all land developments within the New York City Catskill – Delaware water supply watershed within the period starting January 1, 1991 and extending to December 31, 1998. The eight year time period was chosen to bracket the August 1, 1993 issue date of SPDES general permit and the May 1, 1997 implementation of the new watershed rules and regulations. A representative sample was to be collected from a subset of the sample population. This subset was to consist of land developments within a selected reservoir watershed area west of the Hudson.

Judging by the concerns expressed by environmentalists and an alarmed public (NY Times, Aug. 31, 1997), a general consensus seemed to have developed that the New York City water supply system was under a significant and immediate threat from land development activity and other human related undertakings. Anticipating a relatively robust land development climate, the sample selected for the study was to be based on the construction activity which had occurred, or was planned within one of the reservoir watersheds in the west of the Hudson system. However, upon initiating a search for the desired reservoir to sample, it became apparent that, in fact very little land development activity had taken place within the 1991 to 1998 study period. These preliminary findings were confirmed through conversations with representatives of the NYSDEC and the DEP.

An expanded search for land development sites to be sampled confirmed that there was no single reservoir watershed within the west of the Hudson system that contained enough land development activity. Not only was there insufficient land development activity in the drainage basin of any one reservoir, there was insufficient land activity within the entire New York City Catskill – Delaware system. Regions III and IV of the New York Department of Environmental Conservation indicated that recent land development activity within the New York City water supply watersheds west of the Hudson was very limited. In fact, land development related construction activities, which fall under the new watershed regulations, and are located west of the Hudson, seemed to consist solely of the construction and repair of septic systems. The New York

Department of Environmental Conservation Region III office indicated that approximately 2 projects were underway west of the Hudson and approximately 100 projects were being reviewed under the watershed rules and regulations for areas east of the Hudson. Of the 100 projects in areas east of the Hudson, the predominant majority consisted of single home construction, home additions, septic system repair and replacements, or minor road repair projects.

The sample population was originally chosen for areas West of the Hudson, since it is for this area that DEP has filed for filtration avoidance. The watershed areas east of the Hudson, with the exception of West Branch, Boyd's Corner, and the Kensico reservoirs, will ultimately be filtered through the Croton system filtration plant, which is currently under study and development. However, due to the lack of development activity west of the Hudson, the search for a sample turned to watershed areas east of the Hudson which may be representative of the west of the Hudson system. Since, the West Branch, Boyds Corner, and Kensico reservoirs are included in the filtration avoidance application, these seemed to represent the natural location to search for sufficient land development activity to create a sample.

The sampling procedure used to gather variables required for the proposed analysis consisted of extracting data from Storm Water Pollution Prevention Plans (SWPPP) and storm water management plans prepared for land development activities. As previously noted, land development activities that constituted a possible significant impact to the environment due solely to their location within the New York City water supply system were most likely required to file an Environmental Impact Statement (EIS) under the New York State Environmental Quality Review Act (SEQRA). Impacts to surface and groundwater, and the actions taken to avoid adverse impacts are outlined within an EIS under either a SWPPP or a storm water management plan. Using the documentation created through these regulatory requirements, data for the analysis of the hypothesis was extracted from a review of records in DEP files and reviews of Environmental Impact Statements filed under the SEQRA process.

4.5 Mode of Observation / Findings

The Valhalla Office of the DEP is responsible for storm water management reviews for all activities within the water supply areas East of the Hudson. The Valhalla office was contacted to request access to records for new and old site development activities, which had been reviewed by the DEP. In particular, the watersheds of the Boyd's Corner, West Branch and Kensico Reservoirs were targeted based on their inclusion in the filtration avoidance determination. Due to sensitivity over the implementation of the new watershed management regulations, the DEP was reluctant to open their files for review, and required that a Freedom of Information Act (FOIA) request be filed in order to gain access to their records. After significant delays, the FOIA request was granted and files were collected for the review.

DEP records revealed that only four land developments within the subject watersheds had been or were under their review within their newly found jurisdiction provided by the watershed regulations. Interviews with representatives of the DEP confirmed the trend indicated by NYSDEC officials. Limited land development activity is currently taking place within the New York City watershed areas. Most activity consists of septic system repair and replacement, the construction of an occasional single family home on a single lot, or the construction of home additions within reservoir limiting distances. Construction of extensive residential subdivisions, or commercial developments is not taking place, and has not occurred in recent history. The records that were made available by the DEP were reviewed and variable information proposed for the study was recorded.

As a requirement of the New York State Environmental Quality Review Act (SEQRA) all activities that may have a significant environmental impact must develop an Environmental Impact Statement. Also as a requirement of SEQRA, these Environmental Impact Statements must be made accessible to the public through copies provided to public libraries within the communities where the proposed activity is to take place. The second mode of observation used for this study consisted of a systematic review of Environmental Impact Statements filed in the libraries of the communities where the development is taking place. To access these records, field visits were conducted to the libraries of the primary communities within the watersheds of the reservoirs being investigated. The communities of Mount Pleasant, North Castle, Kent, and Carmel were visited to research current and archived EIS's. As a general observation, the towns to the south, including Mount Pleasant and North Castle, seemed to be experiencing the highest level of development activity. However, much of this activity lies in areas outside of the New York City water supply watershed.

Review of the DEP files and Environmental Impact Statements on file in town libraries garnered a total of 11 sample sites located within the targeted reservoir watersheds. Most of these sites are located within the Kensico Reservoir system. A number EIS's for land development sites within the Croton Reservoir were encountered.

Variable information for these sites was also recorded to increase the number of sites, which could be examined for trends in storm water management.

Conversations with DEP representatives combined with observations made during the investigation of Environmental Impact Statements provided some insight to current trends that may not be accurately reflected by readily measurable data or the variables proposed for study. When questioned about the impact of the new watershed rules and regulations, DEP indicated that there was one primary significant difference between the period prior to and subsequent to implementation of the rules and regulations. This difference centered on the jurisdiction offered by the rules and regulations and on the newly created atmosphere of vigorous enforcement through detailed review of development construction plans.

Prior to the adoption of the watershed rules and regulations, DEP would be granted review of storm water management plans as part of the SEQRA process. However, at most times, they would not be the lead agency reviewing the land development plans, and their role was primarily in an advisory capacity. Since they did not have direct jurisdiction or enforcement powers, their comments on proposed storm water management plans were not fully addressed.

When the site being reviewed disturbed an area greater than 5 acres, it fell under the jurisdiction of the NYSDEC and the State general permit. As a part of the general permit requirements, a Storm Water Pollution Prevention Plan would be prepared. Compliance with the general permit is essentially achieved with the development of the SWPPP. SWPPP review by the NYSDEC is cursory, and primarily consists of an determination if the SWPPP has been developed as opposed to a rigorous review of its content. This level of review by the NYSDEC follows the spirit of recent trends away from a command and control regulatory climate towards one of voluntary compliance.

When the site disturbed an area of less than 5 acres it fell under the jurisdiction of the local community or County. The level and accuracy of a review by a local agency is extremely dependent on a number of factors including the technical expertise within the agency, agency and local community budgets, local opinions over the desirability of a development, and potentially the political influence of the developer. Therefore, local review of storm water management plans associated with land development activities can be expected to vary considerably.

The DEP's lack of enforcement power was clearly demonstrated in one of the Environmental Impact Statements reviewed during the data collection process. The Draft EIS contained a SWPPP, which was reviewed by the DEP. The DEP commented that the plan lacked sufficient detail to allow a proper review. Meanwhile, the NYSDEC commented that the application was in compliance based on the development and inclusion of the SWPPP. In response to comments on the Draft EIS, the developer's response to the DEP was that in spite of their comments the application was in compliance, as indicated by the NYSDEC, and no further action was required. DEP's comments were never addressed in detail and they lacked enforcement authority to alter the outcome.

Subsequent to the adoption of the watershed rules and regulations, DEP has been granted full jurisdiction over the implementation of storm water management measures designed to mitigate impacts associated with storm water runoff from new land developments. This jurisdiction and related enforcement powers was demonstrated in the

DEP case file for a site falling under the new watershed rules and regulations. In this case, the DEP performed an in depth extensive review of the subject SWPPP. Through extensive correspondence, revision of plans, and re-submissions, the developer gained DEP approval. However, through the approval process, the DEP ensured that best management practices were designed in detail and properly and fully executed for the entire site development.

In summary, prior to the implementation of the watershed rules and regulations, the DEP was unable to require technical detail sufficient to allow in depth review of storm water management plans. Now, the DEP can ensure that these plans avoid generalizations and include the technical detail required to properly construct storm water management systems, which fulfill the intent of the Watershed Agreement. SWPPP's or storm water management plans filed in EIS's vary in quality and detail depending on who has prepared the plan. This makes it difficult to gain a consistent determination of the true extent of BMP implementation that will ultimately take place on the construction site. However, since the DEP now has the ability and jurisdiction to perform consistent and detailed reviews, BMP implementation for new sites being reviewed under the watershed rules and regulations should be more uniform. A measure of BMP implementation subsequent to DEP review should yield more consistent accurate results, and more consistent and accurate Land Development Scores.

CHAPTER 5

DATA ANALYSIS

5.1 Data Reduction

Data collected during the review of individual SWPPP's and storm water management plans were recorded in notes and then converted into the site record forms included in Appendix A. A summary of the variable values collected is shown in the table at the head of the Appendix. Though only limited data was available for consideration in the study, some data reduction does provide an indication of currently observable trends or lack of trends in the implementation of BMP's in storm water management.

In descriptive terms, the numerical values of Land Development Score may not provide a clear indication of how effectively BMP's are being implemented. However, these scores can be broken into the following descriptive ranges based on the principles of Likert scaling (Babbie, 1995).

- "Effective implementation of BMP's",
- "Somewhat effective implementation of BMP's",
- "Average implementation of BMP's",
- "Minimal Implementation of BMP's",
- "Essentially no BMP implementation".

Since there is a potential for great variation in the methods that a land developer may use to effectively implement storm water management, the assignment of LDS numerical values to the Likert scale is somewhat arbitrary. However, a reasonable approach to this problem is the development of maximum and minimum scores that would likely bracket the activities that may be undertaken as part of a SWPPP program. As an example, a land development project with a LDS score on the high end of the scale would most likely provide storm water treatment through a number of integrated methods. In general, storm water management is more effective in areas with permeable soils, where runoff can be minimized, and a developed site can be designed to more closely mimic natural infiltration conditions. For the purpose of analyzing the proposed hypothesis, an assumed land development having a very high LDS would take advantage of favorable infiltration conditions and maximize the pollutant and runoff mitigation characteristics associated with infiltration facilities. Treatment of such a site might incorporate an array of infiltration techniques including porous pavement plus infiltration basins and trenches collecting runoff that has been pretreated by filtration strips. Application of these techniques to a hypothetical site could reasonably consist of the following breakdown:

Porous Pavement -	Treating 15% of site area
Infiltration Basin -	Treating 60 % of site area
Infiltration Trenches -	Treating 25% of site area
Filter Strips -	Treating 85% of site area.

Transfer of these BMP coverage areas to the LDS worksheet results in a Land Development Score demonstrated in Table 6.

Table 6 - Hypothetical Maximum Land Development Score

BMP	Ranking Score		Percent of Site Treated		Site Score
Porous Pavement	25	x	15%	=	3.75
Infiltration Basin	24	x	60%	=	14.40
Infiltration Trenches	22	x	25%	=	5.50
Filter Strips	19	x	85%	=	16.15
Wet Ponds	18	x	0%	=	0.0
Filtration Basins	18	x	0%	=	0.0
Sand Filters	17	x	0%	=	0.0
Constructed Wetland	15	x	0%	=	0.0
Extended Dry Detention Pond	13	x	0%	=	0.0
Grassed Swales	11	x	0%	=	0.0
Water Quality Inlets	7	x	0%	=	0.0
			Total Land Development Score (LDS)	=	39.8

The stated assumptions when applied to the land development score worksheet results in a score of 39.8. Therefore, for the purpose of the study, it seems that a reasonably valid maximum LDS score would be a value of forty (40). Obviously, the minimum score for a site would be generated through a total lack of storm water management and BMP use resulting in a LDS of zero (0). The mean land development score could be assumed to be somewhere between the values of zero (0) and forty (40). The mean could be based on a straight line average resulting in a value of twenty (20). Another alternative is to examine the mean of LDS scores generated by the sampled sites. Based on the univariate analysis (See Appendix B) of the limited samples available to date, the mean LDS value is 18.1. Using an assessment of the straight line average and the mean of the recorded scores, it seems valid to assume that average implementation of BMP's on any given site would result in a LDS score of approximately twenty (20). Using this rational, the following Likert scale could be applied to the LDS scores recorded for a site development to provide a descriptive value of the degree of BMP implementation.

Proposed Likert Scale Categories	**LDS's**
Effective Implementation of BMP's	33 to 40
Somewhat Effective Implementation of BMP's	25 to 32
Average Implementation of BMP's	17 to 24
Minimal Implementation of BMP's	9 to 16
Essentially no BMP implementation	0 to 8

Using this scale on the fourteen (14) site developments for which data was recorded the following can be observed:

- eleven (11) had "average implementation of BMP's" or lower,
- one (1) had "somewhat effective implementation of BMP's", and
- only two (2) had "effective implementation of BMP's

Of the ten (10) sites designs that were initiated after the adoption of the watershed rules and regulations:

- nine (9) had "average implementation of BMP's" or lower and,

- only one (1) had "somewhat effective implementation of BMP's."

Based on the scores seen here, one may conclude that the watershed rules and regulations are not raising the levels of BMP use to a significantly high standard. However, most of the observed SWPPP's filed under the State SEQRA process had not yet undergone the full review and comment process the DEP. Therefore, the low scores could indicate that land development planners and engineers have not fully adjusted to the new regulatory climate. Their site designs and SWPPP's included in EIS's may not reflect the detail and thoroughness of design that will ultimately be required to obtain DEP approval. Once subjected to the rigor of DEP review, comment, and enforcement they may adjust, and incorporate greater levels of BMP implementation and detail in future EIS's.

The LDS scores assigned to the observed land development project samples were also tested against other variables collected including Watershed, EIS Development year, BMP Practices, SWPPP, Regulatory Control, Development Type and Acreage (The alphanumeric coding of variables and the results of statistical analyses are provided in Appendix B). Variables described by numerical values include:

- EIS Development Year (coded as 1 for the post watershed rule implementation period and 0 for the pre watershed rule implementation period),
- Number of BMP's Practices Implemented, and
- Site acreage

These numeric variables can be compared through a Pearson Correlation analysis, which would confirm a rise or fall in these variable values in conjunction with a rise or fall in the LDS value. A perfect correlation would be demonstrated by a value of one (1) or negative one (–1). No correlation is demonstrated by a value of zero (0). The analysis of these variables for the fourteen (14) sampled sites results in correlation coefficients of 0.056 to 0.451 (See Appendix B) indicating a weak correlation at best.

The remaining independent variables are compared to LDS through partial regression analyses to determine the variance of the LDS value in relation to the development's watershed location, type, and reviewing agency. The R-Square value in the analysis can be examined to determine a correlation between values. Due to the squaring function, a perfect correlation would be demonstrated by a value of one (1). No correlation is demonstrated by a value of zero (0). The R-Square value on the correlation test between these variables and the LDS never exceeds the value of 0.02 indicating no correlation. As a result, for the sites sampled, it can be concluded that the LDS value is not significantly influenced by the watershed within which the development site is located, nor by the type of development, nor by the agency performing the review.

The reduction of data associated with the sampled sites, indicates that there are no readily observable trends between Land Development Scores and other recorded variables. Correlation between the Land Development Scores and all variable with the exception of the EIS year would not necessarily be expected. However, one would expect a relationship between the LDS and the EIS year due to the implementation of the watershed rules and regulations. The lack of correlation in the sample does not necessarily mean that an upward trend in the LDS does not exist. The lack of correlation may be due to the lack of a significant representative sample of land developments or to the inaccuracy in LDS measurements in documents that have not undergone DEP review.

CHAPTER 6

CONCLUSIONS OF THE STUDY

Research indicates that an extremely light rate of new land development activity within the Catskill – Delaware Watershed is occurring. The general lack of land development activity prevents a thorough analysis of new regulation impacts. An attempt was made to locate a representative sample in New York City watershed areas East of the Hudson. Even though land development activities in areas East of the Hudson are occurring at a higher rate, they are still low. One of the results of the analysis is an indication that insufficient time has passed since the adoption of the watershed rules and regulations to allow a proper measure of their effectiveness.

The analysis also indicates that the lack of rising LDS scores does not necessarily mean that the DEP is not having an impact on the rate of BMP implementation. Rather, it may indicate that land development planners and engineers have not fully adjusted to the new regulatory climate. Conversations with the DEP, and observations of SWPPP's and storm water management plans in EIS's indicate that a more important, currently unmeasured variable may exist. This variable would be a "Post DEP Review LDS", which would record the level of review detail that the DEP undertakes in response to the adoption of the watershed rules regulations. The effects of DEP's more detailed level of review could be recorded as a "Post DEP Review LDS" by personnel that are intimately involved with the details of a site's storm water management plan.

In summary, prior to the implementation of the watershed rules and regulations, the DEP was unable to require technical detail sufficient to allow in depth review of storm water management plans. Now, the DEP can ensure that these plans avoid generalizations and include the technical detail required to properly construct storm water management systems, which fill the intent of the Watershed Agreement. SWPPP's or storm water management plans filed in EIS's vary in quality and detail, making it difficult to gain a consistent determination of the true extent of ultimate BMP implementation. However, since the DEP now has the ability and jurisdiction to perform consistent and detailed reviews, BMP implementation for new sites being reviewed under the watershed rules and regulations can be measured more readily. The Land Development Scoring system proposed in this study could be used by the DEP in measuring the effect of their review process, as well as the overall implementation of BMP's throughout the New York City water supply watershed. In addition, the DEP could utilize the Land Development Scoring system to sample constructed land developments built within a preset time increments such as five years. Such a sampling would indicate trends in BMP use and ultimately trends in water quality protection.

APPENDIX A

VARIABLE COMPILATION
SITE RECORD SHEETS

Site Name	LDS	Watershed	EIS Year	BMP	Regulator	Dev. Type	Acreage
Wood Hollow Estates	21.9	Kensico / Croton	1998	Detention Facilities Vegetative Practices	NYCDEP	Residential	40.7
CitiGroup Executive Planning Center Annex	24.0	Kensico	1999	Infiltration Facilities	Local	Commercial	0.9
CitiGroup Executive Planning Center	13.0	Kensico	1996	Detention Facilities	Local	Commercial	25.3
Valhalla Elementary School Expansion	17.6	Kensico	1998	Detention Facilities Infiltration Facilities	NYDEC	Public	5.4
Jahovah Witnesses Circuit Assembly	13.0	West Branch	1999	Detention	NYCDEP	Public	63.5
Improvements for Valhalla Water District	7.0	Kensico	1999	Water Quality Inlets	NYCDEP	Public	5.0
Westchester County Airport	40.0	Kensico	1987	Runoff Diversion	Local	Public	127.0
Hammond Ridge	11.8	Croton	1997	Detention Facilities Filtration Practices Water Quality Inlets	NYDEC	Residential	201.3
Seven Springs	29.7	Croton	1998	Detention Facilities Infiltration Facilities	NYCDEP	Residential	78.2
IBM Learning Center	0.0	Kensico	1997	No Treatment	Local	Commercial	0.8
Westchester Co. Airport (2)	7.0	Kensico	1997	Water Qualtiy Inlets	NYDEC	Public	331.2
Swiss Re-America HQ	17.0	Kensico	1996	Detention Facilities Infiltration Facilities Filtration Practices	NYDEC	Commercial	30.5
IBM Headquarters Office Building	34.0	Kensico	1995	Filtration Practices Infiltration Facilities Detention	NYDEC	Commercial	195.5
Lake Carmel Factory Shops	18.0	Croton	1998	Detention Facilities	NYCDEP	Commercial	128.0

DATA SUMMARY SHEET

DEVELOPMENT NAME:	Wood Hollow Estates
TOWN LOCATION:	North Castle

LAND DEVELOPMENT SCORE			
BMP	**Ranking Score**	**Percent of Site Treated**	**Site Score**
Porous Pavement	25		0.0
Infiltration Basin	24		0.0
Infiltration Trenches	22		0.0
Filter Strips	19	37%	7.0
Wet Ponds	18	60%	10.8
Filtration Basins	18		0.0
Sand Filters	17		0.0
Constructed Wetlands	15		0.0
Extended Dry Detention Pond	13		0.0
Grassed Swales	11	37%	4.1
Water Quality Inlets	7		0.0
Total Land Development Score (LDS)			**21.9**

WATERSHED	Kensico / Croton
EIS DEVELOPMENT (YEAR)	1998
BMP PRACTICES	
Detention Facilities, Infiltration Facilities	Detention Facilities
Filtration Practices, Vegetative Practices	Vegetative Practices
or, Water Quality Inlets	
SWPPP	
Yes or No	Yes
REGULATORY CONTROL	
Agency Name	NYCDEP
DEVELOPMENT TYPE	
Single Family Residential, Cluster Residential	Residential
Commercial, Public, or Industrial	
ACREAGE	40.7
COMMENTS:	28.1 acres of the site drain to the New Croton Reservoir while 12.6 acres of the site drain to the Kensico Reservoir. NYCDEP has performed extensive and detailed reviews of the proposed storm water management plans. Consequently the site has a detailed storm water pollution prevention plan, and all areas of the developed site will be addressed by one or more BMP tyes. The primary form of stormwater treatment is through wet ponds with sediment forebays and emergent marsh vegetation. Areas not treatable by wet ponds are directed to vegetated filter strips and grassed swales.

DATA SUMMARY SHEET

DEVELOPMENT NAME:	CitiGroup Executive Planning Center Annex
TOWN LOCATION:	North Castle

LAND DEVELOPMENT SCORE			
BMP	Ranking Score	Percent of Site Treated	Site Score
Porous Pavement	25		0.0
Infiltration Basin	24	100%	24.0
Infiltration Trenches	22		0.0
Filter Strips	19		0.0
Wet Ponds	18		0.0
Filtration Basins	18		0.0
Sand Filters	17		0.0
Constructed Wetlands	15		0.0
Extended Dry Detention Pond	13		0.0
Grassed Swales	11		0.0
Water Quality Inlets	7		0.0
Total Land Development Score (LDS)			**24.0**

WATERSHED	Kensico
EIS DEVELOPMENT (YEAR)	1999
BMP PRACTICES	
Detention Facilities, Infiltration Facilities	Infiltration Facilities
Filtration Practices, Vegetative Practices	
or, Water Quality Inlets	
SWPPP	
Yes or No	No
REGULATORY CONTROL	
Agency Name	Local
DEVELOPMENT TYPE	
Single Family Residential, Cluster Residential	Commercial
Commercial, Public, or Industrial	
ACREAGE	0.87
COMMENTS:	The intial site proposal would have created 1.5 acres of impervious area. The proposal was revised to reduce the impervious area to 38,000 SF which falls under the 40,000 SF threshhold for the new watershed regulations and NYDEP review. The proposed development consists of a 30,000SF addition to an existing building plus an 8,000 SF parking lot expansion. The new impervious areas will be directed to a subsurface recharge / infiltration facility.

DATA SUMMARY SHEET

DEVELOPMENT NAME:	CitiGroup Executive Planning Center
TOWN LOCATION:	North Castle

LAND DEVELOPMENT SCORE

BMP	Ranking Score	Percent of Site Treated	Site Score
Porous Pavement	25		0.0
Infiltration Basin	24		0.0
Infiltration Trenches	22		0.0
Filter Strips	19		0.0
Wet Ponds	18		0.0
Filtration Basins	18		0.0
Sand Filters	17		0.0
Constructed Wetlands	15		0.0
Extended Dry Detention Pond	13	100%	13.0
Grassed Swales	11		0.0
Water Quality Inlets	7		0.0
Total Land Development Score (LDS)			**13.0**

WATERSHED	Kensico
EIS DEVELOPMENT (YEAR)	1996
BMP PRACTICES	
Detention Facilities, Infiltration Facilities	Detention Facilities
Filtration Practices, Vegetative Practices	
or, Water Quality Inlets	
SWPPP	
Yes or No	No
REGULATORY CONTROL	
Agency Name	Local
DEVELOPMENT TYPE	
Single Family Residential, Cluster Residential	Commercial
Commercial, Public, or Industrial	
ACREAGE	25.3
COMMENTS:	

The existing CitiGroup Executive Planning Center was constructed in 1997 and utilized detention basins for storm water management and treatment. The existing development consisted of a 42,000 SF building plus 21.3 acres of lawn and landscaping and 3 acres of parking lots and roadways.

DATA SUMMARY SHEET

DEVELOPMENT NAME:	Valhalla Elementary School Expansion
TOWN LOCATION:	Mount Pleasant

LAND DEVELOPMENT SCORE			
BMP	**Ranking Score**	**Percent of Site Treated**	**Site Score**
Porous Pavement	25		0.0
Infiltration Basin	24		0.0
Infiltration Trenches	22	52%	11.4
Filter Strips	19		0.0
Wet Ponds	18		0.0
Filtration Basins	18		0.0
Sand Filters	17		0.0
Constructed Wetlands	15		0.0
Extended Dry Detention Pond	13	47%	6.1
Grassed Swales	11		0.0
Water Quality Inlets	7		0.0
Total Land Development Score (LDS)			**17.6**

WATERSHED	Kensico
EIS DEVELOPMENT (YEAR)	1998
BMP PRACTICES	
Detention Facilities, Infiltration Facilities	Detention Facilities
Filtration Practices, Vegetative Practices	Infiltration Facilities
or, Storm Water Adjuncts	
SWPPP	
Yes or No	No
REGULATORY CONTROL	
Agency Name	NYDEC
DEVELOPMENT TYPE	
Single Family Residential, Cluster Residential	Public
Commercial, Public, or Industrial	
ACREAGE	5.37
COMMENTS:	The site drains to both the Kensico watershed and the Bronx River. 5.37 acres under post development conditions will drain to the Kensico Reservoir. Of that area only 24,500 SF of total impervious cover will be created which falls under the threshhold that brings a site under NYCDEP jurisdiction. Since the total site disturbs more than 5 acres it does fall under the jurisdiction of the NYDEC and will ultimately require a SWPPP.

DATA SUMMARY SHEET

DEVELOPMENT NAME:	Jahovah Witnesses Circuit Assembly
TOWN LOCATION:	Town of Kent

LAND DEVELOPMENT SCORE			
BMP	**Ranking Score**	**Percent of Site Treated**	**Site Score**
Porous Pavement	25		0.0
Infiltration Basin	24		0.0
Infiltration Trenches	22		0.0
Filter Strips	19		0.0
Wet Ponds	18		0.0
Filtration Basins	18		0.0
Sand Filters	17		0.0
Constructed Wetlands	15		0.0
Extended Dry Detention Pond	13	100%	13.0
Grassed Swales	11		0.0
Water Quality Inlets	7		0.0
Total Land Development Score (LDS)			**13.0**

WATERSHED	West Branch
EIS DEVELOPMENT (YEAR)	1999
BMP PRACTICES	
Detention Facilities, Infiltration Facilities	Detention
Filtration Practices, Vegetative Practices	
or, Storm Water Adjuncts	
SWPPP	
Yes or No	No
REGULATORY CONTROL	
Agency Name	NYCDEP
DEVELOPMENT TYPE	
Single Family Residential, Cluster Residential	Public
Commercial, Public, or Industrial	
ACREAGE	63.5
COMMENTS:	The proposed construction will consist of a 73,000 SF building plus 70 parking spaces. No further details on the project are available. The project is in the intial steps of the NY State Environmental Quality Review Act scoping stage.

DATA SUMMARY SHEET

DEVELOPMENT NAME:	Joint Supply, Pumping, Storage and Distribution Improvements for Valhalla Water District
TOWN LOCATION:	Hawthorne

LAND DEVELOPMENT SCORE			
BMP	**Ranking Score**	**Percent of Site Treated**	**Site Score**
Porous Pavement	25		0.0
Infiltration Basin	24		0.0
Infiltration Trenches	22		0.0
Filter Strips	19		0.0
Wet Ponds	18		0.0
Filtration Basins	18		0.0
Sand Filters	17		0.0
Constructed Wetlands	15		0.0
Extended Dry Detention Pond	13		0.0
Grassed Swales	11		0.0
Water Quality Inlets	7	100%	7.0
Total Land Development Score (LDS)			**7.0**

WATERSHED	Kensico
EIS DEVELOPMENT (YEAR)	1999
BMP PRACTICES	
Detention Facilities, Infiltration Facilities	Water Quality Inlets
Filtration Practices, Vegetative Practices	
or, Water Quality Inlets	
SWPPP	
Yes or No	No
REGULATORY CONTROL	
Agency Name	NYCDEP
DEVELOPMENT TYPE	
Single Family Residential, Cluster Residential	Public
Commercial, Public, or Industrial	
ACREAGE	5
COMMENTS:	The elevated storage tank and approximately one half of the transmission line lies within the Kensico watershed. The development will create 1.5 acres of new impervious area and 3.5 acres of total disturbance within the Kensico watershed. Though no SWPPP plan has been developed to date, one will be required by the NYCDEP.

DATA SUMMARY SHEET

DEVELOPMENT NAME:	Westchester County Airport		
TOWN LOCATION:	North Castle		
LAND DEVELOPMENT SCORE			
BMP	**Ranking Score**	**Percent of Site Treated**	**Site Score**
Porous Pavement	25		0.0
Infiltration Basin	24		0.0
Infiltration Trenches	22		0.0
Filter Strips	19		0.0
Wet Ponds	18		0.0
Filtration Basins	18		0.0
Sand Filters	17		0.0
Constructed Wetlands	15		0.0
Extended Dry Detention Pond	13		0.0
Grassed Swales	11		0.0
Water Quality Inlets	7		0.0
Total Land Development Score (LDS)			**40.0 ***
	Max. assigned due to total diversion from Kensico watershed		
WATERSHED	Kensico		
EIS DEVELOPMENT (YEAR)	1987		
BMP PRACTICES			
Detention Facilities, Infiltration Facilities			
Filtration Practices, Vegetative Practices			
or, Water Quality Inlets			
SWPPP			
Yes or No	No		
REGULATORY CONTROL			
Agency Name	Local		
DEVELOPMENT TYPE			
Single Family Residential, Cluster Residential	Public		
Commercial, Public, or Industrial			
ACREAGE	127		
COMMENTS:	The development of the Westchester County airport will add 75 acres of impervious area to the Rye Lake watershed and 49 acres of impervious area to the Blind Brook watershed. The proposed storm water management plan to protect NY City water supply consists entirely of divertng strom water runoff form the developed area in the Rye Lake watershed to the Blind Brook watershed. The runoff from the airport to Blind Brook will be managed through the use of detention basins and water quality inlets.		

DATA SUMMARY SHEET

DEVELOPMENT NAME:	Hammond Ridge
TOWN LOCATION:	North Castle

LAND DEVELOPMENT SCORE			
BMP	**Ranking Score**	**Percent of Site Treated**	**Site Score**
Porous Pavement	25		0.0
Infiltration Basin	24		0.0
Infiltration Trenches	22	3%	0.7
Filter Strips	19	12%	2.3
Wet Ponds	18		0.0
Filtration Basins	18		0.0
Sand Filters	17		0.0
Constructed Wetlands	15		0.0
Extended Dry Detention Pond	13	48%	6.2
Grassed Swales	11		0.0
Water Quality Inlets	7	37%	2.6
Total Land Development Score (LDS)			**11.8**

WATERSHED	Croton
EIS DEVELOPMENT (YEAR)	1997
BMP PRACTICES	
Detention Facilities, Infiltration Facilities	Detention Facilities
Filtration Practices, Vegetative Practices	Filtration Practices
or, Water Quality Inlets	Water Quality Inlets
SWPPP	
Yes or No	Yes
REGULATORY CONTROL	
Agency Name	NYDEC
DEVELOPMENT TYPE	
Single Family Residential, Cluster Residential	Residential
Commercial, Public, or Industrial	
ACREAGE	201.3
COMMENTS:	The Hammond Ridge subdivision consits of 43 lots on a site of 220.5 acres draining to the Kisco River and then to the Croton Reservoir. Of this area, approximately 100 acres will be developed with homes, roadways, and associated improvements. Portions of the site will be treated through detention basins, dry wells, or water quality inlets. Both the storm drainage report and the pollutants loading report are over simplified and don not provide enough information for a meaningful review. The percentages of the site treated by BMP's represents an estimate from the information provided.

DATA SUMMARY SHEET

DEVELOPMENT NAME:	Seven Springs
TOWN LOCATION:	North Castle

LAND DEVELOPMENT SCORE			
BMP	**Ranking Score**	**Percent of Site Treated**	**Site Score**
Porous Pavement	25		0.0
Infiltration Basin	24		14.0
Infiltration Trenches	22		0.0
Filter Strips	19		0.0
Wet Ponds	18	45%	8.1
Filtration Basins	18		0.0
Sand Filters	17		0.0
Constructed Wetlands	15		0.0
Extended Dry Detention Pond	13	58%	7.6
Grassed Swales	11		0.0
Water Quality Inlets	7		0.0
Total Land Development Score (LDS)			**29.7**

WATERSHED	Croton
EIS DEVELOPMENT (YEAR)	1998
BMP PRACTICES	
Detention Facilities, Infiltration Facilities	Detention Facilities
Filtration Practices, Vegetative Practices	Infiltration Facilities
or, Water Quality Inlets	
SWPPP	
Yes or No	Yes
REGULATORY CONTROL	
Agency Name	NYCDEP
DEVELOPMENT TYPE	
Single Family Residential, Cluster Residential	Residential
Commercial, Public, or Industrial	Recreational
ACREAGE	78.2
COMMENTS:	Proposed site development encompasses 213 acres of a former estate. Under post-development conditions 78.2 acres of the site will drain to the Kisco River which drains to the Croton Reservoir. This represents a decrease of 0.8 acres from the 79 acres which drain to the Kisco River under existing conditions. The site development will consist of 9 single family homes plus the development of an 18 hole golf club with amenities including club house / pool etc.

DATA SUMMARY SHEET

DEVELOPMENT NAME:	IBM Learning Center
TOWN LOCATION:	North Castle

LAND DEVELOPMENT SCORE			
BMP	**Ranking Score**	**Percent of Site Treated**	**Site Score**
Porous Pavement	25		0.0
Infiltration Basin	24		0.0
Infiltration Trenches	22		0.0
Filter Strips	19		0.0
Wet Ponds	18		0.0
Filtration Basins	18		0.0
Sand Filters	17		0.0
Constructed Wetlands	15		0.0
Extended Dry Detention Pond	13		0.0
Grassed Swales	11		0.0
Water Quality Inlets	7		0.0
Total Land Development Score (LDS)			**0.0**

WATERSHED	Kensico
EIS DEVELOPMENT (YEAR)	1997
BMP PRACTICES	
Detention Facilities, Infiltration Facilities	Detention Facility
Filtration Practices, Vegetative Practices	
or, Water Quality Inlets	
SWPPP	
Yes or No	No
REGULATORY CONTROL	
Agency Name	Local
DEVELOPMENT TYPE	
Single Family Residential, Cluster Residential	Commercial
Commercial, Public, or Industrial	
ACREAGE	0.8
COMMENTS:	The purpose of the project is to add supplemental parking which will convert 0.8 acres of meadow / brushland to impervious area. The project did not include a SWPPP or a storm water management plan. The existing site has 329 parking spaces and 2 loading spaces which currently drain to detention ponds. It is unclear if the new area will also drain to these ponds. In addition, the existing ponds do not appear to provide extended detention for water quality, but provide attenuation for increases in rates of runoff due to impervious areas.

DATA SUMMARY SHEET

DEVELOPMENT NAME:	Westchester Co. Airport (2)
TOWN LOCATION:	North Castle

LAND DEVELOPMENT SCORE			
BMP	**Ranking Score**	**Percent of Site Treated**	**Site Score**
Porous Pavement	25		0.0
Infiltration Basin	24		0.0
Infiltration Trenches	22		0.0
Filter Strips	19		0.0
Wet Ponds	18		0.0
Filtration Basins	18		0.0
Sand Filters	17		0.0
Constructed Wetlands	15		0.0
Extended Dry Detention Pond	13		0.0
Grassed Swales	11		0.0
Water Quality Inlets	7	100%	7.0
Total Land Development Score (LDS)			**7.0**

WATERSHED	Kensico
EIS DEVELOPMENT (YEAR)	1997
BMP PRACTICES	
Detention Facilities, Infiltration Facilities	Water Qualtiy Inlets
Filtration Practices, Vegetative Practices	
or, Water Quality Inlets	
SWPPP	
Yes or No	Yes
REGULATORY CONTROL	
Agency Name	NYDEC
DEVELOPMENT TYPE	
Single Family Residential, Cluster Residential	Public
Commercial, Public, or Industrial	
ACREAGE	331.2
COMMENTS:	The airport development consists of the construction of 2 new fixed base operator sites, storm water management system modifications, tree obstruction removal, and wetland mitigation. The airport violated a SPDES storm water discharge permit by allowing the discharge of ethylene glycol to surfce waters. The storm water pollution prevention plan for the development consists primarily of diversion of impervious surface runoff away from Rye Lake and towards Blind Brook. Runoff to Blind Brook will be treated by detention basins and water quality inlets.

DATA SUMMARY SHEET

DEVELOPMENT NAME:	Swiss Re-America HQ
TOWN LOCATION:	North Castle

LAND DEVELOPMENT SCORE			
BMP	**Ranking Score**	**Percent of Site Treated**	**Site Score**
Porous Pavement	25		0.0
Infiltration Basin	24		0.0
Infiltration Trenches	22	10%	2.2
Filter Strips	19	10%	1.9
Wet Ponds	18		0.0
Filtration Basins	18		0.0
Sand Filters	17		0.0
Constructed Wetlands	15		0.0
Extended Dry Detention Pond	13	100%	13.0
Grassed Swales	11		0.0
Water Quality Inlets	7		0.0
Total Land Development Score (LDS)			**17.0**

WATERSHED	Kensico
EIS DEVELOPMENT (YEAR)	1996
BMP PRACTICES	
Detention Facilities, Infiltration Facilities	Detention Facilities
Filtration Practices, Vegetative Practices	Infiltration Facilities
or, Water Quality Inlets	Filtration Practices
SWPPP	
Yes or No	Yes
REGULATORY CONTROL	
Agency Name	NYDEC
DEVELOPMENT TYPE	
Single Family Residential, Cluster Residential	Commercial
Commercial, Public, or Industrial	
ACREAGE	30.5
COMMENTS:	The Swiss Re-America Headquarters lies on a 126.8 acre site. The proposed redevelopment will increase the total site impervious area from 5.7 acres to 12.4 acres. The area of the site to be treated by storm water management facilities equals 30.5 acres. The environmental impact statement provides calculations for anticipted pollutant loading levels and demonstrates that the proposed development will not increase pollutant loadings.

DATA SUMMARY SHEET

DEVELOPMENT NAME:	IBM Headquarters Office Building
TOWN LOCATION:	North Castle

LAND DEVELOPMENT SCORE			
BMP	**Ranking Score**	**Percent of Site Treated**	**Site Score**
Porous Pavement	25		0.0
Infiltration Basin	24		0.0
Infiltration Trenches	22	76%	16.7
Filter Strips	19	76%	14.4
Wet Ponds	18		0.0
Filtration Basins	18		0.0
Sand Filters	17		0.0
Constructed Wetlands	15		0.0
Extended Dry Detention Pond	13	22%	2.9
Grassed Swales	11		0.0
Water Quality Inlets	7		0.0
Total Land Development Score (LDS)			**34.0**

WATERSHED	Kensico
EIS DEVELOPMENT (YEAR)	1995
BMP PRACTICES	
Detention Facilities, Infiltration Facilities	Filtration Practices
Filtration Practices, Vegetative Practices	Infiltration Facilities
or, Water Quality Inlets	Detention
SWPPP	
Yes or No	Yes
REGULATORY CONTROL	
Agency Name	NYDEC
DEVELOPMENT TYPE	
Single Family Residential, Cluster Residential	Commercial
Commercial, Public, or Industrial	
ACREAGE	195.5
COMMENTS:	The proposed development consists of a 26 acre expansion of the existing IBM Headquarters complex . The treatment of site runoff is provided for the entire portion of the complex draining into the Kensico Reservoir.

DATA SUMMARY SHEET

DEVELOPMENT NAME:	Lake Carmel Factory Shops
TOWN LOCATION:	Kent

LAND DEVELOPMENT SCORE			
BMP	**Ranking Score**	**Percent of Site Treated**	**Site Score**
Porous Pavement	25		0.0
Infiltration Basin	24		0.0
Infiltration Trenches	22		0.0
Filter Strips	19		0.0
Wet Ponds	18	100%	18.0
Filtration Basins	18		0.0
Sand Filters	17		0.0
Constructed Wetlands	15		0.0
Extended Dry Detention Pond	13		0.0
Grassed Swales	11		0.0
Water Quality Inlets	7		0.0
Total Land Development Score (LDS)			**18.0**

WATERSHED	Croton
EIS DEVELOPMENT (YEAR)	1998
BMP PRACTICES	
Detention Facilities, Infiltration Facilities	Detention Facilities
Filtration Practices, Vegetative Practices	
or, Water Quality Inlets	
SWPPP	
Yes or No	Yes
REGULATORY CONTROL	
Agency Name	NYCDEP
DEVELOPMENT TYPE	
Single Family Residential, Cluster Residential	Commercial
Commercial, Public, or Industrial	
ACREAGE	128
COMMENTS:	Total area of site is 103 acres plus 72 acres of offsite area which drains through. The area studied fro strom water treatment includes the western portion of the site plus 72 acres of offsite area for a total of 152 acres. Of this total 24 acres of off-site area is not treated. The SWPPP demonstrates that pollutant loadings are decreased subsequent to development.

APPENDIX B

DATA REDUCTION

Site Name	LDS	Watershed	EIS Year	BMP	Regulator	Dev. Type	Acreage
Wood Hollow Estates	21.9	Kensico / Croton	1998	Detention Facilities Vegetative Practices	NYCDEP	Residential	40.7
CitiGroup Executive Planning Center Annex	24.0	Kensico	1999	Infiltration Facilities	Local	Commercial	0.9
CitiGroup Executive Planning Center	13.0	Kensico	1996	Detention Facilities	Local	Commercial	25.3
Valhalla Elementary School Expansion	17.6	Kensico	1998	Detention Facilities Infiltration Facilities	NYDEC	Public	5.4
Jahovah Witnesses Circuit Assembly	13.0	West Branch	1999	Detention	NYCDEP	Public	63.5
Improvements for Valhalla Water District	7.0	Kensico	1999	Water Quality Inlets	NYCDEP	Public	5.0
Westchester County Airport	40.0	Kensico	1987	Runoff Diversion	Local	Public	127.0
Hammond Ridge	11.8	Croton	1997	Detention Facilities Filtration Practices Water Quality Inlets	NYDEC	Residential	201.3
Seven Springs	29.7	Croton	1998	Detention Facilities Infiltration Facilities	NYCDEP	Residential	78.2
IBM Learning Center	0.0	Kensico	1997	No Treatment	Local	Commercial	0.8
Westchester Co. Airport (2)	7.0	Kensico	1997	Water Qualtiy Inlets	NYDEC	Public	331.2
Swiss Re-America HQ	17.0	Kensico	1996	Detention Facilities Infiltration Facilities Filtration Practices	NYDEC	Commercial	30.5
IBM Headquarters Office Building	34.0	Kensico	1995	Filtration Practices Infiltration Facilities Detention	NYDEC	Commercial	195.5
Lake Carmel Factory Shops	18.0	Croton	1998	Detention Facilities	NYCDEP	Commercial	128.0

Site Name	LDS	Watershed	EIS Year	BMP	Regulator	Dev. Type	Acreage
Wood Hollow Estates	21.9	K	1	2	C	R	40.7
CitiGroup Executive Planning Center Annex	24.0	K	1	1	L	C	0.9
CitiGroup Executive Planning Center	13.0	K	0	1	L	C	25.3
Valhalla Elementary School Expansion	17.6	K	1	2	S	P	5.4
Jahovah Witnesses Circuit Assembly	13.0	W	1	1	C	P	63.5
Improvements for Valhalla Water District	7.0	K	1	1	C	P	5.0
Westchester County Airport	40.0	K	0	2	L	P	127.0
Hammond Ridge	11.8	C	1	3	S	R	201.3
Seven Springs	29.7	C	1	2	C	R	78.2
IBM Learning Center	0.0	K	1	1	L	C	0.8
Westchester Co. Airport (2)	7.0	K	1	1	S	P	331.2
Swiss Re-America HQ	17.0	K	0	3	S	C	30.5
IBM Headquarters Office Building	34.0	K	0	3	S	C	195.5
Lake Carmel Factory Shops	18.0	C	1	1	C	C	128.0

Correlation Analysis

4 'VAR' Variables: LDS EISYR BMP ACREAGE

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
LDS	14	18.142857	11.036354	254.000000	0	40.000000
EISYR	14	0.500000	0.518875	7.000000	0	1.000000
BMP	14	1.714286	0.825420	24.000000	1.000000	3.000000
ACREAGE	14	88.092857	98.345306	1233.300000	0.800000	331.200000

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 14

	LDS	EISYR	BMP	ACREAGE
LDS	1.00000	0.05642	0.45068	0.09834
	0.0	0.8481	0.1058	0.7380
EISYR	0.05642	1.00000	-0.35921	-0.44462
	0.8481	0.0	0.2072	0.1112
BMP	0.45068	-0.35921	1.00000	0.21318
	0.1058	0.2072	0.0	0.4643
ACREAGE	0.09834	-0.44462	0.21318	1.00000
	0.7380	0.1112	0.4643	0.0

General Linear Models Procedure

Dependent Variable: LDS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.00178571	0.00178571	0.00	0.9971
Error	12	1583.41250000	131.95104167		
Corrected Total	13	1583.41428571			

	R-Square	C.V.	Root MSE	LDS Mean
	0.000001	63.31414	11.48699446	18.14285714

Source	DF	Type I SS	Mean Square	F Value	Pr > F
WATER	1	0.00178571	0.00178571	0.00	0.9971

Source	DF	Type III SS	Mean Square	F Value	Pr > F
WATER	1	0.00178571	0.00178571	0.00	0.9971

Parameter	Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT	18.12500000	3.16	0.0083	5.74349723
WATER	0.02500000	0.00	0.9971	6.79579757

General Linear Models Procedure

Dependent Variable: LDS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	28.48351648	28.48351648	0.22	0.6476
Error	12	1554.93076923	129.57756410		
Corrected Total	13	1583.41428571			

	R-Square	C.V.	Root MSE	LDS Mean
	0.017989	62.74213	11.38321414	18.14285714

Source	DF	Type I SS	Mean Square	F Value	Pr > F
WATER	1	28.48351648	28.48351648	0.22	0.6476

Source	DF	Type III SS	Mean Square	F Value	Pr > F
WATER	1	28.48351648	28.48351648	0.22	0.6476

Parameter	Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT	18.53846154	5.87	0.0001	3.15713556
WATER	-5.53846154	-0.47	0.6476	11.81291958

General Linear Models Procedure

Dependent Variable: LDS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	10.91125541	10.91125541	0.08	0.7778
Error	12	1572.50303030	131.04191919		
Corrected Total	13	1583.41428571			

R-Square	C.V.	Root MSE	LDS Mean
0.006891	63.09565	11.44735424	18.14285714

Source	DF	Type I SS	Mean Square	F Value	Pr > F
WATER	1	10.91125541	10.91125541	0.08	0.7778

Source	DF	Type III SS	Mean Square	F Value	Pr > F
WATER	1	10.91125541	10.91125541	0.08	0.7778

Parameter	Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT	17.68181818	5.12	0.0003	3.45150717
WATER	2.15151515	0.29	0.7778	7.45610766

General Linear Models Procedure

Dependent Variable: LDS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.38628571	0.38628571	0.00	0.9577
Error	12	1583.02800000	131.91900000		
Corrected Total	13	1583.41428571			

R-Square	C.V.	Root MSE	LDS Mean
0.000244	63.30645	11.48559968	18.14285714

Source	DF	Type I SS	Mean Square	F Value	Pr > F
REG	1	0.38628571	0.38628571	0.00	0.9577

Source	DF	Type III SS	Mean Square	F Value	Pr > F
REG	1	0.38628571	0.38628571	0.00	0.9577

Parameter	Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT	18.26666667	4.77	0.0005	3.82853323
REG	-0.34666667	-0.05	0.9577	6.40636142

General Linear Models Procedure

Dependent Variable: LDS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	6.86428571	6.86428571	0.05	0.8230
Error	12	1576.55000000	131.37916667		
Corrected Total	13	1583.41428571			

	R-Square	C.V.	Root MSE	LDS Mean
	0.004335	63.17679	11.46207515	18.14285714

Source	DF	Type I SS	Mean Square	F Value	Pr > F
REG	1	6.86428571	6.86428571	0.05	0.8230

Source	DF	Type III SS	Mean Square	F Value	Pr > F
REG	1	6.86428571	6.86428571	0.05	0.8230

Parameter	Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT	17.70000000	4.88	0.0004	3.62462642
REG	1.55000000	0.23	0.8230	6.78105510

General Linear Models Procedure

Dependent Variable: LDS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	3.41739683	3.41739683	0.03	0.8747
Error	12	1579.99688889	131.66640741		
Corrected Total	13	1583.41428571			

R-Square	C.V.	Root MSE	LDS Mean
0.002158	63.24582	11.47459835	18.14285714

Source	DF	Type I SS	Mean Square	F Value	Pr > F
REG	1	3.41739683	3.41739683	0.03	0.8747

Source	DF	Type III SS	Mean Square	F Value	Pr > F
REG	1	3.41739683	3.41739683	0.03	0.8747

Parameter	Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT	18.51111111	4.84	0.0004	3.82486612
REG	-1.03111111	-0.16	0.8747	6.40022518

General Linear Models Procedure

Dependent Variable: LDS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	34.14580087	34.14580087	0.26	0.6164
Error	12	1549.26848485	129.10570707		
Corrected Total	13	1583.41428571			

R-Square	C.V.	Root MSE	LDS Mean
0.021565	62.62778	11.36246923	18.14285714

Source	DF	Type I SS	Mean Square	F Value	Pr > F
DTYPE	1	34.14580087	34.14580087	0.26	0.6164

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DTYPE	1	34.14580087	34.14580087	0.26	0.6164

Parameter	Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT	17.32727273	5.06	0.00C3	3.42591338
DTYPE	3.80606061	0.51	0.6164	7.40081875

General Linear Models Procedure

Dependent Variable: LDS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.38095238	2.38095238	0.02	0.8953
Error	12	1581.03333333	131.75277778		
Corrected Total	13	1583.41428571			

R-Square	C.V.	Root MSE	LDS Mean
0.001504	63.26656	11.47836128	18.14285714

Source	DF	Type I SS	Mean Square	F Value	Pr > F
DTYPE	1	2.38095238	2.38095238	0.02	0.8953

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DTYPE	1	2.38095238	2.38095238	0.02	0.8953

Parameter	Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT	18.50000000	4.56	0.0007	4.05821355
DTYPE	-0.83333333	-0.13	0.8953	6.19902359

General Linear Models Procedure

Dependent Variable: LDS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	11.63073016	11.63073016	0.09	0.7708
Error	12	1571.78355556	130.98196296		
Corrected Total	13	1583.41428571			

R-Square	C.V.	Root MSE	LDS Mean
0.007345	63.08122	11.44473516	18.14285714

Source	DF	Type I SS	Mean Square	F Value	Pr > F
DTYPE	1	11.63073016	11.63073016	0.09	0.7708

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DTYPE	1	11.63073016	11.63073016	0.09	0.7708

Parameter	Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT	18.82222222	4.93	0.0003	3.81491172
DTYPE	-1.90222222	-0.30	0.7708	6.38356828

REFERENCES

A. Ashendorf, M. Principe, A. Seeley, J. La Duca, L. Beckhardt, W. Faber Jr., and J. Mantus, "Watershed protection for New York city's supply," *American Water Works Association Journal*, Volume 89, Issue 3, March 1997

E. Babbie, *The Practice of Social Science Research*, Seventh Edition, Wadsworth Publishing Company, U.S., 1995

M. M. Kaufman, "Community Response to Storm Water Pollution in an Urbanized Watershed," *Water Resources Bulletin,* vol. 31, No. 3 pp. 491-504, June 1995

G. Lindsey, and M. Cannon, "Controlling Storm water: Some Lessons from the Maryland Experience," *U.S. Environmental Protection Agency, Seminar Publication, Nonpoint Source Watershed Workshop,* EPA/625/4-91/027, Sept. 1991

J.C. Meyers, "Working with Local Governments to Enhance the Effectiveness of a Bayside Critical Area Program," *U.S. Environmental Protection Agency, Seminar Publication, Nonpoint Source Watershed Workshop,* EPA/625/4-91/027, Sept. 1991

New York State Department of Environmental Conservation, *SPDES General Permit for Storm Water Discharges from Construction Activities, Permit No. GP-93-06*, July 1993

New York City Department of Environmental Protection, *Final Generic Environmental Impact Statement for the Proposed Watershed Regulations*, vol. II, Nov. 1993

New York City Department of Environmental Protection, *Notice of Completion of the Final Generic Environmental Impact Statement for the Proposed Watershed Regulations*, Nov. 22, 1993

New York City Department of Environmental Protection, "Rules and Regulations for the Protection from Contamination, Degradation, and Pollution of the New York City Water Supply and its Sources," *Final Regulations, Chapter 18, New York City*, May 1997

A. Revkin, "Billion Dollar Plan to Clean New York City Water at its Source," *New York Times*, Aug. 31, 1997

D. Okun, G. Craun, J. Edzwald, J. Gilbert, and J. Rose, "New York City: To Filter or not to Filter?," *American Water Works Association Journal*, vol. 89, issue 3, March 1997

T. Schueler, "Mitigating the Adverse Impacts of Urbanization on Streams: A Comprehensive Strategy for Local Governments," *U.S. Environmental Protection Agency, Seminar Publication, Nonpoint Source Watershed Workshop*, EPA/625/4-91/027, Sept. 1991

T. Schueler, J.Galli, L.Herson, P.Kumble, and D. Schepp, "Developing Effective BMP Systems for Urban Watersheds," *U.S. Environmental Protection Agency, Seminar Publication, Nonpoint Source Watershed Workshop,* EPA/625/4-91/027, Sept. 1991

U.S. Environmental Protection Agency, *Final Report of the Nationwide Urban Runoff Program,* vol. 1, 1983

U.S. Environmental Protection Agency, "Part II - Final NPDES General Permits for Storm Water Discharges from Construction Sites; Construction Permit Language," *Federal Register*, Sept. 9, 1992

U.S. Environmental Protection Agency, "Part II - Final NPDES General Permits for Storm Water Discharges from Construction Sites; Fact Sheet," *Federal Register*, Sept. 9, 1992

U.S. Environmental Protection Agency, "Part III - Final NPDES General Permits for Storm Water Discharges from Construction Sites; Notice," *Federal Register*, Sept. 25, 1992

U.S. Environmental Protection Agency, Office of Research and Development, *Handbook Urban Runoff Pollution Prevention and Control Planning*, EPA/625/R-93/004, Sept. 1993

U.S. Environmental Protection Agency, Office of Water, *Guidance Manual for The Preparation of NPDES Permit Applications Associated with Industrial Activity*, EPA-505/8-91-002, April 1991