

**COLLABORATIVE INTERACTIVE METHODOLOGY FOR  
ENVIRONMENTAL SITE SELECTION**

by

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Bachelor of Science in Agricultural and Biological Engineering  
Cornell University, 1997

Submitted to the Department of Civil and Environmental Engineering  
In Partial Fulfillment of the Requirements for the Degree of

**MASTER OF ENGINEERING  
IN CIVIL AND ENVIRONMENTAL ENGINEERING**

at the

**MASSACHUSETTS INSTITUTE OF TECHNOLOGY**  
June 1998

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May 20, 1998, in partial fulfillment of the requirements for the degree of  
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## ABSTRACT

The motivation for the Boston Harbor Navigation Improvement Project (BHNIP) is to ensure that Boston has a reliable and modern port by deepening the channels for container vessels and improving navigational efficiency. This effort requires the dredging and treatment of sediment that has become contaminated by the dumping of human and industrial wastes and port activity through the years. The BHNIP has selected the use of in-channel capped borrow pits as a treatment method for contaminated sediment. This option is the most cost-effective disposal method with public acceptance. As a result, the site selection for the containment of the dredged material has become highly controversial as the industry and public voice their concerns and opinions.

Confronting the interests to site selection is a difficult task as opinions clash between environmental organizations, businessmen, and the public. Reaching a consensus requires the sharing and understanding of information, along with the cooperation and collaboration of people. The goal of this project was to develop a methodology and a system to aid the communication and collaboration between the involved parties in the decision making process.

In creating the system tool, an interactive web site was generated to provide a common ground for information to be analyzed, shared and transferred. The site also would monitor if and how individuals collaborate their values with one another to reach a consensus. By generating a user profile, the system stored the interests of users and showed how these interests compare with other parties. The system would allow for communication between parties and would capture how interests may change according to the interactions. It is realized that parties would change the priority or threshold of their values based on communications, conversations, and alliances formed with other parties. The tool would then be able to suggest feasible sites for borrow pits based on the adjusted perspectives and expectations of these groups or alliances.

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## ACKNOWLEDGMENTS

Hold Fast to Dreams  
*by Langston Hughes*

Hold fast to dreams  
For if dreams die  
Life is a broken-winged bird  
That cannot fly.

Hold fast to dreams  
For when dreams go  
Life is a barren field  
Frozen with snow.

I thank everyone who encouraged me to dream, believed in my dreams, and kept my dreams alive. May your dreams also be empowering and far reaching.

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# Chapter 1

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## 1 Motivation for Collaborative Interactive Methodology in Environmental Disputes

The Boston Harbor and its waterfront have supported industry and activities for several centuries. The use of the port for fishing, shipping, and commercial industries brings revenue to Boston's economy (USACE & Massport 1995). Silting or sediment deposition in the navigation channels render them inaccessible to ships with deep drafts. These shallower channels make navigation difficult and inconvenient if ships need to wait for high tides before entering the harbor and unloading before low tide. If the vessels use other ports instead, this inefficiency leads to the loss of business for Boston. Sediments can be deposited in three additional ways: (a) from fine solids in rivers and streams settling out of the water column in the slower moving harbor, (b) from current and wave action washing solids in from the ocean as well as redistributing and eroding shorelines and channel boundaries, and (c) deposits from storm water and combined sewer outfalls (USACE & Massport 1995). Much of the city still has a combined sewer outfall system (CSO) that combines runoff with sewage in the same pipelines. When it rains, CSO's send the overflow and associated sediment, particles, and organic material into the harbor. Therefore, after decades of sediment and waste accumulation, the channels require dredging to maintain an operational depth.

The motivation for the Boston Navigation Improvement Project (BHNIP) was to dredge areas of the harbor in order to improve navigational efficiency. Depth maintenance and the creation of a greater depth to accommodate wider and deeper vessels were the primary goals of BHNIP (USACE & Massport 1995). Dredging to a minimum required depth and width would enable larger vessels to maneuver easily in the channel. If the deepening went below the pre-existing bed levels, it could result in the movement of sediment into these deepened areas by currents and waves (Yell & Riddell 1995).



Concerned industries using the port wrote the U.S. Army Corps of Engineers (USACE) with letters rallying for the approval and implementation of the BHNIP. Companies that handled containers in the port were prevented from navigating during low tide. And if the vessels could not afford to wait, they bypassed the port altogether. For companies with an exportation business such as Rexham Inc, the export business represents 15% of more than one hundred million gross sales (USACE & Massport 1995). The loss of revenue threatened the jobs of this business. They felt that it was the obligation of Boston to mandate the accommodation of larger vessels.

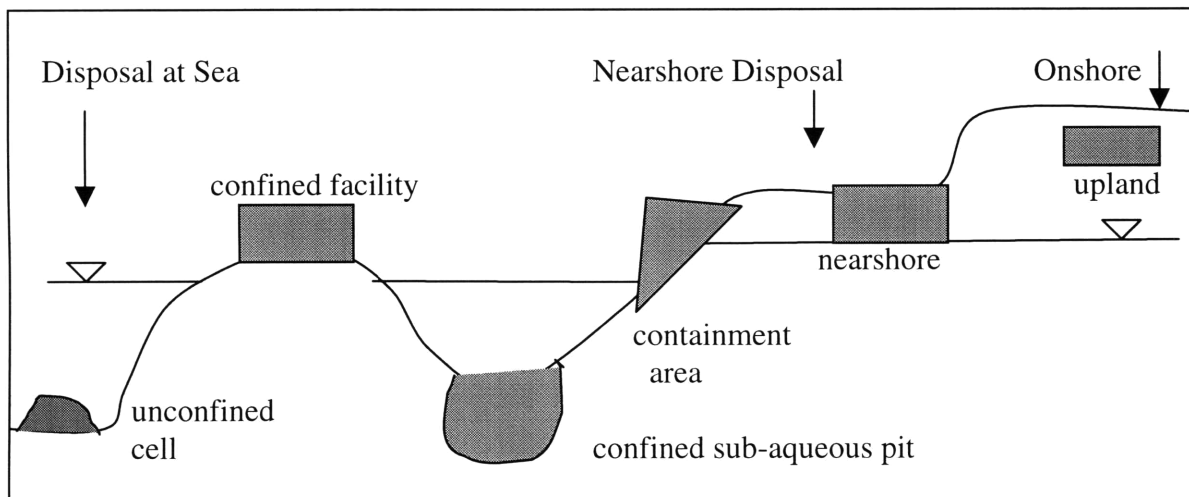
A cost benefit analysis, based on March 1995 price levels. The results listed in Table 1-1 demonstrated that it was beneficial to undergo the dredging project (Table 1-1 USACE & Massport 1995).

**Table 1-1: Economic Analysis (USACE & Massport 1995)**

Annual Benefits	\$ 3,594,000
Annual Cost	\$ 2,487,000
Benefit-Cost Ratio	1.4

Although there was wide support for the BHNIP, the effects of dredging on the environment cannot be ignored. By its very nature, dredging affects the nature and characteristics of the land and waters below. The dredging of the Inner Harbor is estimated to generate 1.0 million cubic yards (cy) of contaminated silt, 1.8 million cy of underlying parent material, and 0.1 million cy of rock. The estimated cost for the disposal of contaminated sediment is over 20 million dollars (USACE & Massport 1996). The underwater excavation and disposal process must be safe, economical and environmentally sound. Several disposal options exist, but an optimal disposal plan will factor regulatory requirements, environmentally acceptable disposal of contaminated sediment, cost, and public opinion in the choice of a preferred option. In the case of Boston Harbor, engineers decided that the Least Environmentally Damaging Alternative was in-channel disposal cells with a clean cap cover.

There are three options for disposal of dredged material: (1) disposal at sea, (2) disposal in shoreline enclosures, and (3) onshore disposal (Dolin & Pederson 1991; Bray et al. 1997). Figure 1-1 shows a diagram of these alternatives (NJDEP 1997). Regulations, cost, and contaminant characteristics are all factors that determine a chosen method. Moreover, each option has its environmental side effects. For example, shoreline enclosures can be low-cost or high integrity depending on the preferred type. They may have high berms or special liners to retain contaminants. However, regulations often prohibit shoreline enclosures to protect the existing ecosystem.



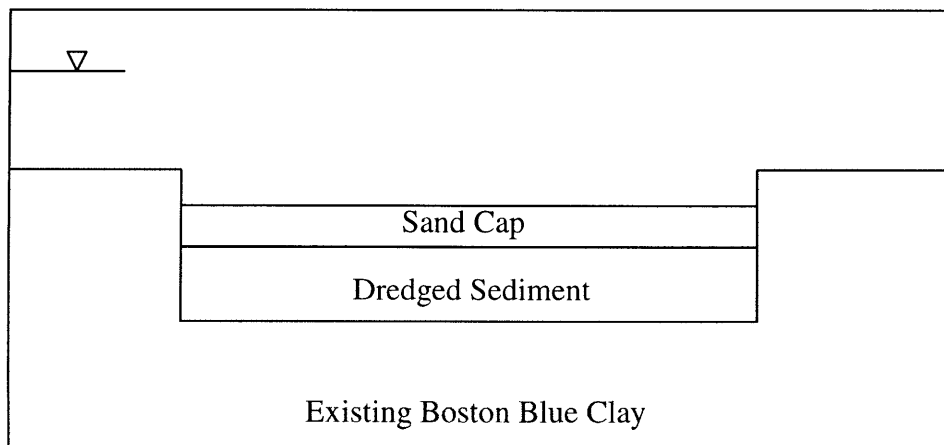
**Figure 1-1: Dredged Material Disposal Alternatives (NJDEP 1997)**

Onshore disposal is an option when there is a site that can accept the dredged material. The dredged material typically must be de-watered and then may be used for landfills, restoring wetlands, or construction materials. De-watering the sediment and decontaminating it to acceptable levels is often costly and the question of how the contaminant will be treated still must be addressed. In addition, on shore disposal may pollute groundwater and be difficult to process and to clean (Bray et al. 1997).

Offshore disposal can occur in several geographical zones such as deep-ocean, inlet, and near-shore. These options breakdown further into specific options. Unconfined disposal, confined disposal into seabed depressions, confined disposal between underwater dykes,

and formation of islands are all a subset of disposal at sea (Bray et al. 1997). Recently, capping of confined disposal, borrow pits have also become popular offshore disposal options.

The alternative determined for the Boston Harbor was the use of borrow pits (cells) constructed in-channel and capped with a three foot layer of clean sand (Massport & USACE 1995). This *in situ*, offshore disposal method is called capping (Fig. 1-2). It is defined as the controlled accurate placement of contaminated dredged material at an open water site, followed by a covering or cap of clean isolating material (Palermo 1994). Capping has been practiced in the U.S. since the mid 1970's and the U.S. Army Corps of Engineers continues to perform and permit capping projects with a total of 20 projects on both East and West Coasts (Clausner 1994). It has been recognized as an effective method for containing and sequestering the toxic effects of contaminated sediment (Engler 1989), although its effectiveness at depths greater than 30-60m is questioned. For Boston Harbor, the displaced clean parent material will be disposed of in 300 feet of water offshore of the Massachusetts Bay Disposal Site (Massport & USACE 1996).



**Figure 1-2: Disposal Cell Schematic** (Fitzgerald 1998)

Although the BHNIP has identified and is testing the use of disposal cells with capping in the Inner Harbor, there remains a need for a long-term solution. The main issue deals with locating additional borrow pits to handle the expected 7 million cy of the

contaminated sediment expected in the next 50 years (USACE & Massport 1996). Concerned industries, public, environmental advocates, and regulatory agencies have begun to voice their preference and concerns with certain locations, while standards and regulations also prevent site selection. The current criteria for sub-aqueous borrow pits as an aquatic containment facility are shown in Table 1-2.

**Table 1-2: Borrow Pit Criteria** (Metcalf and Eddy 1992)

1. Material from the borrow pit excavation should be reusable elsewhere, and therefore the pit must be located in an area where there are commercially-usable sand and/or gravel deposits.
2. To foster reuse of the excess borrow pit excavate, the pit must be located within an economically feasible distance of an area where there is a need for the excess material.
3. The site must be located in an area where the dispersal of dredged sediment into the water column would be minimal
4. Depth to bedrock must be sufficient for excavating the pit
5. The site must be located in an area where oceanographic conditions would not cause disturbance of the cap on the pit.
6. Adverse impacts to threatened or endangered species or their habitat areas must be avoided.
7. The project should not adversely affect other federal, state, or local protection areas, and disposal must be consistent with management of protected areas.
8. The site must not cause adverse impacts to commercial and recreational fishing.
9. The site can not interfere with navigation; therefore channels, anchorages, and other restricted areas were removed from consideration.
10. Aesthetic impacts and impacts to recreational areas must be avoided
11. Disposal must avoid adverse impact to designated historical or cultural resources. Areas which would result in impacts to these resources and to the sites listed on or eligible for listing on the National Register of Historic Places must be avoided.

Although the BHNIP is a positive step for Boston's port industry, it is under the watchful eye of environmental, recreational, and fishing industry proponents. The government has the difficult task of mediating and mitigating the interests and issues among the interest groups. Few system tools and methodologies exist to promote the cooperation, information sharing and analysis between these groups to reach a consensus. The Internet, however, is gaining popularity as a tool for information sharing and analysis.

The dawning of the information age and increasing use of the Internet has rapidly brought both valid and invalid information to users. This capability is global in breadth as it enables people to debate, to share, and to galvanize around central issues, but it does not necessarily create a global community. Locally, the fundamental geographical boundaries that we live, exchange, and interact in create a community. The drawback from obtaining information over the Internet is the void of human interaction. It is the lack of social and casual interaction and collaboration between people over the Internet that fails to create a sense of community. Perhaps as humans, we have not realized how to use technology to form communities. Further compounding the isolation is a lack of tools and systems that promote collaboration and interaction over the Internet.

The motivation for my project was to equip global and local communities with a methodology and system tool that would enable them to contribute ideas and opinions to the issues surrounding environmental site selection.

## 1.1 Importance of Collaboration and Interaction

The selection of dredged material disposal sites for contaminated sediments involves a tedious and often controversial process. The process begins with the dissemination and the clear presentation of information combined with the cooperation of involved parties. Issues arise when individuals and groups require information of varying scope, technicality, and depth. Engineers and scientists may want numerical data to analyze and

to use as quantitative evidence, while the public may only have special interests, qualitative values, and preferences. This dichotomy leaves policymakers with the difficult task to integrate information from all parties to reach a solution. Thus, the methodology in which information is presented, extracted, and utilized, plays a key role in determining the satisfaction, interaction, and success of site selection.

In the case of the BHNIP, policymakers use the input from the public, environmentalists, and scientists to decide on feasible areas within the Inner Harbor to dig cells to hold contaminated sediment. Figure 1-3 shows the area involved in the BHNIP. In the process of selecting containment areas, such as the in-channel disposal sites in Boston Harbor, data are generated for site and risk assessments. Often the volume of data is so large that filtering relevant information to the appropriate people in the appropriate manner becomes a problem.

It is not uncommon for consultants or project proponents to manipulate and bias outcomes to reflect their interests--especially when selecting from a large number of sites where several factors such as regulations and economics are considered. Other compounding issues regarding the data are unequal availability and access. Often not all the issues are equally addressed and represented. This imbalance creates a cornucopia of means and reasons, and it makes reaching a consensus a long road of persuasion and explanation. If a respected data analysis system that represented all issues existed, it would accelerate the consensus process.

To improve the site selection process through common information analysis and sharing, advances in software, such as ArcView, are used to manage and to interpret spatial data. ArcView can extrapolate information such as land coverage from the Geographic Information System (GIS) databases and utilize tables with longitudinal and latitudinal coordinates to visually map the data. Unfortunately these packages are often costly and may require technical training.

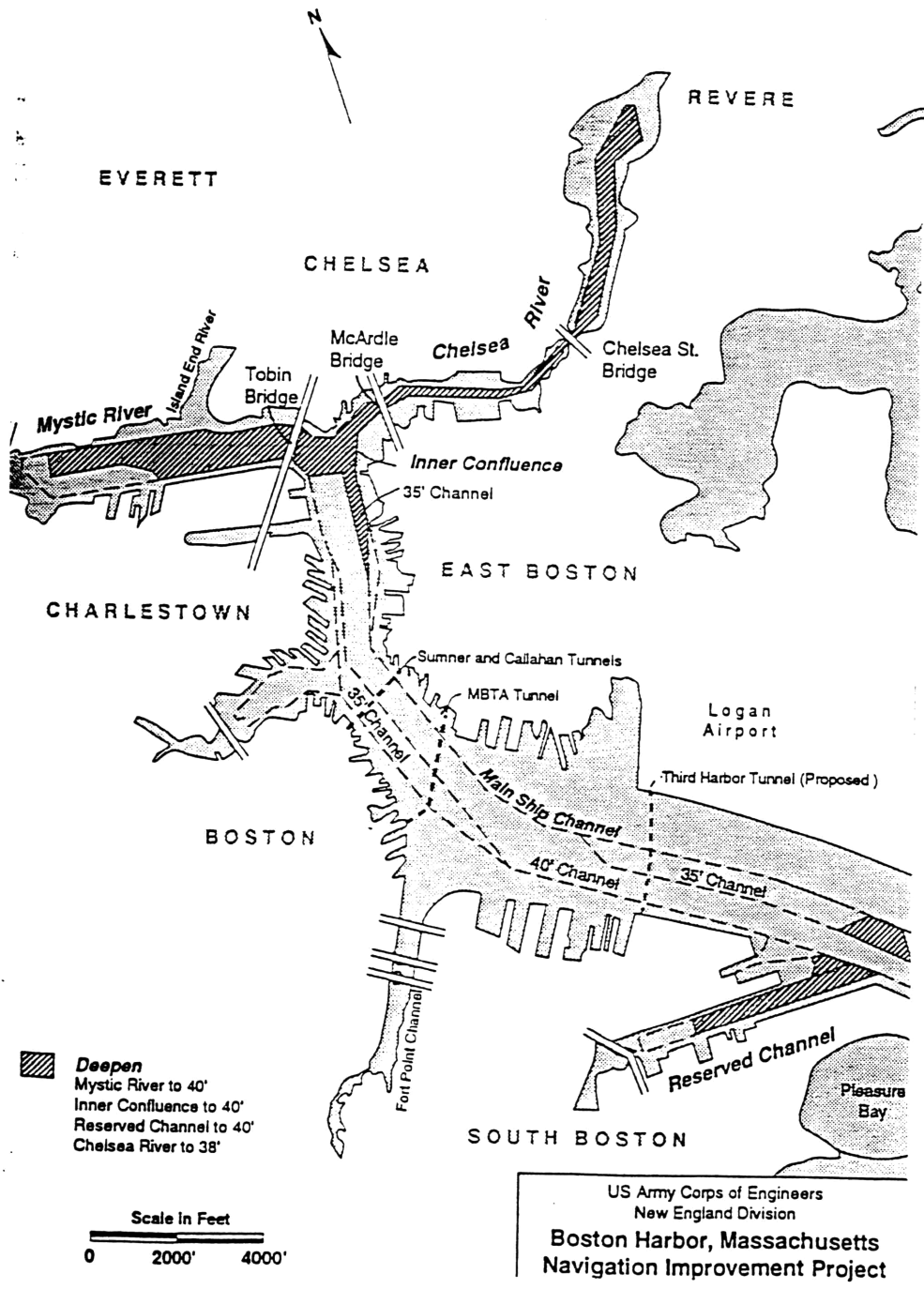


Figure 1-2: Boston Harbor Navigation Improvement Project Area  
(USACE & Massport 1988)

## 1.2 Objectives of the Collaborative Interactive System

As a result of diverse opinions, the cooperation of people to interpret information and to decide on disposal sites has always been complex. In the case of Boston Harbor and other public dredging projects, dissimilar interests and biased knowledge between environmentalists, industry, and the public make consensus for site selection a challenge. There is a formal process that involves public meetings and hearings where involved parties present their gathered information and concerns. There are also comment periods and presentations where opinions and issues are discussed. This project addresses the potential need for a tool designed to supplement and to speed up the consensus process.

The application of collaborative interactive tools toward resolving environmental disputes was the focus of this thesis project. The objective of this project was to develop a methodology that promoted the collaboration between individuals and parties to reach a feasible site selection for contaminated dredged material. An interactive system would observe how and if individuals and groups changed their values—whether it be scientific, industrial, or preferential—to compromise and reach a consensus. The complements that highlighted the collaborative and interactive capabilities over the Internet were the integration of a GIS software package called ArcView and a centralized database. The methodology unified facets of collaboration towards consensus by addressing the human nature of interaction, and common information accessibility and analysis.

## 1.3 Hypothesis of Collaborative Interactive Systems

The fundamental theories of human decision-making explain the actions and decisions of people with their varying interests. I hypothesized that these fundamental assumptions could not be ignored and instead there was a co-operative interaction that evolved to determine the acts, decisions, and negotiations of the involved parties in selecting borrow pit sites. The methodology developed to promote collaboration for environmental site consensus could be used to test the hypothesis.



## 1.4 Benefits of Collaborative Interactive Systems

There were several benefits to an interactive, collaborative system, along with multiple observations gained. Fundamentally, the system was accessible to anyone on the Internet. This feature provided users with information and results regarding feasible disposal sites that normally would be hard to visualize and organize otherwise. The benefits of ArcView were that the project files took and filtered large amounts of data, and then graphically generated images that could be understood by a lay person. The information system challenged the boundaries of how software and programs have evolved so that computer scientists and specialists are not the only people who can develop a system that handles and manipulates large amounts of information.

The second benefit of the system tool would be in the data and insight received by observing how individuals interact with the system to reach a decision. The web-based system was developed to have as little bias as possible, thereby representing all issues equally. Any changes in decisions and original biases would be reflected in the data. The storage of the information created a profile of the user interactions and reasons. The information would be useful to policymakers in determining with whom, when, and if groups form alliances. Also, the interactive system would allow for potential collaboration between groups. Explanations and information provided by users could sway people to change their decision values. Most importantly, the data would show if the system were a functional tool to generate alliances and site consensus.

## Chapter 2

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### 2 Requirement Analysis

The objective of the requirement analysis stage is to collect more detailed requirements for the methodology and to establish a baseline architecture for the development of the system tool. The scope of the problem regarding site selection for the dredging is generally controversial. Therefore, this thesis project developed a collaborative methodology and system tool to catalyze the site selection process. To begin formulating and conceptualizing the methodology, the first step is to perform a requirement analysis. The focus of the analysis is to identify the developed system features and characteristics. Specifically, this chapter pinpoints the requirements for the system tool, how it was built, and the technology used.

#### 2.1 System Accessibility and Interactivity

The accessibility and interactivity of the system is a key requirement. Being able to access the system builds the common ground for information sharing and analysis. As discussed earlier, interpreting volumes of environmental data often form discrepancies between results because people may manipulate them to represent their interests. Also, some analysis software is costly and unrealistic for the general public to purchase for their personal usage. Universal system accessibility allows the use and the ability to analyze the same data using software that is typically unavailable.

Interactivity of the shared data promotes a better understanding of the issue , and the interrelated nature of factors in data analysis. The system must engage the users—encouraging them to input data, see other values, change or store data. Through this means, the system tool and methodology are more flexible and adaptable to the variants in human interaction and decision-making.

## 2.2 System Filtration and Presentation of Information

The system filtration and presentation of information generates and relays different forms of information to the relevant people. In general there are four types of information that are useful in a public debate: (1) data, (2) models, (3) preferences, and (4) conclusions (O'Hare 1987).

1. Data are facts and figures as a result of collection and testing. It is the accepted value of a physical constant. Engineers and scientists use numerical data to conduct analyses and formulations. For Boston Harbor, the data around the issues are collected as explanations, values, professional opinions, and observed results from experts. The compilation of data creates layers of information regarding specific issues around nautical features, recreation, and marine biota. These layers are weighted differently depending on public preferences, thus, generating another set of data that marks the distribution of importance and opinion towards site selection for dredged material (Fitzgerald 1998).
2. Conceptual models are explanations or mechanisms that involve a causal relationship. The data are assumed and do not have to be proven. Formulated models are verified and calibrated using collected data. Users of the system tool need information presented in comprehensible visual manners. Software packages such as ArcView map data input by the users and depict areas of higher suitability given their value selection.
3. Preferences are properties of individuals, and subject to change. Individual preferences for disposal of contaminated sediment in Boston Harbor are based on

economics, ecosystem, and values to create a range of preferred disposal options—offshore, nearshore, onshore.

4. Conclusions are decisions recommended by others. In Boston Harbor, regulations, costs, and public opinion motivate the conclusions of policymakers. In particular, it is in the best interest of policymakers to reach a consensus among the public to avoid lawsuits and time spent in litigation.

## 2.3 Data Storage and Retrieval

Data storage and retrieval allows for the creation and extraction from user profiles. The methodology included the recording of the interactions of the public to generate a profile. These recorded profiles would then be useful in exhibiting the impact and functionality of the system as a tool for collaboration. The responses would also be helpful for policymakers to see the preferences and interactions of the public. This feature holds the essence of collaboration and cooperation--if users can see other values and allow the values to influence their own decisions towards weighed preferences.

## 2.4 System Scenarios

The ideal functionality of the system will support three scenarios: (1) cooperative, (2) competitive, and (3) what-if. Whether these scenarios are utilized depends on how the user interacts with the system--users are given options and choose their scenario.

(1) A cooperative system allows users to see the results of other users' decisions. It gives the user an idea of what the other person values. In true cooperation, users would then compromise or incorporate other interests in addition to their own. For example, the lobstermen realize that in cooperating with recreational users, they will achieve preferred sites. The aspect of the system that will provide this feature will be in the option to see other users' values and results in the GIS page.

(2) In a competitive scenario, the user does not see the results of other users. If the system only supported a user to input their values and to see their results, it would be a true competitive scenario. There may be users who enter the system and only use it to input their values and nothing else. They may choose not to collaborate, not to re-simulate or see other values. For example if the lobstermen took an adamant stance to their site preferences, then they would not care about the other issues and would not factor those concerns in their site preferences.

(3) The “what-if” scenario allows a user to play with the system to see the impact of everyone’s roles. It informs users on hypothetical scenarios and situations that later allow them to foresee and predict the influence of various issues. In the “what-if” situations, extremes can be simulated and the breadth of outcomes is revealed. In this scenario, the lobstermen would change the weight of lobster habitat or other data layers in the simulation to see how it changes the site preferences. It provides a benchmark and a sense for options and alternatives.

## 2.5 Risks

It is important to recognize the risks associated in the creation and elaboration of a system tool and methodology. A large part of the requirement analysis poses questions that break down the system tool into a series of risks (Booch et al. 1997). Risks are obstacles that may hinder the performance and functionality of the system and methodology. Overcoming and recognizing the hurdles are critical to success. In general, there are three categories of risks that must be addressed:

- (1) technological risks—These risks apply to the technology. How well does the technology and equipment work? Can the system tool actually deliver the functions that users need through a Web browser connected to a database?
- (2) skill risks-- Human skills can also be a factor in the development of the system. Are the staff, talent, and expertise available?

(3) political risks-- Especially in value-added projects, political forces can be a hindrance in the use and creation of a system. Are there political forces that can get in the way and seriously affect the project? Funding, publicity, and visibility can all influence what is and is not included in the system. These socio-economic factors are powerful when they arise (Booch et al. 1997).

Technological risks definitely had a role in the development of the system. Sufficient hardware existed in terms of the computer, infrastructure, and architecture. Problems and delays existed in obtaining and installing the proper software. Because this is a rapidly growing area, several versions of the software were released in a few months, each having their own compatibility issues. Obtaining and installing the proper web server and browsers had a significant role on the functionality of the software. Ultimately, Internet Information Server 3.0 with Active Server Pages, Internet Explorer 3.0, ArcView 3.0a, FrontPage98, and Access97 were installed.

Traditionally, the engineers involved in building a system tool, such as the one created for this project, involve people with a strong computer science background. More recently, in an attempt to reach a broader spectrum of consumers, software companies have tried to make their packages extremely user friendly by decreasing the amount of programming necessary and general computer knowledge. The intent is to enable a person to link their knowledge, models, and tools to computer-based information systems. The drawback of this system is relying on the developer to identify and distinguish between system and technological problems. Other resources available to the developers are telephone software support and general knowledge from colleagues.

Since the system was not funded or planned to be integrated into the project, no political risks existed. However, should the system tool ever be used as a methodology for siting additional borrow pit areas, there may be social and public factors which challenge the acceptance of the tool. For example there may be biases as to the number and types of

people to enter and use the system. Also, there may be accessibility issues and questions regarding the assumptions made in collecting and creating the data layers.

# Chapter 3

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## 3 Theories on Decision Making and Negotiation

A collaborative methodology provides a tool which helps increase interactivity, awareness, and communication to reach a consensus for decisions such as site selection for dredged material disposal. In order for the tool to be effective, an understanding of human actions towards decision making and negotiation is necessary. This knowledge provides an insight to how and why users will act, thus, alluding to the reasons for each component of the collaborative system.

### 3.1 Game Theory

Game theory provides a quantitative logic and explanation for the social interactions of individuals. How people behave in society is a constant stream of strategic decisions. The interaction of decisions effect thinking and actions. One of the branches of social science that studies strategic decision making is called game theory. Many types of games such as chess, advertising, and sports are encompassed in this theory. The binding element in these games is that one does not act in a vacuum. The essence of a game of strategy is the interdependence of the players' decisions.

There are two traditional forms of game theory: strategic (sequential) and extensive (simultaneous). For a strategic form, the model is comprised of three things: (1) a list of participants or players (2) a list of strategies for each player, and (3) a list of payoffs that the players must receive for each array of strategies, one for each player (Kreps 1990).



The players make alternating moves. Each player, when it is his/her turn, must look ahead to how his/her current actions will affect the future actions of other, and his/her own future actions in turn. An example of this sort of game is tic-tac-toe. In anticipating the rival's response, a player looks ahead and reasons back. A general point is that for this principle to apply, it is essential that earlier moves be observable to those who choose later.

The second type of model of a game is the extensive form game where the key features are 1) the timing of actions which players may take, and 2) the information they will have when they must take those actions. The popular game of 'rock, paper, scissors' is an example of this form, and the traditional prisoner's dilemma (Dixit & Nalebuff 1994). In the extensive form, players respond at the same time, ignorant of the other players' current actions. However, each must be aware that there are other active players, who in turn, are similarly aware and so on.

The collaborative methodology developed for evaluating responses to the siting of dredged material is of the strategic form. All the features of the strategic model are represented in the collaborative methodology. The players can identify the other groups of players represented (environmental advocate, interested public, shipping industry, among others) and have access to their strategies (weighed values for site preferences). The capabilities of the ArcView simulation scripts show how the payoffs of the weighted values relate to the players.

Regardless of form, game theory has two fundamental assumptions that must be noted: 1) everyone plays to maximize their best interest and gain the most 2) everyone plays only their interest and does not consider the interests of others. This theory would work if it were applied to situations such as competitive markets where a company is entering and competing with others in the same niche. More frequently, this theory is applied to situations where the assumptions are not valid and instead a model of cooperative game theory evolves.

## 3.2 Co-operative Game Theory

Adam Smith (1776) examined the nature and cause of wealthy nations and described an invisible hand that guided people to pursue their own interest, and in doing so the outcome would be the best of all possible worlds. In reality, there are caveats and exceptions to the rule of the invisible hand. For example there are limited resources in the cases of environmental commons—global areas that are available, accessible, and consumed by anyone such as air and water. The tragedy of the commons manifests itself when people unknowingly or unconsciously ruin the commons when having the freedom to use it in their individual best interest (Scarlett 1997). This examples shows that if everyone acts within their best interest, it will bring ruin to the commons and the end result will be in no one's best interest. Therefore it is best to apply a co-operative game theory strategy.

In the situation of cooperative game theory, two parties form alliances to generate a situation that works out best for both of them (Dixit & Nalebuff 1994). These are situations where feasible or realistic solutions do not arise when playing in individual best interest or if players do not want to maximize their gains. In cooperative game theory, groups form alliances to create and to realize outcomes that benefit and satisfy both parties. The problem that arises are the understandings of how these alliances are created, how faithful the groups are to each other, and how to evaluate the fairness and equity of the decisions reached. Broad assumptions must be made because it is not known how and why values are assigned, especially when alliances are formed.

In the case of Boston Harbor, the “game” is a simulation that highlights viable sites for capping. It would be unrealistic to assume that people have not already formed verbal or non-verbal alliances. It is the natural human interaction for people to talk to one another about their interests and preferences. Therefore, when they simulate the selection of

Alliances formed by groups can be a web of possibilities. Understanding each solution for the groups—best and worst case scenarios--can be an even more complicated task. In assuming that alliances are formed, the evaluation of solutions needs to consider if the alliances are isolated incidents, or if there is indeed an entire network of influence effecting an individual decision.

### 3.3 Environmental Negotiation and Conflict Resolution

The outcomes from decision making using game theory is either (1) site selection reached, or (2) no site selection is reached. However, a consensus must be reached in site selection issues and game theory does not account for this. Environmental negotiation and conflict resolution acknowledges that consensus must be reached and that “no site selection” is not an option. Environmental negotiation is defined as a game. “It is a most serious game that people use to decide the quality of their air, of their water, of their soil, and of the life around them. It is the cumulative outcome of these most important games that will determine the quality of human life and the future of all life in our world” (Gorzynski 1991). As in any game, there are players, styles, strategies and tactics to environmental negotiation. Environmental negotiations are multi-disciplinary--combining elements of science and engineering, politics and government, public health and sensitivities, economic theory and marketplace reality.

An approach to negotiation is interactive bargaining. The strategy is to search for both tangible and intangible items to trade or to make deals. It is the deliberate aim or environmental negotiation to incorporate a wide variety of stakeholders. The constructive exploitation of groups with differing values on items creates a situation where all can gain. Hence, the limiting factor is the availability of items, or feasibility of the deals. The success of integrative bargaining is the cooperation and collaboration between parties, where they view each other as mutually dependent. Desired situations rest on the

The success of integrative bargaining is the cooperation and collaboration between parties, where they view each other as mutually dependent. Desired situations rest on the indispensable actions of everyone involved. Such collaboration promotes trust and positive relationships. This emotional and psychological climate strengthens the process that was initiated with the avowed goal of ‘togetherness’ (Glasbergen 1995). The collaborative methodology adopts this approach to negotiation. The ability of the system to represent hypothetical scenarios and to link all the weighted values in mapping feasible regions exemplifies the understanding that all the parties are mutually dependent. In the collaborative system, however, the amount of interaction and collaboration will be to the choice of the player.

### 3.3.1 Escalation and Entrapment

Collaboration can be difficult because of psychological barriers that are explained as escalation and entrapment. Emotions can override the ability to reason. A classic example of this is the dollar bill auction. In this scenario, a mediator auctions a dollar bill to the highest bidder. The catch is that the second highest bidder must pay the mediator the amount of their losing bid, and bidders are not allowed to communicate with one another. The participants, as soon as they go over \$0.50 are trapped in a pattern of escalation. Once the bids exceed \$1, both parties are trapped and locked into destructive bids that are hard to escape. And the same is true of distributional disputes where a conflict of desire, to advance self-interests, leads to disaster. When such conflicts arise, psychological and emotional patterns rise and the situation becomes hard to diffuse. Since it is easy to lose control over these situations, it is suggested that participants pay close attention to escalations of emotions (Susskind et al. 1978).

The BHNIP saw a similar scenario of escalation and entrapment where the emotions of the public prevented conflict resolution. In deciding on a containment or treatment method for the contaminated sediment, the public rejected five preferred alternatives

frustrations raise, the range of acceptable alternatives chosen by the USACE and Massport was narrow. Too narrow, perhaps, because the BHNIP was forced to create additional alternatives that had many pros and cons already represented in the first presented set (USACE & Massport 1995).

### 3.3.2 Effective Consensus Building

Fortunately, approaches to resolving environmental disputes have been developed and tested over the past few years. These tools are negotiated approaches to consensus building. The consensus requires informal, interaction of stakeholder groups and a voluntary effort to seek “all gain” versus “win-lose” situations. Consensual solutions are better—and will be accepted—only if all the stakeholder parties are confident they will get more from a negotiated agreement than they would from unilateral action, or from conventional means for resolving distributional disputes.

Distributional disputes involve several parties and are therefore more difficult to successfully manage. Most distributional disputes require an intermediary who provides nonpartisan assistance at key steps of the negotiation process. Such situations are deemed assisted negotiations. Unassisted negotiation means that no one has been asked to manage the process of negotiating. There is no mediator, rather people work on mutually agreed terms to resolve issues. Assisted or not, negotiations must go through three phases: Pre-negotiation, negotiation, and post negotiation (Susskind et al. 1978). Within each phase there are several steps that must occur. These steps produce agreements that are not challenged in court and likely to be less expensive and more responsive. Resolutions must be handled effectively as the problems turn into creative problem-solving situations. The approach in Table 3-1 transcends the failures of the existing market mechanisms and provides desirable alternatives (Susskind et al. 1978).

**Table 3-1: Negotiation Flow Process (Susskind et al. 1978)**

<b>Prenegotiation Phase</b>
<ol style="list-style-type: none"><li>1. Identifying the parties that have a stake in the outcome</li><li>2. Ensuring that each interest group is adequately represented</li><li>3. Identifying the key issues and narrowing the agenda of points in conflict</li></ol>
<b>Negotiation Phase</b>
<ol style="list-style-type: none"><li>4. Generating a sufficient number of alternatives</li><li>5. Agreeing on the boundaries and time horizon for impact assessment</li><li>6. Weighing, scaling and amalgamating judgements about impacts</li><li>7. Identifying possible compensatory actions</li></ol>
<b>Post Negotiation Phase</b>
<ol style="list-style-type: none"><li>8. Implementing the bargains that are made</li><li>9. Holding the parties to their commitments</li></ol>

### 4 Related Research and Literature Review

As technology drives changes in behavior, there has been an increasing trend to develop tools that promote collaboration and site consensus—such as the goals of this project. Few have combined the two. This chapter discusses the case studies of some of these tools.

#### 4.1 Collaborative Software and Methodology for the Environment

The forefront of activity in the information age revolves around the interactivity and collaboration of people using software packages such as Lotus Notes and accessing the Internet. This concept can be applied to handling the amount of information and negotiation surrounding environmental disputes. Leveraging the Internet as a medium to generate discussion and to promote consensus may make the process less troublesome.

##### 4.1.1 Urban Planning and Riverfront 2000

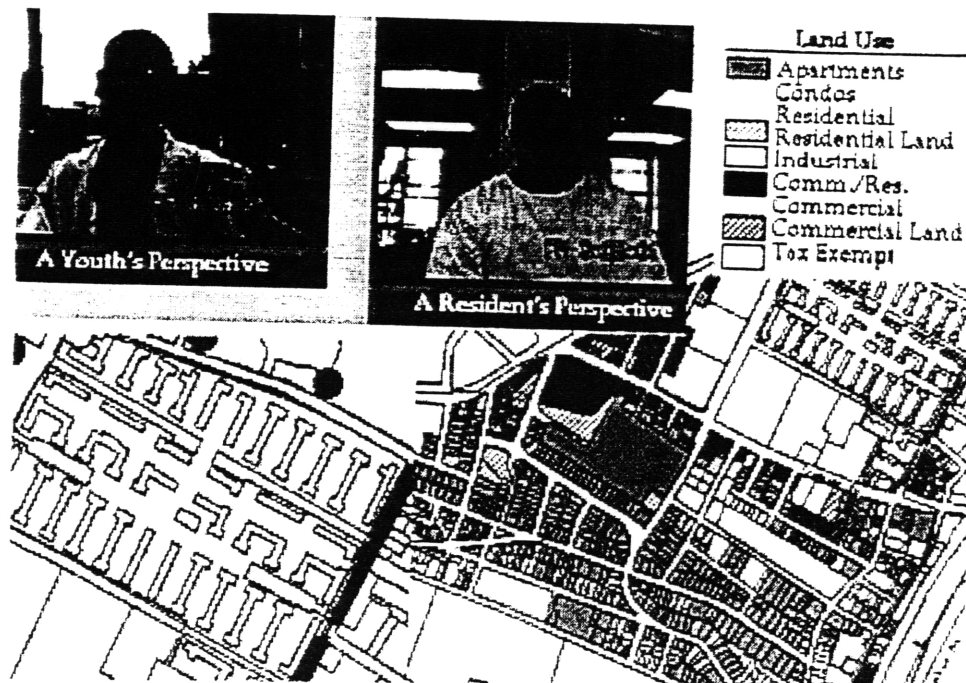
Since computers enable people to communicate and share resources quickly, it has become increasingly popular in the urban planning process. Recently, efforts to share and to discuss issues over the Internet have been used by urban planners to inform the public and bring them together on a common issue such as Riverfront 2000.

The director of research for the Community Development Agency in St. Louis, Missouri, Charles Kindleberger, and a number of experts in hypermedia produced a system called Riverfront 2000 to plan for the future development of St. Louis' 19 miles of Mississippi River shoreline. The objective of the system was to provide environmental, historical, and land use information of potential development sites on the Mississippi River front.

Riverfront 2000 not only provided text, but also maps and videos of the area—thus, illustrating advantages and disadvantages of a location. Information was available to a user by clicking a button on a location along the river. This flexibility allowed for the exploration of "what-if" scenarios as well as reports by "cutting and pasting" in the word-processing mode (Wiggins & Schiffer 1990). Without Riverfront 2000, urban planners would be forced to conduct site visits and to collect all relevant information when discussing a particular area at once. Instead, the St. Louis City Planning Agency established a community network accessible in the neighborhood community centers. Computer-mediated communication facilitated collective action since it reduced group organization transaction costs.

Systems like Riverfront 2000 allow synchronous and asynchronous communication between people and groups of people. Email, chats, bulletins, and postings all provide the means for such communication. But Riverfront 2000's main focus was to post and to retrieve information through a hypermedia context. Where hypermedia is defined as "allowing one to combine interactive video, maps, animation, text, graphics, sound, and statistical data in a non-linear format" (Wiggins & Schiffer 1990). Figure 4-1 shows how two people might interact with a map of the site and land use (Wiggins & Schiffer 1990). In the figure there are two people representing a youth and resident perspective. The idea is for the two individuals to interact and to discuss how they wish for the land to be used, utilizing the map on the computer.





**Figure 4-1: Interaction for Land Use Map (Wiggins & Shiffer 1990)**

#### 4.1.2 Design Rationale

Collaborative systems have also been used for conflict resolution in project management. Especially in large-scale engineering projects, the need to share information is enormous. Design specifications and drawings are often too large, intricate, and lack means to show how the design and decisions were made. Tools are being generated, among other objectives to 1) facilitate effective coordination across engineering disciplines 2) capture process and decision rationale, 3) forecast impact of design decisions (Peña-Mora et al. 1995)

In particular, the Intelligent Engineering Systems Laboratory (IESL) at MIT developed a mitigation system. The Design Recommendation Intent Model (DRIM) captures and manages the design rationale of software development in order to support conflict mitigation. To date, the efforts and focus of the IESL team at MIT is through multiple participants-computer-supported conflict-mitigation-active computer support design rationale.

## 4.2 Disposal Sites for Dredged Sediment

As mentioned earlier, dredging activity in waterways, coasts, and harbors maintains navigation for commercial and recreational uses. For urban harbors and ports, the management and disposal of contaminated dredged sediment involves reaching public consensus for short and long-term solutions. In general there are three categories for disposal: upland, nearshore, and aquatic. Upland involves stabilizing the sediment and then disposing it off site. Upland uses of dredged sediment include landfill cover, construction fill, road base material, concrete blocks, and vaults. Nearshore involves sequestering sediment behind barriers. The other disposal strategy is aquatic. Preferred disposal options for Boston Harbor are aquatic disposal (unconfined offshore) for both clean and contaminated sediments (in-channel, capped). The focus of following case studies will highlight the environmental consequences, actions, agencies, and public sentiments related to aquatic disposal sites options.

### 4.2.1 New York/New Jersey Harbor

The debate between business and environmental groups over the dredging of New York/New Jersey harbors has been long and heated. Since 1973, the Mud Dump Site, an approximately two-square-nautical mile area was used to dump dredged sediment. Thirty dredging projects in the port were authorized by the USACE resulting in the removal of 6.8 million cubic yards of dredged material. Two million cubic yards were used for upland construction projects while the remaining 4.8 million cubic yards were authorized to be disposed of at the Mud Dump Site (USACE NY 1996). September 1997 signaled the last scow to the Mud Dump Site carrying contaminated sediment. Legislative action in the Clinton administration prohibited dumping at sea dredged sediment from New York Harbor and the Upper Newark. As a result, the Army Corps of Engineers has suggested the construction of sub-aqueous pits and containment areas close to shore and

upland disposal for additional dredged sediment. Figure 4-1 shows the study area for the New York/ New Jersey area (NDEP 1997).

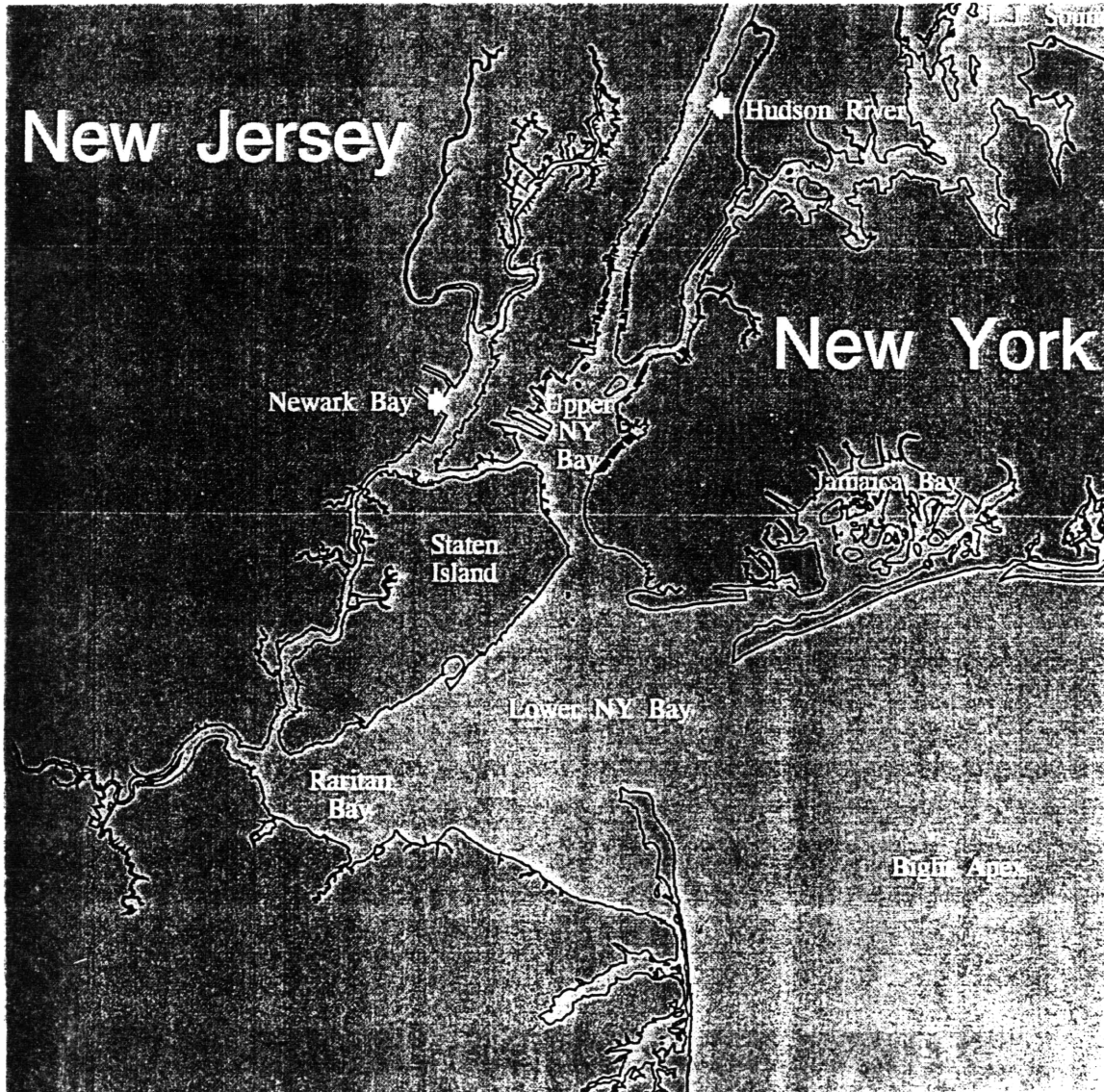


Figure 4-2: New York/New Jersey Project Area (NJDEP 1997)

However, controversy and negative public sentiment over the selected option continues with volatile emotions and restraining orders to halt activity. The outcome of the case is being closely monitored for valuable lessons that may be applied to other projects. Environmental activists in New York explain that U.S. ports lag behind other industrial sectors when it comes to treatment and disposal of environmentally dangerous materials. The public outcry of “not in my backyard” has been a theme that has led to the public involvement in the dredging projects at every level of the permitting process (NJMR 1996).

Meanwhile, the industry has a different perspective. Representatives of the American Association of Port Authorities describe ports nationwide as having reached “crisis proportions”. A survey carried out by the association last year indicated that two thirds of US ports rated environmental problems as the most serious issue facing them (Cottrill 1993). The industry claims that regulations have become overly stringent, and in doing so have effected the viability of ports and the business associated with them.

The current outreach method used by the New York/New Jersey Harbor region to gain community acceptance is through a program by Institute of Marine and Coastal Sciences at Rutgers University and Brookhaven National Laboratories process (NJMR 1996). The project identifies, evaluates, and demonstrates technologies to the public. The goals are first to engage the public in a variety of forums to discuss the costs, benefits, impacts, and issues associated with decontamination strategies. They want to inform the public and to help them understand the scope of technologies and options. More importantly, the project aims to initiate discussion on the siting of future decontamination facilities. Public outreach efforts are designed to ensure that potential host communities receive the best information available on decontamination technologies leading to the informed decisions on the future management of containment dredged materials.

There is a range of approaches to establish and to maintain a dialogue between the parties. The targeted citizenry are elected local officials who require the best available

information to address questions related to siting, economics, and environmental issues. These approaches include making formal presentations, hosting public meetings, facilitating informal discussion groups, and establishing citizens advisory committees (NJMR 1996). This approach has also been used in Massachusetts to facilitate the decisions to use in-channel disposal sites with capping.

# Chapter 5

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## 5 System Tool Model

After analyzing the problem and defining the requirements, integrating an understanding human decision making and negotiation, and finally, reading up on similar case studies, the model for the information tool was developed. This chapter examines where the information lies and what the information contains. The system tool model shows the attributes and characteristics of information held within a case. Moreover, it shows the relationships and links between the entities. In this model, users, site selection, and data storage holds the essential information needed by everyday users. Figure 5-1 shows the attributes and relationships for the system tool model in UML language.

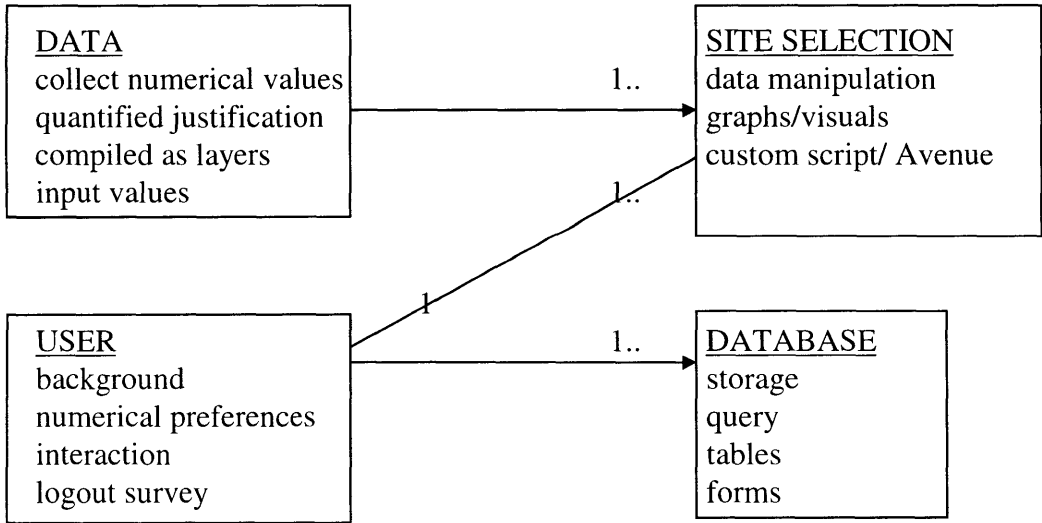


Figure 5-1: System Tool Model

## 5.1 Data

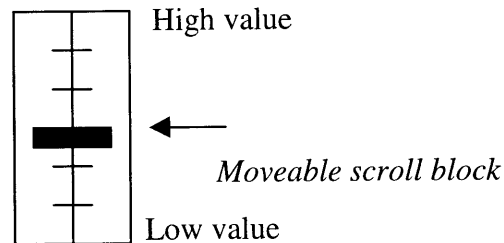
The data were collected and compiled from several resources. In terms of the topological data containing longitudes and latitudes, land boundaries, and coastal areas, the data were obtained from United States Geological Survey (USGS) and Massachusetts GIS database. These are all input as numerical values or characterized by labels.

There was also data transposed from human value to quantified values, by nature the information was not quantifiable. Explanations supplied by experts or knowledgeable individuals and groups provided the numerical data by ranking the values. These experts put a quantified value on qualitative data. These quantified values are explained and justified in the explanations compiled by Scott Fitzgerald and a few examples of bathymetry and currents are shown in Appendix A (Fitzgerald 1998). This transformation of information was a potential area for bias as the numerical data was based on human judgement. However, for each issue (lobster, eelgrass, shellfish, nautical features, etc.) a respected and trusted group or representative was selected to quantify the data. Their reasons were outlined in the explanations that were accessible to all the users.

## 5.2 Site Selection

Site selection results from manipulated, filtered, and mapped data. The preferred option is to take data and convert it to the ArcView files and internal databases. The software package is user friendly and can rapidly graph data. The application developed by Scott Fitzgerald (1998) customized scripts in Avenue that allowed interaction with the system tool. The scripts created a dialog box where users moved scroll bars to change the importance of a data layer. Figure 5-2 shows a sample scroll bar. Each layer (lobster, eelgrass, shellfish, nautical features, etc.) was represented by a scroll bar. The categories are physical harbor features, marine biota, and miscellaneous recreation. Internally, the

system interprets users' "high values", "low values", and "mid-values" and translates them into corresponding numerical values.



**Figure 5-2: Sample Scroll bar**

Once all the user values were placed on each category, the graphing feature of the application utilized the numerical values for the data and graphed it onto a map of Boston Harbor. The results were a color gradient showing the feasible regions in the harbor for borrow pits. The site selection feature and project developed by Scott Fitzgerald (1998) was the common analysis tool for the data. No external data could be added or included without administrators changing the data handling of ArcView. The ArcView project was a management tool that allowed all users to access the same data layers and used the same manipulation tools. In a system where user choices are saved, users could compare and contrast their results (from the color gradient) with others and contribute their site preferences.

### 5.3 User Profile

The user profiles contained the background information and site preferences. The background consisted of relevant experience, education, representative group, interests, harbor usage, and related areas of interest. This information could be useful to policymakers in understanding the context of how users value the resource and dredging of harbors. How users interact could be interpreted from the responses and changes in the outcomes based on other user responses. As discussed earlier, game theory describes scenarios when users pick sites in their best interest.



The user profiles may explain why users choose their site selection preferences based on the site selection model. Any interaction or collaboration with other values and the system in general could be recorded and stored in the databases of profiles. If users logged in several times, or if they reran the simulation often, the iterations would be recorded and policymakers would have a better understanding of what issues and values the users were considering. As a backup to the statistics that correlate the motives behind user interaction, a survey was posted right before logout. The answers to the survey were reflected in the profile and specifically asked the user if any values were changed regarding issues, who influenced them, and in what way (increased value, decreased value). And most importantly, the survey asked if the change occurred (before, during, or after entering the site) and prompted the user to select the time period. This information would be necessary to determine whether or not the system was effective in bringing about change, interaction, and collaboration towards the site preferences and would be a large stride towards accomplishing site consensus.

## 5.4 Database

Tracking and recording the motives to user interaction once they have accessed the site selection model was a difficult task as noted in the development of this system and in other research. Information regarding how users interacted with their options was stored in a database. The data could then be placed in tables, and subsequent queries and summary reports could be performed and created. In other words, the opinions and the amount of interchange between the public groups would be noted with its respective reason and justifications. The storage feature allowed for queries that could be extrapolated from the database system and into the simulation model. For example, if a user wanted to see the preferred values of all interested public, a query to the database for the representing group (interested public) would return their preferred values.

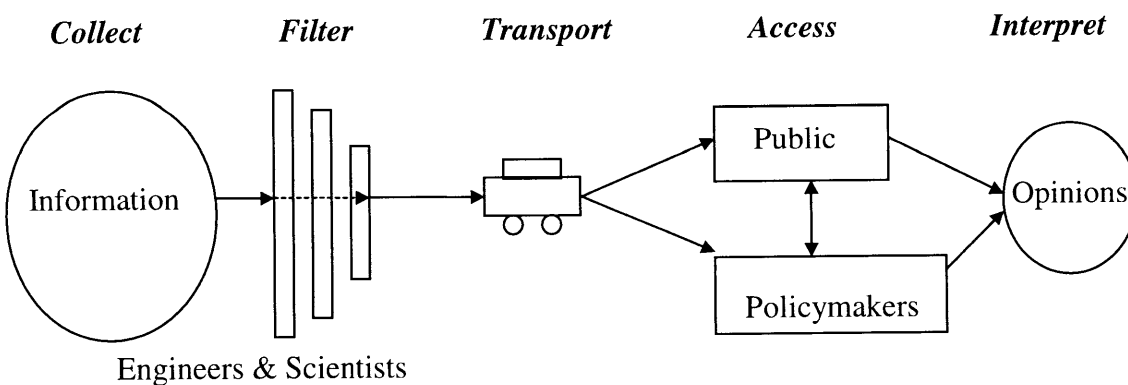
The relevant stored information that is needed by policymakers has yet to be determined. However, in initially creating the database infrastructure and collecting an array of information, it would be easier to query the system and to add to the tables of information in order to generate requested information as forms and reports. Database software packages such as Microsoft Access are designed to handle large amounts of data and are capable of customizing reports, and successfully querying the tables of user profiles.

# Chapter 6

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## 6 Methodology for Collaboration in Environmental Site Selection

This chapter describes a general methodology for information processing and identifies the flow framework of the system tool model. The filtering and the distribution of information were essential features to the system because of the varying types of information and people participating. There are four processes for the information processing: (1) collect, (2) filter, (3) transport, (4) access, and (5) interpret. Intertwined in the process are three primary groups who will handle the information: engineers and scientists, public, and policymakers/authorities. Figure 6-1 depicts the flow of how these groups would enter the system and interact with each component of it.



**Figure 6-1: Information Flow Process**

## 6.1 Collect

The first step in the methodology is to collect the data. Collecting the information typically involves amassing large amounts of data. In collecting, compiling, and ranking data, there exist vast assumptions and points for contention. Frame of reference and context should be taken into consideration and maintained to minimize contention. Also at this stage, when appropriate, qualified data get quantified based on the experience, knowledge, and values. In the ArcView project created by Scott Fitzgerald (1998), collection from tests, samples, and monitoring involved the engineers and scientists. Another form of collected data would be the inputs and weighed disposal site preferences from the public.

## 6.2 Filter

Filtering can be done through mathematical means, assessments, simulations and models. The collected data is manipulated to gather the relevant data. Filtering the information is usually done through computational tools that are rapid and decrease the possibility human errors. Moreover, the advent of better software packages has cut down on the tedious integration of files with calculations and tables. Filtering the data could involve statistical analysis of user inputs or the application of a raster grid, and geometric mean in combining data layers (Fitzgerald 1998).

The filtering process is often the downfall of many environmental projects. Typically an immense amount of information exists and realizing the relevant data pertinent to the project is difficult to identify and apply. In the case of Boston Harbor, some information may be preferred and noticed because users or policymakers do not truly understand the relevance of other information. Users may not be aware of all the issues, or policymakers may tend to notice the preferences of environmental advocates over the industry.

## 6.3 Transport

The next step is the transport of the filtered information to the proper groups, whether it is the public or policymakers. The means to transport the filtered information can be through presentations, personal interactions, media, pressure groups, or lobbying. With the advent of the information age, the Internet is becoming a popular tool to relay, place, and input information. The means by which the information becomes retrievable on the Web are through servers. Boston Harbor information was placed onto the Web through a server that was accessible to the public through a web site.

## 6.4 Access

Individuals or groups have access to the information through the web site and interpret it to generate opinions, options, and alternatives. A constraint to access is having the proper hardware and software installed, which is frequently available at libraries if not on individual computers. Once users access the information, they can proceed with proper feedback. For Boston Harbor, user access and interaction would generate site selection for dredged material disposal sites by facilitating collaboration between the public and policymakers--as seen by the double arrow between the two groups in Figure 6-1. This interactivity is necessary to form opinions as noted in the interpretation phase. In the case of Riverfront 2000, the city set up an internal network (Intranet) where community centers had access to the site. This strategy helped resolve the public access issues. As envisioned, the BHNIP could set up a networked, site to allow public access for those who are not on the Internet. Once, the groups had accessed the information, they could begin to interpret, understand, and form solid judgments.

## 6.5 Interpret

Interpretation is the crux of an information processing methodology. It is the where collaboration and interaction between people may occur. For environmental site selection, interpretation lies in the choice for the user to rerun the simulation, see other values, or exit with their choices. If users simply rerun the simulation, this creates the personal “what-if” scenarios where they would not see the other results and run the simulation for their own benefit and curiosity. The capabilities of database storage and ArcView mapping converge at the web site. The filtered data, users and site selection, and data recording will all occur through the Internet media.

Seeing other values will present a cooperative system where the decisions and results of other users can be seen. In the case of the Boston Harbor, users will select the representative group from which they wish to pull the values. Thus, they can see the results from everyone who represents environmental activists or businessmen. After seeing the values from other groups, users can then go back and rerun the simulation taking into account their values. This ability highlights the cooperative nature of the system.

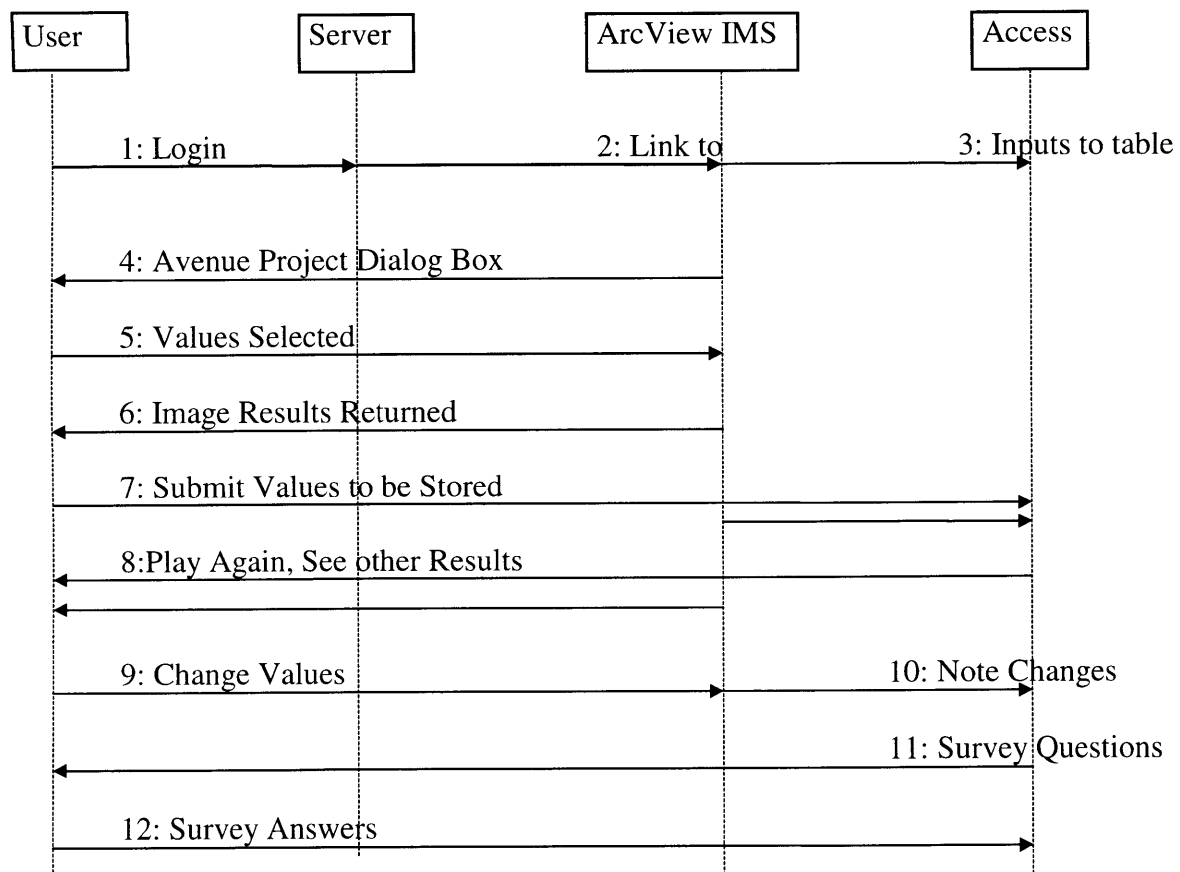
Finally, the exit feature allows the user to logout, but not before filling out a quick survey. The survey is essential in recording and establishing the user motives. It asks users which groups, when, and what issues were influential in any changes they made and whether the changes positively or negatively influenced their values. The purpose of the questionnaire is to delve into how users interact/collaborate with one another and notes whether the system has a role in the collaboration or changes in values and decisions. A key question in the survey asks when the values changed: “before visiting this site, while visiting this site, after visiting this site”. The response backs up the data of action choices recorded by the database. If users had opted to see other values, hence supporting the cooperative nature of the system, it may have influenced their value on an issue. In this case, the system becomes a tool for collaboration.

# Chapter 7

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## 7 Components of the System

There are three primary components that will make up the system. Microsoft FrontPage98 was used for developing the web site, Microsoft Access97 served as the database, and ESRI ArcView GIS was the visualization and mapping tool which showed the feasible site regions. The Figure 7-1 shows the specification analysis.



**Figure 7-1: Specification Analysis**

## 7.1 Microsoft FrontPage98

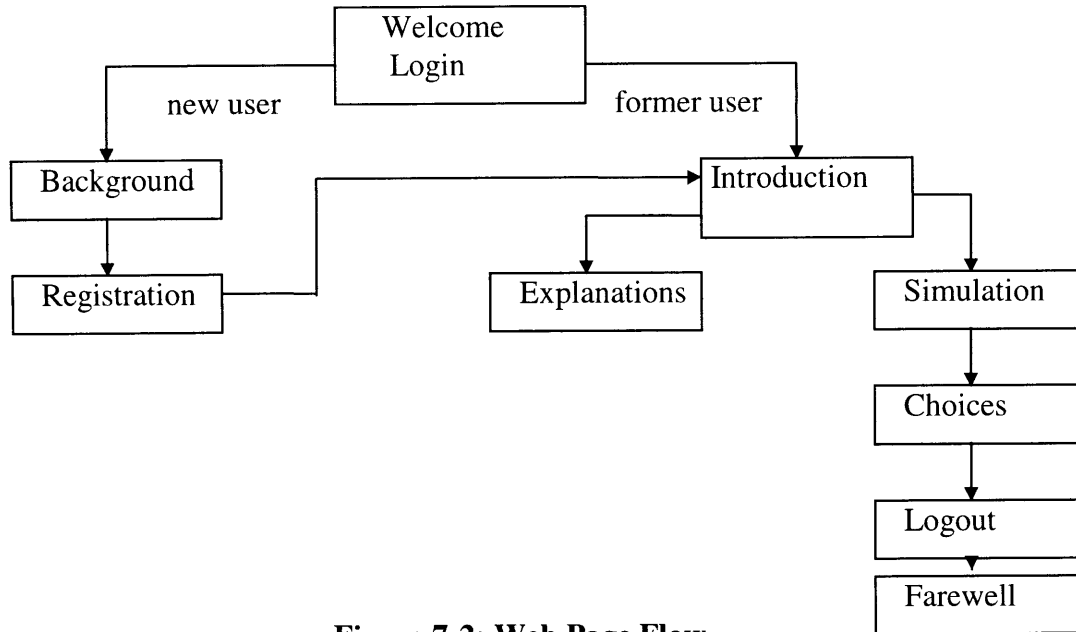
MicrosoftFrontpage98 is a software package to develop web pages. The development of the Internet has led to more complex coding of hypertext markup language (HTML). Furthermore, the demand for authors and people to develop web pages quickly and adeptly has led to new tools that permit creation of Web pages as easily as spreadsheets and desktop documents. FrontPage98 was selected as the Web editor because it is user friendly.

FrontPage is the front-end link to the server. Any values input or requested output by users is done through FrontPage forms and recognized by the server. Furthermore, the ArcView application and any customized scripts are embedded in the HTML code in the web pages. The advantage to FrontPage is that the webmaster can easily switch views from HTML, to preview, to normal web page view. In normal view, the designer can drag and drop text and components without knowing fancy HTML codes. In the background, the code is being written, and if desired the webmaster can add to the code in the HTML view. An additional convenience is how the software easily shows hyperlinks and web site navigation.

### 7.1.1 Web Site

The pages are created as active server pages (ASP) this also means that on the web, these pages have a “.asp” extension versus a “.html” extension. Active server pages allow a dynamic page which track and relay user inputs. ASP is a server-side dynamic web page generation tool. These pages function as an interpreter that executes specially marked lines of script and other languages embedded within HTML. Server-side programs in ASP do not have to be compiled when the pages are changed, and ASP allows script embedding in HTML (Buyens 1997). The web page flow that users encounter is diagrammed below in Figure 7-2.





**Figure 7-2: Web Page Flow**

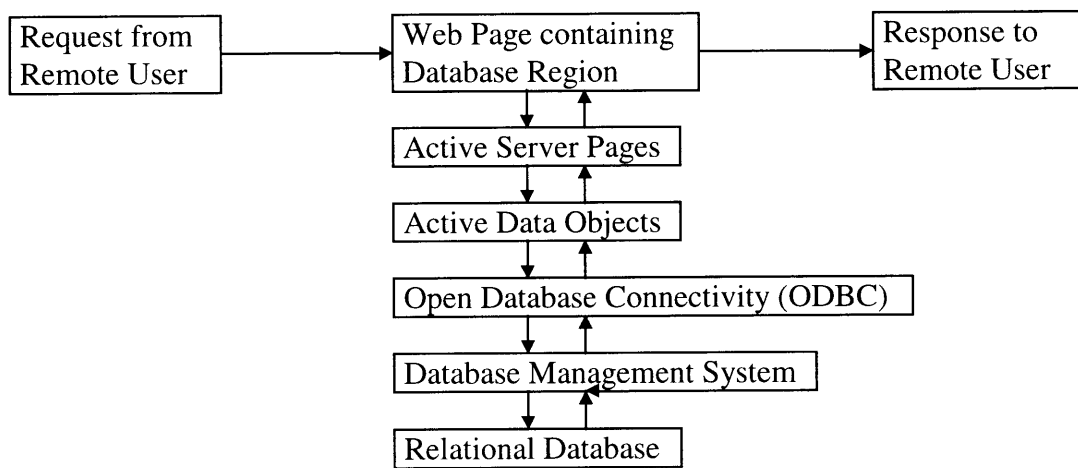
## 7.2 Microsoft Access

Microsoft Access serves as a database, storage and record. In Figure 7-1, all the background submissions, options, and monitoring will be placed into and retrieved from the Access database. In order for it to recognize the inputs from the FrontPage webs, it requires the use of an Internet Database Connector. Figure 7-3 diagrams how database regions work when interfaced with web pages and how the various features work together to link with the web page and remote user. Embedded in the HTML code is the connection to the ODBC. These commands are in the printout of HTML code in Appendix B.

The database itself consists of several tables and forms. One table exists for the user background, another for the values obtained from interacting with ArcView GIS, and the last table to record the logout survey. These tables are also in forms and queries. The original approach was to create forms and link them to the tables, and then serve the Access created forms onto a FrontPage web. In the conversion, a lot of the formatting and compatibility was lost. The form created in Access did not transfer well onto the FrontPage web. Moreover, inputs at the site did not translate well or at all into the

database. Therefore the creation of the forms in FrontPage was required for proper functional code link to the Access tables.

If policymakers desire that the database tables be queried and reported in forms and reports, this will not require the use of the linkage described above. Simply creating forms and reports in Access will be sufficient to serve their purpose. Since these queries do not provide relevant information to the simulation users, it would be simplest to create these forms in Access.



**Figure 7-3: Internet Database Connector** (Buyens 1997)

### 7.3 GIS ArcView

The ArcView package is a software package released by the Environmental Systems Research Institute (ESRI). ESRI is becoming the world leader in GIS mapping software for professionals. ArcView, a simplified version for personal computers, provides for project creation. Within a project there are “themes”; these themes are tables of related data. For example, lobster fishing sites would be one theme while swimming beaches represents another theme. Each theme can be turned on or off, which chooses the display them on the mapped area of the harbor. The system tool creates a theme for all the issues

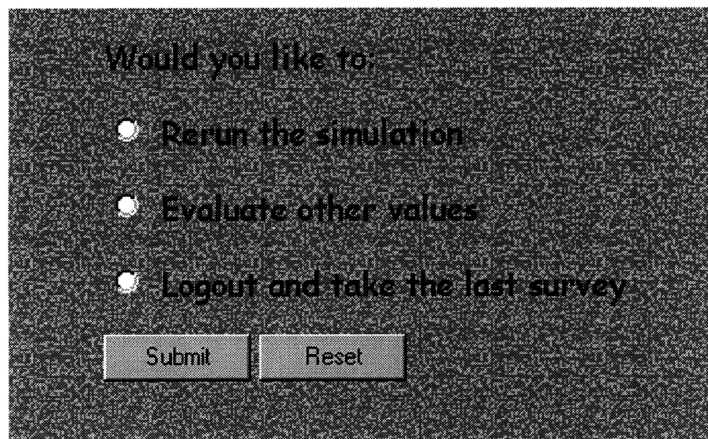
and turns them all on. The creation of a weighted values dialog box incorporated the influence of one theme over another (Fitzgerald 1998).

The dialog box and resultant combined theme grid was a result of applying customized scripts in ArcView (Fitzgerald 1998). The scripting language, called Avenue, works only within ArcView. This feature made serving and capturing the scripts onto the Internet a difficult task. It was necessary to use an extension, called Internet Map Server (IMS), that publishes ArcView maps onto the Internet. It uses the same applet code developed by the company to make information sharing on the web a simple task. However, the applet code does not, by default, grab the customized scripts and therefore the scripts have to be embedded in the system scripts.

The creation of the collaborative system tool required the customization of AVINETMP.Image. The basic needs was for it to obtain the weighed values and use them to create a grid that could then be served onto the web. Appendix C shows the code and comments on the areas of customization.

### 8 Collaborative Interactive System Scenarios

As discussed in Chapter 2 regarding the system scenarios, the collaborative tool aims to create three scenario options for the user: cooperative, competitive, and “what –if”. The web page flow shows the options at the “Choices” page. The user has to select one of three choices in order to proceed through the site: (a) Save choices and logout, (b) See other values, and (c) Run simulation again. Figure 8-1 shows the choices as they appear on the web site. These choices correspond to generating competitive, co-operative, and “what-if” scenarios respectively, see Table 8-1 for comparison. Meanwhile the database records and stores the selected options through the .asp feature of the dynamic web pages.



**Figure 8-1: User Choices for System Scenarios**

**Table 8-1: System Scenarios Comparison**

<i>Hypothetical Scenarios</i>	<i>Choice System Scenarios</i>
<b>Competitive</b> — no other results are shown	<b>Logout</b> — acknowledge to leave the system and not run simulation again
<b>Cooperative</b> — see other’s results and decisions	<b>See Other Values</b> — Users select the representative group whose values they wish to see
<b>“What-If”</b> — hypothetical scenarios are simulated	<b>Rerun Simulation</b> — return to ArcView page where simulation can be rerun

One major assumption is that the scenarios correlate to the choices presented to the user. Rather, the choices are an attempt to match the collaborative scenarios as best as possible--given the complex nature of human reasoning and thought. The options have solid functionality if users enter the system only once. Users, however, may enter a site multiple times. It should also be highlighted that the system does not protect the solidarity of each scenario.

## 8.1 Competitive

The competitive scenario occurs when users enter the site and proceed through the simulation to the Choices page at which point they choose to run the simulation again: option A—“Logout”. At this point, the users will have run the simulation once and supposedly weighted the issues to maximize their best interest and gain. Since the users did not choose to see other values, they simulate only their interest with no other factors or values in consideration. Their lack of interaction should be obvious from the information in the database. Theoretically, if users simulate a truly competitive scenario

there should only one line of data associated with the user. This single line indicates that the users do not choose to collaborate.

## 8.2 Cooperative

Cooperative system scenarios arise when the users select option B—“See other values”. When this option is selected, the site will bring the user to a page that allows them to select chosen weighed values from a representative group. This feature requires a query to the tables in the database that identifies all the users who represent the requested group. The query then grabs all their weighed values and places them in a table on the web.

The drawback to selecting a collection of people (representing a group) versus identifying a single person is that it prevents the user from visually seeing the ArcView representation of where the viable site regions are. If users want to see how the weighed values of a representing group result graphically, they have to go back to the choices and select option C to rerun the simulation and input the values of the other users.

## 8.3 “What-if”

As seen in Table 8-1, option C—“Rerun” creates a “what-if” scenario. When this option is chosen, users once again enter the ArcView mapping capability. As discussed earlier, the “what-if” option is an opportunity for users to consider the extremes along with other issues without having to commit to the results in any way. It is truly a situation to run hypothetical situations and get a sense for the range of feasible regions and borrow pit sites.

Once users have finished rerunning hypothetical “what-if” scenarios, they will once again enter the options page. At this juncture they should logout—choose option a. They should leave the system and have the database records show only a “what-if” scenario

was simulated. However, this action may not be the case for this scenario and the cooperative scenario. When users enter the Choices page a second time, they may (in actuality) choose other options thereby generating and undergoing multiple scenarios for themselves.

# Chapter 9

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## 9 Conclusions

The functionality of the tool reached a point where users could enter the system and create a profile that included their background and interests. The database stored and recorded all the user inputs and all the pages were linked to provide the system scenarios. Static maps of Boston Harbor could be retrieved and when weighed values were input as parameters, a static map would be generated and published onto the web site. The features and functionality of each section is described in this chapter

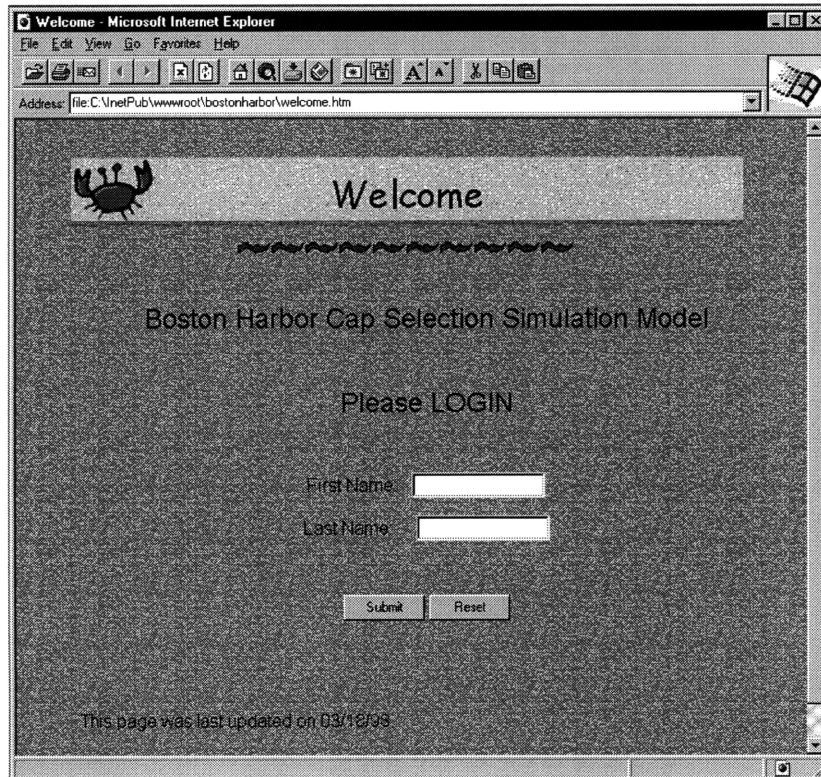
### 9.1 FrontPage Web

The web site and server is where all the connections to the database and mapping software must coincide. The Web site was served through a single stand-alone computer. The web site resided at the following URL: <http://tiller.mit.edu/bostonharbor/welcome.htm>. The opening page is shown in Figure 9-1. A FrontPage template was used as the general background and the editing and form features allowed for the creation of all the web pages.

Links to the Access database and ArcView software were made by adding components and files to the appropriate web pages. Form features such as text boxes and drop-down menus were also provided by the FrontPage editor that was able to relay the inputs to the linked database. Users who had previously visited the site as new users would have already filled the background form and generated a profile in the database. If users entered the site again, the inputs recorded and relayed by the forms in FrontPage would query the database for the users first and last names. The database would then tell



FrontPage to navigate to the beginning of the simulation page. All these components to enable the links and create forms were provided by the editor instead of having to code in HTML.



**Figure 9-1: Opening Page to Web Site**

## 9.2 Access Database

The database is set up with one major table that contains the users last names, first names, and all the corresponding information input while interacting with the site. Several smaller tables exist to break up the information into components such as weighed values and logout survey. The relationships and links between the tables are shown in Figure 9-2. The lines what inputs were linked between tables. However, to keep the query simpler all the data and queries between the database and the web site channel through one table. Figure 9-3 shows sample inputs and structure of the table. As discussed in Chapter 7, the

components for the link between the database and web site were built. The ODBC connection was built and a driver created to point to the data source location called “bosharbor”.

Current information inside the database is fictional and was placed there for all the testing of the web site. Furthermore, the database does not store all the iterations and multiple values for users’ interactions. When users enter the site and generate weighed values and interaction with the site, the database replaces the old information. Weighed data values that come in from ArcView were also not established. The query set up in ArcView only provides functionality for values to be extracted from the tables, not for data to be input. This limited characteristic is a logical function for the ArcView software because normally it only needs to extract data for graphing. The software is not normally used to create output quantities.

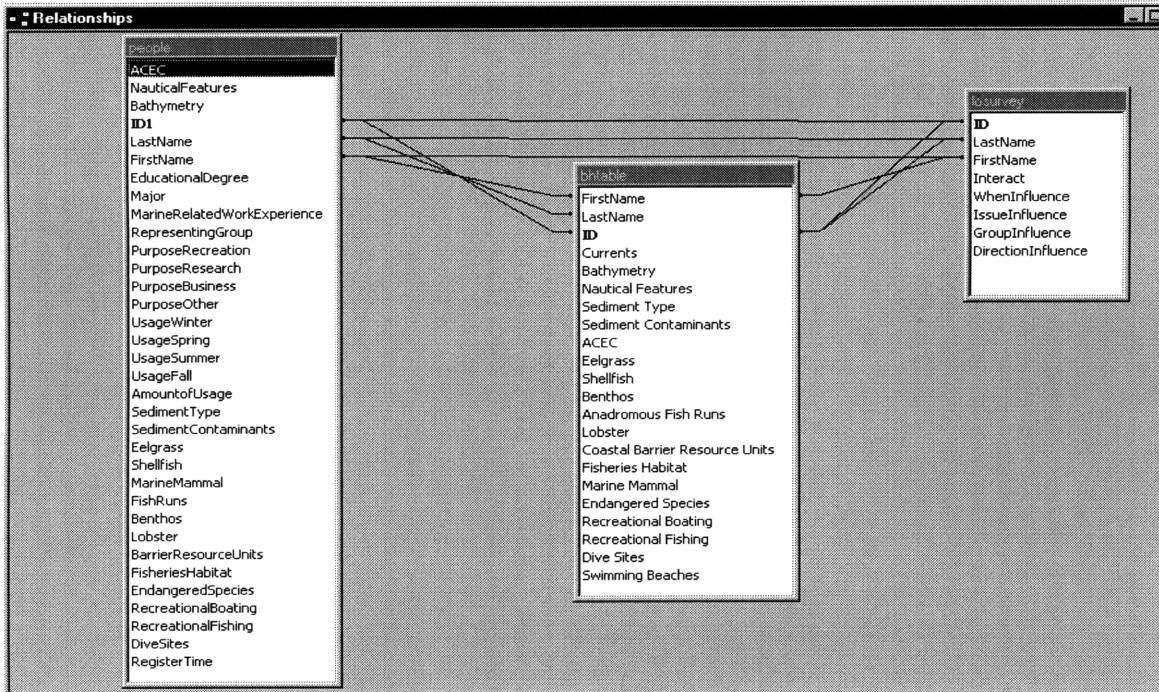


Figure 9-2: Relationships of Database Tables

Microsoft Access

File Edit View Insert Format Records Tools Window Help

people : Table

ID1	LastName	FirstName	EducationalDegree	MarineRel	RepresentingGroup	PurposeRecreation	PurposeResearch
10	wuu	tim			Community Interest	<input type="checkbox"/>	<input type="checkbox"/>
11	Lee	Bernard			Community Interest	<input type="checkbox"/>	<input type="checkbox"/>
12	Washington	Harry				<input type="checkbox"/>	<input type="checkbox"/>
13	Washington	Harry				<input type="checkbox"/>	<input type="checkbox"/>
14	tt	tet				<input type="checkbox"/>	<input type="checkbox"/>
15	Wuu	tim				<input type="checkbox"/>	<input type="checkbox"/>
40			B.S/M.S	None	Community Interest	<input checked="" type="checkbox"/>	<input type="checkbox"/>
41			B.S/M.S	None	Community Interest	<input checked="" type="checkbox"/>	<input type="checkbox"/>
42			Ph.D	None	Environmental Action G	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
43	Wu	Test	Elementary/ Secondary	None	Community Interest	<input checked="" type="checkbox"/>	<input type="checkbox"/>
44	new	friend	M.S./ M.A./ M.Eng	None	Educator/ Student	<input type="checkbox"/>	<input checked="" type="checkbox"/>
45	Hung2	Emilie2	B.S/M.S	None	Interested Public	<input type="checkbox"/>	<input checked="" type="checkbox"/>
46	through	run	B.S/M.S	None	Consultant	<input type="checkbox"/>	<input checked="" type="checkbox"/>
47	through	run	B.S/M.S	None	Consultant	<input type="checkbox"/>	<input checked="" type="checkbox"/>
48	lee1	bernard	Elementary/ Secondary	None	Community Interest	<input checked="" type="checkbox"/>	<input type="checkbox"/>
49	iuo	test	Elementary/ Secondary	None	Educator/ Student	<input checked="" type="checkbox"/>	<input type="checkbox"/>
50						<input type="checkbox"/>	<input type="checkbox"/>
51	Try	Dude	M.S./ M.A./ M.Eng	None	Environmental Action G	<input type="checkbox"/>	<input checked="" type="checkbox"/>
52	0	0	0	None	0	<input type="checkbox"/>	<input checked="" type="checkbox"/>
53	Try	Dude	M.S./ M.A./ M.Eng	None	Environmental Action G	<input type="checkbox"/>	<input checked="" type="checkbox"/>
54	metzger	carrie	M.S./ M.A./ M.Eng	None	Educator/ Student	<input checked="" type="checkbox"/>	<input type="checkbox"/>
55	retest	hello	M.S./ M.A./ M.Eng	None	Government- State	<input type="checkbox"/>	<input checked="" type="checkbox"/>
56	again	hello	Elementary/ Secondary	None	Community Interest	<input type="checkbox"/>	<input type="checkbox"/>
57	again	hello	Elementary/ Secondary	None	Community Interest	<input type="checkbox"/>	<input type="checkbox"/>
58	Pena-Mora	Feniosky	Ph.D	None	Consultant	<input type="checkbox"/>	<input type="checkbox"/>
59	Tarbell	Benoogle	Elementary/ Secondary	None	Environmental Action G	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
60	Jacobs	Bruce	Ph.D	None	Educator/ Student	<input checked="" type="checkbox"/>	<input type="checkbox"/>
61	Yang	Bob	Elementary/ Secondary	None	Consultant	<input checked="" type="checkbox"/>	<input type="checkbox"/>
62	FitzGerald	Scott	Ph.D	dfkj	Community Interest	<input checked="" type="checkbox"/>	<input type="checkbox"/>
63	Cruz	Gregorio	Ph.D	Worked with	Government - Federal	<input type="checkbox"/>	<input type="checkbox"/>
64	Cruz	Greg	Ph.D	Very experi	Government - Federal	<input type="checkbox"/>	<input type="checkbox"/>

Record: 14 of 32

Datasheet View

Microsoft Access unfiled.bmp - Paint Document - WordPad 3 1/2 Floppy (A:) 9:43 PM

Figure 9-3: Database Table with Sample User Profiles

### 9.3 GIS ArcView

The complete link between the ArcView project and the FrontPage web site was the most arduous and unoperative of the components. The main obstacle was getting the customized Avenue scripts read by the Javascripts and server extensions. The incompatibility between Avenue and the Javascripts influenced what was seen on the web site. Therefore, given the capabilities of the Internet Map Server (IMS), an extension provided by ArcView which links ArcView projects with the Internet, only a static background image of the harbor was served on the web.

The incomplete serving of the project required the customization of system scripts. These scripts were grabbed by IMS. Parts of the Avenue scripts were cut and pasted into the system scripts, but they did not provide the full functionality desired. The main system script that was customized was AVINTMP.Image. This script was responsible for the image that appears on the screen. The dialog box with the scroll bars had to be eliminated because the Java or HTML code does not enable the capabilities of a scroll bar on the Internet.

To publish a map with the color gradient of preferred site selections, the weighed values had to be sent in through the URL call as hard coded parameter numbers. The functionality of this command provided a corresponding ArcView picture as seen in Figure 9-4. The elimination of the scroll bars would require the creation of another form or frame with a text box where the input values could be read and realized. The text box frame could be created along side the simulation diagram, but the users would be required to input their weighed values rather than scrolling along the bar. Figure 9-5 shows the dialog box with the scroll bars that was customized in Avenue, but not able to be served on the FrontPage web.

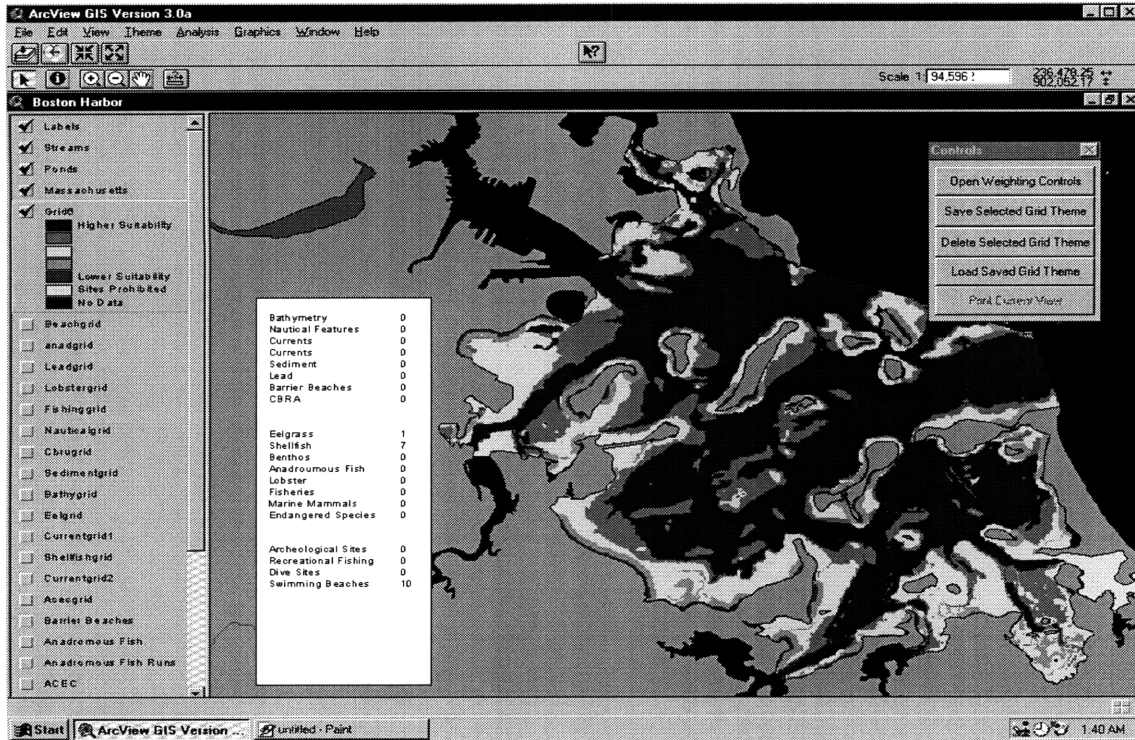


Figure 9-4: Resultant Picture with Feasible Regions (Fitzgerald 1998)

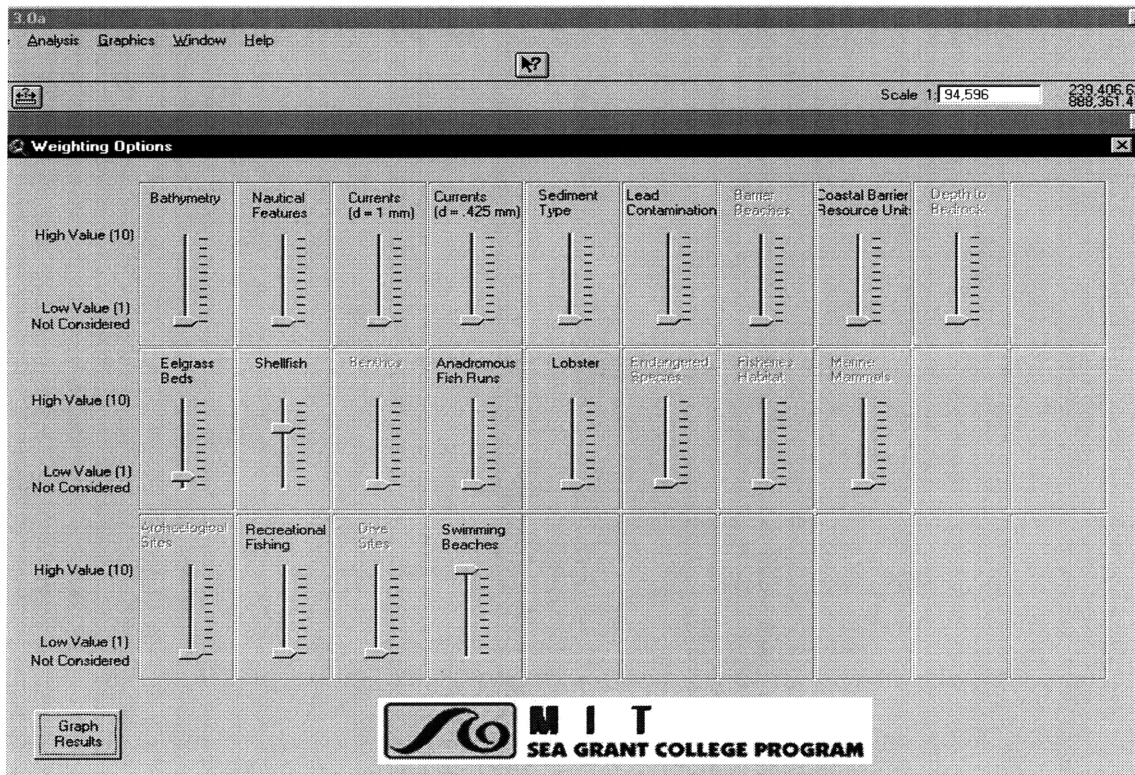


Figure 9-5: Dialog Box of Scroll Bars (Fitzgerald 1998)

## Chapter 10

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### 10 Future Research

More recently, the Internet has been used as a tool to embody interaction and collaboration between people rather than enabling the transfer of information. As technology pushes society to develop an understanding of interaction through technology, it is important to recognize that we are still limited by the inherent needs of social beings.

#### 10.1 Social and Casual Interaction

The incorporation of social and casual interaction would be invaluable to this collaborative system tool. If users were notified that they were interacting in the web site at the same time, they could interact together and chat about their scenarios, results, and choices for borrow pit sites. This capability would allow a more human factor and interaction into the system. If two or more users were interacting at the site, notification and the opportunity to run into each other at the site would promote collaboration beyond the current capabilities.

The DISEL team at MIT worked to incorporate casual and social interaction while users are surfing the Internet. A program called Cliq! was designed where profiles of users were created and the program monitored the TCP/IP ports to see if the users were surfing (Chavez & Rodriguez 1998). In the future, Cliq! could be programmed to monitor the activity around the IP address of the web site for the Boston Harbor. When users come together there, then the characteristics of social and casual interaction for reaching site consensus would be enhanced through Cliq.

## 10.2 Future Applications

The concept of collaboration to reach consensus can be applied to several disciplines. In the environmental arena, collaboration is not necessary only for site selection, but also for reaching consensus of remediation techniques, and developing acceptable strategies for environmental policy such as tradable permits for air pollution. The Kyoto Conference on global climate change lasted several days because countries could not agree on quotas and reductions in greenhouse gas emissions (Bolin 1998). The climate change debate involves factors and issues far more extensive and complex than Boston Harbor, but the journey to consensus is similar. Also other large scale projects involving transportation could be aided by a methodology and system which accelerates the communication and information sharing between several parties. For example state departments of transportation have to decide where and what type of transportation to build in the community. The noise and pollution surrounding these projects heavily involve public and other interested parties whose concerns need to be addressed.

Consensus building and negotiation over the Internet has been constrained because of the lack of human interaction and contact, information sharing, and general structure of web sites. The future research on the impacts and roles of technology on human decision making would improve the effectiveness and development of system tools and web-based methodologies to reach consensus. These studies would lend insight about how humans do and should interact through technological means to create a community.

## 10.3 Simulation Model Development

Real-time information sharing over the Internet could be a valuable feature to the development of simulations and models. Typically, geographical boundaries constrain the communication between scientists and engineers. To minimize the geographical constraint, video, computer, and phone conferencing have become popular distance

communication tools. These tools are effective in bringing people together to share and to talk about ideas. Conversely, there are not many distance tools that allow a visual exchange of ideas and opinions. The Internet could be the common backbone shared between several parties. Being able to discuss and to apply simulation or modeling changes directly could increase the speed of modifications by decreasing the time spent in transferring communication. There could also be potential for more robust models because of the information sharing and idea exchange.

A recent features of simulation development is being able to show a model through a series of time steps—generation of simulations which presents results like a video. Often simulations and models are time dependent. Results are generated for a single time step and then the results for several different time steps are gathered together to exhibit predictions through time. An application for future research in the case of Boston Harbor would be the ability to model the effects of building disposal pits in certain areas. It would be a type of “what-if” scenario where the results to the question extend to actually simulating the effects within the harbor. The results could be simulated over the Internet and then discussed between concerned parties. The advantage to this research application would be that the accessibility and analysis of the tool at a common site would minimize costs to install and obtain software packages. It would also enhance the discussion and interaction about results and site preferences compared to current simulation capabilities.



## APPENDIX A (Fitzgerald 1998)

.....  
These are only a sample of two explanations  
.....

### Bathymetry

---

Bathymetry is the measurement of water depths from a given datum. For this project all depths are measured from Mean Low Water (MLW) which is the average height of the daily low tides. Bathymetry is an important component of siting disposal areas because shallow areas can prevent the entry of ships or barges into certain areas and can require additional dredging.

#### *Rating Scheme*

- 10: All areas with depths greater than 20 ft., within 1 mile of land, and within ½ mile of navigable water (defined to be marked ship channels).
- 8: Areas within ½ mile of navigable water
- 5: Areas greater than 20 ft. deep.
- 1: All other areas

#### *Notes from Tom Fredette, United States Army Corps of Engineers.*

“Because a borrow pit can be dredged, bathymetry may not be a critical factor. Certainly areas that are accessible and are already deep would have some advantages, but even shallow areas could have channels provided for access and then be dredged to whatever depths are needed. Thus areas near land (protected), near a channel (access), and already deep would have the highest potential.”

## Currents

---

Currents are an important consideration in the siting of disposal areas because they have the potential to resuspend and transport capping material and the underlying contaminated sediments. It is desirable to place material in areas where the bottom shear stress developed by the tidal current flow is less than the necessary stress required to initiate movement of the capping material to ensure that contaminated sediments remain isolated and are not transported away from the disposal site.

### *Rating Scheme*

- 10: Ratio of bottom shear stress to critical shear stress  $< 0.8$
- 4:  $0.8 < \text{Ratio of bottom shear stress to critical shear stress} < 1.0$
- 1: Ratio of bottom shear stress to critical shear stress  $> 1.0$

### *Notes from Scott FitzGerald, MIT.*

These data layers looks at the bottom shear stress developed by the maximum yearly tidal currents (as predicted by a current model for Boston Harbor developed by Rich Signell at the U.S.G.S. in Woods Hole) and compares that stress to the stress required to initiate movement of two different sizes of capping material

## APPEDIX B

\*\*\*\*\*

Source code for Background.asp

\*\*\*\*\*

```
<html>

<head>
<meta name="GENERATOR" content="Microsoft FrontPage 3.0">
<title>Background</title>

<meta name="Microsoft Theme" content="tidepool 011, default">
<meta name="Microsoft Border" content="tl, default">
</head>

<body background="../_themes/tidepool/tidbkgde.jpg" bgcolor="#CC9966"
text="#000033" link="#660000" vlink="#CC0000" alink="#FF3300">
<!--msnavigation-->
<table border="0" cellpadding="0" cellspacing="0" width="100%"><tr>
<td>
<!--mstheme-->
<font face="comic sans ms, arial, helvetica">

<p align="center"><font size="6"><strong>
</strong></font><br>
</p>

<!--msthemeseparator-->
<p align="center">

</p>

<p align="center">&nbsp;</p>
<!--mstheme--></font></td></tr>
<!--msnavigation-->
</table><!--msnavigation--><table border="0" cellpadding="0"
cellspacing="0" width="100%"><tr><td valign="top" width="1%">
<!--mstheme-->
<font face="comic sans ms, arial, helvetica">

<p>&nbsp;</p>
<!--mstheme--></font></td><td valign="top" width="24">
</td>
<!--msnavigation--><td valign="top"><!--mstheme-->
<font face="comic sans ms, arial, helvetica">

<p>&nbsp;</p>

<p>
<% ' Substitute in form parameters into the query string
```

```

fp_sQry = "select * from people where LastName='%LastName%' and
FirstName='%FirstName%';"
fp_sDefault = ""
fp_sNoRecords = "Our Records show that you are new to this site.
Please give us some information about yourself"

fp_iMaxRecords = 0
fp_iTimeout = 0
fp_iCurrent = 1
fp_fError = False
fp_bBlankField = False
If fp_iTimeout <> 0 Then Server.ScriptTimeout = fp_iTimeout
Do While (Not fp_fError) And (InStr(fp_iCurrent, fp_sQry, "%") <> 0)
    ' found a opening quote, find the close quote
    fp_iStart = InStr(fp_iCurrent, fp_sQry, "%")
    fp_iEnd = InStr(fp_iStart + 2, fp_sQry, "%")
    If fp_iEnd = 0 Then
        fp_fError = True
        Response.Write "<B>Database Region Error: mismatched parameter delimiters</B>"
    Else
        fp_sField = Mid(fp_sQry, fp_iStart + 2, fp_iEnd - fp_iStart - 2)
        If Mid(fp_sField,1,1) = "%" Then
            fp_sWildcard = "%"
            fp_sField = Mid(fp_sField, 2)
        Else
            fp_sWildCard = ""
        End If
        fp_sValue = Request.Form(fp_sField)

        ' if the named form field doesn't exist, make a note of it
        If (len(fp_sValue) = 0) Then
            fp_iCurrentField = 1
            fp_bFoundField = False
            Do While (InStr(fp_iCurrentField, fp_sDefault, fp_sField) <> 0) _
                And Not fp_bFoundField
                fp_iCurrentField = InStr(fp_iCurrentField, fp_sDefault, fp_sField)
                fp_iStartField = InStr(fp_iCurrentField, fp_sDefault, "=")
                If fp_iStartField = fp_iCurrentField + len(fp_sField) Then
                    fp_iEndField = InStr(fp_iCurrentField, fp_sDefault, "&")
                    If (fp_iEndField = 0) Then fp_iEndField = len(fp_sDefault) + 1
                    p_sValue = Mid(fp_sDefault, fp_iStartField+1, fp_iEndField-1)
                    fp_bFoundField = True
                Else
                    fp_iCurrentField = fp_iCurrentField + len(fp_sField) - 1
                End If
            Loop
        End If

        ' this next finds the named form field value, and substitutes in
        ' doubled single-quotes for all single quotes in the literal value
        ' so that SQL doesn't get confused by seeing unpaired single-quotes
        If (Mid(fp_sQry, fp_iStart - 1, 1) = """) Then
            fp_sValue = Replace(fp_sValue, """, """)
        ElseIf (Mid(fp_sQry, fp_iStart - 1, 1) = "") Then
            fp_sValue = Replace(fp_sValue, "", "")
    
```

```

ElseIf Not IsNumeric(fp_sValue) Then
    fp_sValue = ""
End If

If (len(fp_sValue) = 0) Then fp_bBlankField = True

fp_sQry = Left(fp_sQry, fp_iStart - 1) + fp_sWildCard + fp_sValue + _
    Right(fp_sQry, Len(fp_sQry) - fp_iEnd - 1)

' Fixup the new current position to be after the substituted value
fp_iCurrent = fp_iStart + Len(fp_sValue) + Len(fp_sWildCard)
End If
Loop

If Not fp_fError Then
    ' Use the connection string directly as entered from the wizard
    On Error Resume Next
    set fp_rs = CreateObject("ADODB.Recordset")
    If fp_iMaxRecords <> 0 Then fp_rs.MaxRecords = fp_iMaxRecords
    fp_rs.Open fp_sQry, "DSN=bosharbor"

    If Err.Description <> "" Then
        Response.Write "<B>Database Error: " + Err.Description + "</B>"
        if fp_bBlankField Then
            Response.Write " One or more form fields were empty."
        End If
    Else
        ' Check for the no-record case
        If fp_rs.EOF And fp_rs.BOF Then
            %> </p>

            <p>Welcome <%=Request.Form("FirstName")+ " "> <%=Request.Form("LastName")%> :</p>

            <p>Our Records show that you are new to this site. Please give us some information about
            yourself.</p>
            <a href="registration.asp?LastName=<%=Request.Form("LastName")%>&amp;FirstName=<%=Request.
            Form("FirstName")%>">

            <p>Next</a> </p>

            <p><% Else %> </p>

            <p>Welcome <%=Request.Form("FirstName")+ " "> <%=Request.Form("LastName")%> !</p>
            <a href="intro.asp?LastName=<%=Request.Form("LastName")%>&amp;FirstName=<%=Request.Form
            ("FirstName")%>">

            <p>Next</a> </p>
            <%
                End If
            End If
        End If
        %>
        <!--mstheme--></font><!--msnavigation--></td></tr><!--msnavigation--></table></body>
        </html>

```

## APPENDIX C

```
*****
* AVINETMP.Image *
* Make the map and write to a Server Cache file *
* ready for sending to MapCafe. *
* Returns: a list containing the FN and the *
* content type of the created Map. *
* Or: an error message *
* Or: nil indicating that a new TOC *
* must be dynamically generated instead *
* SELF = request params *
*****

textmode= false

wlink = weblink.the
if (wlink = nil) then
  return "WebLink is unavailable."
end

if (textmode=true) then
  wlink.WriteResponseHeader("Content-type: text/plain"+CR+NL+CR+NL)
  wlink.WriteString("Initialize OK!" +CR+NL)
end

params = SELF

*****
* Customized code below. Setting weighed values to 0 except the first
* value so that geometric mean exists. These values are later input through
* parameters in the URL call.
*****

w01=1
w02=0
w03=0
w04=0
w05=0
w06=0
w07=0
w08=0
w09=0
w10=0
w11=0
w12=0
w13=0
w14=0
w15=0
w16=0
w17=0
w18=0
w19=0
w20=0
w21=0
```

```
w22=0
w23=0
w24=0
```

```
*****
* Make sure we have a viewName before getting to *
* anything else as some subsequent parameters are *
* dependent on a view having been defined.      *
*****
```

```
if (textmode=true) then
  wlink.WriteString("Get Parameters Start OK!" + CR + NL)
end
```

```
for each i in 0 .. (params.count - 1)
  key = params.get(i).get(0).ucase
  val = params.get(i).get(1)
  if (key = "VName") then
    Do nothing because we already did this
  elseif (key = "W01" )then
    w01= val.AsNumber
  elseif (key = "W02" )then
    w02= val.AsNumber
  elseif (key = "W03" )then
    w03= val.AsNumber
  elseif (key = "W04" )then
    w04= val.AsNumber
  elseif (key = "W05" )then
    w05= val.AsNumber
  elseif (key = "W06" )then
    w06= val.AsNumber
  elseif (key = "W07" )then
    w07= val.AsNumber
  elseif (key = "W08" )then
    w08= val.AsNumber
  elseif (key = "W09" )then
    w09= val.AsNumber
  elseif (key = "W10" )then
    w10= val.AsNumber
  elseif (key = "W11" )then
    w11= val.AsNumber
  elseif (key = "W12" )then
    w12= val.AsNumber
  elseif (key = "W13" )then
    w13= val.AsNumber
  elseif (key = "W14" )then
    w14= val.AsNumber
  elseif (key = "W15" )then
    w15= val.AsNumber
  elseif (key = "W16" )then
    w16= val.AsNumber
  elseif (key = "W17" )then
    w17= val.AsNumber
  elseif (key = "W18" )then
```

```

    w18= val.AsNumber
elseif (key = "W19" )then
    w19= val.AsNumber
elseif (key = "W20" )then
    w20= val.AsNumber
elseif (key = "W21" )then
    w21= val.AsNumber
elseif (key = "W22" )then
    w22= val.AsNumber
elseif (key = "W23" )then
    w23= val.AsNumber
elseif (key = "W24" )then
    w24= val.AsNumber
end
end

if (textmode=true) then
    wlink.WriteString("Get Parameters OK!" +CR+NL)
end

***** Program Start ***** Created by S.Fitzgerald*****

*****
'Name: BH.GridCreation
,
'Title: Creates a grid theme using a weighted geometric mean.
,
'Topics: Grids
,
'Description: This script creates a new grid theme from existing
'grid themes by combining the existing themes with a weighted
'geometric mean. The weighing values are obtained from the values
'of the slider bars in the BHweights dialog box.
,
'Requires: Spatial Analyst, Dialog Designer, grid themes loaded
'into view, Suitability.avl on disk
,
'Self:
,
'Returns: Grid Theme

'Get the project directory

prjfile = av.GetProject
prjdir = prjfile.GetFileName.clone
prjdir.StripFile

'Get the Boston Harbor View and Weighting Dialog Box

theView = av.GetProject.FindDoc("Boston Harbor")

if (textmode=true) then
    wlink.WriteString("Get Project OK!" +CR+NL)
end

```



```

' Open the View

theWindow = theView.GetWin
theWindow.Open
theWindow.Maximize

' Lock the TOC so that the display is always correct.

aTOC = theView.GetTOC
aTOC.SetOrderLocked(true)

' Deactivate all themes
theActiveView = theView.GetThemes
for each t in theView.GetThemes
  t.SetActive(False)
  t.SetVisible(False)
end

theView.Invalidate
theView.GetDisplay.Invalidate(true)

' Get each grid and the weighting values from it's slider.
' Divide all weighting values by ten to reduce computational
' dimensioning problems (e.g. 10^9 * 5^7)

if (textmode=true) then
  wink.WriteString("Before Find Theme OK!" + CR + NL)
end

theBathyTheme = theView.FindTheme ("Bathygrid")
g01 = theBathyTheme.GetGrid

if (textmode=true) then
  wink.WriteString("Find Theme 01 OK!" + CR + NL)
end

theNauticalTheme = theView.FindTheme ("Nauticalgrid")
g02 = theNauticalTheme.GetGrid

theCurrent1Theme = theView.FindTheme ("currentgrid1")
g03 = theCurrent1Theme.GetGrid

theCurrent2Theme = theView.FindTheme ("currentgrid2")
g04 = theCurrent1Theme.GetGrid

theSedimentTheme = theView.FindTheme ("Sedimentgrid")
g05 = theSedimentTheme.GetGrid

if (textmode=true) then
  wink.WriteString("Find Theme 05 OK!" + CR + NL)
end

```

```

theLeadTheme = theView.FindTheme ("Leadgrid")
g06 = theLeadTheme.GetGrid

'theBarrierBTheme = theView.FindTheme ("Barrierbgrid")
'g07 = theBarrierBTheme.GetGrid

theCBRUTheme = theView.FindTheme ("CBRUgrid")
g08 = theCBRUTheme.GetGrid

if (textmode=true) then
  wink.WriteString("Find Theme 08 OK!" + CR + NL)
end

theEelTheme = theView.FindTheme ("Eelgrid")
g11 = theEelTheme.GetGrid

theShellfishTheme = theView.FindTheme ("Shellfishgrid")
g12 = theShellfishTheme.GetGrid

'theBenthosTheme = theView.FindTheme ("Benthosgrid")
'g13 = theBenthosTheme.GetGrid

theAnadTheme = theView.FindTheme ("Anadgrid")
g14 = theAnadTheme.GetGrid

theLobsterTheme = theView.FindTheme ("Lobstergrid")
g15 = theLobsterTheme.GetGrid

if (textmode=true) then
  wink.WriteString("Find Theme 15 OK!" + CR + NL)
end

'theArchTheme = theView.FindTheme ("Archgrid")
'g21 = theArchTheme.GetGrid

theFishingTheme = theView.FindTheme ("Fishinggrid")
g22 = theFishingTheme.GetGrid

'theDiveTheme = theView.FindTheme ("Divegrid")
'g23 = theDiveTheme.GetGrid

theBeachTheme = theView.FindTheme ("Beachgrid")
g24 = theBeachTheme.GetGrid

if (textmode=true) then
  wink.WriteString("Find Theme 24 OK!" + CR + NL)
end

' get the acec for the analysis. Needed for final output, but doesn't use a slider.

theACECTheme = theView.FindTheme ("acecgrid")
acecgrid = theACECTheme.GetGrid

' Compute the sum of the weighting values

```

```
t = w01 + w02 + w03 + w04 + w05 + w06 + w08 + w11 + w12 + w14 + w15 + w22 + w24
```

```
' Calculate the new grid values using a weighted geometric mean
```

```
newgrid = acecgrid * ((g01^w01) * (g02^w02) * (g03^w03) * (g04^w04) * (g05^w05) * (g06^w06) *  
(g08^w08) * (g11^w11) * (g12^w12) * (g14^w14) * (g15^w15) * (g22^w22) * (g24^w24))^(1/t)
```

```
' Make newgrid a GridTheme for viewing
```

```
thenewgrid = GTheme.make(newgrid)
```

```
' Deactivate all themes in preparation for adding new GridTheme
```

```
theActiveView = theView.GetThemes
```

```
for each t in theView.GetThemes
```

```
  t.SetActive(False)
```

```
  t.SetVisible(False)
```

```
end
```

```
' Add the new GridTheme to the Boston Harbor view and make it active
```

```
theView.AddTheme(thenewgrid)
```

```
thenewgrid.SetVisible(True)
```

```
thenewgrid.SetActive(True)
```

```
' Load in the Legend for the new theme and apply it
```

```
GridLegend = Legend.Make(#SYMBOL_FILL)
```

```
GridLegend.Load((prjdir.AsString+"\\bhlegends\suitability2.avl").AsFileName,
```

```
#LEGEND_LOADTYPE_ALL)
```

```
thenewgrid.SetLegend(GridLegend)
```

```
thenewgrid.UpdateLegend 'Redraw
```

```
' Move the Theme to its proper location in the TOC
```

```
theThemeList = theView.GetThemes
```

```
theThemeList.Shuffle(theThemeList.Get(0), 5)
```

```
theview.InvalidateTOC(nil)
```

```
theView.GetDisplay.Invalidate(true)
```

```
theThemeList.Get(0).SetVisible(True)
```

```
theThemeList.Get(1).SetVisible(True)
```

```
theThemeList.Get(2).SetVisible(True)
```

```
theThemeList.Get(3).SetVisible(True)
```

```
theThemeList.Get(4).SetVisible(True)
```

```
' Display the Slider Values for the GridTheme
```

```
textalign = 233000 ' Left Stateplane coord for text and box
```

```
vertalign = 889000 ' Botton Stateplan coord for text and box
```

```
numalign = textalign + 3000 ' Offset for numeral from text
```

```
vertsep = 300 ' Vertical separation for text
```

```
textSym = TextSymbol.Make  
textSym.SetSize(9)
```

```
Point1 = Point.Make(textalign,vertalign +(30*vertsep))  
Point1a = Point.Make(numalign, vertalign+(30*vertsep))  
Point2 = Point.Make(textalign,vertalign+(29*vertsep))  
Point2a = Point.Make(numalign, vertalign+(29*vertsep))  
Point3 = Point.Make(textalign,vertalign+(28*vertsep))  
Point3a = Point.Make(numalign, vertalign+(28*vertsep))  
Point4 = Point.Make(textalign,vertalign+(27*vertsep))  
Point4a = Point.Make(numalign, vertalign+(27*vertsep))  
Point5 = Point.Make(textalign,vertalign+(26*vertsep))  
Point5a = Point.Make(numalign,vertalign+(26*vertsep))  
Point6 = Point.Make(textalign,vertalign+(25*vertsep))  
Point6a = Point.Make(numalign,vertalign+(25*vertsep))  
Point7 = Point.Make(textalign,vertalign+(24*vertsep))  
Point7a = Point.Make(numalign, vertalign+(24*vertsep))  
Point8 = Point.Make(textalign,vertalign+(23*vertsep))  
Point8a = Point.Make(numalign, vertalign+(23*vertsep))  
Point9 = Point.Make(textalign,vertalign+(22*vertsep))  
Point9a = Point.Make(numalign, vertalign+(22*vertsep))  
Point10 = Point.Make(textalign,vertalign+(21*vertsep))  
Point10a = Point.Make(numalign, vertalign+(21*vertsep))  
Point11 = Point.Make(textalign,vertalign+(20*vertsep))  
Point11a = Point.Make(numalign, vertalign+(20*vertsep))  
Point12 = Point.Make(textalign,vertalign+(19*vertsep))  
Point12a = Point.Make(numalign, vertalign+(19*vertsep))  
Point13 = Point.Make(textalign,vertalign+(18*vertsep))  
Point13a = Point.Make(numalign, vertalign+(18*vertsep))  
Point14 = Point.Make(textalign,vertalign+(17*vertsep))  
Point14a = Point.Make(numalign, vertalign+(17*vertsep))  
Point15 = Point.Make(textalign,vertalign+(16*vertsep))  
Point15a = Point.Make(numalign, vertalign+(16*vertsep))  
Point16 = Point.Make(textalign,vertalign+(15*vertsep))  
Point16a = Point.Make(numalign, vertalign+(15*vertsep))  
Point17 = Point.Make(textalign,vertalign+(14*vertsep))  
Point17a = Point.Make(numalign, vertalign+(14*vertsep))  
Point18 = Point.Make(textalign,vertalign+(13*vertsep))  
Point18a = Point.Make(numalign, vertalign+(13*vertsep))  
Point19 = Point.Make(textalign,vertalign+(12*vertsep))  
Point19a = Point.Make(numalign, vertalign+(12*vertsep))  
Point20 = Point.Make(textalign,vertalign+(11*vertsep))  
Point20a = Point.Make(numalign, vertalign+(11*vertsep))  
Point21 = Point.Make(textalign,vertalign+(10*vertsep))  
Point21a = Point.Make(numalign, vertalign+(10*vertsep))  
Point22 = Point.Make(textalign,vertalign+(9*vertsep))  
Point22a = Point.Make(numalign, vertalign+(9*vertsep))  
Point23 = Point.Make(textalign,vertalign+(8*vertsep))  
Point23a = Point.Make(numalign, vertalign+(8*vertsep))  
Point24 = Point.Make(textalign,vertalign+(7*vertsep))  
Point24a = Point.Make(numalign, vertalign+(7*vertsep))  
Point25 = Point.Make(textalign,vertalign+(6*vertsep))  
Point25a = Point.Make(numalign, vertalign+(6*vertsep))  
Point26 = Point.Make(textalign,vertalign+(5*vertsep))  
Point26a = Point.Make(numalign, vertalign+(5*vertsep))
```

```
Point27 = Point.Make(textalign,vertalign+(4*vertsep))
Point27a = Point.Make(numalign,vertalign+(4*vertsep))
Point28 = Point.Make(textalign,vertalign+(3*vertsep))
Point28a = Point.Make(numalign,vertalign+(3*vertsep))
Point29 = Point.Make(textalign,vertalign+(2*vertsep))
Point29a = Point.Make(numalign,vertalign+(2*vertsep))
Point30 = Point.Make(textalign,vertalign+(1*vertsep))
Point30a = Point.Make(numalign,vertalign+(1*vertsep))
```

```
theRectangle = Rect.MakeXY(textalign - 300,vertalign - 500,numalign + 700,vertalign +(32*vertsep))
theRectSymbol = Symbol.Make(#Symbol_Fill)
theRectSymbol.SetColor(Color.GetWhite)
GraphicRectangle = GraphicShape.Make(theRectangle)
GraphicRectangle.SetSymbol(theRectSymbol)
```

```
GraphicBathy = GraphicText.Make("Bathymetry",Point1)
GraphicBathy.SetSymbol(textSym)
GraphicBathya = GraphicText.Make((w01*10).AsString,Point1a)
GraphicBathya.SetSymbol(textSym)
```

```
GraphicNautical = GraphicText.Make("Nautical Features",Point2)
GraphicNautical.SetSymbol(textSym)
GraphicNauticala = GraphicText.Make((w02*10).AsString,Point2a)
GraphicNauticala.SetSymbol(textSym)
```

```
GraphicCurrents1 = GraphicText.Make("Currents",Point3)
GraphicCurrents1.SetSymbol(textSym)
GraphicCurrents1a = GraphicText.Make((w03*10).AsString,Point3a)
Graphiccurrents1a.SetSymbol(textSym)
```

```
GraphicCurrents2 = GraphicText.Make("Currents",Point4)
GraphicCurrents2.SetSymbol(textSym)
GraphicCurrents2a = GraphicText.Make((w04*10).AsString,Point4a)
Graphiccurrents2a.SetSymbol(textSym)
```

```
GraphicSediment = GraphicText.Make("Sediment",Point5)
GraphicSediment.SetSymbol(textSym)
GraphicSedimenta = GraphicText.Make((w05*10).AsString,Point5a)
GraphicSedimenta.SetSymbol(textSym)
```

```
GraphicContaminant = GraphicText.Make("Lead",Point6)
GraphicContaminant.SetSymbol(textSym)
GraphicContaminanta = GraphicText.Make((w06*10).AsString,Point6a)
GraphicContaminanta.SetSymbol(textSym)
```

```
GraphicBarrierB = GraphicText.Make("Barrier Beaches",Point7)
GraphicBarrierB.SetSymbol(textSym)
GraphicBarrierBa = GraphicText.Make((w07*10).AsString,Point7a)
GraphicBarrierBa.SetSymbol(textSym)
```

```
GraphicCBRU = GraphicText.Make("CBRA",Point8)
GraphicCBRU.SetSymbol(textSym)
GraphicCBRUa = GraphicText.Make((w08*10).AsString,Point8a)
```

```

GraphicCBRUa.SetSymbol(textSym)

GraphicBedrock = GraphicText.Make("Depth to Bedrock",Point9)
GraphicBedrock.SetSymbol(textSym)
GraphicBedrocka = GraphicText.Make((w09*10).AsString, Point9a)
GraphicBedrocka.SetSymbol(textSym)

GraphicEel = GraphicText.Make("Eelgrass",Point11)
GraphicEel.SetSymbol(textSym)
GraphicEela = GraphicText.Make((w11*10).AsString,Point11a)
GraphicEela.SetSymbol(textSym)

GraphicShellfish = GraphicText.Make("Shellfish",Point12)
GraphicShellfish.SetSymbol(textSym)
GraphicShellfisha = GraphicText.Make((w12*10).AsString,Point12a)
GraphicShellfisha.SetSymbol(textSym)

GraphicBenthos = GraphicText.Make("Benthos",Point13)
GraphicBenthos.SetSymbol(textSym)
GraphicBenthosa = GraphicText.Make((w13*10).AsString,Point13a)
GraphicBenthosa.SetSymbol(textSym)

GraphicANAD = GraphicText.Make("Anadroumous Fish",Point14)
GraphicANAD.SetSymbol(textSym)
GraphicANADa = GraphicText.Make((w14*10).AsString,Point14a)
GraphicANADa.SetSymbol(textSym)

GraphicLobster = GraphicText.Make("Lobster",Point15)
GraphicLobster.SetSymbol(textSym)
GraphicLobstera = GraphicText.Make((w15*10).AsString,Point15a)
GraphicLobstera.SetSymbol(textSym)

GraphicFisheries = GraphicText.Make("Fisheries",Point16)
GraphicFisheries.SetSymbol(textSym)
GraphicFisheriesa = GraphicText.Make((w16*10).AsString,Point16a)
GraphicFisheriesa.SetSymbol(textSym)

GraphicMammals = GraphicText.Make("Marine Mammals",Point17)
GraphicMammals.SetSymbol(textSym)
GraphicMammalsa = GraphicText.Make((w17*10).AsString,Point17a)
GraphicMammalsa.SetSymbol(textSym)

GraphicEndangered = GraphicText.Make("Endangered Species",Point18)
GraphicEndangered.SetSymbol(textSym)
GraphicEndangereda = GraphicText.Make((w18*10).AsString,Point18a)
GraphicEndangereda.SetSymbol(textSym)

GraphicArch = GraphicText.Make("Archeological Sites",Point21)
GraphicArch.SetSymbol(textSym)
GraphicArcha = GraphicText.Make((w21*10).AsString,Point21a)
Graphicarcha.SetSymbol(textSym)

GraphicFishing = GraphicText.Make("Recreational Fishing",Point22)
GraphicFishing.SetSymbol(textSym)
GraphicFishinga = GraphicText.Make((w22*10).AsString,Point22a)

```

GraphicFishinga.SetSymbol(textSym)

GraphicDive = GraphicText.Make("Dive Sites",Point23)

GraphicDive.SetSymbol(textSym)

GraphicDivea = GraphicText.Make((w23\*10).AsString,Point23a)

GraphicDivea.SetSymbol(textSym)

GraphicBeaches = GraphicText.Make("Swimming Beaches",Point24)

GraphicBeaches.SetSymbol(textSym)

GraphicBeachesa = GraphicText.Make((w24\*10).AsString,Point24a)

GraphicBeachesa.SetSymbol(textSym)

theGraphicList = theView.GetGraphics

theGraphicList.Add(GraphicRectangle)

theGraphicList.Add(GraphicBathy)

theGraphicList.Add(GraphicBathya)

theGraphicList.Add(GraphicNautical)

theGraphicList.Add(GraphicNauticala)

theGraphicList.Add(GraphicCurrents1)

theGraphicList.Add(GraphicCurrents1a)

theGraphicList.Add(GraphicCurrents2)

theGraphicList.Add(GraphicCurrents2a)

theGraphicList.Add(GraphicSediment)

theGraphicList.Add(GraphicSedimenta)

theGraphicList.Add(GraphicContaminant)

theGraphicList.Add(GraphicContaminanta)

theGraphicList.Add(GraphicBarrierB)

theGraphicList.Add(GraphicBarrierBa)

theGraphicList.Add(GraphicEel)

theGraphicList.Add(GraphicEela)

theGraphicList.Add(GraphicShellfish)

theGraphicList.Add(GraphicShellfisha)

theGraphicList.Add(GraphicBenthos)

theGraphicList.Add(GraphicBenthosa)

theGraphicList.Add(GraphicANAD)

theGraphicList.Add(GraphicANADa)

theGraphicList.Add(GraphicLobster)

theGraphicList.Add(GraphicLobstera)

theGraphicList.Add(GraphicCBRU)

theGraphicList.Add(GraphicCBRUa)

theGraphicList.Add(GraphicFisheries)

theGraphicList.Add(GraphicFisheriesa)

theGraphicList.Add(GraphicMammals)

theGraphicList.Add(GraphicMammalsa)

theGraphicList.Add(GraphicEndangered)

theGraphicList.Add(GraphicEndangereda)

theGraphicList.Add(GraphicArch)

theGraphicList.Add(GraphicArcha)

theGraphicList.Add(GraphicFishing)

theGraphicList.Add(GraphicFishinga)

theGraphicList.Add(GraphicDive)

theGraphicList.Add(GraphicDivea)

theGraphicList.Add(GraphicBeaches)

theGraphicList.Add(GraphicBeachesa)

```

theGraphicList.SelectAll

theActiveTheme = theView.GetActiveThemes.Get(0)
theGraphicSet = theActiveTheme.GetGraphics
for each g in theView.GetGraphics.GetSelected
  theGraphicSet.Add(g)
end
theGraphicSet.SetVisible(true)
theGraphicList.UnselectAll

*****

if (textmode=true) then
  wink.WriteString("Step X OK!" + CR + NL)
end

extent= rect.makexy(232792,902816,250429,889943)
SafetyOn= true

***** Program End ***** Close S.Fitzgerald Code *****

*****
* Now prepare the map image. *
*****

theFN = viewTheView.ExportToGif(extent,xsize,ysize,nil,SafetyOn)
theFN = theView.ExportToGif(extent,400,400,nil,SafetyOn)
if (theFN = nil) then

  wink.WriteResponseHeader("Content-type: image/jpeg" + CR + NL + CR + NL)

  theFN = theView.ExportToJPEG(extent,400,400,80,SafetyOn)
  if (theFN = nil) then
    return "The Map Server is temporarily unable to produce an image."
  end
else

  wink.WriteResponseHeader("Content-type: image/gif" + CR + NL + CR + NL)

end

wink.WriteFile( theFN)

file.delete(theFN)

return (true)

```



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