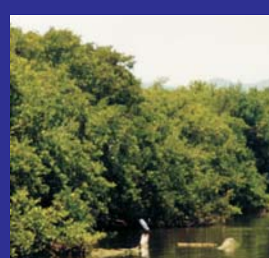
Institutional Strengthening & Preparation of a Zoning & Physical Development Master Plan for Kingston Harbour

Harbour Remediation Experiences Report

Submitted to the

National Environment and Planning Agency

Project No. ATN/SF-8164-JA



By

SMITH WARNER INTERNATIONAL
COASTAL & ENVIRONMENTAL ENGINEERING

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Document Objective

This document has been prepared as a major deliverable for *Component A – Institutional Strengthening and Preparation of a Zoning and Physical Development Master Plan for Kingston Harbour* of the Inter-American Development Bank (IADB) project titled *Institutional Strengthening to Support Environmental Management of Kingston Harbour* (Project No: ATN/SF-8164-JA). This report presents the findings of a review of obtainable information on international experiences in Harbour Remediation. It is intended in a general sense to be a summary document for the purpose of conveying pertinent information for the further completion of this project. At a more specific level, it is intended that wherever possible, the recorded international experiences in harbour remediation should advise the Kingston Harbour situation.

Acknowledgements

Smith Warner would like to thank Professor Alex McCorquodale for his significant contribution to the content and preparation of this document.

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Acronyms

AOC	Areas of Concern
BOD	Biological Oxygen Demand
CCB	Coalition for a Clean Baltic
CDF	Confinement Disposal Facility
CLF	Conservation Law Foundation
CSO	Combined Sewer Overflow
ECAPAG	Guayaquil Water & Sewerage Board
EPA	Environmental Protection Agency
ESPOL	Coastal Polytechnic School
GOJ	Government of Jamaica
IDB	Inter-American Development Bank
MDC	Metropolitan District Commission
MLE	Ministry of Land & Environment
MWRA	Massachusetts Water Resources Authority
NGO	Non-governmental Organisation
NOx	Nitrogen Oxides
PAH	Poly-nuclear Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
RAP	Remedial Action Plan
TEU	Twenty-foot Equivalent Units (container sizing)
TOR	Terms of Reference
UNO	University of New Orleans

1. Introduction

1.1. Background

Kingston Harbour is the main receiving water body for the city of Kingston, and accepts inflows from adjacent rivers, gullies, industrial and commercial facilities, as well as sewage treatment plants. Furthermore, Kingston Harbour is the primary port for the island, handling large volumes of marine traffic and having the associated exposure to vessel-generated wastes and pollutants. The harbour water quality is badly degraded and numerous studies have indicated that, in fact, Kingston Harbour is contaminated and has suffered significant environmental degradation over the past several decades.

The poor condition of the harbour has long been recognized and over the past few decades there have been several attempts to address its environmental health. However, to date none of these efforts have been successful. It is now apparent that the failure of previous attempts to clean up the harbour is directly related to:

1. The lack of clarity as to the authority for and responsibilities of the many institutions that have a role in the use and management of the harbour, and
2. The limited communication and coordination between the relevant agencies.

This situation needs to be addressed sooner, rather than later, before the overall costs are so high that rehabilitation of the harbour becomes infeasible. The logical solution requires that the diverse number of stakeholders be coordinated through an institutional setting, such that ultimately an overall investment plan for the clean-up of Kingston Harbour can be supported and implemented by all.

Based on a recognition of the previous limiting factors to successful harbour rehabilitation, the Ministry of Land and Environment (MLE) led the Government of Jamaica (GOJ) in negotiations with the Inter-American Development Bank (IADB), to formulate a project for *Institutional Strengthening to Support Environmental Management of Kingston Harbour* (Project No: ATN/SF-8164-JA). The first component of this project, *Component A - Institutional Strengthening and Preparation of a Zoning and Physical Development Master Plan for Kingston Harbour* (KgnHrbr – A), seeks to specifically address the environmental management framework for the Harbour.

This document represents a major deliverable for Component A, which is a Review of International Cases in Harbour Remediation.

1.2. Scope of Work

The following is a presentation of the scope of work reported on in this deliverable, as stated in the contract documents:

Task 4 Review and assess international experiences on Harbour clean-up

In addition to the case studies presented in the TOR (Boston Harbour, Guayaquil, Bremen, Stockholm, and Santa Gilla), success stories from the Great Lakes such as Hamilton Harbor will also be reviewed. Several areas in the Great Lakes have had clean-up efforts that addressed similar parameters and will provide substantial information for this study. In the Great Lakes Clean-up Program, several demonstration projects have been completed and documented. These will provide useful data on alternatives that can be considered. Some of the alternatives include: capping, precision environmental dredging and *in situ* treatment. We will also have assistance from Dr. E. LaMotta in the evaluation of the Guayaquil Harbour problem and the proposed solutions that have been developed for that harbour. This example is considered to be of particular relevance to Kingston harbour, since it is the only one of the case studies mentioned in the TOR that is applicable to a developing country. Under Dr. LaMotta's supervision, UNO has completed a study of the Guayaquil sewer system.

The review will examine both the physical and institutional scenarios for each case.

2. Boston Harbour

2.1. Background

Situated on the north east coast of the United States, Boston is one of the oldest cities in the country (Figure 2.1). The city and its surroundings bear the signatures of long-standing industrialization and urbanization, with Boston Harbour in particular, experiencing significant pollution as far back as the 1870s. At that time the main drainage system for the city collected sewage from 18 municipalities and conveyed it untreated into the Harbour.

Figure 2.1 **Map of the United Sates of America, showing the location of Boston, Massachusetts**

Not until the 1950s were any efforts made to address the sewage pollution of Boston Harbour, when two sewage treatment plants were constructed, one on the harbor's Nut Island in 1952 and a second on Deer Island in 1968. However, these treatment plants only provided minimal pollutant removal, such that the pollution of Boston Harbor essentially continued unabated. Over 120 tons of solids and associated scum were dumped daily into the harbor, making the water cloudy and unappealing, covering much of the harbor bottom, changing the composition of the community of organisms living there, and contributing to reduced dissolved oxygen concentrations in the water and in the harbor bottom's sediments.

Compounding the situation was the fact that the sewer system in Boston is made up largely of combined sewers (piping that conveys both sewage and storm-water flow). These systems are designed with release valves called combined sewer overflows (CSOs) that release a mixture of stormwater and raw sewage into the Harbour during heavy rainfall events. This further served to pollute the Harbour.

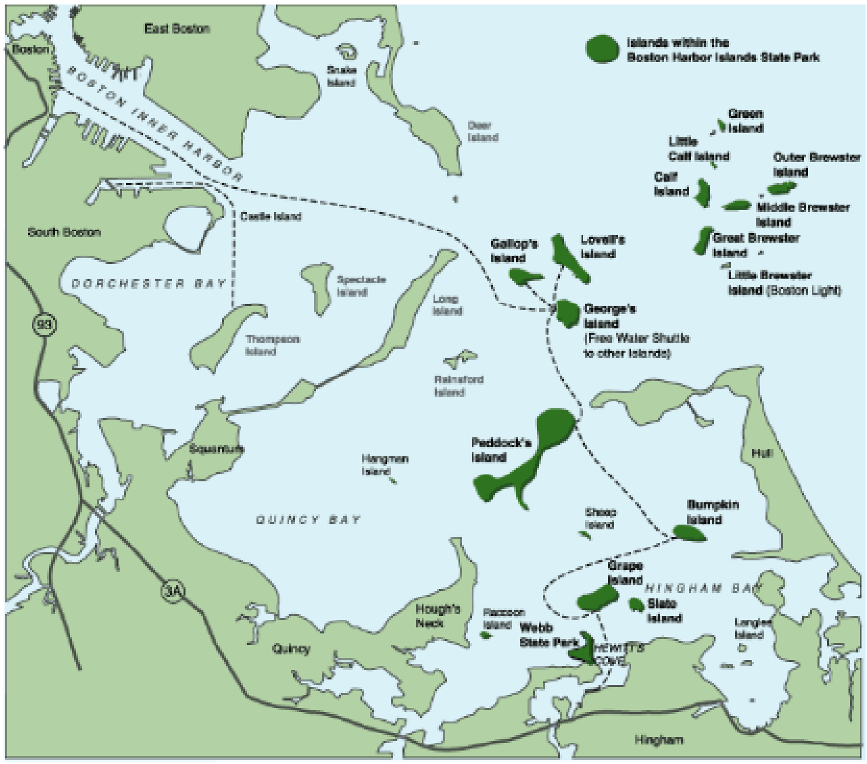


Figure 2.2 **Map of Boston Harbour, showing the Boston Harbour Islands State Park**

By the mid 1900s, Boston Harbour received sewage from more than 2.5 million people and 5,500 industries and businesses in 43 communities in the metropolitan Boston area, amounting to over 450 million gallons of sewage a day.

2.2. The Issues

The result of the long-term input of untreated and, and subsequently, under-treated sewage to Boston Harbour has been a severely polluted water body, impaired for recreational and commercial use. The levels of bacterial contamination often resulted in the closure of public beaches and shellfish beds for public health reasons. Specifically, the following were the effects of the ongoing pollution:

- Cloudy, unappealing water;
- Excessive nutrients causing phytoplankton blooms resulting in hypoxic or anoxic waters;

- Sludge deposition on the bottom, altering the ecology the sediment;
- Increased concentrations of toxins in shellfish and heavy metals in surface sediments;
- Occurrence of tumors and mutations in fish; and
- Reduced dissolved oxygen concentrations in the water column and bottom sediments.

2.3. The Initiatives

2.3.1. The Legal Action

The agency responsible for wastewater management in Boston was the Metropolitan District Commission (MDC). The government, the Commonwealth of Massachusetts, also had a role to play in that they had the responsibility to improve the conditions of the harbour. In 1982 the City of Quincy, MA filed a suit against the MDC for violations against the Massachusetts' water quality regulations. The following year, an environmental advocacy organisation, the Conservation Law Foundation (CLF) sued both the MDC and the US Environmental Protection Agency (EPA) for failing to protect Boston Harbour. The bases for the legal actions were requirements of the 1972 Clean Water Act and a Control Order that affects municipalities with populations over 100,000.

In 1985 the EPA then sued the MDC and the newly formed Massachusetts Water Resources Authority (MWRA), the entity created by the Commonwealth to take over the responsibilities of managing sewer and wastewater treatment.

The result of legal action was seen in 1986 when the US District Court compelled the MWRA and the Commonwealth of Massachusetts to begin the clean-up of Boston Harbour. This was to be achieved by the rapid and radical improvement of the existing, inadequate sewage collection, treatment and disposal system.

In 1988 the MWRA received all the necessary permits to begin the rehabilitation of the Harbour. The outcome of the Federal lawsuit resulted in one of the largest and most expensive sewage treatment projects in the world (US$3.7billion), the Boston Harbour Project.

2.3.2. The Technology

The Massachusetts Water Resource Authority addressed the remediation in three major efforts:

- Upgrading their primary plants to secondary treatment, and stopping the releases of scum and sewage sludge into the harbor.
- Construction of an extended outfall (9.5 mile, 24 ft diameter tunnel) from their Deer Island Treatment Plant to diffuse the effluent into deep water outside the Harbor. The outfall consisted of 55 x 250ft high riser-diffusers spaced along the last 1.25miles of the tunnel in 350-ft deep water.
- Implementation of CSO controls.

Figure 2.3 following shows the new outfall and diffuser. This diffuser was designed and located after extensive field and hydrodynamic model studies. The remedial plan for the CSO problem is outlined in the MWRA Action Plan summarized as follows:

- Upgrading wastewater treatment capacity to reduce the frequency and volume of CSOs;
- Closing CSOs in sensitive areas (shell fish areas and swimming areas);
- Treatment of CSO discharges by screening and disinfection;
- Installation of storage units to hold the CSO waters until they can be treated;
- Conversion from combined to separated sewer systems in some areas.

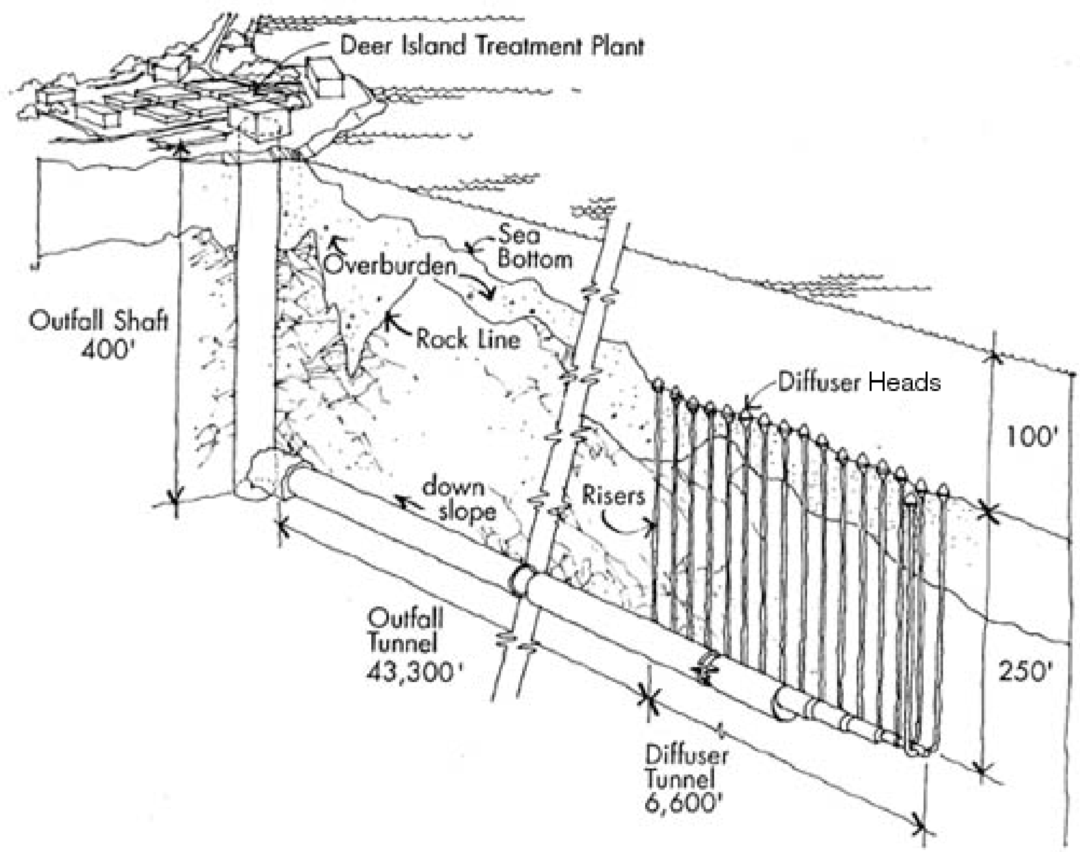


Figure 2.3 **Deer Island Outfall**

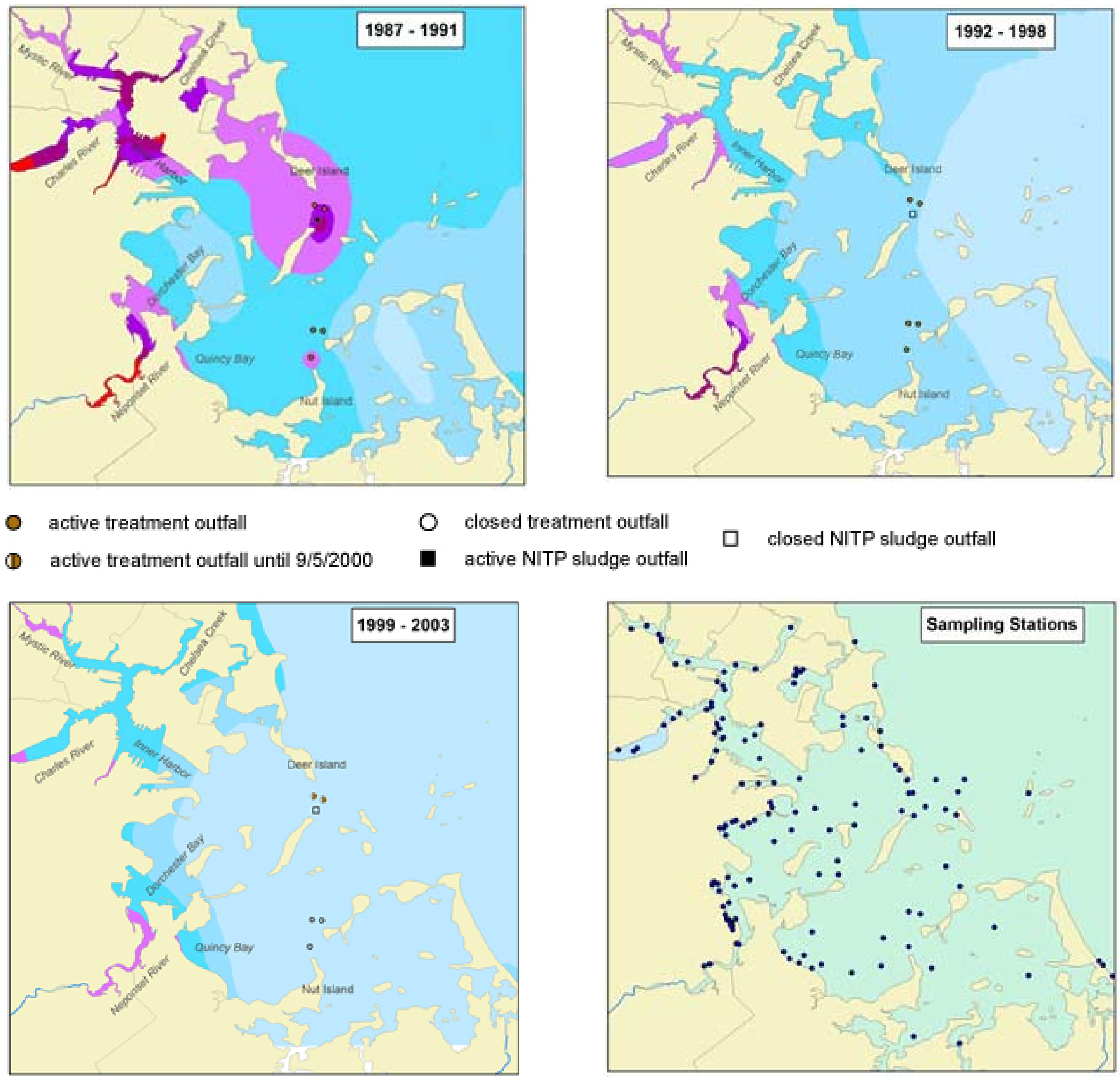
2.4. The Outcomes

There has been a dramatic decrease in the bacteria counts in Boston Harbor due to the implementation of the remedial plan. Figure 2.4 gives the progress since the late 1980s when the remediation plan was initiated.

By 1996 the following had occurred:

- Improved primary treatment at Deer Island and the diversion of sludge discharges reduced the amount of solids released into the harbour to 60 tons per day, less than half the tonnage that was released to the harbour in the 1950s.
- Bacterial counts were reduced.
- PCB concentrations in Lobsters had declined
- Concentrations of toxic heavy metals in surface sediments had declined
- Health of fish had improved
- Bottom dwelling invertebrates had increased dramatically.

Also the water quality improvements resulted in the increased recreational use of the harbour. In 1997 the islands of Boston Harbour were designated as a National Recreational Area by the US National Park Service.



Sampled during rainfall greater than or equal to 0.2 inches within 24 hours. Blue contours meet swimming standard, red-purple contours exceed swimming standard of 35 colonies/100 ml.

Colonies/100ml, geometric mean

Figure 2.4 Changes in Boston Harbor Average *Enterococcus* Counts in Wet Weather (From MWRA Annual Progress Report 2003)

3. Bremen

3.1. Background

The Free Hanseatic City of Bremen is the smallest of the independent states of the Federal Republic of Germany. Bremen, the city, is located on the River Weser (Weser Estuary) approximately 32 nautical miles (60 km) from the North Sea (Figure 3.1). Several major heavy industries operate from Bremen including the manufacturing of automobiles, ships, and electronics. The city is also the centre of successful food and semi-luxury goods manufacturing industries.

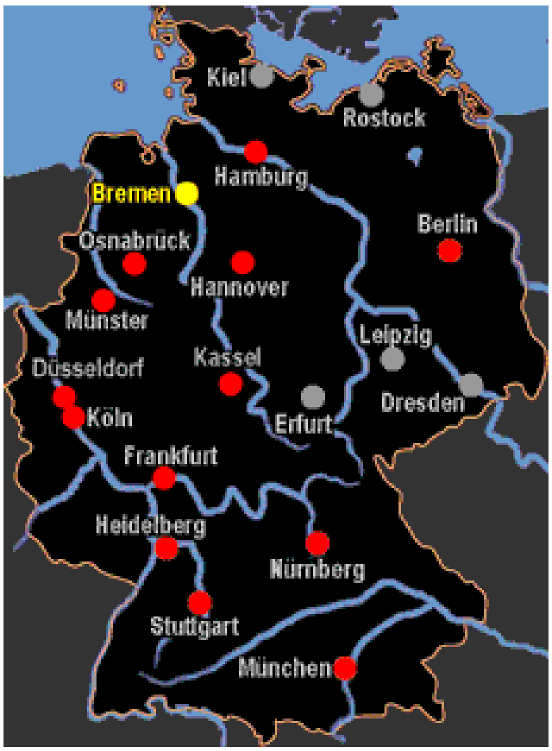


Figure 3.1 Location of Bremen in Germany

Bremen Harbour is the first man-made harbour in Germany and is now the second largest port in the country. The Ports of Bremen and Bremerhaven (the sister city) are major international trans-shipment ports handling approximately 3.2 million TEUs (Twenty foot Equivalent Units) annually.

The average tidal range in the Weser Estuary is 4 m at Bremen. The Weser River has a drainage area of 38,000 km^2. The sediment loads vary from 300,000 to 10,000,000 T/yr. Deposition rates are up to 200 cm/yr and grain sizes vary from < 0.01 mm to 0.1 mm. In order to accommodate the shipping industry, a draft of 9 m is maintained in the harbour, which requires dredging of approximately 350,000 m^3/yr in the Neustadt Basin of the Bremen Harbour.

3.2. The Issues

Due to the large sediment loads and the tendency for this material to deposit in the harbour basin, there is a need to dredge regularly in order to maintain the minimum draft. Given the pressure of heavy industries in the region, the dredge material is contaminated and generally requires special disposal. Contaminants include chemicals such as organic tin. In the past this material was disposed of in the North Sea; however, this practice has been stopped for Bremen.

3.3. The Initiatives

3.3.1. Institutional Arrangements

There is little information available on the social, institutional or legal activities that have prompted the safe disposal of the dredge material from Bremen Harbour. It is assumed that the initiatives are influenced by the general environmental awareness in Europe and Germany.

The Policies and guidelines for Bremen's ports are dictated by the Senator (Minister) for Economic Affairs and Ports of the Hanseatic City of Bremen. The management of the ship traffic is the responsibility of the Harbour Master within the Port Authority of the City government.

Starting in 2002 the responsibilities for the construction, maintenance and operative management of the seaports in Bremen were given to a private limited company, Bremenports.

3.3.2. Management of Dredge Material

The regular dredging of the Bremen Harbour involves the pumping of dredged sediments into a ponding area where the water content is reduced. The concentrated material is then placed in a secure confinement disposal facility (CDF). There is however, limited space for disposal, and efforts are therefore being made to reduce the amount of material that is sent to the CDF. Some of the promising proposals are:

- Use of the sediments for construction materials, e.g. bricks - a demonstration project has shown that the contaminants can be immobilized in bricks which can be used for non-residential construction.
- Introduction of river training groins to reduce the deposition in the harbour area;
- A numerical model based on RMA2 and SED4 was developed to investigate the utility of causing the river currents to bypass river sediments in order to avoid deposition in the harbour. The studies showed that a 25% reduction in the annual dredging amount could be achieved by this approach.

4. Guayaquil

4.1. Background

Guayaquil, Ecuador, was originally founded in the 16th century to protect the interests of Spain in South America. After more than four hundred and fifty years of urban development, Guayaquil has evolved into a major Latin American city, with a very large, uncontrolled and unpredictable population growth. As recently as the mid-nineties, unguarded or poorly secured land was subject to invasion by squatters who constructed large communities seemingly overnight These shanty villages initially consisted of bamboo dwellings laid haphazardly on the ground and in certain cases came about through severe deforestation of the hills surrounding the city. With time, the bamboo shacks evolved into masonry dwellings and the original shanty villages were transformed into unplanned subdivisions, without piped water and sewage collection facilities. There were also several instances of "planned subdivisions" where water and sewerage were not provided before or after construction.

Figure 4.1 **Location of Guayaquil in Equador**

As a consequence of this chaotic situation, the city of Guayaquil, Ecuador, faced severe environmental problems that threatened the health of the population and the local and national economy. In particular, the lack of proper sewage disposal facilities resulted in significant contamination of soil and water bodies (surface and groundwater).

4.2. The Issues

The Guayas River is one of the main water bodies where raw sewage was being discharged. Water quality analyses performed from 1974 through 2003 by several institutions have shown that there is significant wastewater dilution due to the large volumetric flow rate of the river. Indeed, the biochemical oxygen demand (BOD) levels are below 10 mg/L. At the drinking water treatment plant intake, located at 26.5 km upstream from Guayaquil, the BOD values were reported to be as low as 2 mg/L. Dissolved oxygen readings have reached values as low as 2.1 mg/L during ebb tide conditions, thus showing significant oxygen-consuming biological activity in the river. The impact of the sewage discharges were notable at the drinking water treatment plant intake (La Toma), where the fecal coliform readings have been as high as 1240 FC/100 mL during the flood tide and 950 FC/100 mL during the ebb tide.

4.3. The Initiatives

In August 1992 the Ecuadorian Government provided financial support for a study addressing the needs of the sanitary sewerage and wastewater treatment systems and entrusted this task to the technical university in Guayaquil, the Coastal Polytechnic School (ESPOL), in partnership with the University of New Orleans (UNO). In March of 1993, an agreement was signed between ESPOL and the UNO Urban Waste Management and Research Foundation to perform the studies corresponding to the technical feasibility of complete sewerage and wastewater treatment systems for Guayaquil. An administrative, financial and technical framework of shared responsibility between ESPOL and UNO was approved by both institutions for managing "Proyecto Guayaquil."

The principal objectives of the project were to:

a. Develop a conceptual design of the sewerage system rehabilitation plan and a technical feasibility study of the new Guayaquil sewerage and wastewater treatment systems to meet the demands of the year 2025.

b. Provide formalized training for Ecuadorian engineers in the fields of environmental engineering and geographic information systems, so that they could bring this technology back to their native country.

In April 2001, the Government of Ecuador, with the assistance of the Inter-American Development Bank (IDB), through the Guayaquil Water and Sewerage Board (ECAPAG), signed a 30-year concession contract with International Water Services (Guayaquil) [Interagua] for the administration, operation, rehabilitation and expansion of the potable water, wastewater, and drainage systems for Guayaquil. The capital expenditure program contemplates investments of about US$500 million over the 30 years of the concession, which in turn is divided into six five-year periods. Based on the information gathered during the first year of operations, Interagua has been able to assess the capital expenditure program needed to improve quality of services and to achieve the requirement of 55,238 new water and wastewater connections by 2006. As a result, the capital expenditure program currently contemplated is estimated to reach approximately US$146 million for the period of 2002-2006.

5. Santa Gilla Lagoon

5.1. Background

Sardinia is a large Italian island in the Meditteranean Sea. Cagliari, the capital, is bordered on the south by the sea, and on the east and west by lagoons and ponds. One such lagoon, Laguna Santa Gilla, was for decades the major source of sustenance for the island's population, providing food and occupation for many of the people. However, as the farming and fishing industries grew around the lagoon in the early 1900s, the area became rapidly industrialized which ultimately resulted in the stagnation and silting of the lagoon.

Figure 5.1 Location of Sardinia, Cagliari and Santa Gilla Lagoon

The construction of a salt factory in the 1920s reduced the size of the lagoon considerably, and the subsequent construction of a commercial port and the expansion of the local airport further reduced the surface area of the lagoon and the water exchange rate.

In the 1960s the lagoon was used as a dump site for urban and industrial waste, and the port was further expanded, drastically altering the water quality, ecology, marine currents and water exchange. In 1974 the presence of heavy metals in the bottom sediment and fish, and cases of cholera in Cagliari resulted in the closure of the lagoon by local authorities.

5.2. The Issues

In the late 1960s and early 1970s the signs of deterioration in the lagoon, were apparent, and included:

- Materials and leachate from illicit garbage dumps entering the Lagoon;
- Improperly treated waste water reaching the Lagoon;
- Putrid water, with the die off of copious numbers of fish and other forms of animal and plant life; and
- The covering of the lagoon bottom by a layer of mud approximately 1 meter thick. This led to a drop in fishing production and ultimately impacted the local economy.

It was also determined that Laguna Santa Gilla had special archaeological significance, when Roman and Greek artifacts were discovered in approximately one meter of mud. Reclamation works would therefore require consideration of the archeology.

5.3. The Initiatives

5.3.1. Institutional Activities

Several academic and advocacy groups sought to have the lagoon restored and in 1977 the Bureau of Environment of the Government of Sardinia began the preliminary work for the reclamation of the lagoon. In 1984 the same Bureau gave the approvals for the initial stages of the reclamation project. The main objectives of the project were to restore the hydraulic and biological balance of the lagoon. This required:

- Reclamation of the lagoon from an environmental and health perspective;
- Creation of an advanced fisheries habitat;
- Restoration of an environmental resource for tourism;
- Restoration of the resource for scientific activities ; and
- Utilisation of a number of important archeological areas.

In 1987 a consortium of local municipalities (Cagliari, Assimini, Elmas and Capiterra) was formed to implement the clean up of Santa Gilla. The estimated clean up costs of 5 billion Lira was equally split between the consortium and the European Union. A Technical Scientific Committee was formed composed of a variety of experts including engineers, biologists, economists and archaeologists. This committee was responsible for carrying out public meetings in the communities of the Consortium to ensure support for the project.

Ultimately the Consortium formulated a plan for the hatitat-management of the lagoon to ensure that:

- The ecological diversity of the lagoon was restored, and in particular the birds;
- Illicit dumping of rubbish would be stopped;

- No more untreated sewage would be disposed of in the lagoon;
- A method for the safe disposal of the dredged material would be developed to involve the separation of mud from inert material for separated disposal; and
- Ongoing bio-monitoring of the Santa Gilla Lagoon during and after the clean up phase was carried out.

5.3.2. Technical Activities

Prior to the dredging a survey of the potential archaeological sites in the lagoon was completed. This led to the setting of zones for dredging operations. The primary division was between areas that had been frequented by humans and associated activities and those areas that had not experienced human activities. In this way certain sensitive areas could be avoided and other areas dredged by either precision operations or by conventional methods depending on the likelihood of disturbing or destroying artifacts.

The intitial dredging work involved the construction of one canal at an elevation beneath that of the lagoon and two peripheral (circumfrence) canals, designed to promote the draw off of flood waters during the winter, and to promote the water-exchange rate between the sea and the lagoon. Cutter suction dredgers were used, some modified for operation in very shallow areas. Later stages of the dredging involved the creation of smaller 'fishbone canals' aimed at further improving the movement of water in the laggon. The contaminated sediments were mixed with clean sediments in order and to create a sediment with an 'acceptable average degree' of contamination. Enormous reclamation areas were created to hold the dredged material.

5.4. The Outcomes

Without the reclamation (and ultimately restructuring) works, the Santa Gilla Lagoon would have ceased to exist. The dredging and construction of a series of canals allowed for improved water circulation, and have resulted in the dramatic improvement of the water quality in the lagoon. The ecology and commercial fisheries have also improved, although not to the extent initially expected and desired.

6. Stockholm

6.1. Background

Stockholm is an ancient harbour city, and is today home to Sweden's seventh largest Port (Figure 6.1). The Port handles approximately 7 million passengers and 8 million tones of goods annually, a majority of which travel on combined freight and passenger vessels. The use of the Port continues to grow, and the demand for docking facilities and storage is greater than the existing location can facilitate. A new port has therefore been proposed, to be constructed to the south of the present harbour.

Figure 6.1 Map of Stockholm Harbour

The NGO Coalition for a Clean Baltic (CCB) has rated this planned harbour as one of the environmental concerns in the region because it may threaten important nature conservation and recreation areas. However, Stockholm has become a leader in environmental planning and implementation in the Baltic Region, and in addition to the management of municipal waste, the ports have worked to reduce the impact of shipping activities on the harbour and surrounding environment.

6.2. The Initiatives

Over the past 15 years the Ports of Stockholm have succeeded in the following areas of environmental improvement:

- Stockholm has implemented a world class wastewater treatment facility that includes: tertiary treatment, energy recovery and production of soil conditioners. Phosphorus controls have been successful in reducing this limiting nutrient to less than 50 mg/m^3 in the receiving waters.
- A small lake (Langsjon) has been dredged and cleaned.
- Ferries have voluntarily switched to low sulphur fuel.
- Introduced differential fees for double hull ships.
- Supported catalytic converters by differential fees to reduce nitric oxide emissions.
- Built collection and treatment facilities for "black" and "grey" water to avoid these being discharged in the harbour or at sea.

By the end of 2004, applications will be submitted under the new Environmental Act in Sweden. This act covers air, water and noise pollution. Under this act the operators of the Harbour must have a permit which specifies the permissible operations and the environmental impacts of these operations.

New stormwater technologies are being implements to further improve on the receiving water quality. Both stormwater treatment and storage facilities are in-place or are being planned. Attention is being focused on highway runoff.

6.3. The Outcomes

The following are some of the success stories for Stockholm Harbour:

- Single hull ships are no longer using the Harbour.
- Control of point sources of pollution through treatment of municipal waste water.
- Elimination of pollution from "black" and "grey" water in the harbour.
- 43% reduction in NOx emissions from ships.
- To ensure a rapid response, the Ports of Stockholm AB have accepted the responsibility for oil spills in the Harbour.
- The receiving water quality has improve dramatically over the past 30 years. Salmon have returned and the water clarity has more than doubled.

Green areas in the city are being preserved to reduce the impacts of urban storm runoff. To prevent urban sprawl and preserve the green wedges, Stockholm's 1999 Comprehensive Plan adopted the concept of "building the city inward."

7. The Great Lakes - Hamilton Harbour

7.1. Background

Hamilton Harbour is a 2,150 hectare embayment located at the western end of Lake Ontario in the Great Lakes region of North America. The Harbour is connected to Lake Ontario by a ship canal, and is the main water body for a population of approximately 500,000 located mainly in two cities, Hamilton and Burlington. The cities take drinking water from Lake Ontario and discharge treated sewage and combined sewage overflows to the Harbour. Two steel producers, Stelco and Dofasco, occupy about 30% of the Harbour's waterfront. Figure 7.1 shows the harbour and the adjacent City of Hamilton and the Steel Industries.

Figure 7.1 Satellite Photo of Hamilton Harbour

7.2. The Issues

For decades the industry and the municipality discharged relatively untreated waste into the harbour. Contaminants include polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), cyanide, phenols, copper, nickel, zinc, cadmium, lead, iron, manganese, mercury, arsenic, ammonia, phosphorus, benzene, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans. The most severely impacted sediment is the Randle Reef which is located near the steel industry; the primary contaminant here is PAH.

Table 7.1 Summary of Issues and Sources of Problems in Hamilton Harbour

USE IMPAIRMENT	INCIDENCE	SOURCE(S) OF PROBLEM
Restrictions on fish and wildlife consumption	consumption advisories (mercury, PCBs, and mirex) exist for 5 species mostly due to lakewide conditions, elevated PCB levels in wildlife	contaminated sediment, sewage treatment plants, non-point sources including atmospheric deposition
Tainting of fish and wildlife flavour	tainting has not been observed	not applicable
Degraded fish and wildlife populations	current fish community indicates a highly degraded eutrophic system	algal blooms, contaminated sediment, shoreline filling, exotic species
Fish tumours or other deformities	liver and skin neoplasms and epidermal papillomas have been reported	contaminated sediment from steel mills operations and other industry combustion, urban runoff, and sewer systems
Bird or animal deformities or reproductive problems	to date, control sites for bird and animal populations have not been selected	contaminated sediment in Hamilton Harbour and contaminants in Lake Ontario
Degradation of benthos	benthic community is characteristic of a highly eutrophic urban/industrial environment	sewage treatment plant effluent, deposits of organic material in sediment
restrictions on dredging activities	sediment exceeds acceptable limits for open water disposal	sewage treatment plants, industry, urban and rural runoff, combined sewer overflows
Eutrophication or undesirable algae	ammonia and phosphorus concentrations are excessive	combined sewer overflows, sewerage treatment plants, steel industry, agricultural and urban runoff
Beaches Closed for Swimming	swimming has been prohibited due to bacteria levels	raw sewage from combined sewer overflows and sewage treatment plants
Degradation of aesthetics	oil sheens, objectionable turbidity, floating scum, and debris have been observed	industrial, highway, and shipping spills, runoff events, sewage treatment plants and combined sewer overflows

Added costs to agriculture or industry	no added costs	sewage treatment plants, combined sewer overflows, and storm runoff have potential to contribute objectionable material
Degradation of phytoplankton and zooplankton populations	abundance is high, reflecting eutrophication	municipal and industrial sources including sewage treatment plants and combined sewer overflows
Loss of fish and wildlife habitat	Low dissolved oxygen, loss of submerged aquatic vegetation, loss of marsh and development impacts are problems	filling from development, algal blooms, high lake levels, and Resuspension of sediment

7.3. The Initiatives

The approach to remediating impaired sites in the Great Lakes Region has been to form Remedial Action Plan committees that consist of representatives from interested parties including government agencies, industry and the public. The following is the stated goal of the RAPs:

> "*The goal of Remedial Action Plans (RAPs) is to restore and protect beneficial uses in 42 identified Areas of Concern (AOCs) within the Great Lakes basin. AOCs are geographic areas where human activities have caused or are likely to cause impairment of beneficial uses or the area's ability to support aquatic life. The United States and Canada (the Parties), in cooperation with state and provincial governments, agreed to develop and implement RAPs in a 1987 protocol to the Agreement. Each RAP is to embody a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses and serves as an important step toward virtual elimination of persistent toxic substances. Further, the Parties, in cooperation with state and provincial governments are to ensure that the public is consulted in all actions undertaken pursuant to Annex 2 of the Agreement.*
>
> *The IJC is to review and comment on RAPs during three stages of development: when the definition of the problem has been completed; when remedial and regulatory measures are selected; and when monitoring indicates that impaired beneficial uses have been restored. In 1996, after more than ten years of reviewing and assisting in development of RAPs, and expressing concern with overall progress in development and implementation of cleanup and prevention strategies in some AOCs, the IJC adopted a new initiative to examine progress toward restoration of beneficial uses by initiating status assessments in individual AOCs in an attempt to enhance the restoration process".*

Typically RAPs are organized in stages: Stage 1 -problem identification and Stage 2 selection of remedial measures. RAPs are available for the Hamilton Harbour Area of Concern. Table 1, pursuant to Annex 2 of the Great Lakes Water Quality Agreement (Agreement), presents the 14 possible beneficial use impairments, their significance, sources of problems, and information deficiencies. The identified sources of contaminants include: contaminated sediment; point source discharges from municipal and industrial sources including combined sewer overflows; and non-point sources of pollution from such sources as urban and agricultural runoff. In addition environmental concerns include: oxygen depletion; fish consumption advisories; changes in fish community structure; loss of fish and wildlife habitat; and adverse impacts of exotic species on fish and wildlife habitat.

The Hamilton Harbour Remedial Action Plan (RAP) is a community-based project. The objectives of the project are to re-establish a healthy aquatic ecosystem and improve recreation uses while maintaining the harbour's economic function. The targets to (1) improve access (2) restore land uses and (3) increase healthy fish plankton and wildlife. A long term objective is for "Delisting" Hamilton Harbour as an "Area of Concern" under the Great Lakes Water Quality Agreement (Stage 1 1992, Stage 2 1992 and updated in 2002).

7.4. The Outcomes

Nearly $16 million dollars in federal, provincial, municipal and private sector funding has resulted in:

- fish and wildlife habitat restoration projects in Cootes Paradise, LaSalle Park and the eastern end of the Harbour;
- extension of the Waterfront Trail from Burlington to Stoney Creek, and the creation of Hamilton's award winning Bayfront and Pier Four parks, both of which contribute to the RAP goal of creating public access along 25% of the harbour shoreline;
- construction of five combined sewer overflow tanks (out of a planned 14 tanks) which have reduced storm sewer overflow events by 45% and opened Hamilton's western beaches to swimmers;

8. Summary and Conclusion

The following summarises the general findings and applicable lessons from the harbour rehabilitation/remediation cases reviewed. While there was little information available on the institutional arrangements or implementation plans for most of the cases, some general institutional requirements and activities were evident and these have been briefly discussed below.

8.1. Main Harbour Issues

Three main items emerge as the issues which have contributed the most to the degradation of the harbours reviewed, and, as such, have prompted the rehabilitation of these harbours: Sewage discharge, industrialization/manufacturing, and shipping. The actual impetus for these clean-up cases differ in each scenario, however there are some common themes. For instance, all were related to the urban growth and waterfront use in each location. In some instances, there was a strong push to rehabilitate wildlife habitat, to improve recreational facilities, or to ensure the health of these coastal communities through the safeguarding of water sources.

Table 8.1 Summary of Issues, Impacts and Examples

Issue	*Impacts*	*Examples*
Sewage Disharge	The practice of discharging partially treated or untreated sewage into water bodies has resulted in significant impact on water quality/Ecology/human health	Boston, Guayaquil, Santa Gilla, Hamilton
Industrialisation/ Manufacturing	Contaminated sediments has an impact on aquatic life and on water quality.	Great lakes, Santa Gilla, Bremen
Shipping	General environmental impacts, User Conflicts	Bremen, Stockholm

8.2. Institutional/Social Activities

The scenarios prompting and initiating the rehabilitation/remediation projects were seen to be:

1. Legal action (Boston)/legal requirement (Great Lakes)
2. NGO pressure/social activitism (Boston, Santa Gilla)

3. Collaboration between the government, private sector interests and international funding agencies (Guayaquil), and
4. Economic pressures (Stockholm)

8.3. Technical Solutions

The main technical solutions employed for the cases studied were:

- Point source management of pollutant discharges.
- Improved sewage treatment facilities.
- Dredging and careful disposal of often contaminated dredged material.
- Operations management for more efficient waterbody usage.
- Environmental management for better recreational and habitat recovery.

Table 8.2 Summary of Technical Solutions

Case	*Major Environmental Isssues*	*Tools for Evaluation*	*Proposed Technical Solutions*
Bremen	Contaminated Sediments	RMA2/SED2D Models	Hydraulic dredging, de-watering pond, CDF and some re-use as building materials. River training to reduce the volume of deposits. Fee structure to reduce the risk of accidents.
Boston	Water Quality	3-D hydrodynamic and water qualaity models	Improved wastewater treatment, extended tunnel and diffuser.
Guayaquil	Water Quality	Standard Water Quality Surveys.	Privatization of the Water-Wastewater services. Diversion of some wastewater to the Guayas River away from the ocean inlets.
The Great Lakes – Hamilton Harbour	Contaminated Sediments	GIS + Hydrodynamic and water quality models, Detailed Sediment Surveys	Source control, Capping in shallow areas, precision dredging, Self remediation in deep areas.
Stockholm	Water Quality, Air Quality	Conventional Water Quality and Biomonitoring	Use of harbour fee structure to reduce risk of accidents (Double Hulls), Solids and liquid waste collection and control at the Harbour.
Santa Gilla	Contamnated Sediments and Water at an Archeological Site Ecological restoration (fishery and water fowl are impaired).	Detailed Archeological Survey to Map zones of Archeological Importance. GIS and Biomonitoring	Control of point sources of pollution, Reduction of illicit dumping, Co-ordianted engineerig-archeological teams manage the dredging. Ecological mangement plan is being formuated.

8.4. Lessons Learnt

8.4.1. Management

- Point source control was the cornerstone for most of the sites that were reviewed.
- The concept of Ecological Mangement has been introduced in the clean-up plan for Santa Gilla Lagoon.
- The use of harbour fee structures to encourage responsible shipping behaviour has been successful at Stockholm and Bremen. This technique has been used to get shippers to switch to double hulled ships and to reduce NOx emissions.
- The on-site collection and treatment of ship wastes has been introduced at Stockholm.
- The Guayaquil case showed that privatization, if properly implemented, can overcome historical barriers to providing services. The public appears to be supportive of the private firm which provides an opportunity to make progress on the serious water quality issues related to inadequate wastewater treatment.

8.4.2. Technological

- Application of 2-D and 3-D models to asses the fate and mobility of contaminated sediments. This was done at the St. Clair, Hamilton and Bremen Sites. Similar models were used in Boston Harbor to locate the new outfall and diffuser.
- The use of GPS and divers to accurately map the bottom artefacts at Santa Gilla will permit the most cost effective dredging technology to be selected based on pre-determined zones of 'risk'. This concept can be combined with modelling and GIS techniques to map sediment according to the most appropriate treatment technology.
- Bremen has reduced the CDF requirements by de-watering the dredged sediments and using some of this material for making building bricks.

8.4.3. Applicability to Kingston Harbour

All of the cases reviewed had some relevance to the Kingston Harbour case, although some more so than others. In general, the issues that appear to be critical and which should be carried forward in the Kingston Harbour claen-up include:

- The need for a "champion" to puch the case for clean-up. This "champion" could be an NGO, the user community at large, an environmental agency or the government.

- The need to have a single agency with the responsibility for clean-up activities. This agency should represent, at some level, the stakeholders and/or users of the harbour.
- The technologies exist to effect clean-up for harbours that were even more badly degraded than Kingston Harbour. Primary among these is the proper treatment and disposal of sewage.
- Any clean-up option of this scale will be expensive, and would therefore benefit from comprehensive boy-in from relevant stakeholders.