Final Report to
The Hudson River Foundation

Determining the Area of Man-Made Land, New Jersey Shore, Lower Hudson Region

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The purpose of this research was to determine the area of man-made land on the New Jersey shore of the Lower Hudson Estuary (New York Harbor) utilizing the resources of the New Jersey Department of Environmental Protection, Division of Coastal Resources, Bureau of Tidelands. This project is a part of a larger study documenting the human modification of the shore of New York Harbor and identifying the technologic, economic, social and political factors driving those modifications. In addition to several articles in proceedings and journals, a book is planned which has been tentatively titled "The Shaping of the Harbor: Human alteration of New York Harbor 1609-1989." Determination of comparable data on the extent of human modification of the New York shore of New York Harbor has been accomplished under other auspices.

The Findings

The following table summarizes the findings from this research.

Period: early Seventeenth Century to the Present

Tidal marsh remaining tidal marsh:	@ 5,200 acres
Tidal marsh landfilled:	@ 28,000 acres
Underwater lands landfilled:	@ 293,000 acres
Land area converted to water:	@ 40 acres
Tidal marsh converted to water:	@ 950 acres
Land area now tidal marsh:	@ 150 acres
Water area now tidal marsh:	@ 500 acres
Net loss of tidal marsh to landfill:	@ 29,000 acres
Net underwater land landfilled:	@ 321,000 acres
Net loss of tidal marsh and land to dredging and/or erosion:	@ 100 acres
Net remaining tidal marsh	@ 5,900 acres

The following caveats are offered for these data:

1. The term "tidal marsh" has been deliberately used to avoid a term which might convey a more precise definition of the entity. Tidal marsh, as used here is meant to include those areas of wetlands (or, in the parlance of New Jersey officialdom, tidelands) which were interpreted by map makers past, or by us, as being tidally flooded.

2. Quality of tideland or tidal wetland is not to be inferred. That represented as tidal marsh, as distinguished from freshwater marsh, on maps was

used for the calculations in this paper. We have no means of knowing the biological composition of those marshes represented nor of the accuracy of their denomination.

3. The final disposition of each category listed above is that of the ultimate human action taken. That is, the assignment of the category "landfilled" means that the ultimate action was landfilling. But, the area may have been dredged at an earlier time and then landfilled. Similarly, marsh areas landfilled and then dredged are included only as "marsh to water."

4. Tidal marsh landfilled may include areas filled by natural accretion.

5. Land and water areas "converted" to water may be the result of dredging or of erosion, or of errors in digitization.

6. Land and water areas "now" tidal marsh may represent new growth of marsh, but more probably represent errors in the digitizing or in the original cartography.

7. All data are subject to the errors discussed below. Therefore they should not be taken as absolute numbers, but utilized as approximations.

Background

During the 1970's and 1980's the Office of Environmental Analysis (OEA) of the New Jersey Department of Environmental Protection (DEP) mounted an extensive program for the Tidelands Bureau of delineating the State's tidelands and in particular, determining the position of the original (pre-European contact) shoreline in order to establish its riparian rights. This important effort, accomplished with great rigor, resulted in the accumulation of an important collection of data, field documentation, aerial photographs, and other contemporary materials as well as historic maps and charts, many of which were enlarged and photo corrected for use as overlays on the 1/2400 scale 1977/1978 aerial photographs used as a rectified photo base for mapping. Most recently this tidelands line has been incorporated into the Department's geographic information system so that digital data may be extracted from the files as well as the production of maps at various scales. Additionally, the Division of Coastal Resources has an assortment of documents and other historic materials of great value to environmental historians together with an organizational memory which leads to yet other resources.

Through the financial support of this grant, I was able to visit the Bureau of Tidelands in Trenton, New Jersey, and to spend, in aggregate, over two weeks working on the maps and other materials there. Additionally, the opportunity was taken to visit for almost a week, the Office of New Jersey Heritage library, particularly the reports of the archaeologists working under the auspices of the New York Harbor Drift Removal Project of the U.S. Army Corps of Engineers. These reports are of very limited availability but an excellent and accessible collection is located in that Office. Additionally, support from this grant made possible visiting of the Hackensack Meadowlands Development Commission to gain information on the Meadowlands. That portion of the New Jersey shoreline was mapped separately, and earlier (1970). It has, since the time of this study, been incorporated into the digital file of the Tidelands Bureau.

Only part of the data collected are recorded in this report. Those presented are final calculations of the amount of landfill on the New Jersey shoreline between the Raritan River and the New Jersey/New York border to the north. Data additional to that reported on here includes calculations of the sequential landfill of both wetlands and shorelands, derived from the historic

overlay maps. That information will be more appropriately and fully presented in "The Shaping of the Harbor."

Procedure

A tape containing the digitized present day and historic shorelines of New Jersey was obtained from the Division of Science and Research, GIS Unit, Department of Environmental Protection. Through the cooperation of the Natural Resource Center, Connecticut Department of Environmental Protection, that tape was read and formatted on floppy disks for use in the University of Connecticut's Geographic Information Systems Laboratory, Department of Geography. Comparisons were made between the shoreline delineated by the OEA and those recorded from historic literature, maps and charts. It was quickly apparent that in areas of fill or perturbed shore the OEA's shoreline was that of the open water/land interface--the black line boundary of hydrography. This conservative shoreline thus failed to incorporate marshes flooded at high tide. As the acreage of those marshes which had been filled was of prime importance to this study, it was necessary to construct an additional map coverage.

For the purpose of delineating those tidal wetlands which had been filled, we selected the 1900 series U.S. Geological Survey maps of New York Harbor (Merrill et al, 1902). These topographic sheets, the earliest "official" standard projection maps of the region, depict those areas of tidal wetlands existing at the time of mapping (@ 1897). Additionally, the Surficial Geology maps show areas of filled land, at that time, as identified by the mappers. It should be noted in passing that the Folio 83, which includes New York Harbor, is not easily accessed. The Library of the Port Authority of New York and New Jersey has one as does the New York Public Library but only the latter institution has the photographic capabilities to reproduce the maps. Copies were made of both the Surficial and Historical Geological Maps in both black and white (slightly reduced photostats) and color (35 mm slides). The topographic maps accompanying the Folio are more widely held and were used as a base for preparing a new digital map of the presumed high tide line--that is, the shoreward margin of tidal wetlands. The extent of the Hackensack Meadowlands as mapped in 1897 (Merrill et al, 1902) was also digitized. It was also necessary to prepare a modern shoreline map of the Meadowlands for this area was not included in the Tidelands digitized shoreline made for us by NJ DEP. For the modern shoreline, we used mapping of disturbed and undisturbed marsh represented on an aerial photographic mosaic prepared by the Hackensack Meadowlands Development Commission.

Although it was unsatisfactory to compare shorelines digitized from scales of 1/62,500 (U.S. Geological Survey maps) and 1/2400 (Tidelands Bureau Base Maps), there was no alternative. There was an adequate degree of correspondence in projection between the two maps although they remained quite dissimilar in detail. Further corrections were made to the presumptive high tide line of the Geologic Folio maps from an assessment of historical maps, charts and reports I have assembled over the past three years. The final product was then two coverages or maps: a "modern" (@ 1980) shoreline and a shoreline approximating the high tide line of the 17th Century. From these, it was then possible to calculate the amount of landfilling. Further, because the Tidelands mapping was of the black line or open water boundary, it was possible to calculate the acreage of open water which had been filled (the areal difference between the "black line" historical shoreline and the modern shoreline) as well as the

acreage of tidal wetlands filled (the areal difference between the "historical high tide line and the "black line" shoreline).

The differences between the two shorelines was calculated from digital map coverages prepared in ARC/Info in the following matrix where: L = Land; W = Water; and, S = Tidal marsh.

Original land remaining land - L > L

Original land becoming water - L > W (presumptive dredging, erosion or map non-conformance)

Original land becoming wetland - L > S (possible dredging, more probably map non-conformance)

Original wetland remaining wetland - S > S

Original wetland becoming water - S > W (presumptive dredging)

Original wetland becoming land - S > L (presumptive landfilling)

Original water remaining water - W > W

Original water becoming wetland - W > S (Natural processes ? or, landfill? Possibly map non-conformance)

Original water becoming land - W > L (presumptive landfill)

Cumulative areas for each matrix category were calculated by ARC/Info in square feet and subsequently converted from square feet to acres. The areas reported above have been rounded upward to relieve a false impression of precision.

Error Estimation

The tidelands maps, and those prepared from digital data provided by OEA, represent an extremely detailed and accurate line in terms of analyses, placement and digitizing accuracy. The process utilized by staff scientists of the Office of Environmental Analysis, NJ DEP, in identifying that original shoreline was careful, conservative and well documented. Although judgement by OEA staff identifying the shoreline was involved in selection of the least altered, or natural, shoreline, those judgements were checked independently by at least two other OEA scientists. Placement of the shoreline on the photo mosaics was done by local fit to known features on other source map and historic map, and the delineation checked independently by two OEA scientists. Finally, the digitized line was proof plotted back to the original and checked to determine that the line was +/- 5 feet of the original line at 1/2400 scale. Further additions to this base were of considerably lesser accuracy. I am grateful to Richard Castagna, Bureau of Tidelands and Lawrence L. Thornton, Division of Science and Research, NJ DEP, for that description of process.

While the modern and historic shorelines provided by NJ DEP were detailed and highly accurate, the process used to derive a high tide line shoreward of the "black line" shoreline mapped by OEA introduced some substantial errors into the process. The scales of the two maps compared were substantially different (1/2400 vs. 1/62500) and accordingly the detail of the shoreline represented varied considerably. The accuracy of the earlier mapping compared with the modern (1897 vs. 1979) introduced further disparity.

Most authorities suggest that errors amounting to about 4% of the areal coverage are introduced by digitizing operator error and fatigue. While the New Jersey base maps were cross-checked to eliminate such error, digital maps prepared for this study did not receive such treatment. Further errors were introduced in the process of "adjusting" the various maps so that an overlay was

possible. The U.S. Geological Survey maps, despite high standards and excellent data collection techniques, also contain errors--some can be of significance (e.g. Butler, 1989). The largest source of error, of course, is in the interpretation of historical documents or in the acceptance of those accounts of what once was.

Because there is often no alternative source for the information contained in historical texts, maps and documents we lack instruments with which to cross check data. But, some quantification had been independently made of the areal extent of present day tidelands in New Jersey. By comparing those existing quantifications with the results obtained in this study, some sense of scale of possible error could be obtained. For example, Tiner (1984) estimated 4,061 acres of tidal wetlands in Bergen, Hudson, Essex and Union Counties (the latter two having no remaining tidal wetlands. That portion of Middlesex County north of the Raritan River is not included in his figure, but if half of its 3374 acres were included (4,061 + 1,687 = 5,784) there would be reasonable coincidence between the data calculated in this study (5,856 acres) and the estimate based upon Tiner's data (5,784 acres).

The Hackensack Meadowlands were subjected to special treatment in this study as both historic and present shorelines were digitized by my assistant. We calculated that 5,900 acres of marsh remain. A 1984 estimate made by the Hackensack Meadowlands Development Commission was of 6,120 acres of wetlands remaining (Data provided by Mark Kraus, formerly of Hackensack Meadowlands Development Commission). These two estimates are satisfactorily close because of the difficulties we encountered in interpreting the photographic images.

As an additional check, the data presented here were submitted to a number of acknowledged authorities on northern New Jersey coastal wetlands who were asked to assess the acceptability of the estimates. There was concurrence that the effort reported on here fairly represents the available information and that the procedures and caveats are appropriate.

The greatest source of error in the development of these data lies in the comparison of the U.S. Geological Survey maps (1/62,500 scale) to the digital maps of the DEP (1/2,400 scale). These maps are of such different detail of rendering of the shoreline, independently of errors of map making, that the estimate of landfilling may be too high. I feel confident that the wetlands data are probably correct to a factor of +/- 15%, that of the landfilled underwater lands may be as much as 30% too high.

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