Assessing Stormwater Runoff and Policy in the Kayaderosseras Watershed, New York

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Abstract

Our study examines the impact of land-use on stormwater runoff in the Kayaderosseras watershed using the Long-Term Hydrologic Impact Assessment (L-THIA) model. We also examine local management goals aimed at fulfilling federal and state stormwater policy and assessed implementation success based on town annual reports. We interviewed local officials and site inspectors regarding the challenges of implementing local stormwater management policies, and in particular, sediment and erosion control at construction sites.

Introduction

Non-point source pollution is currently the leading cause of water contamination in the United States. Unfortunately, the regulation of non-point source pollution remains a considerable challenge because the exact sources of contamination are difficult to determine (Haejin et al. 2007). However, most non-point pollution enters surface waters via stormwater runoff (Carpenter, et al. 1998).

Stormwater runoff is the excess precipitation that does not infiltrate land surfaces, and flows through a watershed to its drainage basin, in most cases a lake. As the excess precipitation flows across various land-use types, it absorbs an assortment of chemicals. These include: lawn and golf course fertilizers, pesticides; metals, salts, vehicle related contaminants, sediment, and other compounds whose source is not immediately obvious (EPA 1995). These contaminants are then introduced to surface waters where they can have deleterious effects on ecological systems and drinking water quality. For instance, the EPA ranks urban runoff as the second, third and fourth leading sources of impairment in estuaries, lakes, and rivers, respectively (EPA 2002). Adopting and applying effective stormwater management policy is imperative to reducing these harmful impacts of non-point source pollution nationwide.

Environmental Impacts of Stormwater Runoff

Excess nutrients, heavy metals, and sedimentation from runoff are the most significant pollutants in lakes. Nutrient loading is a common problem in both agricultural and urban areas, such is the case of the Kayaderosseras watershed and its drainage basin, Saratoga Lake. Nutrients such as nitrogen and phosphorous (N, P, respectively) are present in fertilizers and pesticides, which are used to treat lawns and golf courses. Runoff carries these nutrients into lakes where they function as limiting factors; if an excessive amount of N and P are added to a water body, they can cause an overabundant growth of algae and aquatic plants. Eutrophication occurs when these organisms decompose, a process that removes oxygen from the water. Consequently, depleted levels of dissolved oxygen can harm other aquatic animals and even result in fish kills (Murphey 2007). Additionally, nutrient loading will decrease water quality in Saratoga Lake, compromising its ability to serve as a potential drinking water source.

In addition to nutrients, sedimentation and heavy metals are also significant non-point pollutants. As areas develop, forested land is converted to dirt. During storm events, rain removes large amounts of exposed topsoil and washes the sediment into drainage basins. Typically, for one acre of land cleared for development, ten tons of eroded sediment makes its way into our water bodies. Additionally, one acre of impervious surface cover causes one million gallons of runoff to flow into our drainage basins (Blue Neils, Pers. Comm. March 18, 2008). The easiest way to prevent these impacts is to control sediment at the source—that is, these impacts will never occur if sediment is effectively contained on site. Sedimentation in lakes and other water bodies can have negative effects on the physiology of fish and other macroinvertebrates. Furthermore, increased sediment also prevents light from reaching aquatic plants, which has a detrimental effect on the health of the lake (EPA 1995).

Heavy metals naturally occur in rock minerals, vegetation, sand, and salt, however, they are also present in car and truck exhaust, worn tires, engine parts, brake linings, weathered pains and rust. These pollutants are toxic to aquatic life and can also contaminate ground water (EPA 1995). Saratoga County is the second fastest growing county in the state, and as such, development plans should adequately address the risks of non-point pollutants like N and P, sediment and heavy metals on local water bodies.

Development and Stormwater Runoff

The amount of runoff generated by a rain event is dependent on the duration, amount, and distribution of precipitation during the storm, coupled with watershed characteristics such as size, shape, topography, soil permeability, and land use practices (Ma 2004). Urbanization and development cause drastic increases in impervious surface cover in the form of roads, parking lots and roofs. The increases in imperviousness prevent stormwater runoff from infiltrating the ground and recharging groundwater supplies, as it did prior to development (Walsh 2005). Literature reports state that areas with 7-15% impervious surface cover begin to experience lower water quality, an effect associated with runoff-carrying non-point pollutants (Morin 2007). Because many of the risks to local water bodies are associated with imperviousness and sediment loading from construction sites, the importance of managing stormwater runoff is gaining attention from city planners and local advocates.

Stormwater Management

Because stormwater runoff plays such a large role in polluting our waters it has encouraged policies, standards, and practices at federal, state, and municipal levels. The Clean Water Act (CWA), managed by Environmental Protection Agency (EPA), originally functioned as the main federal legislation for managing point source pollution. The Act required states to develop their own water quality standards based on individual water bodies, however, methodology for monitoring water quality was still in its infancy and enforcement was nearly impossible. In 1972, the CWA was amended to require permits for polluting from point sources (Federal Water Pollution Control Act Summary). Permits are obtained from the National Pollution Discharge Elimination System (NPDES) and limitations can also be added to a permit in order to ensure that water quality is not only maintained, but also improved. This requires polluters to set up treatment and filtering facilities before wastewater can be piped to a body of water. In 1987, the Water Quality Act was passed, which also required industrial stormwater dischargers and municipal separate storm sewer systems (MS4s) and construction sites that disturb more than one acre obtain permits from the NPDES (NPDES 2007). MS4s are a network of stormwater drains that pipe runoff to an alternate location-this is the system in place in Saratoga Springs (Stormwater Management Report, Saratoga Springs 2008).

Stormwater Management in Saratoga County

To implement federal regulations, the New York State Department of Environmental Conservation (NYSDEC) also requires permits for MS4s and construction sites. In New York State laws, the governing body also has the authority to enforce these federal regulations. Recently, nation-wide attention has shifted towards assessing the impacts associated with stormwater runoff, though currently there are no laws or regulations (NYSDEC 2008). Locally, however, the Saratoga County Intermunicipal

Stormwater Management Program aims to educate effected communities and municipal governments about federal regulations governing local stormwater management and non-point source pollution, in order to find solutions to protect local water resources (Saratoga County Intermunicipal Stormwater Management Program). While their effort is primarily educational, it is a progressive step towards shifting focus towards better management and prevention of non-point pollutants in Saratoga Lake. This study will investigate current policies and local action and evaluate their effectiveness in terms of reducing pollutants associated with stormwater runoff.

Study Area

We focus on the issues surrounding stormwater management implementation as well as the strategies used to reduce non-point pollutants in the Kayaderosseras watershed. The Kayaderosseras watershed covers an area of approximately 204 square miles, and encompasses ten municipalities (Figure 1). All of the precipitation that falls within the watershed boundaries eventually makes its way to its drainage basin, Saratoga Lake. Saratoga Lake is 5.8 square miles in size, has significant residential and commercial development on its shores, and serves the community as a recreational hotspot.

The lake also serves as the final destination for stormwater that flows over the impervious surfaces, and through the municipal separate storm sewer system (MS4) in Saratoga Springs. The system consists of stormwater drains that lead to a network of underground channels that release into "City Brook" on Excelsior Ave. City Brook connects with Spring Run, a stream that flows from Loughberry Lake to Saratoga Lake.

During heavy rain events, water is released from the channels beneath the city at a high volume which flows at a rapid rate. This stormwater remains untreated as it is released into the environment and most likely contains concentrated levels of pollutants. Many of these pollutants are probably dissipated throughout the watershed on their way to Saratoga Lake, but it's likely that significant portion will still make it to the lake. Without a monitoring system in place, this is merely a speculative statement. The overarching goal of this project is to assess the extent of non-point source pollutants in the watershed using a predictive hydrologic water model, through the examination of stormwater management policies of municipalities within the watershed.

Methods

The interdisciplinary nature of this project required an assortment of data collection, including: the completion of a Long-Term Hydrologic Impact Assessment model, interviews, construction site inspections, and an analysis of municipal stormwater management goals and annual reports.

Long-Term Hydrologic Impact Assessment

In order to better understand the extent of non-point source pollution within the Kayaderosseras watershed, we used a predictive Long-Term Hydrologic Impact Assessment (L-THIA) model. The model, created by Purdue University, combines rainfall data, land-use data, area, and hydrologic soil data to determine the average annual runoff for each specified land-use type within the watershed. L-THIA then applies these runoff results to known ratios of runoff volume to pollutant mass, known as Event Mean Concentration (EMC) data, to generate a NPS pollution profile for each land-use type.

We ran the model for each municipality within the watershed and combined the results to create NPS pollution profiles for each. By doing so, we have determined the extent to which municipalities generate specific NPS pollutants (Figures 2-5). We have also identified the municipalities that have the greatest NPS impact on the Kayaderosseras watershed (Figure 6).

Management Goals and Annual Reports

To gain an understanding of how municipalities within the watershed intend to implement the minimum control measures of the SPDES permit, we collected and analyzed management plans for each town within the watershed that meets the management criteria. We extracted and grouped goals to see where the towns' goals overlapped and stood alone. Additionally, we obtained what annual reports that were available (some towns were unavailable) to determine how successful a town was in implementing their projected goals.

Interviews

To better understand how policy impacts those required to implement and enforce stormwater regulations, we performed a series of interviews with the following people:

- Blue Neils, Coordinator, Saratoga County Intermunicipal Stormwater Management Program
- Paul Males, Saratoga Springs City Engineer

- Dave Carr, Architect and construction site inspector, LA Group, LLC.
- Matt Gabryshak, Owner, Gabryshak Constructions
- John Witt, Owner, Witt Constructions

We also attended the annual meeting of Saratoga County stormwater coordinators.

Construction Site Inspections

To see first hand how sediment runoff control methods work, how regulations are monitored and enforced, and how a developer implements methods to comply with federal and state regulations, we accompanied Dave Carr and Paul Males on several construction site inspections. Two of the inspections were large-scale residential developments: Ridgewood Estates in Malta, and Saratoga Farms, just outside of Saratoga Springs. Additionally, we accompanied the professionals on three commercial site inspections, including: Skidmore College Zankel Music Building; a commercial site on the corner of West Street and Church Street, Saratoga Springs; and a site on Excelsior Avenue in Saratoga Springs.

Results and Discussion

The following findings have emerged from our research on the stormwater management policies and implementation strategies of the municipalities within the Kayaderosseras watershed.

Long-Term Hydrologic Impact Assessment Model

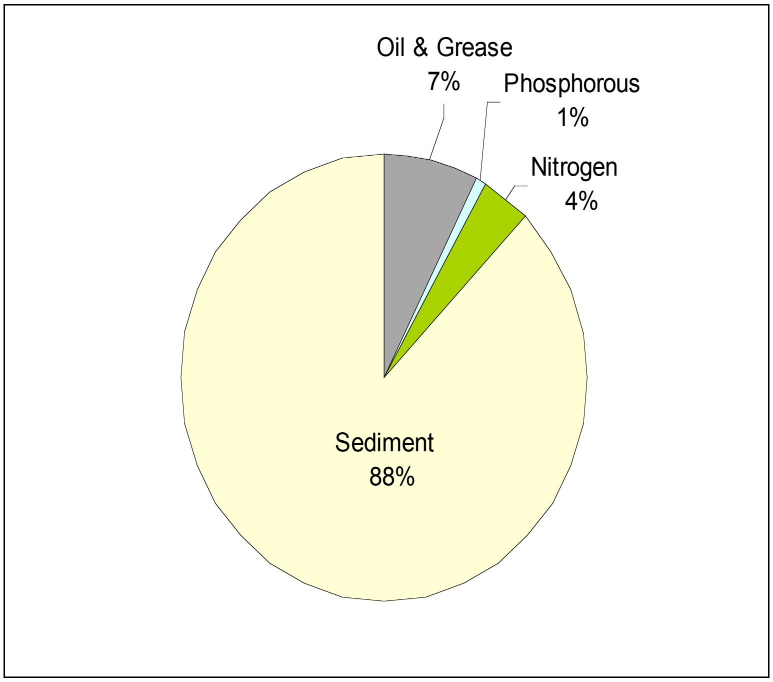
The L-THIA model provided estimates of various contaminants contributed annually to the watershed from stormwater runoff (Table 1). Among these, we identified four major pollutants in the watershed, based on mass: suspended solids, nitrogen, phosphorous, and oil & grease (Figure 1).

Table 1: Predicted Nonpoint Source Pollutant Loads in the Kayaderosseras Watershed

Suspended Solids (lbs)	**720,650.00**
Oil & Grease (lbs)	**58,748.00**
Nitrogen (lbs)	**33,915.00**
Phosphorous (lbs)	**6,857.09**
Zinc (lbs)	1,437.05
Copper (lbs)	253.63
Chromium (lbs)	188.82
Lead (lbs)	172.60
Nickel (lbs)	98.00
Cadmium (lbs)	22.04
Fecal Coliform (millions of coliform)	766561
Fecal Strep (millions of coliform)	1321263

Of these four major pollutants, we found that sediment loading, primarily from construction sites, ranks as the most severe and preventable hazard to the Kayaderosseras watershed. The L-THIA model estimates that 720,650 pounds of suspended solids are added to the watershed each year, comprising approximately 88% of the overall pollutant loading (Figure 1). In comparison, oil and grease, nitrogen, and phosphorous, comprise 7%, 4%, and 1% of the annual pollutant loading, respectively. While other forms of non-point pollutants make their way into the watershed, their mass is negligible when compared to these top four pollutants. It's important to note that while these values are purely predictive, sediment is the main non-point pollutant in the watershed. Fortunately, sedimentation and erosion control are the easiest forms of non-point pollution to manage, as they primarily originate from construction site runoff and winter road maintenance.

Figure 1. Percentage of Major Non-Point Source Pollutants in the Kayaderosseras Watershed



Individual Municipalities

Individual municipalities input varying amounts pollutants into the watershed. The amount of pollutants contributed by each municipality is dependent on its land use practices, how much of its area is contained within the boundaries of the watershed, and its soil composition. Certain land-use types are characterized by more impervious surface area and thus generate more stormwater runoff and NPS pollution than others. Soil composition affects runoff volume as well, as some soils are more permeable than others. Municipalities with less development, i.e. less impervious surface cover, and more permeable soils, will generate substantially less runoff and NPS pollution than municipalities characterized by greater development and impermeable soil types. Our results indicate which stormwater NPS pollutants municipalities should focus their stormwater management programs on.

Figure 2. Municipalities within the Kayaderosseras Watershed

Of all the municipalities within the watershed (Ballston, Wilton, Milton, Malta, Saratoga Springs, Greenfield, Corinth, Providence, Galway, and Charlton) (Figure 2), we found that Saratoga Springs and Milton are the top two contributors for all four of the identified major pollutants (Figures 2-5). Saratoga Springs contributes 32% to the total sediment load, 44% to the total oil & grease load, 30% to the total phosphorous load, and 23% to the total nitrogen load. Milton contributes 19% to the total sediment load, 16% to the total oil & grease load, 21% to the total phosphorous load, and 19% to the total nitrogen load. These results are most likely attributed to increased levels of development within Saratoga and Milton, compared to other towns within the watershed. Our results indicate the need for more stringent and progressive action particularly within municipalities that are a main source of stormwater pollutant loading, like Saratoga Springs and Milton. They also indicate the need to improve regulation of construction sites, the main source of sediment loading.

Figure 2. Predicted Sediment Contribution by Municipality in the Kayaderosseras Watershed

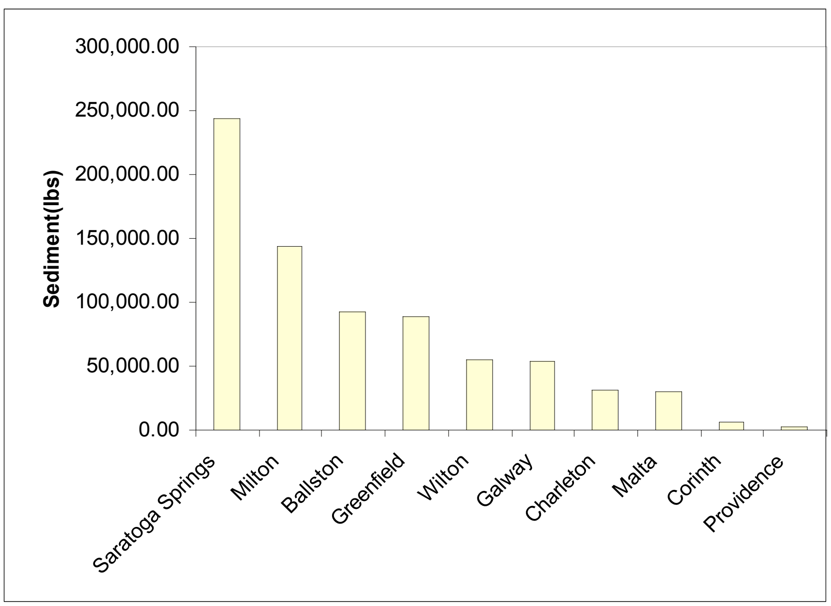


Figure 3. Predicted Phosphorous Contribution by Municipality within the Kayaderosseras Watershed

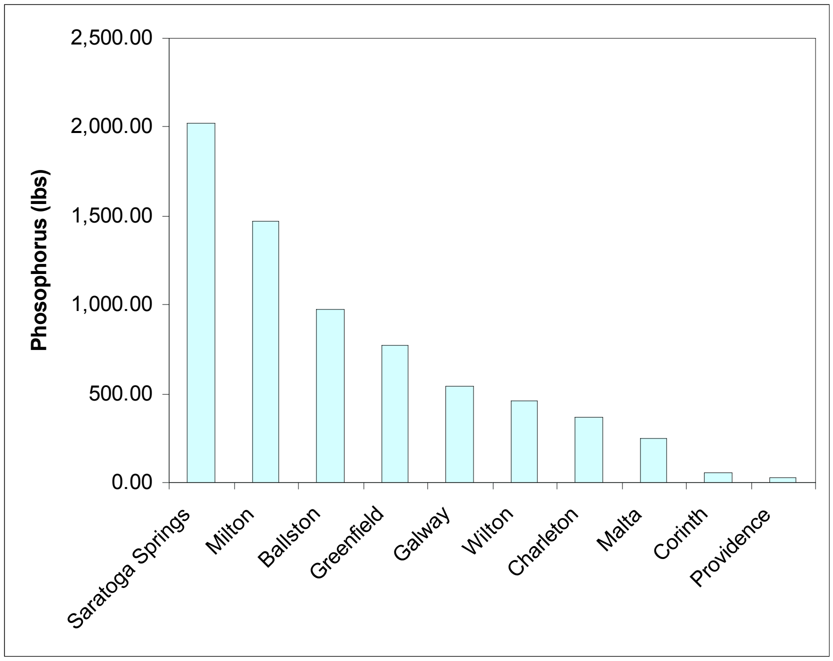


Figure 4. Predicted Nitrogen Contribution by Municipality within the Kayaderosseras Watershed

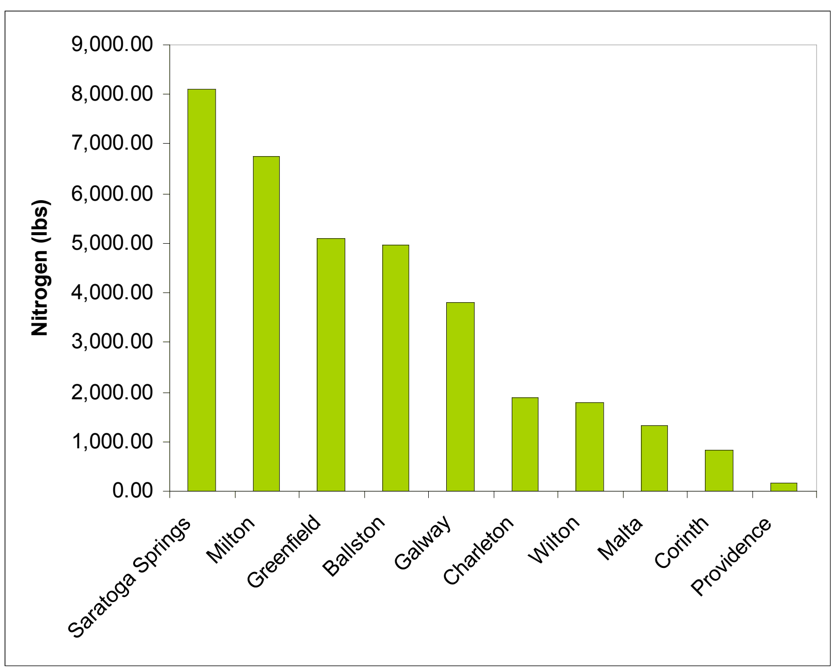


Figure 5. Predicted Oil and Grease Contribution by Municipality in the Kayaderosseras Watershed

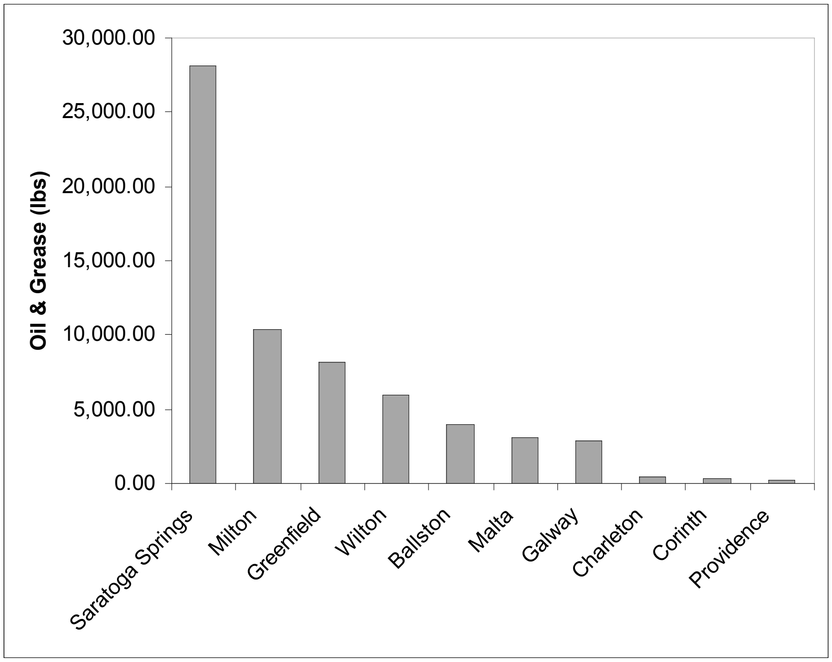
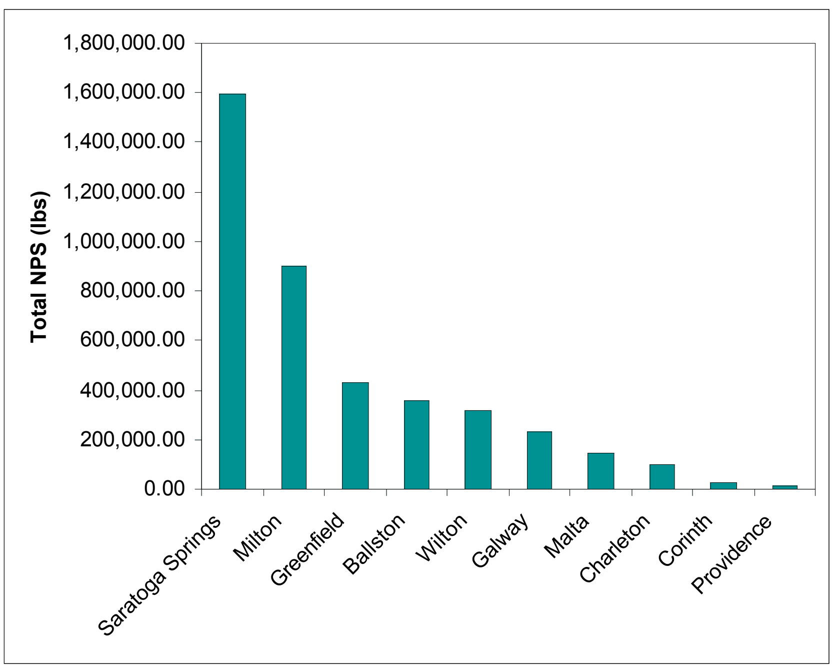


Figure 6. Total Predicted Non-Point Source Pollutant Loading by Municipality



State Pollution Discharge Elimination System (SPDES)

The information gathered from the predictive L-THIA model discussed above is intended to put stormwater policy and implementation into perspective as we discuss municipality goals and efforts to comply with federal and state regulations as well as implement actions aimed at reducing non-point pollutant loading into local water bodies.

Minimum Control Measures

We have provided evidence that private-sector or municipal compliance with state environmental regulations can be very difficult to achieve, as few of the municipalities' stormwater management goals (Section D of the SPDES permit) seem to achieve their full list of projected goals. Part IV of the SPDES permit requires each town with a population greater than 1000 people per square mile that is also connected to a continuous urban area develop management strategies that aim to implement minimum control measures required by the state. The minimum control measures of the Stormwater Management Program (SWMP) include:

1. Public education and outreach on stormwater impacts
2. Public involvement and participation
3. Illicit discharge detection and elimination
4. Construction site stormwater runoff control
5. Post-construction stormwater management
6. Pollution prevention and good housekeeping for municipal operations.

These minimum control measures are supported with detailed goals (Appendix 1) that strive towards an overall improvement in water quality and public awareness of stormwater. Each town was given the task in 2003 of coming up with management strategies and an implementation schedule of this 5-year management plan.

The six minimum control measures proposed in the SPDES permit in effect, force each town to think about stormwater management in a thorough, interdisciplinary manner. All the goals proposed by the towns hold great potential for progressive stormwater management strategy, and provide and integrate framework on which to base a management program. Because stormwater management must consider ecological, political, social, and economic factors, no one control measure can be deemed more important than another.

Implementation of Management Goals

Data was compiled from Section D reports of the SPDES General Permit for Discharges from Small Municipal Separate Storm Sewer System. These documents were written in 2003, by either town stormwater coordinators, or private contractors (Appendix 1). Goals were established by using preexisting materials from other municipalities with similar population densities and urban environments, and by using recommended strategies outlined by the EPA.

The towns within the watershed all have access to information, support, and resources from the Cornell Cooperative Extension, Saratoga County Intermunicipal Stormwater Program. This program aims to aid towns with understanding the multi-faceted and extremely complex issue of stormwater management. A key difference between towns, however, is the funding that is available for implementation of stormwater management goals. However, according to Blue Neils,

> from a financial standpoint, there is big difference in terms of what [smaller, poorer towns] can implement, but it's not to say that they can't implement as good as or equivalent to a town with very deep pockets. It's a matter of scale; smaller towns have certain key things that they can tee off on, even if they have a limited workforce with limited training but they've also got a very small management area so they can chip away at those things very effectively with a few small measures. (pers. comm. April, 2008)

This implies that the financial situation of a town does not condemn it to an ineffective stormwater management program.

Through thorough analysis of the management goals proposed by the towns within the Kayaderosseras Watershed, it appears as though the goals of the towns are not overly ambitious. This is not to say that they are invalid, however, it merely means that the goals seem to appease the minimum control measures, but not much more. Regardless of the scale of ambition, the management goals aim at improving non-point pollutant loading of local water bodies, which is adequate for compliance with federal regulations.

Additionally, when considering the difficulties of implementation of management goals, the size of the municipality matters. Blue Neils explains that a small government's lack of professionals specially trained in stormwater management affects their ability to carry out proposed management goals. The employees in these smaller towns that often hold several job titles can easily go out and perform maintenance and tasks, but when it comes to fully understanding the whole issue, they lack the time, commitment, and capacity to completely understand the importance something like educating the public. Blue Neils asserts that this stems from difficulties with the permits themselves, rather than the towns.

> You're talking about educating the public, business-owners, contractors, the general public and your own employee base. You're asking people who have no expertise on stormwater or hydrology to carry those kinds of things out or even have the time to compile that information, that I think is the most difficult part about the permits themselves. It pulls from so many different elements and has such a broad, reaching effect that it is very difficult for these municipalities to get their heads around. (Blue Neils, April, 2008)

Through the analysis of our data, achieving actual implementation of public outreach and education is easily done through the availability of printed materials and information provided in town newsletters. These actions are easily done at little cost. Additionally, public involvement and participation is also achieved through the participation of local community interest groups, such as the Friends of the Kayaderosseras, and Boy and Girl Scout troops at just the cost of materials. These groups help achieve management goals by stenciling storm drains and cleaning up parks and roadsides. Also, achieving management goals regarding construction site runoff are also more easily managed because success or failure of a site's silt fences and other runoff control measures is obvious upon site inspection. This issue is elaborated on later in this paper.

Goals that seem to be more difficult to achieve include those regarding post-construction runoff. These goals tend to be more difficult because they involve much more time and money to do things such as observe and maintain town-owned storm basins and outfalls, inventory water quality problems and identify pollutants of concern. The same is true for implementation of goals regarding illicit discharge detection and elimination, which requires inspection and monitoring of stormwater outfalls. Also, it is more difficult for towns to achieve full compliance of their pollution prevention and good housekeeping goals, because this requires training employees (which requires hiring a private consultant), maintaining roads and highways, and establishing long-term inspection programs for stormwater management.

As part of this research, we also attempted to analyze which municipalities are better at implementing their stormwater programs than others. In terms of being able to get things accomplished, having a willing and able staff is key. This, however, requires that the town have the funds to hire a stormwater coordinator that is able to focus entirely on the stormwater program rather than juggle several important tasks.

Annual Reports

Based off of the Section D management goals proposed laid by each municipality, the annual reports serve as a reference that indicate whether each municipality is actively working towards the management goals they proposed in 2003. Although in most municipalities the complete list of measurable goals listed have not been achieved, through the analysis of the annual reports, as well as through personal communication with Blue Neils, our study has indicated that the municipalities within the Kayaderosseras watershed have enacted most, if not all of the goals possible for implementation based on each municipalities' resources. Therefore, although they may lack the sufficient resources to achieve 100% of their management goals, Blue Neils states, "by in large they've all got something. They all do something that is particularly good."

Additionally, Mr. Neils suggests that the political background of the county makes total compliance difficult at times and that the most difficult aspect of achieving implementation of measurable goals appears to be the lack of funding, as each municipality is responsible for funding the program. Despite this, town stormwater coordinators, in conjunction with the Saratoga County Intermunicipal Stormwater Program and the Cornell Cooperative Extension, appear to be dedicated and motivated to improve local water bodies through effective and feasible stormwater management strategies.

Future Permits

The stormwater management program was designed to be a five-year program in which municipalities would move from planning to implementation. After five years (the end of the permitting cycle occurring in May of 2008), the towns expected an extension involving an additional five-year program in which they could fine tune and continue to implement their management goals. However, as of May 1, 2008, the New York State Department of Conservation began regulating new, more stringent permitting requirements. These updated requirements can be costly (up to $2 million/year/town), and local stormwater managers are concerned with the financial burden associated with complying with the new permits (pers.comm. April 18, 2008). Additionally, the more stringent permitting process and regulations could also make some of the implementation steps already taken seem trivial, when in actuality, towns have worked hard to get to this point. Local stormwater coordinators are frustrated with the new 2-year permitting program, particularly because two years is not enough time to effectively plan, fund, and implement an entirely new set of permitting requirements. Also, the stormwater coordinators in Saratoga County are upset with the new permitting requirements because they feel that they are being punished for the lack of action taken by other municipalities around the state, when they have worked hard to plan and implement an effective stormwater management program (pers. comm. April 18, 2008).

Stormwater Management of Construction Sites

In order to better understand the relationship that exists between stormwater regulation and actual compliance, we went on five construction site inspections with local professional inspectors. The sites included: (1) the Skidmore College Zankel Music Building site; (2) Ridgewood Estates in Malta; (3) Saratoga Farms; (4) the commercial site on West and Church; and (5) the Andre Site at Excelsior.

Construction sites disturbing more than one acre are required to adhere to a site-specific Stormwater Pollution Prevention Plan (SWPPP). The SWPPP requires that the developer engages in effective stormwater management practices, such as the installation and maintenance of silt fences, stone check dams, and retention ponds. Additionally, the SWPPP requires developers to stabilize the inactive but disturbed areas of the site using hay or hydro-seed methods. In a conversation with Dave Carr, a landscape architect and construction site inspector for the LA Group, we learned that inspection costs can run up to $5,000 per site, per year, in addition to the costs of installing and maintaining methods of runoff control. While these costs appear to be worthwhile in the name of environmental protection, the additional expense ultimately drives up the price of homes, placing an economic strain on both developers and buyers.

These large costs accumulate for the developer, as construction sites must be inspected once every 7 days, or after every half inch of rain. The sites that we inspected were all within relative compliance with the SPDES permit and the site-specific SWPPP. In a previous inspection of Ridgewood Estates in Malta, Dave Carr indicated several things that needed to be done, such as the maintenance of a silt fence on the downhill slope of one site, the creation of stone check dams that would block movement of sediment, and the cleaning out of the fore pond of a retention basin. The first two had been done, and the positive impacts could already been seen.

In order to explore the inevitable tensions that exist between these interests, we conducted several interviews with local developers to better understand their perspective on stormwater regulations. Ultimately we found that developers are split on the issue of the importance of sediment control. Some believe that protecting the environment is imperative, where others simply comply because it is the law. One developer stated, “If it wasn’t the law, I wouldn’t do it” (Anonymous, April 17, 2008) while others expressed that they respected the regulations as a means to ensure environmental protection in the watershed. Despite these differing perspectives—even in the case of those who favored environmental compliance—our interviews unanimously confirmed that the high level of costs associated with sedimentation and erosion control are seen as very frustrating to local developers.

Methods of Compliance

In order to better understand implementation of stormwater management in the Kayaderosseras watershed, we explored several possible methods of achieving environmental compliance. Our research—which was collected from interviewed professionals such as Blue Neils as well as through journal articles—suggests that in order to achieve higher performance standards and improve overall compliance with respect to stormwater management, what are known as “deterrent” and “cooperative” approaches should be followed and used in combination. Simply put, these terms mean that state or local governments should stimulate environmental compliance through the use of monitoring and inspections, with fines for noncompliance, as well as build a more cooperative approach by building commitment and capacity to obey the law. Our research revealed that in order to improve successful implementation and compliance at the municipal level municipalities must seek to use both of these strategies.

Through our research on compliance, we also determined that while local governments can be as effective as state governments in administering and inspecting implementation of municipal stormwater policies, in most municipalities of the Kayaderosseras watershed these issues cannot be given priority status due to a lack of time, resources, and manpower. Therefore, our study suggests that the role of the state should be much larger in the regulation of stormwater practices at the municipal level in order to ensure the full capacity to regulate. Based on our conversations with Blue Neils, we learned that in many cases the local municipalities are simply not equipped with the necessary means to implement their management goals and would therefore benefit from the state playing a larger role in regulation.

Conclusions

Our results provide a baseline study on stormwater management in regards to environmental impacts, as well as the efficacy of federal and state policy by local towns. This study shows that sedimentation is probably the largest non-point pollution source, which is also the most manageable of non-point pollutants. As supported by our predictive L-THIA model, we also found that as development increases—corresponding to a greater impervious surface cover—we see an increase in sediment and other non-point source pollutants within the watershed. Therefore, understanding stormwater requires a thorough knowledge of the overarching environmental implications that are associated with an increase in development in a watershed. Non-point source pollution is the leading cause of water contamination in the United States, and therefore it is essential that we come up with suitable regulatory standards to protect our natural resources. If we plan to use Saratoga Lake as a supplemental drinking water source, it is vital that we have a thorough understanding of non-point pollutant loading, as well as plans to reduce the adverse affects of these pollutants on the ecosystem and recreational function of the lake. Therefore it is essential that we find the balance between the needs for environmental protection and the drive to use, expand and develop.

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