Enhancing Local Capacities for Stormwater Management in Nassau, New Providence, The Bahamas

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NOTE: This initial Report is part of an ongoing study of stormwater runoff in Nassau, The Bahamas, and its conclusions are necessarily preliminary and subject to refinement and revision based on further water quality testing and analysis.

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Abstract

Stormwater pollution is recognized as one of the most significant sources of pollution in coastal waters (NRDC, 1999). Stormwater management is essential in Nassau, New Providence, and in Caribbean island states as a whole, as their economies are closely tied to the environmental and ecological integrity of the coastal zone. An assessment of The Bahamas' regulatory and non-regulatory capacity to address stormwater management was conducted. The findings were informed through a literature review, a series of interviews with governmental agencies and non-governmental organizations, and pollutant loading estimates based upon an on-the-ground land use survey. The results indicate that The Bahamian government does not currently have capacity for stormwater management, and that non-regulatory approaches to stormwater management could be more feasible short-term solutions. Recommendations for building government capacity as well as specific non-regulatory stormwater management strategies are provided.

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Stormwater pollution is recognized as one of the most significant sources of pollution in coastal waters (NRDC, 1999). Stormwater runoff occurs every time it rains as water runs across land, picking up contaminants that result from varied land uses, such as residential developments, roads, parking lots, roof tops, golf courses and urban areas. Most population centers, including Nassau, are located along coastal waterways, exposing these natural resources to increased pollution levels and often leaving them highly degraded. Although stormwater management systems have been developed to help address the problem of the quantity of water flowing over the land surface, untreated stormwater is still frequently discharged into the nearest body of water (NRDC, 1999).

Stormwater management is essential in Nassau, New Providence, and in Caribbean island states as a whole, as their economies are closely tied to the environmental and ecological integrity of the coastal zone. Unmanaged stormwater runoff can lead to significant environmental degradation, which in turn can have negative social and economic implications. The objective of this study was to complete an integrated stormwater management assessment of Nassau Harbor, New Providence, establishing the current extent of management and potential capacities for future management. This study attempts to answer the following questions:

- How does the success of regulatory strategies or lack thereof, impact the success of stormwater management and coastal environmental quality?
- To what extent does the lack of successful regulatory strategies provide opportunity for the development of non-regulatory strategies in managing stormwater in The Bahamas?

Executive Summary

The stormwater management assessment and recommendations were largely informed by field work conducted in March 2008, which was performed in conjunction with the College of the Bahamas (COB) and the Tufts Water: Science, Systems, and Society (WSSS) program. These data included the results of a land use survey of the study area, information gathered during interviews with governmental agencies and non-governmental organizations, and a brief public survey.

The results of the interviews identified that the Bahamian government does not currently have capacity for stormwater management, and that non-regulatory approaches to stormwater management could provide more feasible short-term solutions. The lack of regulatory capacity is largely based on the absence of a centralized regulatory framework for environmental management, and a lack of communication, coordination and collaboration among existing environment agencies. Additionally, the interviews with NGOs identified that public education is vital for the success of any program introduced to manage stormwater, and that baseline data would be needed for management programs to be fully effective. The NGO interviewees expressed interest in implementing stormwater management programs, provided the necessary funding.

An essential component to any integrated water resource management approach is technical baseline data (US EPA, 2005). To quantify the amount of stormwater runoff and degree of pollution that the study area is contributing to Nassau Harbor, the "Simple Method" was used to model pollutant loading, based on the land use survey results (SMRC, 2008). The model results indicate that among the land use categories in the study area, roadways and parking lots, which have the highest degree of imperviousness, contribute the greatest amount of pollution to Nassau Harbor.

Although a non-regulatory approach to stormwater management in Nassau was determined to be the most feasible short-term solution, based on the results of the pollutant loading model and interviews, a series of regulatory recommendations for stormwater management were prepared. Government oversight of stormwater management is necessary for comprehensive, long-term management of stormwater runoff; therefore, specific recommendations for the expansion of government capacity are suggested. The recommended regulatory techniques include: an overarching Department of the Environment; a memorandum of understanding and a joint stormwater management committee among existing environmental agencies; a stormwater utility; and fulfillment of ratified international conventions.

Contrary to a regulatory approach that requires government action, oversight and funding, a non-regulatory approach can be overseen by a non-governmental organization and implemented through grants, loans, volunteers, or a combination of funding sources. There are many reputable and motivated environmentally-focused NGOs in the Bahamas; several of which expressed interest in providing stormwater management if they had available capacity (Moultrie, 2008; McKinney,

2008; Duncombe, 2008). Recommendations for implementing specific structural and nonstructural stormwater management techniques are made, along with strategies for non-regulatory implementation. The recommended non-regulatory techniques include: bioretention retrofits in parking lots; high performance landscaping techniques; rain barrels and cisterns; a water quality monitoring program; an adopt-a-beach/roadway program; and a stromwater education and outreach program.

Recommendations for further research have also been identified in order to gain a more comprehensive understanding of stormwater runoff and associated pollution entering Nassau Harbor. The WSSS program is hoping to build upon this study and continue research regarding the impacts of stormwater runoff and potential solutions for stormwater management in Nassau, The Bahamas.

Chapter One

Purpose of the Study

Stormwater pollution is recognized as one of the most significant sources of pollution in coastal waters (NRDC, 1999). Stormwater runoff occurs every time it rains as water runs across land, picking up contaminants that result from varied land uses, such as residential developments, roads, parking lots, roof tops, golf courses and urban areas. Most population centers are located along coastal waterways, exposing these natural resources to increased pollution levels and often leaving them highly degraded. Although stormwater systems have been developed to help address the problem of the quantity of water flowing over the land surface, untreated stormwater is still frequently discharged into the nearest body of water (NRDC, 1999).

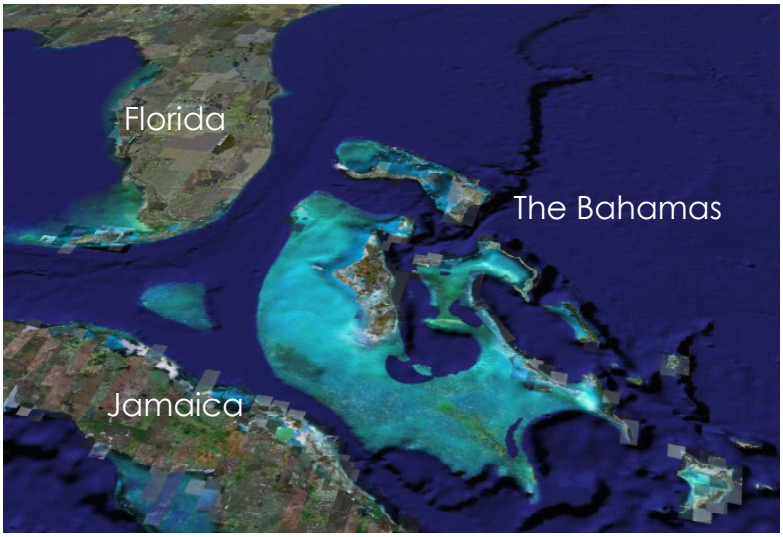
Stormwater management is essential in Nassau, New Providence, and in Caribbean island states as a whole, as their economies are closely tied to the environmental and ecological integrity of the coastal zone. Unmanaged stormwater runoff can lead to significant environmental degradation, which in turn can have negative social and economic implications.

The objective of this study was to complete an integrated stormwater management assessment of Nassau Harbor, New Providence, establishing the current extent of management and potential capacities for future management. This study attempts to answer the following questions:

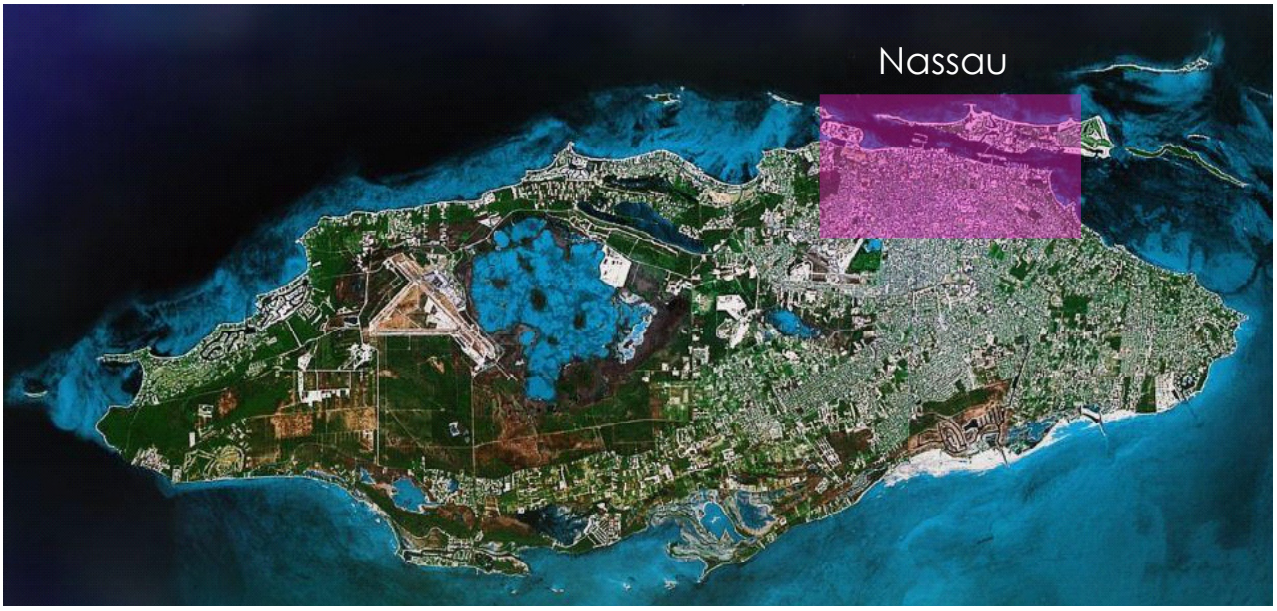
- How does the success of regulatory strategies or lack thereof, impact the success of stormwater management and coastal environmental quality?
- To what extent does the lack of successful regulatory strategies provide opportunity for the development of non-regulatory strategies in managing stormwater in The Bahamas?

An essential component of an integrated stormwater management assessment is to assess the link between policy and management decision and ecosystem health. To determine this connection a field study was conducted with students and professors from the College of The Bahamas (COB) and Tufts Water: Science, Systems, and Society (WSSS) program. Field work was conducted to determine the land use patterns around Nassau Harbor and the extent of stormwater pollution in the coastal zone. Specifically, a land use-based pollutant loading model was used to determine expected levels of pollution entering the coastal zone. The results are interpreted in light of known site-specific stormwater management practices. Additionally, interviews were conducted with government agencies and non-governmental organizations to determine the extent of management regimes and potential capacity to address identified issues. Recommendations for regulatory and non-regulatory strategies are based on the technical data established though the field work, interviews conducted, and Best Management Practices (BMPs) reviewed in the literature.

The Bahamas Islands



New Providence Island



Source: Google Earth

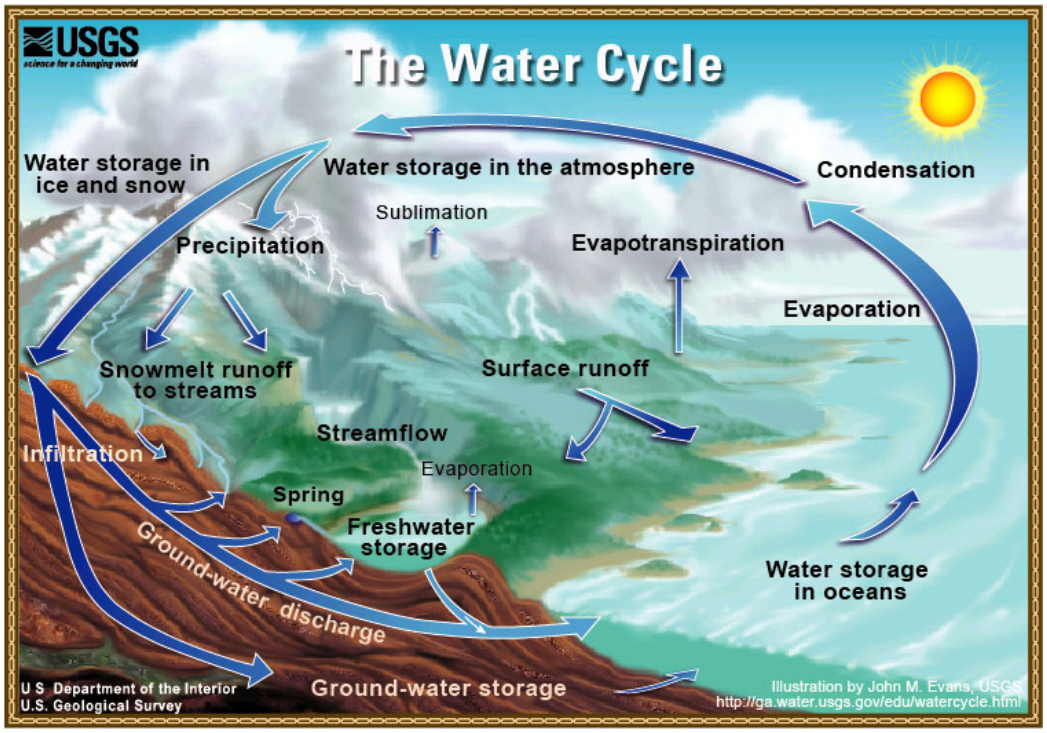
Chapter Two

Stormwater in Context

2.1 Stormwater

It is important to fully understand where stormwater fits in the hydrologic cycle. There are five main components of the cycle: (1) precipitation, (2) infiltration, (3) evapotranspiration, which includes both evaporation and transpiration (the process through which plants release water into the atmosphere), (4) surface water storage, and (5) groundwater storage (Figure 1). The hydrologic cycle in The Bahamas differs slightly, as there are no bodies of surface water.

Figure 1. The Water Cycle

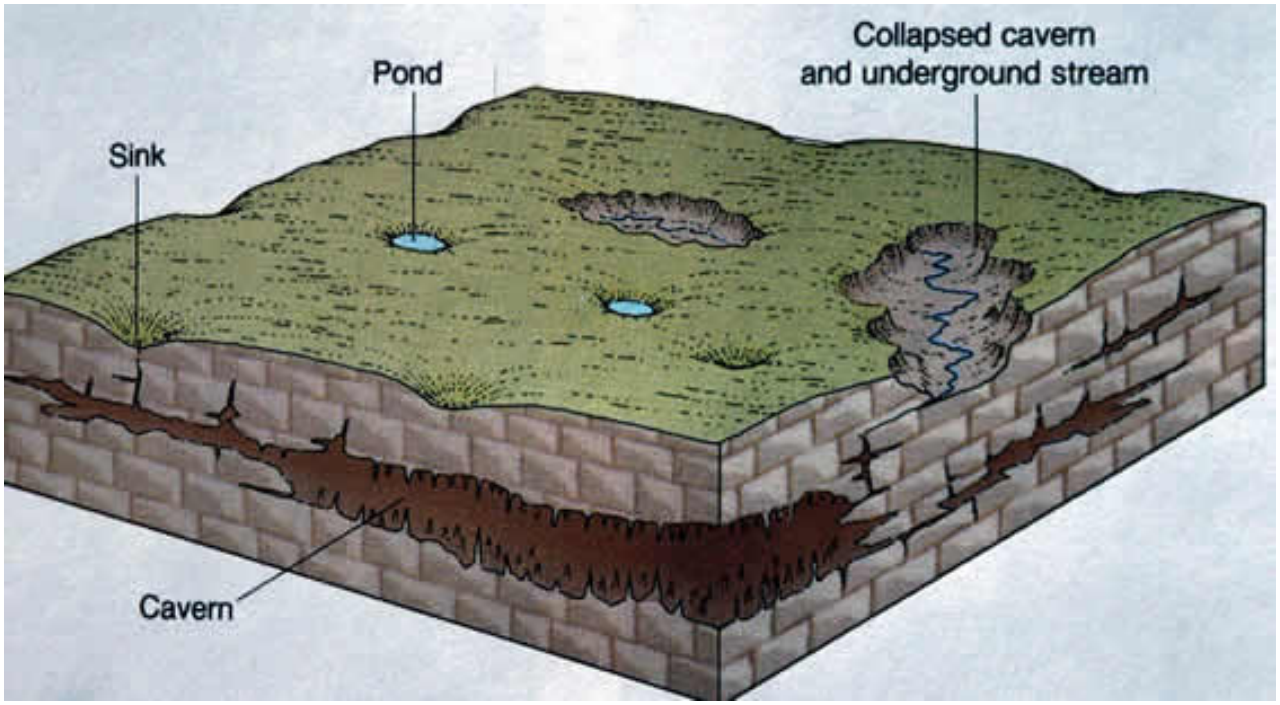


Source: U.S. Department of the Interior, U.S. Geological Survey, http://ga.water.usgs.gov/edu/watercycle.html

When it rains in The Bahamas, water may take several of the above mentioned paths. The amount of water taking each of these paths varies depending on precipitation patterns, soil types, climate, and vegetation. The amount of runoff is most significantly influenced by the amount of rainfall, the intensity of the storm, and the characteristics of the land on which the rain falls. According to EPA, the southeastern United States has an average annual rainfall of 45.1 inches. A single storm has an average volume of 0.49 inches, average intensity of 0.102 inches per hour, average duration of 6.2 hours and occurrence of one storm every 89 hours (US EPA, 1999b, p. 6-26 – 6-31). These numbers are used as a proxy for The Bahamas, since data specific to The Bahamas is not available and the climate in Florida and the southeastern US is most similar.

The water cycle in The Bahamas is further complicated by the karst geology. Limestone is composed of calcium carbonate from the shells and fossils of coastal marine life. Calcium carbonate dissolves easily when exposed to even weak acids. Rainwater naturally absorbs carbon dioxide as it falls to the surface, making it slightly acidic. As rainwater infiltrates the land surface it dissolves the limestone, leaving channels in the subsurface. With enough dissolution of limestone, large underground caverns and rivers systems can be created, such as the Mammoth Cave system in Kentucky (Plummer, 1999, p. 275). (Figure 2) Water can flow through these chambers much faster than

Figure 2. Generalized Diagram of Karst Geology



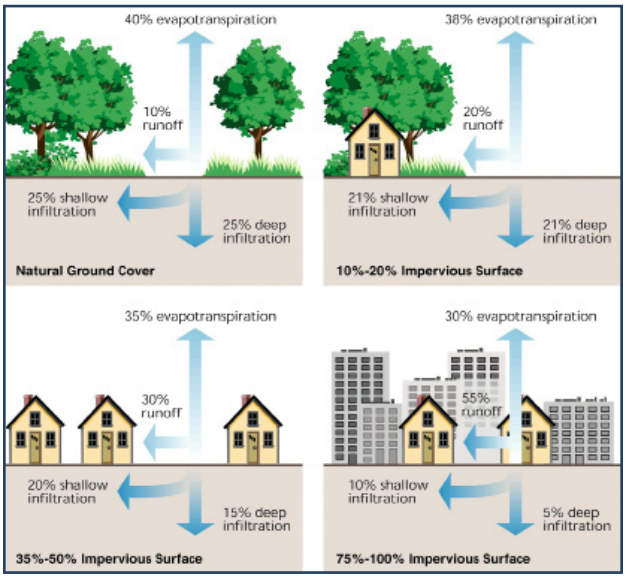
Source: Lew, Alan. US Geography - Appalachia Virtual Field Trip, 2002, http://www.geog.nau.edu/courses/alew/ggr346/ft/e-highlands/limestone.jpg

through typical soils. The result is that stormwater which infiltrates the subsurface may very quickly end up in coastal waters, despite appearing to disappear into the ground. This does not allow for the typical slower filtration process, which is important in removing pollutants from the infiltrating stormwater.

Development greatly alters the natural hydrologic cycle because it increases the amount of impervious surface. Studies have shown that when impervious surfaces reach 10-20% in a given watershed, ecological stress becomes apparent (US EPA, 1999b, p. 6-26) (Figure 3). It is estimated that impervious surface in Nassau is around 60% (WSSS, 2008), suggesting that the ecological integrity of the coastal zone is greatly threatened. As impervious surface area increases, infiltration and evapotranspiration decrease dramatically (See Table 1). As a result, precipitation travels as surface runoff across impervious surfaces, accumulating pollutants from land-based activities, and greatly damaging water quality once it reaches a receiving water body (Figure 4). Increased impervious surfaces also means greater volumes of water being discharged directly into receiving bodies of water, rather than infiltrating into the subsurface and traveling as groundwater or being used by vegetation. Additionally, the velocity of stormwater runoff increases as the total imperviousness increases causing more erosion as it travels.

In addition to being concerned with the increased volume of water resulting from changing land uses, runoff pollutant levels associated with different land uses are also a serious concern. There are seven main categories of stormwater pollutants: metals, organic chemicals, pathogens, nutrients, sediments, salts, and biochemical oxygen demands, such as grass clippings and hydrocarbons (NRDC, 1999). These pollutants are derived from various anthropogenic activi-

Figure 3. Impacts of Impervious Surface on Water Cycle



Source: The Federal Interagency Stream Restoration Working Group, In Stream Corridor Restoration: Principles, Processes, and Practices (1998), http://www.nrcs.usda.gov/Technical/stream_restoration/newgra.html

Table 1. Water Cycle Changes Associated with Development

Surface Type	% Evapotranspiration	% Runoff	% Shallow Infiltration	% Deep Infiltration
Natural Ground Cover	40	10	25	25
10-20% Impervious Surface	38	20	21	21
35-50% Impervious Cover	35	55	10	5
75-100% Impervious Cover	20	55	10	5

Source: US EPA, 1999b, p. 6-14

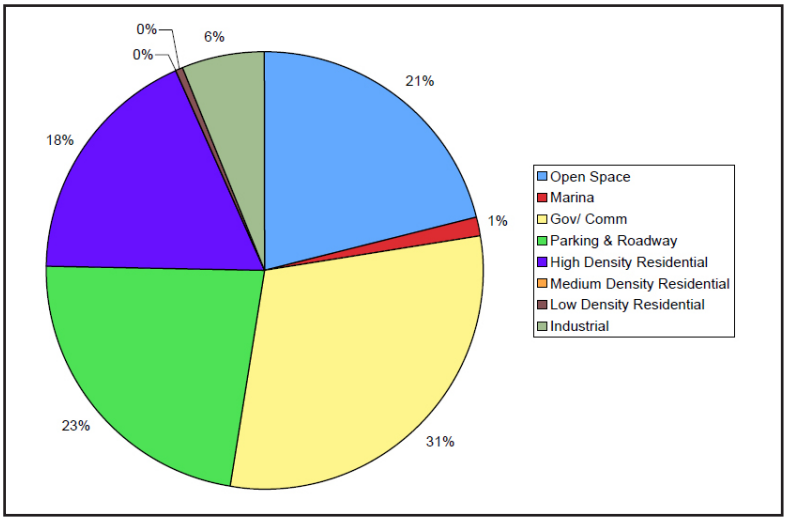
ties. Most impervious surface is a result of transportation systems- roads and parking lots. Pollutants accumulate on these surfaces during dry weather and get washed away in the stormwater when it rains. Studies have shown that transportation related land uses have the second highest concentrations of pollutants; only piped industrial sources have higher concentrations (NRDC, 1999).

Different types of land uses contribute a variety of pollutants to the environment, which are swept away by stormwater runoff. In Nassau, it is estimated that commercial areas, government buildings, and marinas make up 32% of the study area, 23% consists of parking lots and roadways, 21% is made up of open space, followed by 18% residential, 6% industrial land uses (see Figure 5) (WSSS, 2008). Such urban land uses contribute sediments, nutrients, biological pathogens and hazards, metals (copper, zinc, lead, chromium, and cadmium), hydrocarbons, salts, and litter (US EPA, 1999a, p. 6-26 – 6-31). When they are washed away in stormwater runoff, there is great potential for environmental degradation.

Figure 4. Stormwater Runoff

Source: U.S. Environmental Protection Agency, Non-oint Source Outreach Toolbox, "Stormwater & You"

Figure 5. Distribution of Land Uses Within the Study Site



Source: WSSS, 2008

2.2 Environmental Impacts

A number of environmental impacts have been identified as a result of stormwater pollution and runoff. Flooding and property damage is one of the most significant impacts (NRDC, 1999). This is of particular concern in The Bahamas, as the geography is relatively flat, with average elevations of less than 10 meters. The landscape generally consists of rock from coral formations or mangrove swamps with low shrubs. New Providence Island also contains large brackish lakes. These characteristics make the islands particularly susceptible to flooding, and as a result, property damage is of high concern. This has far reaching impacts on quality of life, the local tourism industry and water resources (US Army Corps of Engineers, 2004, p. 3).

Stormwater runoff also increases erosion and sedimentation of receiving waters. As discussed above, volume and velocity of runoff is greatly affected by the percentage of impervious surface. As the volume and velocity increases, the runoff picks up sediments in its pathway and deposits them in receiving waters. This has negative ecological impacts. As the sediments settle out of the receiving body of water, it covers important habitat, such as coral reefs, sea grass and spawning beds. Sedimentation can also be greatly increased at construction sites if proper practices are not followed. It is estimated that erosion from construction sites deposits 80 million tons of sediment into receiving water bodies every year (NRDC, 1999). The Bahamas has seen a proliferation of high-end resort development and small sub-division development in recent years (England, 2005).

Pollutants carried in stormwater runoff can have significant adverse impacts on receiving water quality, and in turn significantly impact marine ecosystems. Some of the most significant contributors to water quality impairment are nutrients, particularly nitrogen and phosphorus. These are a result of septic systems, urban landscapes, agricultural runoff, and atmospheric deposition from sources such as automobiles and industry (US EPA, 1999a, p. 6-27 – 6-28). Nitrogen based compounds are the limiting nutrient in marine ecosystems, and therefore nitrogen is of more concern than phosphorus. Nitrogen loading can lead to eutrophication in marine ecosystems, which is characterized by explosive algal growth. Eutrophication leads to increased turbidity and lower dissolved oxygen levels, which are further exacerbated as the algal growth dies off. As dissolved oxygen levels decrease, it can lead to fish kills and reduce the aesthetic and recreational value of the waters (US EPA, 1999a, p. 6-27 – 6-28). In combination, these negative environmental impacts of stormwater have great potential to significantly degrade coastal marine ecosystems.

Polluted Runoff on Coastal Area

"Note the darker, murky water flowing from the developed area at the lower right."

Source: National Oceanic and Atmospheric Administration (NOAA), Ocean and Coastal Resource Management, http://coastalmanagement.noaa.gov/nonpoint/welcome.html

Another concern is elevated temperatures in receiving waters as a result of stormwater runoff. Studies have shown that impervious surfaces (namely unshaded rooftops, roads, and parking lots) are often 5.6 to 6.7 degrees Celsius (10 – 12 degrees Fahrenheit) warmer than surrounding natural areas and can therefore heat passing runoff to 90 degrees Fahrenheit or more. Research has also shown that increased water temperatures are directly proportionate to the increased percentages of impervious surface within the watershed. Additionally, development often replaces trees and natural vegetation, which play a significant role in shading water bodies. This has devastating effects on aquatic ecosystems that depend on specific water temperatures (NRDC, 1999).

Climate change has the potential to increase stormwater runoff, which leads to sedimentation, erosion, flooding, property damage, degradation of coastal water quality, and increased coastal water temperature.

In addition to the identified environmental impacts of stormwater runoff, climate change impacts further highlight the immediacy of developing an integrated strategy in The Bahamas that is capable of handling the predicted extreme weather patterns. Sea level rise associated with climate change will increase storm surges, erosion, storm inundation, and other natural hazards (IPCC, 2007). Additionally, it is predicted that there will be more extreme rainfall conditions, with dryer dry seasons and wetter wet seasons extending into the transitional season. The most fluctuation in extreme conditions is predicted for the Northern Caribbean, where The Bahamas is located (Singh, 1997). Without a stormwater management strategy, the changes in weather patterns have the potential to increase stormwater runoff, which, as previously discussed, leads to sedimentation, erosion, flooding, property damage, degradation of coastal water quality, and increased coastal water temperature. Climate change implications underline the immediacy of an integrated stormwater management strategy in The Bahamas.

2.3 Social Impacts

The above described environmental impacts of stormwater have great social and economic implications on surrounding coastal communities. The population of The Bahamas is largely concentrated on New Providence Island in the city of Nassau, with a population density of 2,655 people per square mile. Population growth is projected at 1.8 percent per year. Additionally, the tourism industry brings another four million people to the islands per year (US Army Corps of Engineers, 2004, p. 4). All of these people are dependent on healthy coastal ecosystems and marine environments for their livelihoods.

The tourism industry contributes 50-60 percent of total GDP and employs 50- 60 percent of the total workforce (UNEP, 2005). The success of the tourism industry is directly dependant on the health of marine ecosystems as it has been documented that "pollution of the beaches, and associated health risks for tourists and the local population is a tremendous threat to the industry, and therefore the economy of the entire nation (Us Army Corps of Engineers, 2004, p. 6)." The Bahamas continues to expand the industry though marketing techniques and developing niche markets including ecotourism, cultural heritage, film industry, and private aviation (UNEP, 2005). The industry as a whole is expected to grow by 40% over the next ten years, as predicted by the World Trade Organization (Us Army Corps of Engineers, 2004, p. 6)." In order to continue to have such prominence in the tourism sector, The Bahamas must take environment management into consideration as economic planning of this sector is developed.

The fishing industry, both commercial and sport, contributes about $70 million per year to the Bahamian economy and generates about 4,000 jobs. The Bahamas has some of the most diverse marine resources in the Caribbean, including sea grass beds and coral reefs, which contribute to the country's status as having the largest area of productive shallow waters in the Western North Atlantic (Us Army Corps of Engineers, 2004, p. 6). These near coast resources have potential to be threatened by stormwater pollution leading to declining stocks of sport and commercial fisheries.

Atlantis Hotel in Paradise Island and Cruise Ship on Nassau Harbor

Source: WSSS, 2008

Local Fish Market near Fort Montague

Source: WSSS, 2008

In addition to these economic concerns, polluted stormwater runoff also has the potential to have negative social impacts. Increased flooding and poor drainage have been documented to disproportionately affect low income communities. Property damage, loss of possessions, and other stresses from dealing with periodic flooding can place significant financial and emotional strain on low income households. Poor drainage has also been shown to increase environmental health impacts in surrounding communities and large-scale flooding can disrupt water supply and sanitation systems, resulting in disease epidemics (Parkinson, 2003). Although, The Bahamas has one of the highest GDPs in the Western Hemisphere for a developing nation, this does not accurately portray wealth distribution within the country. However, the wealth is poorly distributed with clear upper and lower classes (UNEP, 2005, p. 18).

Yard Flooding after Hurricane Noel in The Bahamas

Source: Photo by Letisha Henderson, The Nassau Guardian, November 6, 2007,

2.4 Integrated Stormwater Management

Traditionally, stormwater has been managed by collecting rainfall and diverting it as quickly as possible into nearby water bodies (Ristenpart, 1999, p. 253). However, as watersheds become urbanized and increased volume and pollutant levels further degrade receiving waters, it has been realized that a more holistic and decentralized stormwater management regime is necessary (Villarreal, 200, p. 279). Preventing or treating pollutants in stormwater is challenging as the sources are both point-source and diffuse sources. New approaches are combining infiltration, distributed storage and treatment, while seeking to mimic natural systems. Additionally, ecological criteria are taken into account (Ristenpart, 1999, p. 253).

In response to this paradigm shift, a series of Best Management Practices (BMPs) have been developed, which, when used in combination, work to prevent and treat polluted runoff while mimicking natural hydrological systems. The US EPA defines BMPs as "techniques, measures, or structural controls that are used for a given set of conditions to manage the quantity and improve the quality of storm water runoff in the most cost-effective manner (US EPA, 1999b, p. 5-1)." BMPs generally fit into two categories of structural or non-structural solutions. Structural BMPs are engineered and constructed systems that address quality and quantity concerns, and focus on treating polluted runoff. Non-structural BMPs address pollution prevention, seeking to control the quality and quantity of the runoff often using institutional or educational strategies (US EPA, 1999b, p. 5-1 – 5-2).

BMPs can be implemented through regulatory or non-regulatory measures. Regulatory strategies are stormwater management tools or techniques that are required through a governmental policy or program or supported by governmental funding. They require enforcement and monitoring. Non-regulatory strategies do not require government action or political will and are often coordinated by non-governmental organizations or community groups. They do not require enforcement; compliance is achieved through education and outreach.

In addition to addressing pollution prevention and treatment of polluted runoff through regulatory and non-regulatory strategies, stormwater management regimes have also become more collaborative, encouraging dialogue between governments, non-governmental organizations, and the public and incorporating stakeholder input during the planning process (US EPA, 2005a, p. 1). Environmental management policies and programs have also moved toward "the integration of science in the decision making process (US EPA, 2005a, p. 4)." This is important as it provides technical basis for policy development and regulation. This type of holistic management approach is referred to as integrated stormwater management (British Colombia Planning Guide, 2002, p. 3-3).

A number of characteristics of successful integrated stormwater management programs have been established. They include advance planning and setting clear goals; encouraging and facilitating broad government and community participation; prioritizing pollution prevention over treatment of polluted runoff; establishing and maintaining accountability of partners and citizens; creating a stable funding source such as a stormwater utility; tailoring strategies to local needs and problems; including education, public participation, monitoring, and enforcement components; evaluating and improving programs as they evolve; and recognizing and publicizing the quality-of-life benefits of parks, ponds, and clean streets (NRDC, 1999).

As an integrated stormwater management program is developed, it is important that it be taken into consideration within the larger framework of integrated water resources management, which includes wastewater, drinking water, and coastal zone management regimes. Addressing any of them individually will not provide successful management programs, as all of these environmental, social, and economic impacts of stormwater pollution are interconnected and influenced by the management choices of wastewater, drinking water, and coastal zone programs. Integrated management requires additional coordination, capacity, and resources to successfully develop and implement (UNEP, 2000, p. 1-2).

This project specifically addresses integrated stormwater management in Nassau, New Providence, The Bahamas and does not attempt to identify how stormwater management fits into the larger integrated water resources scheme of The Bahamas. However, the larger systems should be kept in mind as an integrated stormwater management approach is developed.

Chapter Three

Assessment of Stormwater Management in Nassau

As identified in the literature review, there are three key stakeholder groups in an integrated stormwater management approach: government agencies, non-governmental organizations, and the general public. These stakeholder groups were all interviewed in The Bahamas to identify successes and challenges in institutionalizing environmental management and developing an integrated stormwater management scheme. Consistent with an integrated stormwater management approach, the theoretical framework within which each stakeholder

Key Stakeholder Groups in The Bahamas

- Government Agencies
- Non-Governmental Organizations (NGOs)
- Local Communities

group in The Bahamas operates was established. Lessons learned were then developed, stemming from a series of interviews, reports, and agency and organizational websites. These identified lessons were then used to develop recommendations for next steps in improving stormwater management in Nassau, New Providence, The Bahamas. Please see Appendix I for an annotated list of agencies and organizations interviewed, Appendix II for sample interview questions for government agencies and NGOs, and Appendix III for the public awareness survey. Case studies from the Caribbean region are used to further illustrate the benefits of having a successful government structure, partnerships between governments and NGOs and an informed public for stormwater management.

3.1 Government Actors

As a strategy for environmental protection, regulatory approaches have the advantage of being established and enforceable by the authority of a national or local government. This typically ensures that resources and capacity necessary to establish and enforce environmental standards and regulations are available.

The use of regulatory authority to manage environmental issues is well documented in developed nations. Beginning with the establishment of the

Lessons Learned

Environmental responsibility is spread throughout the government, without a central office to direct environmental protection.

The Bahamas Environment, Science, and Technology Commission (BEST) is mandated to manage a number of environmental responsibilities, including coordinating international agreements pertaining to the environment, formulating environmental policy, coordinating preservation and management of the environment throughout The Bahamas, and carrying out Environmental Impact Assessments (EIAs) for proposed development (BEST, 2008). BEST is the first government entity to be established for the purpose of protecting and preserving the environment as opposed to managing the environment with respect to human health issues. However, BEST does not have regulatory authority. As an advisory commission, it can only advise the Prime Minister or other Ministers on issues pertaining to the environment, but it does not have any capabilities of investigating environmental problems or enforcing their proposed standards (Cox, 2008). It would be beneficial to their mandates if the BEST Commission was granted regulatory authority, however, is unlikely at this time (Cox, 2008).

Other agencies that have responsibilities regarding the environment include the Ministry of Health and Social Services and the Department of Environmental Health Services, which are concerned with environmental threats to public health; the Department of Lands and Surveys, responsible for advising the Prime Minister on matters that involve the use of land and natural resources within The Bahamas; the Ministry of Works and Transport, along with the Department of Public Works, constructs and maintains public infrastructure and drainage, including the storm drainage system in Nassau; and finally, the Water and Sewerage Corporation is a government mandated private entity that provides water and wastewater removal for the island of New Providence.

The decentralized responsibility of environmental affairs further complicates coordination, accountability, and responsible use of monetary and human capacity resources. In 2005-2006 there were efforts to address these issues. The National Environmental Management Action Plan was developed to place all agencies on the same page in regards to environmental management issues. The Capacity Self-Assessment publication fed into this larger proposal,

Clean Air Act in 1970, the United States has passed a number of laws geared towards protecting the environment and has established the Environmental Protection Agency (EPA) as the national actor responsible for the establishment and enforcement of environmental regulation (US EPA, 2008a). Each state also has its own environmental department or agency to more directly manage environmental issues specific to the locality. While not directly managed by the EPA, these state agencies must adhere to the guidelines set forth by the EPA (US EPA, 2008b). This structure allows for comprehensive management of environmental issues in the United States.

specifically outlining standards and guidelines for environmental management. Land-based sources of pollution, including stormwater, were included; however, the action plan did not come to fruition. An action plan of this extent is absolutely necessary in developing a comprehensive, integrated environmental management plan. Having a vision and defined plan of action would help increase efficiency and use of limited resources (Moultrie, 2008).

The current legislation does not adequately address stormwater or related environmental concerns.

The existing regulatory framework highlights many environmental issues related to stormwater, but does not provide steps for implementation or enforcement. The Environmental Health Act of 1987 defines stormwater as "liquid waste," coming from a number of different sources including industrial, medical, agricultural and manufacturing uses. According to the act, it is "unlawful to dispose of such materials in a way that endangers the environmental health of the island community (Government of The Bahamas, 2008, Chapter 232)." The act states that the Department of Environmental Health Services shall carry out all functions related to environmental health concerns, including contamination of "any waters" from "liquid waste."

Because of the natural stormwater storage and treatment capacities of wetland systems, wetlands protection is an important component of integrated stormwater management; however, it is not directly addressed in the current Bahamian legislation. Under Chapter 204: Coast Protection and Chapter 260: Conservation and Protection of the Physical Landscape , there are no provisions to protect wetland areas, such as mangroves. Additionally, Chapter 259: Reclamation and Drainage, the filling of swamps and wetlands is permitted through the Ministry of Public Works (Government of The Bahamas, 2008). BEST has acknowledged the deficiency in legislation to adequately protect, conserve and value wetland areas. They have developed "The Bahamas National Wetlands Policy," detailing the importance of wetlands and establishing a series of guidelines for the proper implementation of a wetlands policy. Nevertheless, the document itself is not a comprehensive wetlands protection plan (BEST, 2007). The BEST Commission has had some success implementing the policy through their EIA program, preventing the filling of wetlands by new development (Cox, 2008).

It has been recognized that the environment of The Bahamas would greatly benefit from a centralized regulatory unit to manage environmental affairs. The Inter-American Development Bank stated that such an arrangement would "strengthen the country's ability to meet the challenges in the areas of water and sanitation, solid waste, and coastal zone management (IDB, 2004)." However, through a series of interviews with government officials, as well as a review of relevant literature, it has been determined that at present environmental regulation is unfocused in The Bahamas, and that the government is currently facing difficulties regarding communication and coordination with respect to environmental issues.

The Department of Public Works has regulations for stormwater in place for new subdivisions, detailing preferred systems to treat stormwater that may contain harmful pollutants (Curtis & Bethel, 2008). The use of drainage wells and detention ponds is recommended to abate flooding. It was also recommended that any concerns regarding drainage conduits emptying into coastal waters be referred to the BEST Commission (Ministry of Public Works & Utilities, 2004). This document was later revised with pollution concerns highlighted, and requirements for stormwater management, such as requiring developers to ensure that development does not change the amount of runoff generated by a site (Ministry of Public Works & Utilities, 2005).

There are several other laws that pertain to environmental management; however, as with the above noted legislation, they are not comprehensive and remain unchanged despite a changing perspective of the environment. Additionally, enforcement of these regulations continues to be challenging (Curtis & Bethel, 2008).

Government agencies have limited capacity and resources.

Expanding government agency programs to specifically include stormwater management is unlikely without expanding their capacity and providing additional resources. Lorraine Cox of the BEST Commission expressed that BEST can only reliably work on fulfilling existing international agreements and executing EIA reports due to a lack of staff and resources (Cox, 2008). Similarly, Dwayne Curtis, the Assistant Director of the Department of Environmental Health Services, explained that there are currently six professional staff within DEHS, which is not adequate to fulfill their mandates and responsibilities. Curtis also explained that DEHS lacks sufficient laboratory space and equipment to perform analytical tests required to adequately monitor the state of the environment. For example, petroleum pollution samples must be shipped to the United States for analysis (Curtis & Bethel, 2008). The lack of staff and resources, combined with multiple pressing environmental issues, prevents DEHS from effectively managing stormwater. "We're reactive, not proactive," Arlington Bethel, former DEHS employee and current employee of the Water and Sewerage Corporation said of DEHS. This prevents DEHS from developing implementation strategies to manage stormwater. Furthermore, DEHS expressed difficulties enforcing regulations that currently exist (Curtis & Bethel, 2008).

Communication, coordination and collaboration among Ministries and Departments is minimal.

The lack of communication, coordination and collaboration among Ministries and Departments leads to confusion of responsibility and missed opportunities for stormwater management (IDB, 2004). Curtis, of DEHS, explained that other governmental agencies may have beneficial data, but lack of inter-governmental communication and coordination prevents knowledge of and access to these data (Curtis & Bethel, 2008). Similar frustration has been expressed regarding The Bahamas National Geographical Information Systems Centre (BNGIS), which collects and makes available national GIS data (Cox, 2008).

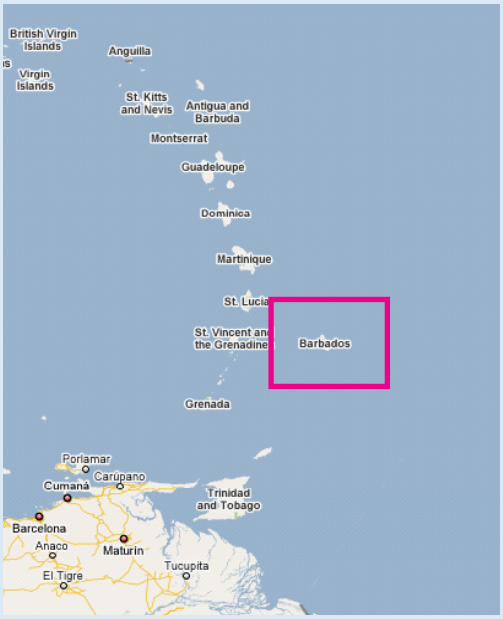
Inter-governmental coordination is especially important when there is such decentralized authority regarding environmental policies and management. The BEST Commission has little interaction with other government actors, although they have mandated responsibility for a number of environmental issues. Additionally, DEHS has expressed that they are unsure of the full extent of BEST's responsibilities regarding environmental management (Curits & Bethel, 2008). This departmental isolation can lead to missed opportunities for stormwater control measures.

Additional environmental baseline data is needed to provide sufficient grounds for development of environmental policies.

DEHS (Curtis & Bethel, 2008) highlighted the importance of the technical data being collected for this study as a vital starting point for any action to be taken. Baseline data helps document current environmental conditions and over time, allows documentation of decline or improvement.

Case Study 1: Barbados

A Successful Institutional Structure for Stormwater Management



Environmental management in Barbados operates under a regulatory structure that designates specific agencies to manage and monitor different sectors of the environment.

Ministry of Energy and Environment

- Coastal Zone Management Act and Marine Pollution Act, 1998
- From 2002-2009, the Coastal Zone Management Unit allocated $24.2 million for public awareness, shoreline stabilization, erosion control and restoration of habitats. The CZM Unit also monitors off-shore water quality (Government of Barbados 2008).

Environmental Protection Department

- Responsible for monitoring oil spills, sewage and wastewater pollution issues. The EPD conducts a water quality monitoring program with the Coastal Zone Management Unit and tests for more than 50 different pollutants in coastal waters (Government of Barbados 2008).

Town and Country Development Planning Office

- Coordinates with other departments such as CZM Unit for technical advice concerning development in the coastal zone.
- Established the "Physical Development Plan," a comprehensive management plan for land which includes sediment control for developments, forcing preservation, controlling development within the parks system and open spaces and erosion protection (Environmental Advisors 2007).

3.2 Non-Governmental Actors

Due to the identified challenges of the regulatory approach, environmental management has seen a paradigm shift from that of a command- and-control approach to one of collaboration, involving multiple stakeholders. This "bottom-up", or decentralized approach can be very effective as it considers community values in addition to social, economic, and environmental factors. The encouragement of long-term community support and involvement is essential as the "immediate cause of most environmental problems are the resource decisions of grassroots stakeholders (Lubell, 2004, p. 342)."

To fulfill the role of implementing this "bottom-up" approach, environmental management has seen a proliferation of intermediary, facilitating organizations. These are organizations that have the capacity to "forge links between the beneficiaries and often remote levels of government, donor, and financial institutions… perform[ing] coordinating or networking functions (Carroll, 1992, p. 11)." They are typically non-governmental and serve to bridge gaps between

Lessons Learned

Public education is essential in changing behavior.

Public education was identified as one of the most important aspects in changing individual behavior (McKinney, 2008). McKinney (2008), current Director of BREEF, a national environmental education organization, explained that once the public understands the issues at hand, they are empowered to take positive action. She also acknowledged that implementation and enforcement is an issue from a policy perspective. However, public education helps people make positive, informed choices about the environmental issue at hand because they know it will have a positive impact, not out of fear of being fined or regulated. For example, BREEF works with the Police and Defense Force to enforce restrictions on closed fishing seasons and develop a strong public education campaign to supplement the regulations (McKinney, 2008).

The education and outreach tools BREEF most typically uses are educational pamphlets, flyers, post cards, posters, and on-line resources. Additionally, they work to foster resource sharing between teachers through an online database of local environmental lesson plans. The Nature Conservancy (TNC), a leading international conservation organization, has also developed a series of public outreach tools that have been successful. Most of these tools focus on education and awareness through speaking at conferences and school events, speaking with government agency staff and developing informational websites, brochures, and CDs. Additionally they use media outlets, such as the radio and television, to educate and communicate with the general public (Moultrie, 2008). The importance of public education and successful dissemination strategies should not be overlooked as recommendations for stormwater management are being developed.

private individuals and government institutions or communities and private organizations (Berger, 1996). Additionally, they are usually 'development oriented' and emphasize "respectful reciprocity between the supporter and supported (Carroll, 1992, p. 12)."

The World Bank also discusses the potential for non-governmental organizations (NGOs) to act as intermediary organizations, particularly with projects that "depend on participation and capacity building (World Bank, 2006)." This type of development often focuses on resource management, depends on the ability of intermediary organizations with specialized skills and experience to provide links between communities and national government. In specific reference to World Bank projects, "the intermediary functions include facilitating communication between project beneficiaries and government; helping to identify and voice community needs; supporting participation and group formation, training, and building the capacity of community groups; and channeling resources to the community level (World Bank, 2006)."

Resources are limited. Therefore, government agencies and NGOs must be encouraged to develop partnerships to share information, technical data, and coordinate resources.

Many NGOs have established partnerships with each other and government agencies. The most beneficial partnerships tend to be defined, encourage accountability, have specific tasks, and a common, agreed upon goal. For example, a formal Memorandum of Understanding (MOU) was established between TNC, the Department of Marine Resources, BEST, and Bahamas National Trust (BNT). This MOU seeks to implement the National Implementation Support Program, funded by TNC, the United Nations Environmental Programme, and the Global Environmental Facility. They also have more informal partnerships with the Department of Lands and Surveys, the Ministry of Public Works, BREEF, Friends of the Environment, Living Jewels, reEarth, and National Hope for Andros. Stacey Moultrie, Senior Policy Analyst at TNC, stated that government agencies involved in a formal MOU are typically more responsive than those involved in informal partnerships, as they often ignore environmental issues not directly in their scope of work. Moultrie also expressed frustration in these informal partnerships stating that there is a lot of duplication of effort and little coordination, which results in wasted resources and little sharing of information, data, and strategies (Moultrie, 2008).

BREEF also has formal and informal partnerships. They have a formal partnership with the Ministry of Education to help facilitate workshops and incorporate local environmental and ecological issues into the required academic tests. BREEF also collaborates with The Nature Conservancy, Bahamas National Trust, the Ministry of Tourism, BEST, and the Port Authority. Their role in these partnerships remains educationally based. Additionally, they work to forge relationships between

Much of the available literature focuses on the role of intermediaries in developing nations and are documented as filling an essential role in environmental management and restoration projects. This directly correlates to this study on stormwater management in The Bahamas and identifies NGOs as important, significant actors in an environmental management scheme. There are a number of active NGOs in The Bahamas. In addition to reviewing their work through reports and organization websites, interviews were conducted with each to identify current activities, successful strategies for implementing programs and potential capacity for each to implement strategies for stormwater management.

governmental actors and local communities, so residents know who to contact for information or to report environmental or ecological concerns.

Base-line environmental data is essential in establishing appropriate policy and educating the public.

TNC does not directly address stormwater in their programs; however, Moultrie shared approaches for stormwater management and environmental management more generally, that might be successful in The Bahamas. She noted that having published base-line water quality data would be helpful, providing evidence to the problem. McKinney, executive director of BREEF, agreed, stating that it is important to have pro-active policies and programs in place that have a monitoring component.

Case Study 2: Belize

Strong Partnerships Between Government and NGOs

The Belizean Government has established partnerships with the Mesoamerican Barrier Reef System Project (MBRS) and other NGOs to facilitate management of natural areas.

Mesoamerican Barrier Reef System Project

- In coordination with the governments of Mexico, Honduras and Guatemala, United Nations Development Program, Global Environment Facility, World Bank, and the Central American Commission on Environment and Development (MBRS 2006) .
- The program has brought together member states to coordinate water quality monitoring programs (Synoptic Monitoring Program), environmental education programs, and technical expertise. The role of the MBRS has built a framework for cooperation between governments and establishes universal benchmarks for each of the four member governments (MBRS 2006).

Friends of Nature Co-management of Marine Protected Areas (MPAs) and Community Management of Protected Areas Conservation

- In collaboration with the Belizean Government's Fisheries Department, Friends of Nature, an NGO, manages several natural areas and trains Belizean fisheries officers in MPA management. These park rangers assist government officials to monitor ecosystem health and local fish populations (UNDP & GEF 2008).
- With funds from the United Nations small grants program, Friends of Nature has started a program to train local people to become guides for diving expeditions (UNDP 2008). These guides then participate in the biological monitoring program, expanding Friends of Nature's overall capacity to manage ecosystem health around their MPAs.

3.3 Public Awareness

In addition to engaging governmental agencies and non-governmental organizations, it is essential to include the public in environmental management decisions. Including the community increases the likeliness of long-term success because "ownership of the solutions extends to community members who must play a role in achieving them (US EPA, 2005, p. 5)." An educated public facilitates the implementation of environmental management programs, since these programs require support for funding and changes in day-to-day behavior of individuals. Community participation can provide a broader public support, shorter

Lessons Learned

Public awareness of stormwater issues is minimal.

Although the extent of public knowledge regarding stormwater can not be clearly defined by the public survey, the results indicate that there exists at least some concern about stormwater among Nassau residents. Of the 20 individuals interviewed, ten indicated concern about stormwater in the Nassau area. Nine individuals said that they do not worry, and one person expressed concern "at times in some areas." Of those who are worried about stormwater, three justified their concerns by mentioning fears about public health/ sanitation. Two people indicated specific concern about damage that stormwater causes to public infrastructure, such as roads. Detailed information regarding the results of the survey is provided below.

Awareness of government efforts to control stormwater is minimal.

Of the ten individuals who expressed concern about stormwater, three were familiar with efforts of the government to correct the problems, three said they were unfamiliar, and four people said they thought there were activities, but could not name specific details. Of the ten people who did not express concern, four were familiar with stormwater-related government activities, four were not familiar, and two thought that there were some activities but could not name specific details.

Public sources of information about stormwater and its affects are important.

Of the seven individuals who were aware of stormwater-related activities in the community, the following sources of information were cited: TV, radio, newspapers, public meetings, academic institutions/ schools, employer, internet, direct notification by government officials (especially during hurricanes).

implementation schedules, a broader base of expertise, and the development of important relationships with other community and government programs (Maguire, 2003).

A brief public awareness survey was conducted at Arawak Cay and Fort Montague beaches in Nassau, New Providence to determine the level of public awareness regarding stormwater pollution, runoff, and management strategies (Appendix III). Although a limited number of people were interviewed, the results begin to show trends and can provide evidence of lack of awareness. This anecdotal evidence was used to inform recommendations for an integrated stormwater management approach in Nassau.

Potential stormwater contaminants are widely used.

Most individuals surveyed use house paint, which is typically used until finished and then thrown away. One participant mentioned Bahamas Waste Management is responsible for disposing of paint containers. Pesticides are also commonly used. Only one person mentioned the use of fertilizer. Additionally, several people indicated disposing of motor oil in soak-aways, and that this is done commonly throughout Nassau.

Sewage systems are widely used throughout Nassau.

Sixteen of 20 participants have septic tanks, of which four indicated that the tank has flooded at least once. The remaining four out of 20 participants either are connected to the city sewer system or are not sure where their sewage goes.

Floods

Five out of 20 participants indicated that their house has flooded. 16 out of 20 participants indicated that they have crossed flooded streets. Several people surveyed at Arawak Cay said that Pinewood Gardens area in particular is prone to flooding.

Drinking Water Source

All 20 participants indicated that bottled water is their only source of drinking water, although one person said that he believes the city water to be potable.

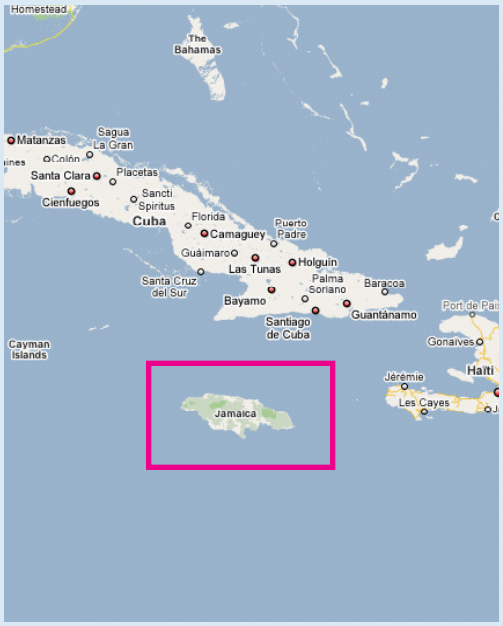
The coastal zone is used for fishing, swimming and additional recreational activities.

Although it appears that fishing does occur within the harbor, at Fort Montague, and at Arawak Cay, and that this fish is consumed locally, most respondents indicated that the majority of fishing is conducted farther out to sea. Out of the eight individuals surveyed at Fort Montegue, six indicated that they swim locally. Of the twelve surveyed at Arawak Cay, seven indicated that they swim locally.

Case Study 3: Jamaica

Foundation for integration between regulatory agencies and local stakeholders

Two USAID funded programs helped establish an integrated approach to watershed management and environmental monitoring that included community stakeholders.



Ridge to Reef Watershed project (R2RW)

- The R2RW program adopted an integrated approach to watershed management by establishing the National Integrated Watershed Management Council. The NIWMC is made up of several agencies that also work with Local group Coordination Working Group (LGCWG) and Local Watershed Managemente Committees (LWMCs) to build linkages with community stakeholders and the watershed management activities (Associates 2005).
- A community tree planting project aimed to reduce erosion in the Rio Grande Valley, along with other erosion control techniques, was implemented by encouraging citizens to plant fruit trees in areas prone to erosion. Other community projects included pesticide disposal and deforestation education, carried out in partnership with the National Environment and Planning Agency (USAID 2006).

Coastal Water Quality Improvement Project, 1998-2003

- Community groups were key participants in a water quality monitoring program and environmental education projects. The program also worked with community participants on local clean up activities by providing equipment and logistical support (Associates 2005).

Chapter Four

Baseline Assessment

An essential component to an integrated water resource management approach is technical baseline data (US EPA, 2005b). To gain an understanding of the amount of stormwater runoff and degree of pollution that is currently entering Nassau harbor, land use data was collected and pollutant loads were modeled.

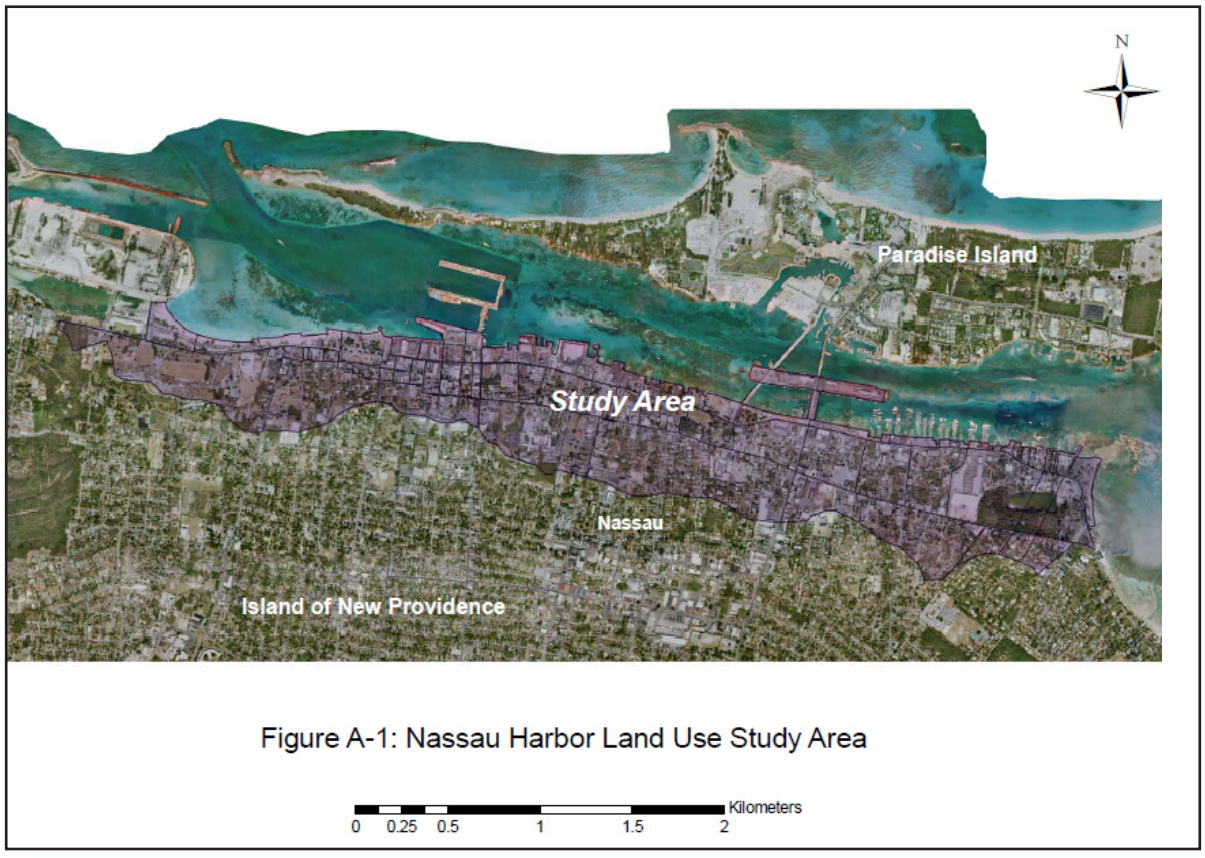
In order to estimate the amount of contaminants entering Nassau Harbor, a pollution-loading model was utilized to predict the amount of nitrogen, phosphorous, and common heavy metals running off the land surface during precipitation events. Several models were evaluated for use in this study. 'The Simple Method' was chosen based upon its ease of use and because the data required by the model were attainable during the brief field visit. Additionally, this method was designed specifically to model the amount of pollutants carried by stormwater in urban areas (Stormwater Management Resource Center (SMRC), 2008). Inputs required are the average annual runoff, determined largely by average annual precipitation, the area of the study location, and the concentration of contaminants in runoff. The concentrations of the contaminants are given default values in the model, and have different values depending on the land use type (SMRC, 2008).

'The Simple Method' divides urban land uses into several categories, including residential, industrial, commercial and parking lots and roadways, taking into account the imperviousness of a particular land use type. During the March 2008 site visit, a field survey was conducted in the city of Nassau to assess the various land use types. The study area (Figure 6) is bounded by Nassau Harbor to the north, Fort Montague to the east, a hillcrest to the south, which acts as a natural drainage divide, and Arawak Cay to the west. This area was divided into a total of 69 parcels. The parcels are predominantly divided by city blocks, though in some areas, such as the larger parcels to the south, the parcels were divided based upon common land use types. The parcels were then further divided into several land use categories. The land use was qualitatively determined by conducting a walk of the study area. Each parcel was assigned different percentages of land use type depending on the field observation. 'The Simple Method' was then used

to determine the amount of pollutants being generated from each site during rain events, measured in pounds per year (lbs/yr). Data was entered into GIS to allow users to spatially identify parcels which were determined to have the highest loads of contaminants released during rain events.

There are a few potential sources of error in this method. First, 'The Simple Method' assumes fixed variables for the concentration of runoff for the different land use types. These values were determined from studies performed in Canada and the United States, where there are significant environmental regulations in place. Therefore, the runoff concentration values assumed in 'The Simple Method' may be different than the actual concentrations found in Nassau Harbor. Secondly, the determination of land use type in Nassau was based upon the observations of several different people. Individuals may assess land use differently, resulting in variations in the land use data. The pollutant loads determined in this study should be viewed as an indicator of runoff and pollution entering the harbor, not as an exact measurement.

Figure 6. Map of Study Area, Nassau Harbor



Source: WSSS, 2008

4.1 Discussion of Results

The loading calculations indicate that the land use contributing the greatest amount of stormwater pollution are parking lots and roadways. Though they do not cover the most area in the watershed, they do represent a significant source of contamination due to heavy motor traffic. Roadways and parking lots, being mostly paved, are predominantly impervious and therefore able to generate high levels of stormwater runoff. Loading calculations for metals - copper, zinc, and lead - were only performed for roadways and parking lots because runoff concentration data was only available for this category. All loading results can be found in Table 2, below.

Commercial/government areas make up the majority of Nassau, and contribute the second highest loads of contaminants to Nassau harbor. While it uses higher contaminant concentration coefficients, it contributes less total pollution commercial/government areas are considered to have more permeable surfaces than roadways and parking lots. Industrial areas have the highest concentration coefficients, but make up the least amount of area in Nassau, and therefore contribute the least amount of total pollution. Residential areas, like industrial, do not make up a significant area in the study area and therefore do not contribute as much pollution as commercial/government and roadways and parking lots.

Total loads can be compared to each other in terms of magnitude. However, the severity of the load and impact on the ecological health of Nassau Harbor cannot be determined, as standards for pollution loading have not been established for the harbor. In the United States, the Environmental Protection Agency (EPA) established Total Maximum Daily Loads (TMDLs), which is the "maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources" (US

Table 2. Contaminant Loading Summary

Land Use Category	Percentage of Land Use within Subject Site*	Total Nitrogen Loading (kilograms/year)	Total Phosphorous Loading (kilograms/year)	Copper Loading (kilograms/year)	Zinc Loading (kilograms/year)	Lead Loading (kilograms/year)
Parking lots and roadways	23%	1754.15	292.36	24.09	90.21	92.26
Industrial	6%	368.64	58.98	N/A	N/A	N/A
Commercial/ Government/	31%	1697.37	169.74	N/A	N/A	N/A
Residential	18%	549.32	99.88	N/A	N/A	N/A

* Percentages do not add to 100%. The remaining 22% consist of natural open space, which is assumed to not contribute additional contaminants.

Source: WSSS, 2008

EPA, 2008c). Water quality standards vary depending upon their use, as drinking water sources have stricter water quality standards than recreational waters. The TMDL is calculated as "the sum of the allowable loads of a single pollutant from all contributing point and non-point sources" (US EPA, 2008c). A TMDL is useful in order to manage land areas that contribute pollutants and runoff to the water body; these land areas are cumulatively referred to as the watershed. Once a water quality standard and TMDLs have been determined for a given pollutant, such as phosphorous, the total loading of the pollutant can be estimated for the watershed and compared to the TMDL. It would be useful to establish the equivalent of TMDLs for Nassau Harbor, so there are standards for each contributing pollutant.

Chapter Five

Recommendations

Based upon interviews with governmental agencies, non-governmental organizations (NGOs), the public awareness survey, and the land use survey, it was concluded that a non-regulatory approach is the best short-term feasible solution to stormwater management in The Bahamas. The interviews established that the government recognizes and would like to mitigate the negative impacts of stormwater in Nassau, however, they simply do not have the capacity to create, implement and enforce necessary policies at this time. There are still steps that could be taken by the government to begin to develop capacity for stormwater management and other environmental programs. In addition, stormwater can be actively managed within the greater Nassau region through a non-regulatory approach implemented through NGOs in The Bahamas.

Regulatory Strategies – Building Government Capacity

- *Department of the Environment*
- *MOUs and Joint Committee*
- *Stormwater Utility*
- *International Conventions*

Non-regulatory Strategies - Structural

- *Bioretention retrofits*
- *High performance landscaping techniques*
- *Rain barrels and cisterns*

Non-regulatory Strategies - Non-Structural

- *Volunteer water quality monitoring*
- *An Adopt-a-beach/roadway program*
- *Stormwater education and outreach program*

5.1 Building Governmental Capacity for Stormwater Management

Although a non-regulatory approach to stormwater management in Nassau is determined as the most appropriate solution at this time, government oversight of stormwater management is necessary for comprehensive, long-term management of stormwater runoff. There following initiatives are recommended to the government of The Bahamas to foster development of stormwater management and other environmental needs: establsihing a comprehensive Department of the Environment, implementing a Joint Committee and formal MOUs for stormwater management, developing a stable funding source in the form of a stormwater utility, and fulfilling requirements of international conventions.

These specific recommendations are a product of discussions with government agencies in The Bahamas, in which officials identified needs and concerns regarding stormwater management and environmental management in general.

5.1.1 Department of the Environment

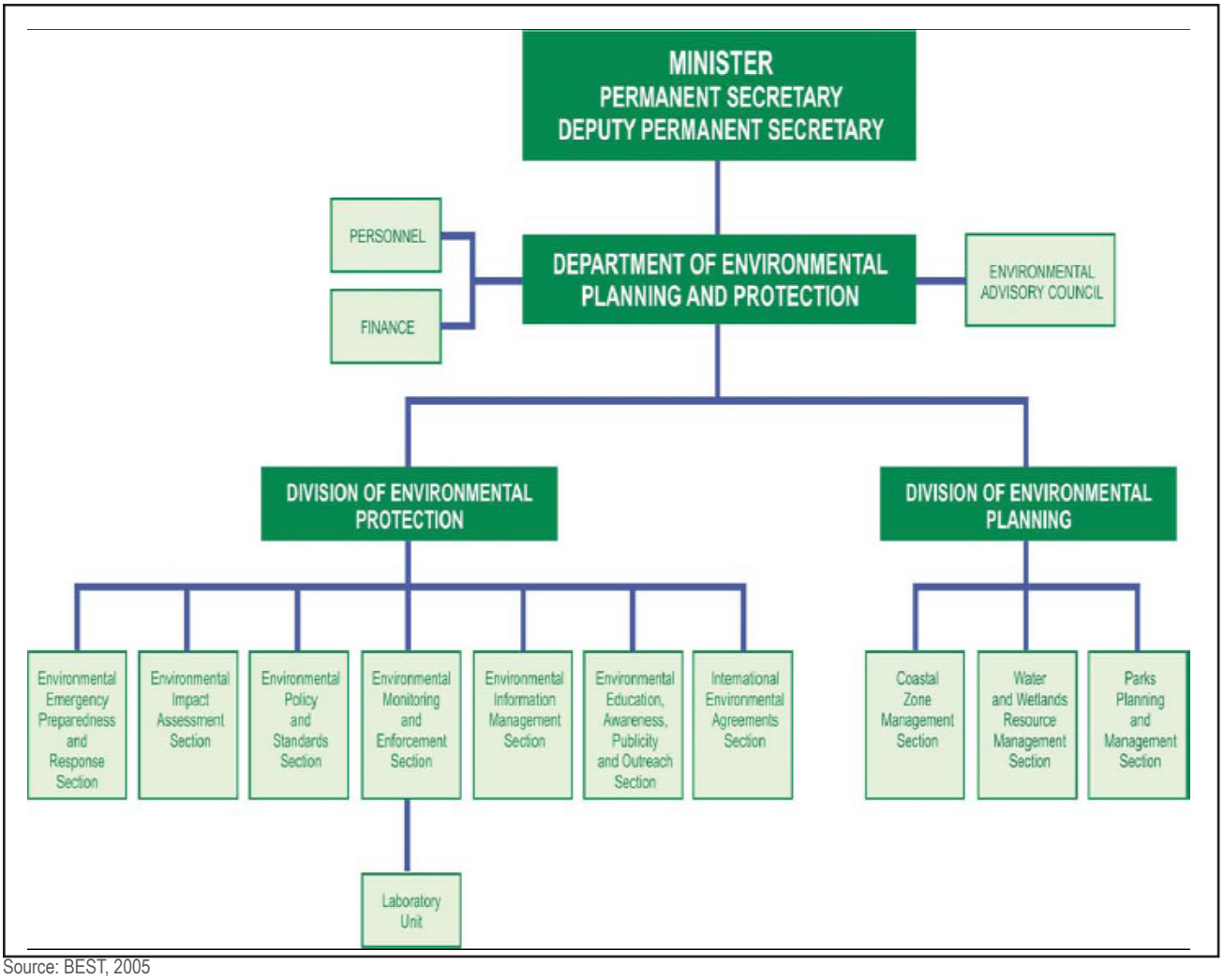
To strengthen overall environmental management in The Bahamas, the government would be well served by establishing a comprehensive "Department of the Environment." Legislation to create such a department has been drafted under past administrations. In 2005, a National Environmental Management Action Plan (NEMAP) for the Bahamas was developed (BEST, 2005), through which an initial proposal for a Department of the Environment was presented as a Bill to the government of the Bahamas (GOB). The recommended structure of the Department is provided in Figure 7, below. The proposal included a preliminary Department of the Environment that was understood to eventually expand into a "Ministry of Environmental Planning and Protection, amalgamating the responsibilities of DEHS, BEST, the Department of Lands and Surveys and the Department of Physical Planning" (BEST, 2005). Despite strong efforts on the part of the government and private sector, the bill was not passed (Moultrie, 2008).

In 2008, several representatives of government agencies and non-governmental organizations noted that an overarching Department of the Environment would be helpful in enforcing environmental regulations and reducing duplication of effort (Moultrie, 2008; Cox, 2008; Curtis, 2008; Mcinney, 2008). Stacey Moultrie, a former DEHS and BEST employee, who is currently a senior policy advisor at TNC's Northern Caribbean program, stated that she supported the development of NEMAP, which was designed to address environmental manage-

ment including land-based sources of pollution, such as stormwater runoff. She stated that "recommendations for a department [of the Environment] and standards and guidelines [regarding environmental management] were included in the plan, but many agencies have not seen [the plan], the plan was never incorporated [into existing programs], and legislation for a Department of the Environment remains in draft form; therefore, the plan never became a reality." It is recommended that this legislation be revisited, and that a Department of the Environment be created.

The implementation of a distinct Department of the Environment has been shown to have positive results for managing water quality and marine pollution in other Caribbean nations, such as Barbados. The Environmental Protection Department (EPD) in Barbados has developed a strong water quality monitoring program that incorporates efforts from the Coastal Zone Management Unit,

Figure 7. Proposed Department of the Environment Structure



Source: BEST, 2005

Government Analytical Services and staff from EPD (Government of Barbados, 2008b). These combined efforts, realized through the overarching EPD, have created a strong water quality monitoring program, in addition to programs focused on solid waste management, air pollution control, building development control and marine pollution control. Each of these programs incorporates different ministries and agencies within those ministries (Government of Barbados, 2008b). Utilizing this type of structure in the Bahamas would mandate a clear goal concerning environmental monitoring and incorporate a number of isolated agencies within the current government structure.

5.1.2 Implementation of a Formal MOU and Joint Committee

Although it is recognized that an overarching Department of the Environment is needed for effective environmental management in the Bahamas, an intermediate step is recommended. Establishing a formal Memorandum of Understanding (MOU) and a joint committee would provide the opportunity to build capacity needed to eventually implement and manage a Department of the Environment. MOUs and joint committees would increase efficiency and reduce duplication of effort through increased communication and cooperation among agencies. Interviews with government agencies, including DEHS, the BEST Commission, WSC and DPW, found that agencies would like to be able to provide more environmental management, but each has setbacks for implementing and enforcing environmental policy (Curtis, 2008; Cox, 2008; Bethal, 2008; England, 2008). For example, the BEST Commission is charged with creating environmental policies; however lacks enforcement power, whereas DEHS is mandated to enforce policies, but is often not involved in policy development stages (Curtis, 2008). DEHS, the BEST Commission, WSC, and DPW stated that they would be far more effective if each had more capacity. They also expressed that there is a lack of communication among agencies that likely leads to duplication of effort (Curtis, 2008; Cox, 2008; Bethal, 2008; England, 2008).

A specific recommendation that would increase communication and cooperation of agencies involved in stormwater management would be the establishment of a joint committee comprised of individuals from all of the agencies that are charged with creating and implementing policies related to stormwater management. Increasing communication and cooperation among the agencies would reduce duplication and increase individual capacity of each agency.

In addition to forming a joint committee, another method for establishing a coordinating network of agencies would be to create a Memorandum of Understanding (MOU) among the agencies working together on stormwater management. An example of an existing MOU in The Bahamas is one among TNC, the Department of Marine Resources, BNT, and the BEST Commission (Moultrie,

2008). The MOU was created in order to increase communication and cooperation on projects regarding environmental management (Moultrie, 2008). Moultrie also stated that the MOU has been helpful in that "agencies within the MOU are generally more responsive than those which are not" (Moultrie, 2008). Replicating this practice and forming partnerships for stormwater management could be a short term goal with long term results, by forming a culture of cooperation and coordination in The Bahamas.

Lessons from Jamaica have shown that communication and cooperation are necessary to ensure maximum success in managing environmental issues, although it can be challenging to achieve. With the creation of the National Integrated Watershed Management Council, Jamaica has adopted a framework for addressing issues in an integrated approach. The council works with local water committees to address local concerns for watershed management, public participation and community control of local watersheds. While results from this program have not yet shown an increase in communication and cooperation amongst different stakeholders (Associates in Rural Development, 2005), it provides a model for which a program could be implemented in The Bahamas. The establishment of this program also can be seen as a symbolic gesture by the government to adopt an integrated approach to watershed management and involve the public in the environmental decision making process. Although specific results from this program have not been documented, it is a good example of a starting point for increasing cooperation and communication between agencies working on environmental management.

5.1.3 Develop a Stable Funding Source

Once capacity is developed to support an integrated stormwater management program, it will be necessary to provide a stable funding source. They have been cited in the literature as one of the key characteristics of successful stormwater management programs (NRDC, 1999). A stormwater utility is recommended for Nassau, as once established it is a self-feeding funding source and their success has been widely documented in the United States.

It has been noted by many government agencies in The Bahamas that funds for environmental activities are currently limited and it is therefore difficult to recommend that funds be reallocated from another program specifically to stormwater management programs. Many cities and towns experience similar resource constraints. To address a lack of government resources dedicated to stormwater management, alternative funding mechanisms have been developed to implement stormwater pollution controls and measures (NRDC, 1999). One of which is a stormwater utility. A stormwater utility is an entity that "provides an umbrella

under which the financial, organizational, and management approaches of each local stormwater program can be orchestrated to achieve practical and efficient solutions (US EPA, 2005)." There is no single model for stormwater utilities, but the concept can be adapted to fit the needs of Nassau.

There are a few key steps that can make a stormwater utility a reality in Nassau. Firstly, government action would be required, potentially designating responsibility through the Ministry of Works and Transport, to establish the specific components of the utility. In a recent survey of 77 utilities in 22 U.S. states, 37% were combined with the Department of Public Works and 49% were established as a separate utility. The majority (82%) of utilities were designed within city limits (Black & Veatch, 2007, p. 2).

The second step is to establish a rate structure. Rate structures can be developed in a variety of ways. Most utility programs (65%) base this on the percentage of impervious surface area of each parcel and hold the property owner, not the resident, responsible for the payment of the fee (Black & Veatch, 2007, p. 6). Average monthly fees for 2007 ranged from $0.75 to $16.82. Seventy-seven percent of utilities bill property owners with water or other utility bills. This limits the need for additional processing (Black & Veatch, 2007, p. 6-8). The public often regards this fee as a new tax, but it is important to explain that it is a special assessment, such as for sewer services or garbage pick-up. It costs the city money to properly maintain a stormwater management program that treats polluted runoff before it is deposited into the coastal zone (England, 2001).

Once the rate structure is developed, the third step is determining how the funding source gets used to manage stormwater pollution and runoff. The majority of utilities (87%) use fees to fund capital improvements and operations and maintenance expenses. The top ten programs and practices used by surveyed utilities are public education, erosion/sediment controls, street sweeping, detention/retention basins, illegal discharge detection, inlet stenciling, stormwater quality monitoring, residential toxins collection, commercial/industrial regulation, and constructed wetlands (Black & Veatch, 2007, p. 8).

It is important to note that there are recognized challenges in implementing a stormwater utility in Nassau. Public support and awareness is critical in a successful program (NRDC, 1999). As anecdotally established through the public awareness survey, public stormwater awareness is minimal in the Nassau area. Creating a public outreach survey to disseminate to citizens that would be required to participate in the stormwater utility would be one way to gage public interest/awareness. Providing public education about the causes and threats of stormwater pollution would also be necessary. Advertisements in the newspaper and local television programs would be a good way to reach the target audience (Duncombe, 2008).

It is also recognized that developing and implementing a stormwater utility requires significant agency coordination, communication, and data sharing, all of which have been identified as challenges. Acknowledging that agency capacity and resources are already limited, the development of a stormwater utility could be set as a future goal. Developing comprehensive environmental management strategies, and working toward improving agency communication and collaboration are more immediate actions that would support and ease the implementation of a stormwater utility in the future.

5.1.4 Fulfilling Requirements of International Conventions

To further support the development of comprehensive stormwater management program it is additionally recommended that the goals set forth by ratified international conventions concerning marine water quality are achieved. The Bahamas have signed and ratified several conventions concerning marine and/or freshwater quality and land based sources of pollution. The United Nations Convention on the Law of the Sea and the Barbados Programme of Action for the Sustainable Development of Small Island Developing States are those that present the best opportunities to develop a framework to address stormwater.

The United Nations Convention on the Law of the Sea (UNCLOS) addresses marine pollution in several articles and includes requirements for nations to develop policies that limit marine pollution (UNCLOS, 1982). Specific articles of the convention address developing national legislation to prevent pollution from land based sources and eligibility to receive assistance and equipment from nations with technical capabilities and personnel (UNCLOS, 2006). Under the "Train-Sea-Coast" program, UNCLOS provides a number of technical and legal training courses including those related to development and management of marine protected areas and control of marine pollution (UNCLOS, 2006). It is unclear whether or not the BEST Commission has sought this assistance, but it could provide an opportunity to strengthen capacities for establishing a stormwater pollution management program.

The Barbados Programme of Action (BPOA) calls for the development of an appropriate regulatory framework to control, monitor and reduce pollution from all sources, including land based sources (United Nations, 1994). To supplement these actions, BPOA stresses the importance of regional pollution prevention programs that would train and educate regional leaders and develop economic incentives for pollution prevention. These objectives set forth by the BPOA could have a meaningful impact on stormwater management in The Bahamas if implemented. There are many examples of successful programs implemented as a result of BPOA initiatives, including the establishment of the Coastal Zone Management

Programme in Barbados (SIDSNET, 2008). The project involved several responsible organizations including private consultants, the Canadian government, and Barbadian Ministry of Environment, Energy and Natural Resources. The project built government capacity by strengthening institutional mechanisms for coastal management in Barbados (SIDSNET, 2008). A similar program could be used to build capacities in The Bahamas to manage stormwater pollution by establishing a stormwater utility, department of the environment or formally implementing best practices for redevelopment and retrofitting in downtown Nassau.

Additionally, following in the footsteps of Belize, Jamaica and Barbados, ratifying the Cartagena "Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region" could assist The Bahamas. Currently it is one of only four nations in the wider Caribbean region to not sign nor ratify the Cartagena convention. Within the Cartagena framework, adopting and ratifying the "Protocol Concerning Pollution from Land-Based Sources and Activities" (LBS), could build a useful standard from which the government could operate its environmental management practices. The LBS protocol establishes effluent standards for point source and non-point source pollution, such as stormwater runoff. As a result of signing the Cartagena convention, Barbados has used standards set by the convention for their water quality monitoring program. The Environmental Protection Department monitors various pollutants based on LBS standards including total suspended solids, biochemical oxygen demand and fecal coliform (University of the West Indies, 2004).

Combined with other regulatory efforts described above, complying with international conventions and taking advantage of technical assistance and resources, would provide another avenue though which the Government of The Bahamas can begin to build capacity to successfully manage stormwater runoff.

5.2 Non-regulatory Strategies for Stormwater Management in Nassau

Studies conducted around the world have shown that a non-regulatory approach to environmental management can be successful (Dietz and Clausen, 2004; Richmond et al., 2007; Taylor, et al., 2007). Given the current

lack of governmental capacity for regulatory approachs to stormwater management in Nassau, a non-regulatory approach may be of particular significance in this region and is currently the most successful approach for all types of environmental management in The Bahamas (McKinney, 2008). Currently, there is a lack of enforcement regarding environmental policies. However, if the public is educated on the specific reasons for environmental protection (i.e. erosion fencing during construction to prevent erosion from stormwater runoff from causing reef destruction), they will be more likely to protect the environment without enforcement (McKinney, 2008).

Contrary to a regulatory approach that requires government action, oversight and funding, a non-regulatory approach can be overseen by non-governmental organizations and implemented through grants, loans, volunteers, or a combination of funding sources. There are many reputable and motivated environmentally-focused NGOs in the Bahamas; several of which expressed interest in providing stormwater management if they had available capacity (Moultrie, 2008; McKinney, 2008; Duncombe, 2008). The stormwater management strategies recommended range in cost and level of effort required to implement; many of them, such as education campaigns can be incorporated into existing NGO curricula and be offered at little additional cost and with a minimal of effort. There are also several potential grant opportunities for stormwater management projects in Nassau; specific options and details regarding grant funding for stormwater management in Nassau are provided in Appendix IV.

As discussed in the literature review (Section 2.0), stormwater management strategies can be divided into structural and non-structural techniques. Structural stormwater management strategies refer to "physical structures designed to remove pollutants from storm water runoff, reduce downstream erosion, provide flood control and promote groundwater recharge (EPA, 1999, p. 6-1)." Non-structural stormwater management strategies include "institutional, education or pollution prevention practices designed to limit the generation of storm water runoff or reduce the amounts of pollutants contained in the runoff (EPA, 1999a, p. 6-1)." Specific examples of structural stormwater management strategies and implementation techniques are provided in Section 5.2.1; Non-structural stormwater management strategies are provided in Section 5.2.2.

5.2.1 Structural Stormwater Management Strategies

Implementing structural stormwater management strategies in Nassau would serve to reduce stormwater pollution entering the harbor as well as the quantity of water that floods streets during rain events. This study identified that pollution in the form of nutrients (nitrogen and phosphorous) and metals (copper, zinc

and lead) is entering Nassau harbor via stormwater runoff from the land uses within the study area (WSSS, 2008). Interviews with potential stakeholders of an integrated stormwater management program for Nassau (government agencies, NGOs and the public) also identified water quantity issues resulting from stormwater runoff .

Although the pollutant loading model demonstrated that parking lots and roadways contribute the most pollutants, industrial, commercial and residential land uses all contribute pollution to the harbor (Table 2). There are many types of structural stormwater management strategies, or stormwater Best Management Practices (BMPs), that can be retrofit into existing development in Nassau to limit and/or treat stormwater runoff (US EPA, 2005a). The use of stormwater BMPs, which are "methods for preventing or reducing the pollution resulting from an activity," originated from rules and regulation in Section 208 of the 1972 United States Clean Water Act (33 U.S.C. §1251 et seq.; BBNEP, 1991). The CWA requires states to establish a program to encourage implementation of BMPs to control non-point sources of pollution such as stormwater runoff (33 U.S.C. §1251 et seq.). For this reason, there are many examples of BMPs being used throughout the U.S. to manage stormwater runoff. Some examples of structural stormwater management strategies (US EPA, 2005a, p.23) that would be most applicable in Nassau include:

These strategies were chosen because they control the pollutants that are generated by the land uses within Nassau and/or water quantity issues faced in Nassau. They are also relatively inexpensive, easy to construct, and may be implemented through a non-regulatory process. Based on interviews with key stakeholders, these characteristics are all determined to be important factors to citing structural stormwater management strategies in Nassau include: bioretention retrofits in parking lots, high performanace landscaping techniques, and rain barrels and cisterns for rooftop runoff capture and reuse.

5.2.1.1 Bioretention Retrofits in Parking Lots

According to the results of the stormwater pollutant model, parking lots and roadways were shown to contribute the most significant load of pollutants to Nassau harbor. Although most roadways are under government jurisdiction, the majority of parking lots are privately owned, and therefore can be managed through a non-regulatory approach. There are many tested strategies for capturing and treating stormwater generated from parking areas, one being bioretention systems.

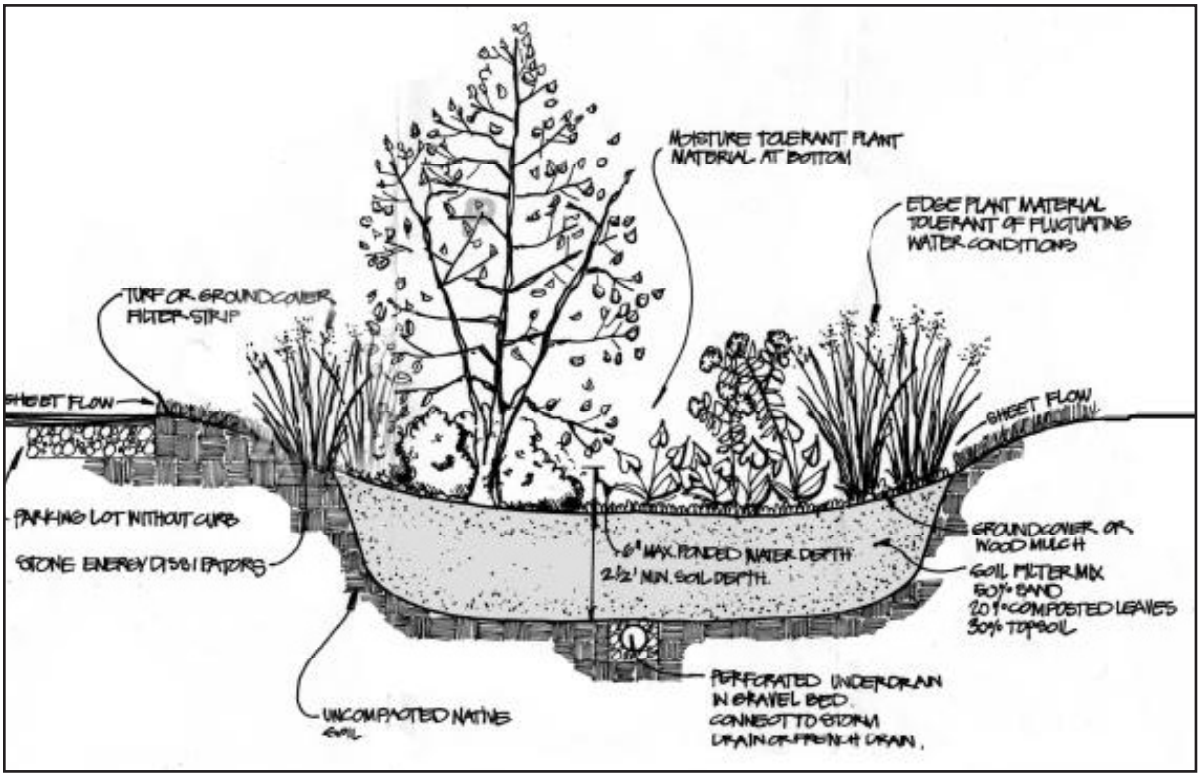
Bioretention systems are stormwater BMPs that are "designed to mimic the functions of a natural ecosystem for treating stormwater runoff" (US EPA, 1999b, p. 5-23). Stormwater runoff is directed to the bioretention system, where

it ponds at the surface and then gradually infiltrates into the soil bed. Pollutants are removed through adsorption, filtration, volatilization, ion exchange and decomposition. Figure 8 displays a typical bioretention system. Engineers at the University of Maryland conducted a study in the early 1990s that concluded, depending on the depth of the system, that bioretention systems can have significant pollutant removal rates (See Table 3; Prince George's County, MD, 1993, p. 1-7).

There are many opportunities to incorporate bioretention systems on commercial sites in Nassau. One option is to retrofit the system into existing parking lots of commercial sites in Nassau. Figure 9 is an image of one of the commercial sites within the study area that is composed of a high percentage of parking area and could benefit from incorporating bioretention systems for stormwater management. A representation of what this bioretention system could look like is provided in Figure 10.

Although costs of retrofitting bioretention systems vary depending on site characteristics and the required size of the facility to treat the identified pollutants, bioretention systems can be much more cost effective than other forms of stormwater management (Prince George's County, MD, p. 1-30). A retrofitted bioretention system that was used as a case study by the US EPA in Largo, Maryland cost

Figure 8. Typical Bioretention System Cross-Section



Source: Prince George's County, MD, 1993, p. 1-12

Table 3. Stormwater Pollution: Cumulative Percent Removal by Depth*

Depth	Copper	Lead	Zinc	Phosphorous	Total Nitrogen
1 foot	90	93	87	0	-29
2 feet	93	99	98	73	0
3 feet	93	99	99	81	43

*Modified form experimentation performed by Dr. Allen Davis, University of Maryland

Source: Prince George's County, MD, 1993, p. 1-7

$4,500 to construct and treats approximately one-half acre of impervious surface (Figure 11; US EPA, 2000, p. 1-2). The Nassau commercial site highlighted above in Figure 9 is composed of approximately four acres of impervious surface.

Implementation Strategy

In order for this strategy to be successful without regulatory pressure, education and outreach will need to be provided to business owners regarding the benefits of incorporating bioretention retrofits in parking lots. In addition to education and outreach, financial incentives will most likely be necessary for business owners to actually be able to afford construction of bioretention facilities.

To encourage the use of bioretention in Nassau, an NGO could apply for grant funding and then direct the funds to businesses that are interested in incorporating bioretention facilities on their property. Examples of applicable grants are available in Appendix IV. A portion of the funds would need to be used to provide education and outreach to the business owners to encourage acknowledgment of the benefits of stormwater management. Coastal water quality

Figure 9. Commercial Site within Nassau Study Area

Source: WSSS, 2008

Figure 10. Bioretention System within Parking Lot Island

Source: NEMO, 2008, p.1

monitoring could also be conducted, either prior to the program or using the grant funds in order to determine baseline conditions. Once the funding has been secured, businesses could apply for grant money through the NGO. The NGO would administer the funds and oversee the projects.

The Community Watershed Stewardship program, which is a public-private partnership in Portland, Oregon, provides a similar program to that being proposed (BES, 2008). They offer grants of up to $10,000 to schools, churches, businesses and other community organizations for projects that protect and enhance watershed health, including structural stormwater management projects. One example project is the St. Philip Neri Bioswale. St. Philip Neri, a church in Portland, was awarded $5,000 to help fund a project to construct a bioswale to reduce stormwater runoff from rooftops and the parking lot. Donations and volunteers have also helped to make the project a reality. Similar initiatives could be started in The Bahamas.

Figure 11. Inglewood Bioretention Site, Largo, Maryland

Source: US EPA, 2000, p. 1

5.2.1.2 High-Performance Landscaping Techniques

High-performance landscaping techniques such as rain gardens and vegetated or grass swales have been shown to control stormwater pollutants of concern in this study (Prince George's County, MD, 1993, p. 1-7). Additional benefits include low cost and improved aesthetic appeal (US EPA, 1999b, p. 5-25). Landscaping techniques are typically incorporated into the site design to treat runoff. When incorporated into the landscaping of a residential or commercial site they are often referred to as rain gardens. (Figure 12).

Swales are "broad, shallow channels" that are either grassy (grass swales) or filled with a "dense stand of vegetation covering the side slopes and channel bottom (US EPA, 1999b, p. 5-28)." Swales are "designed to slowly convey stormwater runoff, and in the process trap pollutants, promote infiltration and reduce flow velocities (US EPA, 1999b, p. 5-28)." Although the terms rain garden and swale are often used interchangeably, swales are typically thought of as channels, whereas rain gradens are more like plots. Vegetated swales can function as pretreatment systems for water entering a bioretention system (Figure 13).

The use of swales to treat stormwater runoff is most appropriate for relatively small sites (NEMO, 2008). Within Nassau, swales would be most applica-

ble on low to medium density residential areas, and small commercial lots; however swales could be used for pretreatment in conjunction with other stormwater treatment practices within higher density commercial and industrial land uses (NEMO, 2008). Figure 14 displays an example of a site in Nassau that could benefit from using vegetated stormwater management facilities such as swales and bioretention systems.

Retrofitting stormwater management strategies can be costly; however, rain gardens and grass/vegetated swales are among the most inexpensive (CWP, 2007, p. 19). Rain gardens and bioretention systems range from $4-11 per cubic foot of stormwater treated, and swales cost approximately $13 per cubic foot of stormwater treated (CWP, 2007, p. 19).

Implementation strategy

An implementation strategy is needed in order to mitigate costs endured by residents and business owners in Nassau to retrofit their sites with high per-

Figure 12. Rain Garden to Treat Rooftop Runoff

Source: NRDC, 2008, p.1

Figure 13. Combination of Swale and Bioretention System to Control Stormwater Runoff

Source: NCDEQ, 2008, p. 1

formance landscaping practices. One strategy would be for an NGO to administer a funding program similar to that proposed above for incorporating bioretention systems in parking lots. However, there are other options, such as NGO sponsored workshops on how to create your own rain garden, and even rain garden contests for cash prizes as incentive for residents to construct and maintain their gardens. This second strategy would require significant education and outreach in order to familiarize residents with the practice of constructing a rain garden and ensure that they are constructed properly.

Figure 14. Nassau Site That Could Benefit from Vegetated Stormwater Management

Source: WSSS, 2008

5.2.1.3 Rain Barrels and Cisterns for Rooftop Runoff Capture and Reuse

Using cisterns and rain barrels to capture rooftop runoff is another type of low-cost structural storm-

water management strategy that is appropriate for home or business owners in Nassau. An advantage to these systems is that the captured stormwater may be reused for irrigation and other non-potable uses. These systems are able to mitigate the stormwater quantity issues faced in Nassau and also redirect relatively clean rooftop runoff from flowing over dirty paved areas and instead allowing it to infiltrate it into the ground when used for irrigation. The most common form of rain barrel is simply a 55-gallon barrel connected to a downspout from a rooftop. A hose is attached to a faucet at the bottom of the barrel and water is distributed by gravity pressure (MAPC, 2008, p. 1). Residents are often able to make these systems themselves (Figure 15). A more advanced technique, often used for commercial sites or shared by multiple households, is to route multiple downspouts to a large tank, or cistern, with an electric pump for distribution (Figure 16). Sharing the system among multiple households can lower the cost by achieving economies of scale (MAPC, 2008, p. 1). When the rain barrels or cisterns are full, rooftop runoff can be directed to other stormwater management strategies, such as bioretention areas, discussed above (MAPC, 2008, p. 1).

Although the use of rain barrels and cisterns are more expensive than the landscaping techniques discussed above, the benefits of using these devices include reuse of water, therefore reducing the total amount of water use and associated costs. Rain barrels cost approximately $25 per cubic foot of stormwater treated, and cisterns, due to their large storage volume cost about $15 per cubic foot of stormwater treated (CWA, 2007, p. 19). There are also incentive programs that can be used to assuage these costs, described in Appendix IV.

Figure 15. Example of a Rain Barrel Used to Capture Residential Rooftop Runoff

Source: CWP, 2002, p.1

Implementation Strategy

The recommended strategy for implementing cisterns on commercial properties is to implement a program similar to that proposed for retrofitting parking lots with bioretention systems. However, the low cost and ability for residents to build rain barrels themselves provides for alternative implementation strategies, such as providing training workshops to residents on how to construct their own rain barrel system and distributing barrels to residents.

There are several examples of programs that have implemented a non-regulatory approach to promote the use of rain barrels by residents. One successful program was the Nine Mile Run Rain Barrel Initiative in Pittsburgh, Pennsylvania, where a local watershed association conducted an outreach campaign via direct mail, door-to-door canvassing and newspaper, posters and radio ads. Thirteen percent of the contacted owners participated in the program, which

involved free rain barrel assessments and installations by trained student volunteers (CWA, 2007, p. 133).

Figure 16. Example of Cisterns Used to Capture Commercial Rooftop Runoff

Source: CWA, 2007, p. 126

Another example of a non-regulatory approach to implementing rain barrels on residential properties is the Rainscapes program in Montgomery County, Maryland. The purpose of the program was to enhance water quality and habitat of receiving waters (CWA, 2007, p. 133). The Rainscapes organization provides outreach through their website (www.rainscapes.org), which provides instructions for creating your own rain barrel, and notes that assembling "a large capacity rain barrel can be as little as $15." The organization also provides free "make your own rain barrel" workshops. Similar strategies, headed by local NGOs would work well and have potential for success in Nassau.

5.2.2 Non-structural Stormwater Management Strategies

Non-structural stormwater management strategies are those that do not require engineering and construction and often include "institutional, education or pollution prevention practices designed to limit the generation of storm water runoff or reduce the amounts of pollutants contained in the runoff (US EPA, 1999a, p. 6-1)." The nonstructural strategies that are recommended based upon interviews with government agencies and NGOs in The Bahamas include: volunteer water quality monitoring, an adopt-a-beach roadway program, and a stormwater education and outreach program.

These specific strategies were chosen because they were identified as being useful for stormwater management and they have been successful means of distributing environmental information to Nassau residents and business owners in the past. They are also relatively inexpensive, easy to implement, and some may be incorporated into existing programs, minimizing new program development. These strategies are often implemented through a non-regulatory process,

which, based on interviews with key stakeholders, is important for short-term stormwater management in Nassau.

5.2.2.1 Volunteer Water Quality Monitoring Program

A common need that was identified during interviews with Bahamian government agencies and NGOs is the need for baseline water quality data (Cox, 2008; Curtis, 2008; Bethal, 2008; England, 2008; Moultrie, 2008; McKinney, 2008; Duncombe, 2008). DEHS noted that baseline data is "the number one priority" for stormwater management in the Bahamas (Curtis, 2008). These data are necessary to simultaneously educate and empower the public, while collecting valuable base-line environmental data. These data would be necessary to evaluate the performance of BMPs, should they be constructed. They would also be useful in informing the development of policies to regulate stormwater.

Source: WSSS, 2008

Although DEHS has conducted coastal water quality sampling in the past, the program ceased several years ago (Curtis, 2008). DEHS officials explained that they do not have capacity to perform the sampling at this time (Curtis, 2008). It would be helpful for stormwater management in The Bahamas for the government to resume this water quality monitoring program; however, an alternative to government sponsored water quality sampling would be a volunteer water quality monitoring program, which could be managed by a local NGO.

An NGO that is committed to protecting coral reef systems on the nearby British Virgin Islands, the Association of Reef Keepers', has implemented a volunteer water quality monitoring program, the Reef Keepers' Reef Check program, which has been successful for public education and provided much needed baseline data (ARK, 2008, p. 1). Casuarina McKinney, executive director of BREEF, a proactive reef conservation NGO in The Bahamas, expressed interest in incorporating stormwater issues into their educational programs and also recognized the importance of water quality monitoring (McKinney, 2008).

Implementation Strategy

In order to implement a successful volunteer water quality monitoring program in The Bahamas without government oversight, it is necessary for an NGO,

such as BREEF to take the initiative. It would be advantageous for the NGO managing the water quality monitoring program to examine other programs in the Caribbean, such as the BVI's Reef Check program to learn what has helped and hindered the program's progress. Funds are needed to purchase sampling bottles and instruments, as well as to cover laboratory fees, and personnel costs in conducting sampling. The use of volunteers to conduct the sampling would significantly reduce the required funding; although in order to have accurate data, the volunteers would need to be trained properly by experienced water sampling technicians.

The College of The Bahamas (COB) is also a valuable resource, which could provide both the expertise and equipment necessary for a volunteer water quality monitoring program. It would be extremely advantageous for an NGO to partner with the COB, and more specifically seek the support of the COB's Marine and Environmental Studies Institute (MESI). Dr. Kathleen Sullivan-Seally, director of MESI, and expert in Caribbean water resource management has extensive experience in water quality monitoring in The Bahamas. A partnership between a Bahamian-based NGO and MESI would allow students at MESI to gain experience working with professionals in the field of environmental management while providing the NGO with water quality monitoring trainers.

There are many grant opportunities available to fund water quality monitoring, such as the United Nations Development Programme Small Grants Programme, which donates up to $50,000 U.S. to NGO-led programs (See Appendix IV). A grant such as this could help an NGO jumpstart a water quality monitoring program in Nassau.

5.2.2.2 Adopt-a-Beach or Adopt-a-Roadway

Although this study examined the impacts of stormwater pollutants such as nutrients and metals, litter and trash are also significant sources of stormwater pollution. Adopt-a-Beach and Adopt-a-Roadway programs would directly reduce pollution caused by trash and litter and would also provide opportunities for local residents to actively participate in their community and learn about sources of coastal water pollution. The programs involve businesses or organizations "adopting" a beach or a roadway by accepting responsibility for cleaning it up periodically or providing trash cans, among other activities. In return for keeping the beach or roadway clean, the business or organization would benefit from the free advertisement, as they can hang a sign indicating their adoption of the area. It is possible to implement these programs with little additional cost and to include people of all ages, such as school or community groups. Participation in the program does not require technical skills, therefore appealing to a wide range

of people. Local businesses can get involved by sponsoring cleanup events, enhancing their reputation in the community.

An Adopt-a-beach program has been implemented in Barbados. The project, which began in 1995, encourages individuals, communities, organizations and agencies to adopt Barbados ' beaches and participate in one or more of the following activities (CZMU, 2008, p. 1): regular beach and underwater clean ups , International Coastal Clean-up Day, certified first-aid courses, design and provision of creative and effective garbage receptacles, benches and tables, revegetation initiatives, or the development and execution of community awareness programs for beach users.

Although The Bahamas does not currently maintain an official Adopt-a-Beach or Adopt-a-Roadway program, the Bahamas National Trust (BNT), a national land conservation organization, annually coordinates beach cleanups in conjunction with various international and local actors (TimeWorks, 2004). The events give both children and adults a hands-on experience with protecting their local environment, as seen in Figure 17.

Implementation Strategy

Adopt-a-Beach and Adopt-a-Roadway programs have been implemented in other regions through regulatory approaches, non-regulatory approaches or through partnerships between government agencies and NGOs. In order to implement an Adopt-a-Beach or Adopt-a-Roadway program in Nassau without government oversight, the programs could be implemented by a Bahamas-based NGO, such as BNT or BREEF, which was involved in the 2005 beach cleanup of Adelaide Beach (TimeWorks 2005). One advantage of these programs is that they may be implemented without outside funding sources. If additional funding is needed or desired; however, there are several grant funding opportunities in Appendix IV.

5.2.2.3 Stormwater Education and Outreach Program

Public participation in environmental resources and management programs has been identified as an essential component of successful programs (US EPA, 2005b). Public education and outreach programs, often implemented by local NGOs or educational institutions, are essential to gaining public participation. The following mechanisms have been identified as potential successful

strategies for delivering environmental education and outreach in Nassau:

- Media outlets;
- Educational flyers and brochures; and
- Incorporation of stormwater management into school curricula.

Education Through the Media

According to a local NGO, reEarth, the media in The Bahamas can be a powerful tool to educate the public on environmental matters (Duncombe, 2008). Duncombe, founder of reEarth uses local newspapers to inform Bahamians about environmental issues and stated that local newspaper articles may be the most useful media source to inform the public about stormwater (Duncombe, 2008). Duncombe also noted that although newspaper articles can be powerful, maintaining a sustained message that keeps the attention of the public over time is often challenging, requiring time and resources. In order to use the media to make the public aware of the need for stormwater management, it is important to acknowl-

Figure 17. Beach clean-up in The Bahamas

Source: TimeWorks 2005

edge the commitment of time and resources that this method requires. Education through the media could be incorporated as part of one of the other structural and non-structural strategies recommended above. For example, a newspaper article promoting efforts made to organize an Adopt-a-Beach program or new bioretention facility in downtown Nassau would further public awareness about stormwater pollution and the need for stormwater management.

Stormwater Brochures and Flyers

Several NGOs and government agencies suggested that mailings, such as brochures and flyers, are a good method for distributing environmental information, and may be a successful strategy for providing public education regarding stormwater (Moultrie, 2008; McKinney, 2008; Curtis, 2008). BREEF currently uses mailed cards and flyers to inform the public about environmental issues, such as the impacts of over-fishing (McKinney, 2008). McKinney, executive director of BREEF, also expressed interest in incorporating a stormwater brochure or flyer in their education materials (McKinney, 2008).

Distributing outreach and educational brochures and flyers about the causes of and solutions to stormwater pollution is a strategy that has been successfully implemented in the U.S. and other countries. The United States Environmental Protection Agency (EPA) has developed a series of stormwater outreach materials, including brochures and flyers to educate the public on stormwater pollution and management, which are all available for download on their website (http://cfpub.epa.gov/npdes/stormwatermonth.cfm).

In order for an NGO, such as BREEF to be able to distribute brochures and flyers, the organization would need funding to be able to create the outreach materials. Another Bahamian NGO that may be a good candidate for education and outreach via brochures and flyers would be TNC. TNC is an international organization, which recognizes that "the demands of a growing population are damaging marine ecosystems and depleting ocean and coastal resources", and "is working to combat these threats through new and innovative strategies (TNC, 2008)" Other branches of TNC in the U.S. have been involved in stormwater management, and funds from TNC's core budget may be available to support stormwater programs in the Caribbean.

Incorporating Stormwater into School Curriculums

Incorporating stormwater into school curriculums would provide an additional avenue for education and outreach. BREEF has the potential to play a significant role in this effort, as stormwater education could be incorporated into

their teacher training workshops (BREEF, 2006). This is relevant to BREEF's mission, as polluted stormwater runoff has potential to impact coral reefs, mangrove ecosystems, and native aquatic species. BREEF has trained teachers in 200 of the 263 schools in The Bahamas. Trained teachers implement lessons in their curricula and train other teachers in their school system. If stormwater curricula are developed, there is potential to educate residents throughout the islands and judging by BREEF's success, they are well positioned to incorporate land based sources of pollution and its effects on marine ecosystems into their teacher training program.

BREEF has also demonstrated success in influencing the course of curriculum development in The Bahamas. A recent national exam included questions concerning a key component of BREEF's curriculum about the Nassau Grouper (McKinney, 2008). If this level of importance was applied to stormwater issues, the cumulative effect of these programs could have a meaningful impact on stormwater education and understanding if incorporated into standardized tests.

It would also be beneficial for stormwater education to be incorporated in higher education. A key step forward was made in 2005 with the establishment of the Marine and Environmental Studies Institute (MESI) within The College of The Bahamas (COB). The Institute is a multidisciplinary program, focused on the development of information that is vital for safe-guarding the ecological health of The Bahamas. MESI seeks to educate students in both scientific practices and policy applications, which will enable graduating student to bring about change in environmental management. If not already part of the curriculum, integrated water resource management coursework could be added to the program, which includes a focus on stormwater control.

The Academy of Natural Science of Philadelphia recently developed curriculum focusing on non-point source pollution control. At the request of students and professors, a program focusing on physical, chemical, and biological assessments of watershed and impacts of non-point source pollution on coastal ecosystems is regularly offered (NOAA, 2007). Additionally, this provides further opportunity to train government officials and NGO staff. A course of this nature has the potential to be developed through COB's continuing education program.

Chapter Six

Conclusions and Areas for Further Research

Based on a literature review and interviews with stakeholder groups in The Bahamas, including government agencies, non-governmental organizations, and the public, it was determined that the limited regulatory management of stormwater runoff and pollution has the potential to impact the integrity of the coastal zone; however, the specific extent of pollution has not been established. In order to make recommendations and to estimate the amount of runoff and potential pollution entering Nassau Harbor for this study, a pollutant loading model was used. In the future, it is important to develop more specific management strategies based upon tangible measurements of contaminant concentration in the harbor; therefore, it is recommended that baseline water quality data be established and monitored over time.

It was also established that the current lack of regulatory capacity to manage stormwater necessitates non-regulatory strategies for short-term stormwater management solutions. It is important to acknowledge the benefits of integrated stormwater management, where there is collaboration and dialogue among government agencies, non-governmental organizations, and the public. Although research indicates that integrated stormwater management, which involves both governmental and non-governmental actors, is not currently feasible, a number of intermediary steps have been identified to help increase government agency capacity. Additionally, encouraging dialogue between stakeholders will ease the transition to an integrated approach. The non-regulatory strategies identified seek to immediately address the lack of stormwater management due to the unrealistic nature of integrated management. All of these strategies can be incorporated into an integrated approach as it is developed.

A number of areas for further research have been identified. In addition to establishing baseline water quality data, it would also be beneficial to determine acceptable loading rates for the different pollutants to Nassau Harbor. These are specifically developed for an individual body of water and vary depending upon

volume and flushing rates, among other factors. Establishing appropriate loading rates would allow the extent of stormwater pollution to be determined and based upon these results specific contaminants and land uses could be targeted.

It is also important to consider that stormwater is not the only contributor to pollution in the coastal zone. Wastewater effluent and the maritime industry, which includes discharges from fishing boats and cruise ships, could have significant adverse impacts on coastal water quality. Finally, The Bahamas is significantly vulnerable to climate change. In order to provide proper stormwater management strategies to account for future potential vulnerabilities, it is critical to gain a more comprehensive understanding of present conditions in The Bahamas.

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Appendix I

Agencies and NGOs Interviewed

The following government agencies and NGOs were interviewed during the week of field work conducted in Nassau, New Providence. Selection was based on the organization's potential stake in stormwater management and availability during March 16 – 21, 2008

Government Agencies

Bahamas Environment, Science & Technology Commission

Website: http://www.best.bs/about_us.html
Lorraine Cox, Sean Cunningham, and Diangelo Stewart, BEST Commission

Established in 1994, the Bahamas Environment, Science & Technology Commission (BEST) is charged with protecting, conserving, and managing the environmental resources of the Bahamas. It is attached directly to the Office of the Prime Minister, and acts primarily in an advisory role to the Prime Minister. BEST has a number of publications which state a variety of environmental standards and policies, but it does not appear that they have any capabilities of investigating environmental problems or enforcing their proposed standards.

Department of Environmental Health Services

Website: (not available at this time)
Duane Curtis, Assistant Director, Bahamas Ministry of Health, DEHS

The Department of Environmental Health Services (DEHS) was formed in 1987 under the Environmental Health Services Act. Organizationally, the DEHS falls under the Ministry of Health. The Act declares the DEHS responsible for investigating, preventing, and remediating environmental hazards, in addition to staying abreast of new technology and interfacing with other entities within the government which may handle environmental affairs. As such, it would appear that the DEHS has the authority which the BEST Commission lacks. They do not have an organizational website with publications of standards and measures for the protection of the environment. There are three divisions within DEHS- The Health Inspectorate Division, The Environmental Monitoring and Risk Assessment Division, and The Waste Management- with responsibilities regarding environment, beautification and maintenance of roadsides, sidewalks and road verges, parks and beaches, environmental control, solid waste collection and disposal, poisons, vector control, and relations with the National Health Insurance Commission

Water and Sewage Corporation

Website: http://www.wsc.com.bs
Arlington (Arli) Bethel, and Chantal Lopez, GIS specialist, Water and Sewerage Corporation

The Water and Sewerage Corporation is a government mandated private entity that operates in conjunction with the government of the Bahamas to provide water for most of the Bahamas and the removal of wastewater for the island of New Providence. Established in 1976 with the Water and Sewerage Corporation Act, it manages groundwater extraction, reverse osmosis plants, and the import of water to supply the island of New Providence. They have also established a policy for the island of New Providence in conjunction with the Ministry of Works and the Dept. of Environmental Health to require each new subdivision of at least 24 lots to have a central sewage collection system. However, at the moment these collection points are not linked into an island-wide network. They do not address the issue of stormwater, and the Water and Sewerage Act prohibits the infiltration of stormwater into the sewer system (Chapter 196 of Bahamian Law).

Non-Governmental Organizations

The Nature Conservancy

Website: http://www.nature.org/wherewework/caribbean/bahamas/
Stacey Moultrie, Senior Policy Analyst

The Nature Conservancy (TNC) was founded in 1951 and is one of the leading international conservation organizations. Globally, they have protected over 117 million acres of land, 5,000 miles of rivers, and operate over 100 marine conservation projects. In the Caribbean, TNC has programs in The Bahamas, Dominican Republic, Jamaica, and all of the states in the Lesser Antilles. In The Bahamas specifically, TNC has established 25 terrestrial parks as well as Exuma Cays Land and Sea Park. TNC's goal is to protect 10% of land areas by 2010 and 10% of coastal areas by 2012.

Bahamas Reef Environmental Education Foundation (BREEF)

Website: www.breef.org
Casuarina McKinney, Executive Director, BREEF

BREEF was founded in 1993 by Sir Nicholas Nuttall to "address growing concerns on the state of The Bahamas' marine environments." The organization's objectives are to support the implementation of a network of marine reserves; to protect fish spawning aggregations; and to ensure a continued supply of fish and conch for Bahamians. In order to fulfill these objectives, BREEF focuses on teacher education through workshops and teacher training events. They have trained at least one teacher in 200 of the 263 schools in the Bahamas. Their teacher education program, Marine Conservation Teacher Training Program, focuses on overfishing, coastal habitat loss and degradation, and integrating local ecology into the larger educational curriculum. The workshops are free, however they expect ideas to be integrated into the broader curriculum. Focus is placed on the link between activities on land and negative impacts to the coastal zone. Interconnectedness of human activity and environmental quality is stressed.

reEarth

Website: http://reearth.org/
Sam Duncombee, Founder, reEarth

reEarth is an environmental advocacy organization located in Nassau, The Bahamas, approaching its 18th year in April 2008. Sam Duncombee, founder of reEarth, states that the organization's focus is on educating the public and bringing to light important environmental issues in The Bahamas. The organization's website maintains an archive of posts regarding environmental issues in the Bahamas.

Appendix II

Interview Questions

The following questions were developed to guide interviews with government agencies and NGOs, respectively. Interviews were conducted as a discussion and actual conversations went above and beyond the guiding topics below. However, the following questions provided a starting point and most were addressed with all interviewees, if relevant.

Questions for Government Actors:

- Does your agency have a role in the management or monitoring of stormwater? If so, what is it?
- What do you think the problems with stormwater are?
- What other government agencies or department's do you feel have significant authority over stormwater management?
- Is your ministry/department/commissions committed to any international conventions? If so, what commitment of time and resources do they require? Ask later
- What opportunities have you had/could have to include stormwater management or monitoring in an existing program/project/policy/legislation? If yes- tease out why they think it is an opportunity.
- How important is the issue of stormwater compared to other issues your dept/ministry is responsible for addressing?
- What do you think is an ideal way is to address stormwater management issues you have identified? What are the barriers that keep this from happening? What do you think could improve this situation?
- What is your awareness/perception concerning the public's knowledge of stormwater run-off? Public's concept? Are they aware of any phenomena other than flooding?
- How does information about stormwater get to your department/ministry? Do members of the public bring info re stormwater to the agency/department? Ask earlier
- Who else can help us?
- Does your agency/dept have any public/private partnerships? Example…
- How are public health risks or advisories relayed to the people who live here?
- Are you aware of any current environmental monitoring taking place?
- What is your sense of the impact of stormwater issues on the tourism industy?

Questions for Non-regulatory actors/ NGOs:

- Do you feel that stormwater is an issue of concern for the island of New Providence?
- What strategies are most efficient when implementing programs? What works best? Which ones are most cost effective? To what extend do you depend on or want help from the government?
- What resources would need to be gathered in order to enact a successful stormwater management program?
- Is there any opportunity to include stormwater management into an existing project?
- Do you see any opportunity for public-private partnerships for the management of stormwater?
- Can you recommend any additional Non-governmental actors that have the potential to be involved in stormwater management?
- What is your perception concerning the public's knowledge of stormwater runoff? Are they aware of any phenomena other than flooding?
- Are you aware of any other useful resources
- Do members of the public bring info re stormwater to your NGO?
- What is your sense of the impact of stormwater issues on the tourism industry?

Appendix III

Public Awareness Survey

Stormwater Management Practices on the Island of New Providence, The Bahamas

The following survey was conducted on March 21, 2008 by a number of Tufts University Water: Science, Systems, and Society students and professors to gauge the level of public awareness regarding stormwater management practices in Nassau. The survey was conducted at Fort Montague and Arawak Cay.

Introduction: "We are graduate students from Tufts University, a research university outside of Boston in the United States, working with the College of the Bahamas here on a project to investigate stormwater pollution in Nassau Harbor and related issues. Part of our study involves asking people who live here on New Providence a few questions about their knowledge and opinions about stormwater. Would you be willing to respond to our survey? This will take 5 to 7 minutes and the answers will be anonymous (that is, we won't ask you for your name or address)."

(1) When it rains heavily in your community, do you worry about the resulting stormwater?

___ Yes ___ No

If Yes, what are your biggest concerns?

(2) Which of the following statements best describes your level of awareness about current efforts by your local government to improve water quality in your community?

(a) I am not aware of any existing efforts.

(b) I think activities are taking place, but I don't know very much about them.

(c) I am generally familiar with efforts to improve water quality in my community.

(d) I am very knowledgeable about existing efforts.

If (c) or (d):

(i) Please describe those efforts.

(ii) If you have a problem with water quality or water pollution, do you look to a government agency or a private organization for help? If so, which one(s)?

(3) ***[If (2)(c) or (2)(d):]*** From which sources do you receive information about stormwater and how it affects your community or your environment? (Note all that apply.)

___ Public meetings or events	___ Television
___ Local newspaper	___ Radio
___ Through local schools	___ Discussion with local officials
___ Community newsletters	___ Employer
___ Educational workshops	___ Computer (websites, email, etc.)
___ Meetings organized by private environmental organizations	___ Other:
___ Meetings organized by private firms	___ I am not interested in this type of information

(4) Contaminants

(a)(i) What kinds of agricultural products (for example, fertilizers or pesticides) do you use?

(a)(ii) How do you dispose of these products?

(b)(i) What kinds of paint products do you use?

(b)(ii) How do you dispose of these products?

(c) If you own a car and change your own motor oil, how do you dispose of the old oil?

(5) Septic tanks

(a) Does your house have a septic tank?

___ Yes ___ No

(b) Has the septic tank ever flooded?

___ Yes ___ No

(6) Sewage

(a) ***[If answer to (5)(a) is No:]*** Where does your sewage go?

(7) When a storm causes a flood, does water enter your house?

___ Yes ___ No

(8) Do you have to cross flooded areas after a storm?

___ Yes ___ No

(9) Where do you get your drinking water from?

___ Tap water ___ Rain barrel

___ Bottled water ___ Other: _____

(10) Fishing

(a)(i) Do people fish here or nearby? ___ Yes ___ No

(a)(ii) If nearby, where?

(a)(iii) If they fish here or nearby, is the fish then eaten?

___ Yes ___ No

(b)(i) Do you fish here or nearby? ___ Yes ___ No

(b)(ii) If nearby, where?

(b)(iii) If you fish here or nearby, is the fish then eaten?

___ Yes ___ No

(b)(iv) How often (each month) do you fish in the area you've identified?

(11) Swimming

(a) Do you swim in the harbor or ocean? ___ Yes ___ No

(b) If so, where?

(12) Demographics

(a) Estimate age (without asking)

(b) Sex (without asking)

(c) Employment (which of the following is your area of work?):

___ Tourism ___ Fisheries ___ Farming

___ Industry ___ Other: _____

(d) What neighborhood on the island do you live in?

Thank you for participating in our survey.

Appendix IV

Grant Opportunities

The grant opportunities described below are a sample of those currently available to NGOs to either directly or indirectly provide stormwater management.

NOAA International Coral Grant Program

Website: http://nosinternational.noaa.gov/coralgrants.html

This is an opportunity from the US National Oceanographic and Atmospheric Administration (NOAA) for international coral reef projects. The first of the four project areas is to "promote watershed management in the Wider Caribbean, Brazil, and Bermuda" and specifically addresses stormwater management.

Promote Watershed Management in the Wider Caribbean, Brazil, and Bermuda

In 2004, the United Nations Environment Program-Global Program of Action (UNEP-GPA) and NOAA entered into a Memorandum of Understanding (MOU) to provide assistance to countries in the Wider Caribbean to promote, develop, and implement National Programs of Action for the Protection of the Marine Environment against Land-based activities, The MOU emphasizes a cross-sectoral approach to watershed and marine resources management. Effects of watershed on the near shore marine environment may affect coral ecosystems, including those in marine protected areas. This view of integrating watershed and coastal management approaches, also helps to implement international and regional agreements, such as the Barbados Programme of Action for the Sustainable Development of Small Island Developing States, the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (the Cartagena Convention) and its protocol concerning Pollution from Land-based Sources and Activities, and the International Coral Reef Initiative.

Therefore, IPO will fund activities that promote integrated watershed and coastal management practices that reduce or control runoff to near shore coral reef ecosystems, including programs that prioritize marine protected areas and the conservation of biodiversity within watershed planning and management, assess effectiveness of these management practices, engage stakeholders and government agencies in collaborative partnerships to implement these practices; and recommend a set of best management practices that can be applied to the Wider Caribbean region, Brazil and Bermuda. Allowable activities consist of the following:

a) Analyses of regulatory and legislative frameworks to identify areas needing strengthening;

b) Education and outreach to promote integrated watershed and coastal management practices;

c) Workshops to enhance stakeholder participation and implementation of integrated watershed management;

d) Identify national/sub-national goals, objectives, and activities toward the development of an action plan to integrated watershed and coastal management activities;

e) Assessments of land use impacts that threaten to degrade near-shore coral reefs and development of management practices to reduce and/or eliminate the identified threats;

f) Demonstrations of best management practices or implementation of at least one best management practice for the agricultural sector to control nutrients, sediments and pesticides that threaten near-shore reefs; or

g) Follow-up activities of previously funded projects related to the topics in a-f.

UNEP Caribbean Environment Programme (CEP) Small Grants Funds (SGF)

Website:http://www.cep.unep.org/information-services/plonearticlemultipage.2005-12-07.7619538743/plonearticle.2006-01-20.9342620100

Small Grants Fund of CEP are CaMPAM, Sustainable Fisheries and also Best Management Practices in Agriculture. CaMPAM is a network dedicated to the protection of Marine Protected Areas in the Caribbean. The grants are announced through a call for proposals on the website.

CaMPAM Small Grants Fund

As part of its support to CaMPAM, UNEP-CEP has established a small grants fund, the goals of which are:

- To strengthen the management capability of marine protected area (MPA) managers in the WCR;
- To strengthen the capacities of institutions managing MPAs;
- To develop and implement strategies for increased involvement of stakeholders in MPA management;
- To develop and implement training programmes, strategies, and tools for improved management of MPAs;
- To act as a catalyst in attracting funds from other bilateral and multilateral initiatives for the purpose of addressing stated priority problems and issues;
- To promote "best management" MPA sites to serve as sites for demonstration, training, and internships; and
- To promote horizontal exchanges of all types among MPAs, including twinning and mentoring programmes.

The website also includes eligibility and application information.

US EPA International Programs

South America, Central America and the Caribbean Open Grant and Cooperative Agreement Announcements

Website: http://www.epa.gov/international/regions/sa/index.html

This web page provides current grant opportunities available for environmental related projects in South America, Central America and the Caribbean.