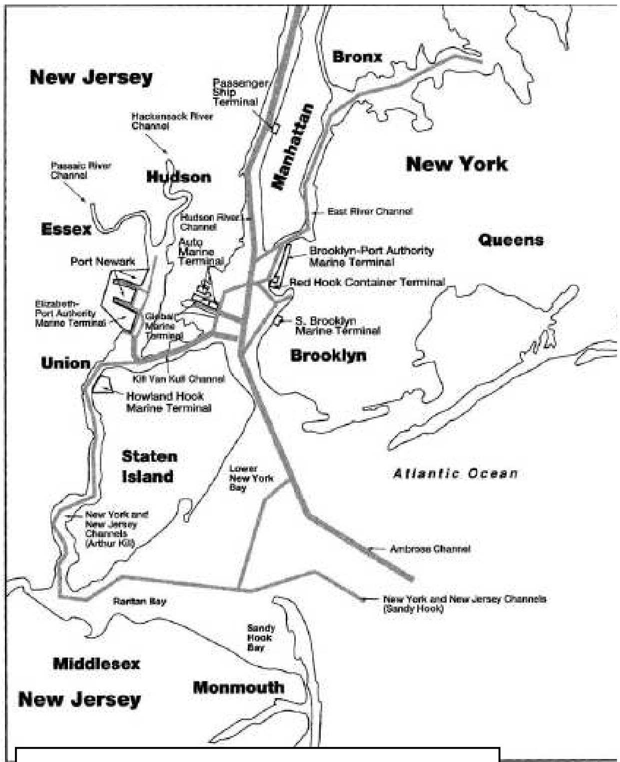
New York/New Jersey Harbor

Background

The New York / New Jersey Harbor is a busy, iconic shipping center and a community resource for surrounding city. The Harbor drains the Hudson-Raritan Watershed, which introduces 1-2 million m^3 of sediment annually (Wakeman and Themelis 2001). Due to the shallow nature of the harbor (~6m) and the tendency of sediment to settle in the deep sections necessary for vessel traffic, 6.5 million m^3 of sediment are dredged annually (2001); this type of dredging would be classified as "maintenance dredging" due to its annual nature and typically has fewer / smaller repercussions than a capital dredging project, such as the deepening of a channel (Bray 2008). Dredging in the harbor has a colorful history. In the 1990s, dioxins were found in both the biota and in the sediments, the result of centuries of habitation and industrial growth in the Hudson-Raritan watershed (Wakeman, Dunlop et al. 1997). Current sediment influxes are cleaner than these older sediments, much of the Harbor sediment is contaminated to the level that new regulations no longer allow the disposal of dredged sediment into the sensitive



Source: (Wakeman and Themelis 2001)

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ocean dump sites (like the historic "Mud Dump Site") wherein disposal formerly occurred (Wakeman, Dunlop et al. 1997; Wakeman and Themelis 2001).

At the intersection of shipping interest, a variety of industries, as well as ecological and human health provides a broad base of interested parties; contaminated fisheries, public concern and use of the harbor, ecological and human health risks draw in many people. Overall, dredging activities can have impacts ranging from ecosystem destruction, threats to fisheries, threats to human health, noise / visual pollution, costs, and more (Institution of Civil Engineers 2004). The stakeholders may include politicians, financiers, activists, contractors, consultants, administrators / standards institutes, and owners (Bray 2008). Siting of disposal sites along is described as "controversial, expensive... time consuming... [and] politically difficult" (Wakeman, Dunlop et al. 1997). In the case of the Harbor, the governors of New York and New Jersey called for a "coordinated and comprehensive approach" underscoring the difficulties in making decisions that cut across many interests and are technically challenging to assess and manage from an engineering perspective (William J. Librizzi and P.E. 1997). As such, decision makers cannot necessarily rely on simple decision making frameworks to process the large amount of data and diverse opinions requisite to making the "best" decision. (2) Problem Structuring / Formulation of Criteria and Alternatives

Alternatives Selection

The following alternatives were presented for analysis on this project; they comprise the "alternatives vector" $\bar{A} = \{a_s \dots s = 1 - 8\}$ where s represents each alternative sediment management option. Stakeholder input was requested and a basic review of these alternatives was conducted both for applicability and feasibility before these alternatives were put forward for further consideration and review (Kiker, Bridges et al. 2008).

Alternatives a_s:	**Description**
Confined Aquatic Disposal (CAD)	Contaminated sediment is placed into a sea-floor depression / excavation with a layer of clean material overlaid as a cap
Island Confined Disposal Facility (C	A diked structure in open water areas is filled with sediment slurry and capped upon closure
Near Shore CDF	A CDF is constructed in shallow waters adjacent to land with retaining dikes to hold sediment; it is capped upon closure
Upland CDF	A CDF is constructed on adjacent land with retaining dikes to hold sediment; it is capped upon closure
Landfill	Sediment is dewatered and transported by truck or rail to landfill; it is capped upon closure
No Action	No dredging occurs and contamir sediments remain in place in the ho
Cement lock technology	Sediment is combusted with modifiers and converted to a

	cement-like product
Manufactured Soil technology	Sediment is combined with soil-building amendments to create a product used to form vegetative caps at landfills
Adapted from (Kiker, Bridges et al. 2008)	

Criteria Selection

A vector $\overline{X}$ is created such that $\bar{X} = \{x_i \dots i = 1 - 7\}$ where i represents each of the seven criteria by which the alternatives a_s will be assessed (Kiker, Bridges et al. 2008); these criteria are detailed below. These criteria should reflect stakeholder and expert input and values (Linkov, Satterstrom et al. 2006).

	Decision Criteria x_i	**Description**
Ecological criteria	Ecological Exposure Pathways	Number of uninterrupted source-to-ecological endpoint paths that occur when using that alternative as derived from conceptual site models; captures risk of contaminants reaching biota from a given enclosure
	Magnitude of Ecological Hazard Quotient	Ratio of chemical exposure to reference level; the Hazard Quotient is the expected dose divided by a reference dose (which represents a potentially toxic dose) -- HQ > 1 indicate that a hazard exists (see e.g. Davis and Masten 2009); combined

		with the number of pathways, this gives a holistic risk picture
Human health criteria	Human Exposure Pathways	Number of uninterrupted source-to-human-endpoint paths; captures risk of contaminants reaching humans
	Magnitude of Maximum Cancer Risk	Highest estimated cancer risk using that alternative; this risk is calculated using expected intake (from expected environmental concentration) and an empirically measured slope factor, such as those calculated by the EPA (see e.g. Davis and Masten 2009)
	Estimated Fish Contaminant of Concern (COC) / Risk Level	Highest level of estimated concentration of COC in fish compared to a risk-based concentration; used to describe risk for fishers and those consuming seafood products from the management area
Proxy for public acceptability	Impacted Area: Facility Capacity Ratio	Measure of ecological footprint; defined as the ratio of the area directly impacted by management operations for the alternative to the total capacity of the alternative
Cost	Operational Cost	$ per cu. yd. of dredged material
Adapted from (Kiker, Bridges et al. 2008)		

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