

1992 - 2007

NEW JERSEY MEADOWLANDS



The Use of Historic GIS & 3D Terrain Modeling to Reconstruct the Archaeological Sensitivity of the Hackensack Meadowlands, New Jersey

Joel W. Grossman, Ph.D.

Between 1992 and 1995, Dr. Grossman directed the multi-staged federally mandated archaeological and historical sensitivity study of the New Jersey Meadowlands, known as the Special Area Management Plan, (or SAMP). The basin-wide and parcel specific investigations were undertaken as part of a federal Draft Environmental Impact Statement for hundreds of proposed development parcels within the basin. The staged series of cultural resource studies were conducted under contract with the CDM Corporation in compliance with Section 106 of the National Historical Preservation Act. It was executed as a multi-agency partnership between the U.S. Environmental Protection Agency, the U.S. Army Corps of Engineers, the New Jersey Department of Environmental Protection, and the Hackensack Meadowlands Commission.

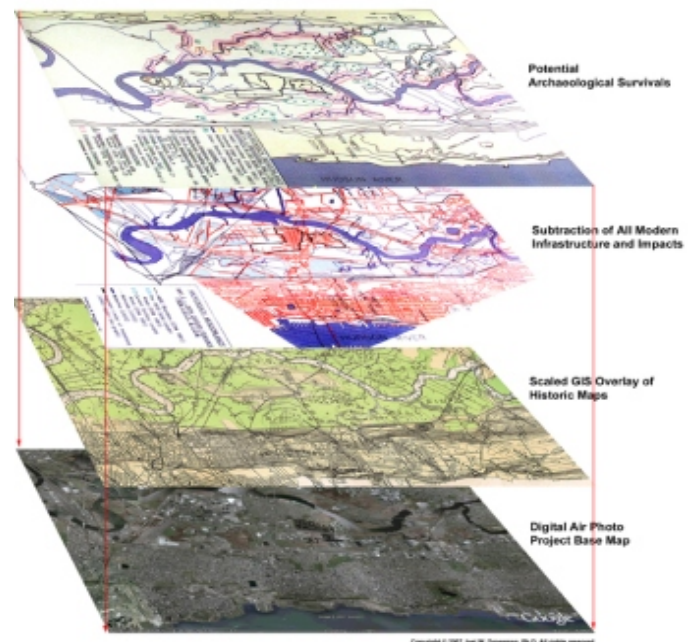
The study innovated through the early use of two geospatial strategies to evaluate the archaeological sensitivity of the Hackensack Meadowlands: the use of early GIS for the scaled comparison of historic and modern maps and air photos, and 3D paleo-environmental modeling to project colonial and prehistoric land use patterns over the past 3000 years. These approaches reflected four assumptions, 1) that the environment of the study area has changed significantly over the time span of human occupation in the region, 2) that potential archaeological sensitivity must be based on the evaluation of past, versus contemporary, environmental conditions, 3) that the now inundated basin contained extensive areas of formally exposed dry land and 4) that the ancient shoreline was some nine to 12 feet lower two to three thousand years before the present.

The 3D reconstruction used a mid-19th century Army survey of mud depths to render 3D terrain models of the now inundated landscape. It used modern dated pollen cores to then accurately populate the prehistoric topography with appropriate contemporary plant and tree varieties. The historic New Jersey State-commissioned bathymetric survey was digitized and georeferenced to the modern New Jersey State Plane coordinate system. Once tied to real world coordinates, the historic mud-depth records were

computer-processed into 2D contour plots and 3D mesh, or terrain, models of the basin as it appeared prior to being inundated by rising sea levels over the last three millennia. The resultant georeferenced terrain models defined areas of former dry land with fresh-water drainage, marshes and plant communities once amenable to human occupation.

GIS-based comparisons of historic and prehistoric land forms, and modern impacts, defined both areas of potential archaeological sensitivity, as well as disturbed or destroyed areas that could be excluded from the sample recommended for additional parcel-specific investigation. This process of *Historic Impact Analysis* focused project resources on only those parcels demonstrated to be both potentially sensitive, and devoid of past impacts. This non-random geospatial evaluation strategy also reduced the scope of project-wide cultural resource evaluation requirements by 80 percent (from 178 to 35).

These applied technology solutions – historic GIS to project historic survivals and 3D paleoenvironmental reconstruction to project prehistoric archaeological sensitivity -- have served as the primary analytical framework for the review of hundreds of New Jersey land use permit reviews by the NJDEP over the past decade. In 2007, in recognition of the potential sensitivity of now-submerged wetlands and in response to potential impacts from current federal marsh restoration efforts, a major US Army Corps of Engineers study recommended that these geospatial and paleo-environmental strategies (the “Grossman model”) continue to be implemented for current and future federally-mandated cultural resource evaluations of the Meadowlands.



Grossman, Joel W.

In Press Cultural Resource Investigation of Ten Sites in the Hackensack Meadowlands Restoration Project, Hudson and Bergen Counties, New Jersey. Prepared for the US Army Corps of Engineers, Region II, New York by Hunter Research with contributions and recommendations by Joel W. Grossman, Ph.D. and Dorothy Petecet, Ph.D. Contract No. DACW51-01-D-0018 Delivery Order No. 0046 - Draft 2006

2003 Revisiting the SAMP: The Use of GIS & 3D Terrain Modeling to Reconstruct the Meadowlands. Invited Paper before the NJ Meadowlands Commission, October 10, 2003

1995 “Historic and Cultural Resources” in Draft Environmental Impact Statement on the Special Area Management Plan for the Hackensack Meadowlands District, NJ. Vol. Sec. 5.16; Appendix J. Prepared for CDM, the USACE, NOAA, USEPA, NJDEP and the New Jersey Meadowlands Commission. June, 1995

1994 Hackensack Meadowlands Archaeological and Historical Sensitivity and Impact Evaluation, Vols. I-II. Prepared as part of the Multi Agency Special Area Study (SAMP) for CDM, the USACE, NOAA, USEPA, NJDEP and the New Jersey Meadowlands Commission.

1992 Stage IA Archaeological and Historical Sensitivity Evaluation of the Hackensack Meadowlands, New Jersey. Prepared for the Hackensack Meadowlands Commission.

INVITED PAPER ABSTRACT

Revisiting the SAMP: The Use of Historic GIS & 3D Terrain Modeling to Reconstruct the New Jersey Meadowlands

By

Joel W. Grossman, Ph.D.

*Abstract prepared for the Meadowlands Symposium,
New Jersey Meadowlands Commission, October 9-10, 2003*

Between 1992 and 1995, working as a sub-consultant to the CDM Corporation, Dr. Grossman directed a series of map based archaeological and historical sensitivity evaluations of the New Jersey Meadowlands Basin as part of the now superceded multi-agency Special Area Management Plan (SAMP) study. This staged series of increasingly more refined parcel assessments used GIS and 3D terrain modeling to reconstruct, project and evaluate past environmental conditions and archaeological sensitivity for 175 proposed development parcels covering a total of 6,200 acres out of a district total of 20,000, or for about 30% of the Meadowlands District. This GIS-based framework served to reduce the scope of project-wide cultural resource evaluation requirements by 80 percent (from 175 to 36) and, over the past decade, has served as the analytical framework for many New Jersey SHPO determinations regarding the possibility of the presence of cultural resources in the Meadowlands .

This paper will summarize the methodology and results of the original multi-staged SAMP historic/cultural studies, illustrating the two step process of first using GIS-based scaled comparisons of historic maps to define areas of potential archaeological sensitivity, both historic and prehistoric, and then second, examine the use of *Historic Impact Analysis*, or the scaled subtraction of all impacts to a study area, to refine and focus recommendations for additional archaeological assessment only to areas of limited, or no, demonstrable past disturbance. The paper will also illustrate the 1994 and modern application of 3D terrain modeling and paleo-environmental reconstruction using georeferenced historic Civil War era military bathymetry, dated pollen cores and marine transgression curves to graphically project the changing landforms and habitat of the Hackensack Meadowlands over the past 3000 years.

Finally, the presentation will highlight the untapped potential of these newer 3D GIS and terrain modeling technologies in conjunction with the emerging data base of critical historic and environmental map sources at the Meadowlands Commission to provide new insights into current and past environmental conditions of the now inundated New Jersey Meadowlands.

AUDIO VISUAL REQUIREMENTS: The talk will be accompanied with a CDR of digital images and streaming video animations of reconstructed past environmental conditions in the Meadowlands. A video projector and large format screen will be required.

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Between 1992 and 1995, working as a sub-consultant to the CDM Corporation, I directed a series of map based archaeological and historical sensitivity evaluations of the New Jersey Meadowlands Basin as part of the now superceded multi-agency Special Area Management Plan (SAMP) study. This staged series of increasingly more refined parcel assessments used GIS and 3D terrain modeling to reconstruct, project and evaluate past environmental conditions and archaeological sensitivity for 175 proposed development parcels covering a total of 6,200 acres out of a district total of 20,000, or for about 30% of the Meadowlands District.

This paper will summarize the methodology and results of the original multi-staged SAMP historic/cultural studies, illustrating the two step process of first using GIS-based scaled comparisons of historic maps to define areas of potential archaeological sensitivity, both historic and prehistoric, and then second, examine the use of Historic Impact Analysis, or the scaled subtraction of all impacts to a study area, to refine and focus recommendations for additional archaeological assessment only to areas of limited, or no, demonstrable past disturbance. The paper will also illustrate the 1994 and modern application of 3D terrain modeling and paleo-environmental reconstruction using georeferenced historic Civil War era military bathymetry, dated pollen cores and marine transgression curves to graphically project the changing landforms and habitat of the Hackensack Meadowlands over the past 3000 years. The study was conducted in two phases between 1992 and 1995 under the auspices of the United States Environmental Protection Agency, the U.S. Army Corps of Engineers, the New Jersey Department of Protection and Energy, and the Hackensack Meadowlands Commission.

The initial 1992 study summarized and plotted all known prehistoric and historic sites, the extent of past survey coverage and areas of potential sensitivity. A series of map overlays of different periods and information were overlaid and referenced onto the CDM

(Camp Dresser McGee) project maps of wetland, infrastructure and potential development areas. In addition to published archival and cartographic sources, oral history and the files of the NJDEP OHP, much of this first study drew upon the work and preservation concerns raised by our recently deceased colleague and mentor, Ed Rutsch in his 1978 study.

In 1994 and 95 a second phase was initiated by the agencies to address new alternatives and to evaluate and reduce the number of parcels in need of additional archaeological survey and assessment through the elimination of disturbed or impacted areas. Identified impacts included, historic and recent ditching, land fills, road and rail construction, and impacts from industrial development. Field survey data was augmented with quantified image analysis of low altitude 1963 - 1992 air photos.

This strategy of scaled map comparisons through time provided a concrete set of criteria for reducing the overall sample to a relatively small number of potentially sensitive study areas and that demonstrated a potential for survival due the lack of any demonstrable and substantial impacts.

The staged GIS-based **Historic Impact Analysis** focused project resources on only those parcels demonstrated to be both potentially sensitive and devoid of past impact and. reduced the scope of project-wide cultural resource evaluation requirements by 80 percent (from 178 to 35). As was by Tedrow of Rutgers University in 1969 as part of his study of environmental change as in-depth study done for litigation over riparian rights, we recommended five localities be investigated with radiocarbon dated pollen cores for environmental reconstruction (Grossman 1994; Terdrow 1969).

(SLIDE) In 1996 and 97 the Department of the Army Planning unit of Aberdeen Proving Ground, in conjunction with the Advisory Council of Historic preservation, requested that I summarize and codify this methodology and provide case studies from prior Federal projects to develop a protocol or framework on the use of applied technology, including historic GIS based Impact Analysis in the cultural resource planning process. In addition to being cost effective, it also helps the archaeologist find things, both at the regional, local and site specific level. Here, for example in Puerto Rico we georeferenced and compared (added and subtracted) scaled plots of Total Station

surveyed coconut tree locations, geophysical anomalies of trash concentrations, land crab nests and artifact density plots. By first defining and then avoiding disturbed and/or low yield or integrity areas of the site, the rescue excavation yielded thousands of undisturbed prehistoric Carib artifacts and the in tact house remains dating to 600 A.D., and as a result finished on time and on budget. .

In Lower Manhattan, we used computer scaled map comparisons of the South Ferry Terminal project to identify areas of potentially surviving early 17th and 18th century deposits, comparable to those of the Dutch West India Company site discovered in tact beneath the modern water table and the subsequent 19th and 20th century rubble and basement floors.

The scaled historic map comparisons of the Meadowlands provided good data on the 19th and 20th centuries, less for the 17th and 18th centuries, and little for the prehistoric periods. To address the earlier 17th century and prehistoric sensitivity of the Meadowlands it was necessary to reconstruct what it was or may have been several hundred or thousand years ago, based on what it looked like then versus today. What was the past topography and landscape like, what was the habitat diversity of the area?

To answer these questions it was necessary to reconstruct the meadowlands basin as it looked like thousands of years ago before it was inundated. Two independent lines of evidence, the first from pollen, the second, cartographic from a unique mid-19th century map, clearly suggest that the environment and ecology of the Meadowlands has undergone significant change, both over at least 3,000 years of prehistoric human occupation, and even perhaps over the more recent historic period, from the 17th and 20th centuries, as well.

The first line of evidence, from vertically controlled and radiocarbon dated pollen cores, suggests that the Hackensack Meadowlands began to emerge as a salt marsh some 1,500 to 1,800 years before the present, during the Woodland Period of Native American occupation. At around 2,500 years before the present, the Hackensack Meadowlands consisted of a hardwood forest environment with stands of oak and alder growing beside fresh water streams. About 800 years before the present (ca. 1,200 A.D.), a time period which correlates with the latter phases of the Native American Woodland Period, the

vertical pollen record indicates that the salt grass dominated Meadowlands were significantly altered by the spread of cedar trees, until they died off from saline intrusion and human harvesting in the by the mid 19th century (Grossman 1992, 1994, 1995; Heusser 1963; Carmichael 1980; Sirkin 1982; Rue and Traverse 1997). More recent pollen sequences by Rue and Travers have expanded the repertoire of pre-marsh habitat to include oak hemlock and hickory, sedges and other indicator plants that suggest a shift to warmer conditions around 2000 to 3000 years ago. Their work also picked up trace amounts of pollen of white cedar in the columns to an ill defined time depth. The issue of refining the onset of cedar into the basin holds the promise of becoming much clearer with the new and very exciting controlled dendro-chronological studies here by Zimmerman (2003). Instead of being nearly flat, this computer generated topography from Bien and Cooks mud depth probes suggest a varied topography with a vertical range of at least 15 to 20 feet.

The second line of evidence was cartographic, and was made possible by the availability of an 1869 map produced as part of an Annual Report of the State Geologist on the Environment of Sedimentary Conditions of the New Jersey Meadowlands (Cook 1869). George Cook had been appointed in 1864 to produce an accurate map of New Jersey. Surveyed by Edward Bowser, the resultant 1869 map published by Julius Bien, represented the state's initial attempt to produce an accurately surveyed map of this and other major drainages. The map was decried as being too inaccurate, and, brought about the appointment of Cornelius C. Vermuele in 1879 to produce a more accurate topographic, drainage, and vegetation survey of the Hackensack drainage than the Cook and Bowser version of two decades earlier (Thomas Flagg 1994, pers. comm.).

Cook did two things for to make his map. He surveyed and described the extent of various mud and marsh deposits, "Blue Mud; Blue Mud and Peat, versus Cedar Swamps" in an effort to understand why 19th century reclamation efforts had failed in this drainage while succeeding elsewhere (Ibid). Second, Cooks probed, surveyed and recorded detailed bathymetric data on sediment depths at a large number of sample locations in the lower portion of the drainage, especially in the vicinity of Snake Hill, formally Indian Hill in the 18th Century. The Bien Cook data was plotted and turned into 2D contour and 3D mesh models. This step gave us the skeleton or raw mesh surface of

the basis as was before being filled with sediment. But to address what the place actually looked like we need a tight chronological control of the relative sea level over the same period and here is where we run into trouble. What it looked like depended on how far down below the modern level the mean high tide actually was. Given the vertical topographic range of Bien's marsh depth readings, the deeper or lower the prehistoric and historic water levels, the more diverse the environment and ecology the exposed land.

What remained a bit more open ended was just how low the sea level 400 or even 1000 years ago was? When we did the original study almost ten years ago, we adopted the consensus at that time that sea level rise was a gradual and easily quantifiable process which in turn would permit us to fix the relative transgression levels within the basin over time as a straight regression curve. Then available studies suggested that the sea level had risen at a rate of approximately 1 to 1.5 meters (ca. 3 to 4.5 feet) per 1,000 years, or at about 11 inches per century (Heusser 1963; Stuiver and Daddario 1963; Bloom 1978; Oldale 1986, Kraft 1980). In terms of the New Jersey Meadowlands, these averaged long term rates of marine transgression then suggested that rise in mean high tide in the area was somewhere around 1.5 to 2 feet below present levels only 500 years ago, some 3 to 4 feet lower 1,000 years ago, and 6 to 8 feet lower some 2,500 years ago (Grossman 1992).

Since, I had not looked at the data for this area pertaining to regional patterns of sea level rise since the mid 1990's, and spurred by a recent boat ride with Brent Bragan, I took this occasion to review the literature for new insights concerning sea level rates for the late prehistoric and historic periods. I started with the most recent, EPA, Environmental Defense Fund and UN and the most current world-wide syntheses, including the Chapter 11, the Scientific Basis, from the 2001 Climate Change Report by the IPCC. I looked at regional sources, and I looked at current archaeological and geomorphological sources from work in the marshes both here, the Chesapeake marshes to the south, and from Connecticut, Rhode Island and Massachusetts to the north.

Basically, as I argue, we don't in fact have much to go on. To my surprise, I found relatively little that would help answer my question for the colonial and prehistoric periods in the New Jersey Meadowlands. As I will argue below, more recent findings now suggest that the rate during the late prehistoric and historic periods may have been both greater than previously assumed, and perhaps not uniform or gradual. In fact, it now

looks like we can not, or better do not have good data, to determine what the rate, or rates actually were for the intervening period between ca. 400 and 2,500 years ago. And even the near historic pre tide gage period from between 150 and 400 years ago may not be an open an shut case.

There is a general consensus that the average global trends in sea level rise have ranged somewhere between 5 and 30 cm/ century, with a median range 10 and 25 centimeters over the 20th century commonly cited (Neumann, et. al. 2000; Nichols 2002, 86; Bloomfield 1999; Gornitz 1993; Bird 1993; Houghton et al., 2001). Most in turn, cite the world wide records of the Intergovernmental panel on Clime Change (IPCC) as the primary source, with a “best estimate” of 18 cm per century, over the last 100 to 150 years.

The 2001, Third Assessment of the Intergovernmental Panel on Climate Change Climate Change 2001: the Scientific Basis, cites long term trends the general trends for the last 6000 years of 2.5 to 3.5 meters, with a reduced rate suggested for the last 3000 years of 10 to 12 cm per century, and transatlantic contrasts suggested by a rate of 10 cm per century for the North Sea region of northern Europe, versus a rate of between 14 and 19 cm/century for the Atlantic Coast of North America (Houghton 2001, 661). As Gornitz has underscored with her work on criteria for using internal sea level trends, we can’t use northern European data (Gornitz 1993).

But this is where the consensus lessens, and the gaps in our data become more prominent. The 2001 Climate Change study highlights, or better, bemoans, the fact that our current projections are based on either recent tide gage records or considerably older radiocarbon dates from the basal deposits of estuary sediment formations, but pointed to little available data for the intervening period between some 2500 years ago and 150 years ago (Carmichael 1983???, Heusser , Thorbahn abd Cox, 1988). **We have models and** assumptions, and models based on models, but little concrete data, and when available as I argue below, even these sources must be approached with caution.

(SLIDE) The earliest continuous European tide Gage records is that from the seal level records taken at the Stockholm sluice gates controlling the flow between the Lake Mälaren and the Baltic Sea with an almost an uninterrupted measurements of seal levels from 1774 to the present (Ekman 2003).. However, as this graph of annual readings

readily demonstrates, the pattern of change is the obverse of ours in the Mid-Atlantic, and is thus of little use for characterizing 18th century trends in the Meadowlands.

The earliest records in continental US are from Key West, Florida beginning in 1846, but the lack of glacial impacts makes this data iffy for the Mid-Atlantic region (Houghton et. al., 2001, 663). For our immediate region of New York and New Jersey, historical trends have relied predominantly on patterns evidenced by 19th century Tide Gage records which begin only as of 1856. But even these are subject to interpretation. As of today there are four different estimates from short term NYC 19th and 20th century tide gage records alone, ranging from 10 to 20 cm per century over 150 years, two at 15cm per century, one with 19 cm per century, and one at 2.0 cm per century, hardly a consensus (Gornitz 1995, Davis and Mitrovica 1996, Peltier 1996, and Peltier and Jiang 1997).

But a record of only 150 years does little to reveal past rates of marine transgression for the prior several hundred to thousand years. While most of the historical treatments of sea level rise were limited to the ca. 150 year sequence of tide gage readings, a number of scientists have attempted to use marsh accretion rates and archival records of shoreline erosion and land loss to extend this the historical record of sea level rise back in time by several hundred years into the colonial period. Working in the marshes of the Chesapeake in Maryland, Kearney and Stevenson utilized historic land grant records from the 17th and 18th centuries to project the onset of rapid increase erosion and submersion beginning in the mid-19th century, with formally inhabited islands of 600-1,400 acres dropping to a fraction of their original size or to submerged shoals between ca. 1850 and 1980 (1991). This pattern is paralleled by the inundation and abandonment of 17th Dutch land grant areas in the vicinity of Penhorn and Chromakil Creeks, in the now inundated meadows east of Secaucus (Grossman 1994, 1995).

Recent studies to the north along the coasts of Nova Scotia and Main by Gehrels and Cairns have used have used foraminiferal and salt marsh sequences to project push sea level records back 300 years to 1750 AD. This historic sequence in turn yielded unexpected rates of sea level rise from this period of 30-50 cm per century in Main and of upwards to 60 cm. for Nova Scotia with most of the rise taking place in the 18th century and with little or no increase in the 19th century (Gehrels, 2001).

This pattern of historical fluctuations in the rate of sea level rise has been echoed by comparable arguments for the coastal marshes of Connecticut. Cited as a key source in the 2001 Climate Change synthesis, Venekamp, Thomas and Van de Plesch used relative sequence of foraminifera coupled with fluctuations metal trace elements to project patterns of sea level rise back in time to some 1500 years before the present. Their findings are both radically at odds with a quiescent view of uniform and slow sea level rise in the prehistoric historic period. Their work suggested that historic sea level rise was neither gradual or uniform, but in fact “punctuated” by three historic intervals of rapid and relatively sudden sea level rise, the first around 1200 – 1450 A.D., and the second around 1700 AD., with a third increase in sea level rise between 1876 and 1900 A.D. (ibid, 298).

I have no squabble with their findings which are important and refreshing, but what concerns me as an archaeologist, is the chronological framework upon which their elegant modeling is based. I accept their relative chronology of floral and faunal succession. This is a relative sequence, and I’m not competent to access it, or other similar geomorphological models based on the same approach, what concerns me is the evidence used for dating these events. The authors tagged their sequence at it’s upper end to the influx of iron and copper effluents into the ecosystems as key time markers. To quote, they fixed their chronology with the brief characterization that ...”cu and zinc provides a useful marker of A.D. 1860” with no less than four citations to support this chronological benchmark for their sequence (Verekemp, Thomas and Van de Plassche (1992, 295). In other words, it was simply taken for granted that this date is a good one.

The reconstruction has no historical or chronological time markers for the 17th and 18th centuries. Of equal concern, is the use of the appearance of copper and zinc to “date” the upper end of their sequence to 1860. It doesn’t match comparable traced element data taken from the Hudson fronting West Point.

(SLIDE) Between 1989 and 1994 I spent five years directing the mitigation of the terrestrial and marine remains of the 1730 to 1860 remains of West Point Foundry. On land, our the Hazmat archaeologists excavated the remains of elements of the Unions 30,000 pound rifled cannon, workers housing and a preserved prehistoric site beneath their foundations of their homes. (SLIDE) We also undertook intensive marine side scan

sonar, magnetometer, historic GIS based bathymetric studies to look for sunken ships and submerged ordinance. I needed to know what depth any such items may have sunk into the river sediments. We also took controlled *vibra*-core sample to measure metallic trace elements as potential time markers to date the sediments.

Instead of the mid 19th century, these contaminants appear to have been present from the onset of Foundry operations, beginning in 1818, not half a century later during the Civil War era production.

Given the limited dating evidence available for these late Holocene models, I decided look in my own back yard for possible data, namely the historical archaeological record of the mid-Atlantic. I kept harking back to an earlier 1985 paper by Dr. Shomrette, a noted expert in the historical archaeology of the Chesapeake and an archaeologist with considerable experience in the excavation of now submerged 17th and 18th century Colonial features. (SLIDE) In 1985 Shomrette excavated a waterlogged double barreled cistern from a Colonial settlement dating to between 1683 and 1776

Describe original and alternate interpretation.

But examples were in Maryland, so I looked closer to home, (SLIDE) to my earlier work on the discovery of the buried mid-17th century Dutch West India Company (SLIDE) site, found intact and well preserved between 8 and 12 feet below modern grade (SLIDE) together with some 25,000 well preserved diagnostic features and artifacts dating to 1650 and 1680. (SLIDE) As I did with the Maryland archaeological features, (SLIDE) I compared the 1985 high water mark to what I projected to be the maximal mid-17th century high watermark. I based this projection on the assumption that the double barrel features were for fresh water collection and/ or storage. I also assumed that the colonial high water mark was below the base of each feature, and that they had been initially constructed by the Dutch to be above the level of brackish water from high tides.

The results do not jive with historic 19th C records. In contrast to tide gage derived trend of ca 11“ per century in the 19th and 20 centuries, these Colonial Dutch below water table features suggest episodes of higher rates of 18 and 23 inches for the earlier 17th and 18th centuries. Whatever the case, these archaeological records do not substantiate the unquestioned projection of historic tide gage data back into the 18th and 17th centuries without caution.

Now I don't know what this previously unnoticed data means in the larger scheme of advanced climate and marine transgression modeling, but at the very least these common features of Colonial archaeological sites may hold some helpful evidence and an independent chronological framework for approaching the question of sea level rise for the 17th and 18th centuries, equal to, if not chronologically tighter than, many of the purported sequences of faunal and floral shifts in the literature. For years archaeologists have viewed these features as critical environmental time capsules. Now perhaps we should also see them as inadvertent archaeological tide gages as well.

(SLIDE) So let's assume that in fact the water table in the colonial table was lower by some four to five feet, versus only two or three feet, and if we add even a conservative of three feet per millennium rate to this, then the colonial landscape would have been much dryer and more amenable to occupation than we had supposed. The prehistoric landscape could have been some 15 to 20 feet lower around 2000 years ago. This greater level of exposed land would also imply a greater environmental diversity for the pre-marsh drainage than previously projected. Instead of being limited to merely a single brackish swamp environment, given the topographic diversity indicated by Cook and Bien's depth readings, and using Peterson's field guide as reference, we may have had a diverse range of habitats, including low, middle and high marsh settings, an upland Oak-Hickory complex, Northern Riverene (Floodplain) and Northern Riverene Forrest habitats, as well as damp fresh water Boreal Bogs low lying areas.

And as a final exercise, let us bring the Meadowlands back to the present, with a little help from the Boss (Last slide-3D Animation of Meadowlands Inundated over time).

Thank you.

Documentary References

Alade, Damilola, et. al.

- 2002 Climate Impacts in New York City: Sea Level Rise and Coastal Floods. Institute for Climate and Planets Goddard Institute for Space Studies.

Alterman, Michael L., et al.

- 1989 New Jersey Turnpike Widening Project, Cultural Resources Investigation, Interchange 11 to Southern Mixing Bowl . Prepared for the New Jersey Turnpike Authority.

Anderson, Matthew G. and Jill Cremer

- 1990 Historic Preservation Fund Survey and Planning Grant Activities in New Jersey Trenton, NJ: Office of New Jersey Heritage.

Anonymous

- 1973 An Historical Consideration of Tidal Flow in the Hackensack Meadowlands. Prepared for the HMDC. July, 1973.

Anonymous

- 1887 Geological Survey of New Jersey. Annual Report of the State Geologist for the year 1886.

Antonioli, Fabrizio & Oliverio, Marco

- 1996 Holocene Sea- Level Rise Recorded by a Radiocarbon- Dated Mussel in a Submerged Speleothem beneath the Mediterranean Sea.(Art. In, Quaternary Research 45, 241-244, art. No. 0024)

Archaeological Survey Consultants, Inc.

- 1981 An Archaeological Survey of the Proposed Secaucus Housing Project, Secaucus, Hudson County, New Jersey,. Montclair, NJ:

Archaeological Survey Consultants.

- 1982 A Phase IA Archaeological Survey of the Proposed 201 Step 1 Facility Plan for the Borough of Wood- Ridge, New Jersey . Montclair, NJ: Archaeological Survey Consultants, Inc.

Artemel, Janice

- 1979 Historic and Archaeological Resources of the Northeast Corridor New Jersey Newton, NJ: Cultural Resource Management Services, Inc. Prepared for DeLeuw, Cather/Parsons.

Barghoorn, E.S.

- 1953 Recent Changes in Sea Level along the New England Coast: New Archaeological Evidence. Science Volume 117 No. 3048 pgs. 597-598, May 29, 1953. Washington, D.C.

Bateman, Fred

- 1978 "The Marketable Surplus" in Northern Dairy Farming: New Evidence by Size of Farm in 1860. Agricultural History 52:345-363.

- Berger, Louis and Assoc.
1984 A Phase IA Cultural Resource Reconnaissance for the Veterans Nursing Facility, Paramus, New Jersey. East Orange, NJ: Louis Berger and Associates, Inc.
- Bernabo, J.C., and Webb, T., III
1977 Changing Patterns in the Holocene Pollen Record of Northeastern North America: A Mapped Summary. Quaternary Research (Academic Press, New York) Volume 8 No. 1 pgs. 64-96, July 1977
- Bird, E.
1993 Submerging Coasts: The Effects of a Rising Sea Level on Coastal Environments. John Wiley & Sons.
- Bloom, Arthur L.
1978 Geomorphology. A Systematic Analysis of Late Cenozoic Landforms. Prentice-Hall, Inc., Englewood Cliffs, NJ.
- Bloom, A.L. and Stuiver, M.
1963 Submergence of the Connecticut Coast. Science Volume 139 No. 3 552 pgs. 332-334, January 25, 1963. Washington, D.C.
- Bloomfield, et al.
1999 "Hot Nights in the City Global Warming, Sea Level Rise and the New York Metropolitan Region." www.edf.org/.
- Bodie, Debra C. and Patrick H. Garrow
1983 Assessment-Level and Reconnaissance-Level Review of the U.S. Army Corps of Engineers Proposed Saddle River - Sprout Brook Flood Control Project, Bergen County, New Jersey . Marietta, GA: Soil Systems, Inc.
- Boylan, James
1979 Phase I Archaeological Survey of Proposed Passaic Valley Sewerage Commission's Newark Sewage Treatment Plant Sludge Storage Facility. Report on file, Office of New Jersey Heritage, Trenton.
- Braun, D.P.
1974 Explanatory Models for the Evolution of Coastal Adaptation in Prehistoric New England. American Antiquity Volume 39 No. 4 Pp. 582-596, October 1974. Washington, D.C.
- Britton, Nathaniel Lord.
1889 Catalogue of Plants Found in New Jersey. NJ Geological Survey, Final Report State Geologist 642 p. (in Sipple 1972).

- Britton, Nathaniel Lord and Hon. Addison Brown
1913 An Illustrated Flora of the Northern United States and Canada. Volumes I-III, Reprinted 1970. Dover Publications, Inc. New York, NY.
- Brooks, John
1957 A Reporter at Large: The Meadows, Parts I and II. The New Yorker March 9, 1957, pp. 98-104, and March 16, 1957, pp. 108-114. New York.
- Brush, Grace S.
n.d. Palynological Analyses of Borings From the Lyndhurst Site of the New Jersey Meadowlands. Report prepared for the U.S. Environmental Protection Agency, by the New Jersey Turnpike Authority.
- Brydon, Norman F.
1974 The Passaic River: Past, Present, Future. Rutgers University Press, New Brunswick, New Jersey.
- Burnett, Louise Howes, Howard I. Durie, and Frederick W. Bogert
1966 Guide to the Documentary Collections of the Bergen County Historical Society. Bergen County Historical Society, Hackensack, New Jersey.
- Carmichael, D.P.
1980 A Record of Environmental Change During Recent Millennia in the Hackensack Tidal Marsh, New Jersey. Torrey Botanical Club Bulletin Volume 107(4):514-524, Oct.-Dec. 1980. Lancaster, Pa.
- Chesler, Olga, ed.
1982 New Jersey's Archaeological Resources from the Paleo-Indian Period to the Present: A Review of the Research Problems and Survey Priorities. Trenton: Office of Cultural and Environmental Services, New Jersey Department of Environmental Protection.
- Chittick, William F., et al.
1980 Preliminary Cultural Assessment for Proposed Widening of Route 1 and 9, Tonnel Avenue Bergen and Hudson Counties New Jersey .
- Church, J.A., J.M. Gregory, P. Hugbrechts, M. Kuhn, K. Lambrecht, M.J. Nhuan, Q. Qin and P.L. Woodsworth
2001 Changes in Sea Level. In Houghton, et. al., Climate Change 2001: The Scientific Basis. Cambridge University Press, Cambridge, pp. 639-693.
- Clayton, Woodford W.
1882 History of Bergen and Passaic Counties . Philadelphia: Everts and Peck.

Meadowlands References-2003

Joel W. Grossman, Ph.D.

Coad, Oral S.

- 1972 New Jersey in 'Travelers' Accounts, 1524-1971: A Descriptive Bibliography.
 Scarecrow Press, Metuchen, New Jersey.

Colman, S.M., and Bratton, J.F.

- 2001 Changes in sediment flux and diatom productivity over the last millennium in Chesapeake Bay.
(International Geosphere Biosphere Program, Open Science Meeting, July 2001.)
<http://woodshole.er.usgs.gov/bibliographies/inpress/2117.html>

Cunningham, John T.

- 1959a Monumental Meadows: Few Realize the Importance of 30,000 Acres of Wasteland Lying in
Shadow of the World's Greatest Metropolis. Newark Sunday News Magazine, February 8,
1959, pp. 5, 22-25.
- 1959b Natural Wonderland: Progress Has Cost the Jersey Meadows Its White Cedar Forest, but the
Marshes Still Offer Assorted Game for Hunters, Many Birds and Flowers for the Nature Lovers.
Newark Sunday News Magazine, March 1, 1959, pp. 20-23.

Dally, Joseph W.

- 1873 Woodbridge and Vicinity: The Story of a New Jersey Township. Reprinted 1967. Hunterdon
House, Madison, New Jersey.

DeLotto, Sister Doris

- 1973 An overview of the Hackensack Meadowlands from its Geological Beginning to the Present.
M.A. thesis, St. Louis University, St. Louis, Missouri. Available at the New Jersey Historical
Society, Newark, New Jersey.

Douglas, B.C.

- 2000 Sea Level Change in the Era of Recording Tide Gages. In Douglas, B.C., M.S. Kearny and S.P.
Leatherman (eds), **Sea Level Rise: History and Consequences**. Academic Press, London, pp.
37-64

Douglas, B et al.

- 2001: Sea Level Rise: *History and Consequences*. Academic Press.

Drummond, James O.

- 1979 Transportation and the Shaping of the Physical Environment in an Urban Place: Newark
1820-1900. Ph.D. dissertation, New York University.

Dumont, E.

- 1979 Of Paradigms and Projectile Points: Two Perspectives on the Early Archaic in the Northeast.
Bulletin of the New York State Archaeological Association 74:38-52.

- Ekman, Martin
1988 The worlds longest continued series of sea level observations. *Pure and Applied Geophysics*, 127, 73-77
- Ekman, Martin
1999 Climate Changes detected through the worlds longest sea level series. *Global and Planetary Change*, 21, 215-224.
- Ekman, Martin
2003 "The World's Longest Sea Level Series and a Winter Oscillation Index for Northern Europe 1774-2000", *Small Publications in Historical Geophysics* No.12 .
- Emery, K.O. and D.G. Aubry
1991 Sea Levels, Land Levels and Tide Gages. *Springer Verlag*, New York.
- Fairbridge Rodes W.
1960 The Changing Level of the Sea. (reprinted from *Scientific American* May 1960)
- Fimbel, Deborah
1987 Investigation of the Outwater Family Cemetery, Washington Avenue, Borough of Carlstadt, Bergen County, Technical Environmental Study Cultural Resource Investigation . Prepared for the New Jersey Department of Transportation Bureau of Environmental Analysis.
- Fittipaldi, Janet
1983 Subsurface Cultural Resource Survey of Proposed Electric and Telephone Lines at Von Steuben House River Edge, Bergen County . New Jersey Department of Environmental Protection Green Acres Program.
- Fleming, K, P. Johnston, D. Zwartz, Y. Yokoyama, K Lambeck, and J. Chapell,
1998: Refining the eustatic sea level curve since the Last Glacial Maximum using far- and intermediate-field sites, *Earth Planetary Science Letters*, **165**,327-342.
- Fleming, N.C. and C.O. Webb,
1986: Regional patterns of costal tectonics and eustatic change of sea level in the Mediterranean during the last 10,000 years derived from archaeological data. *Zeitschrift für Geomorphologie*. December, Suppl – Bd62, p.1-29.
- Gaffin, S.
1997 (November) “ Impact of Sea Level Rise on Selected Coasts and Islands” www.edf.org/...
- Galvin, Cyril
2003 Measuring The Sea. Letter to the editors of the New York Review of Books, in response to What a World! <http://www.nybooks.com/articles/16530>

- Garfinkel, Alan P. and Bobby L. Lister
1983 Effects of High Embankment Construction on Archaeological Materials Transportation Laboratory, California Department of Transportation, Sacramento.
- Gaudeau, Denise C.
1988 The Distribution of Late Quaternary Forest Regions in the Northeast: Pollen Data, Physiography, and the Prehistoric Record. In *Holocene Human Ecology in Northeastern North America*, Edited by George P. Nicholas. Plenum Press, New York and London. Pp. 215-253.
- Gehrels, W. Roland and Cairns Ann
2001 New Evidence for Sea-Level Rise Along the Coasts of Maine and Nova Scotia. Media Alerts Archive. <http://earthobservatory.nasa.gov/Newsroom/MediaAlerts/2001/200111055281.html>
- Gifford, J.
1895 A Preliminary Report on the Forest Conditions of South Jersey. N. J. Geol. Survey, Annual Report of the State Geologist, 41 p. (in Sipple 1972).
- Gimigliano, Michael N. et al.
ca.1979 An Archaeological Survey for the Erie-Lackawana Improvements Project . Newton, NJ: Cultural Resource Management Services, Inc.
- 1979 A Stage IA Cultural Resources Survey of the Proposed Bergen County Utilities Authority Composting and Incineration Facilities Bergen County, New Jersey . Newton, NJ: Cultural Resource Management Services, Inc. Prepared for Clinton Bogert Associates.
- Goldman, Clifford A.
1975 Hackensack Meadowlands. M.A. thesis, Princeton University, Princeton, New Jersey. Available at the New Jersey State Library, Trenton.
- Gornitz, V.,
1995: A comparison of differences between recent and late Holocene sea level trends from eastern North America and other selected regions. *Journal of Coastal Research*, Special Issue 17, Holocene Cycles: Cycles Climate, Sea levels and Sedimentation, C.W. Finkl, Jr (ed.), pp.287-297.
- Gornitz, V,
2000: Impoundment, groundwater mining, and other hydrologic transformations: impacts on global sea level rise. In *sea level rise: .history and consequences*, B.C. Douglas, M.S. Kearney and S.P. Leatherman (eds.), Academic Press, 97-119.
- Gornitz, V., and S.Lebedeff,
1987: Global sea level changes during the past century. In: *sea level Fluctuation and Coastal Evolution*, D Nummedal, O.H. Pilkey and J.D. Howard (eds.), Society for Economic Paleontologists and Mineralogists, pp. 3-16 (SEPM Special Publication No. 41).

Gornitz V. and Solow, A.

- 1991: Observation of long -term tide-gauge records for indications of accelerated sea level rise. In, Greenhouse-gas-induced climatic change: a critical appraisal of simulations and observations, M.E. Schlesinger (ed.), Elsevier, Amsterdam, pp.347-367.

Gornitz V.

- 1993: *Mean sea level changes in the recent past.* Art. In Climate and sea level change: observations, projections and implications. (ed. By R.A. Warrick)

- 2000: Rising Seas: A View from New York City. Goddard Institute for Space Studies.

<http://www.giss.nasa.gov/research/intro/gornitz-05/>

Gornitz, V.S. Couch, and E.K. Harting.

- 2000: Climate change and the coast: Impacts in the New York City metropolitan region. *Eos* 81, S73

- 2001: Impacts of the sea level rise in the New York metropolitan area. *Global Planet, Change* 32, 61-88.

Gornitz V., C Rosenzweig, and D. Hillel,

- 1997: Effects of anthropogenic intervention in the land hydrological cycle on global sea level rise. *Global and Planetary Change*, 14, 147-161.

Graham, John Patton

- 1982 Union County Historic Sites Inventory. Sponsored by the Union County Cultural and Heritage Council and Office of Cultural and Environmental Services, Trenton, New Jersey. On file, Office of New Jersey Heritage, Trenton.

Green, Martha

- 1976 The Hackensack Water Company: A National Reputation for Water Quality. Meadowlands USA, July 4, 1976, p.9.

Grossman, Joel W.

- 1992 Stage IA Archaeological and Historical Sensitivity Evaluation of the Hackensack Meadowlands, New Jersey, Prepared for the Hackensack Meadowlands Development Commission.

- 1994 Hackensack Meadowlands Archaeological and Historical Sensitivity and Impact Evaluation, Vols. I-II. Prepared as part of the Multi Agency Special Area Study (SAMP) for CDM, the USACE, NOAA, USEPA, NJDEP and the Meadowlands Commission.

- 1995 “Historic and Cultural Resources” in Draft Environmental Impact Statement on the Special Area Management Plan for the Hackensack Meadowlands District, NJ. Prepared CDM, the USACE, NOAA,USEPA, NJDEP and the Meadowlands Commission. June, 1995

- 1997 “Applied Technology in Archaeological Investigation.” U.S. Army Environmental Center, Aberdeen Proving Ground Maryland, 139 pp.

- 2003 *From Raritan Landing to Albany's Riverfront: The Path Toward Total 3D Archaeological Site Recording.* In Fisher, Charles, Ed. *People, Places and Material Things: Historical Archaeology of Albany, New York.* Chapter 15: Battles and Breakthroughs, 167-186. New York State Museum Bulletin 499, The University of The State of New York, The State Education Department, Albany, New York.
 - 2003 Revisiting the SAMP: The Use of GIS & 3D Terrain Modeling to Reconstruct the Meadowlands. Invited Paper before the NJ Meadowlands Commission, October 10, 2003
- Grubb, Richard
- 1989 Stage IB Cultural Resource Survey Wood-Ridge Wastewater Treatment Plant Borough of Wood-Ridge, Bergen County, New Jersey Somerset, NJ: Richard Grubb and Assoc., Inc. Prepared for the Borough of Wood-Ridge c/o Neglia Engineering Assoc.
- Hackensack Meadowlands Development Commission
- 1970 Comprehensive Land Use Plan. Hackensack Meadowlands Development Commission, Lyndhurst, New Jersey.
- Harlow, William M.
- 1957 *Trees of the Eastern and Central United States and Canada.* Dover Publications, Inc. New York,
- Harmon, Kathryn P. and John C.F. Tedrow, and the New Jersey Agricultural Experiment Station
- 1969 A Phytopedologic Study of the Hackensack Meadowlands. Unpublished report available at the New Jersey State Library, Trenton.
- Harrison, W., and Lyons, C.J.
- 1963 Sea Level and Crustal Movements along the New England Acadian Shore 4,500-3,000 B.P. *Journal of Geology* 71:96-108. No. 1.
- Harshberger, John W.
- 1900 An Ecological Study of the New Jersey Strand Flora. Proceedings of the Academy of Natural Sciences of Philadelphia 20:623-671.
 - 1909 The vegetation of the Salt Marshes and of the Salt and Fresh Water Ponds of Northern Coastal New Jersey. Proceedings of the Academy of Natural Sciences of Philadelphia 61:373-400.
 - 1916 The Origin and Vegetation of Salt Marsh Pools. American Philosophical Society Proceedings 55:481-484.
- Harshberger, J.W. and V.G. Burns.
- 1919 The Vegetation of the Hackensack Marsh: A typical American Fen. *Wagner Institute of Science* 9:1-35 (in Sipple 1972).

Meadowlands References-2003

Joel W. Grossman, Ph.D.

- Headlee, Thomas J., and the New Jersey Agricultural Experiment Station
1915 The Mosquitoes of New Jersey and Their Control. New Jersey Agricultural Experiment Station, New Brunswick, New Jersey.
- Hester, R.E. and R.M. Harrison
2002 Global Climate: Change- Issues in Environmental Science and Technology .
 Publisher and Location.
- Heusser, Calvin J.
1949 History of an Estuarine Bog at Secaucus New Jersey. Bulletin of Torrey Botanical Club 76: 385-406 (in Sipple 1972).
- 1963 Pollen Diagrams from Three Former Cedar Bogs in the Hackensack Tidal Marsh, Northeastern New Jersey. Torrey Botanical Club, Bulletin Jan.-Feb., 1963, 90(1):16-28. Lancaster, Pa.
- Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., Van der Linden, P.J., Dai, X., Maskell K. and Johnson, C.A. (eds.)
2001 Climate Change 2001: The Scientific Basis. Contribution of Working Group 1 to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA, 881pp.
- Howard, W. Keene
1971 Postglacial Submergence and Salt Marsh Evolution in New Hampshire. Maritime Sediments, Volume 7:64-68, Halifax, Nova Scotia.
- Hydrographic Data General Drafting, Inc.
n.d. The Hackensack Valley in 1776. Bergen County Historical Society, North Hackensack, New Jersey.
- Iannuzzi, Timothy J., Ludwig, David F., Kinnell, Jason C., Wallin, Jennifer M., Desvousges, William H., Dunford, Ricard W.
2002 Common Tragedy: History of an Urban River. Amherst Scientific Publishers.
- Kalm, Peter, Johann Reinhold Foster, Edith Marie Linnbea Carlborg, and Adolph B. Benson
1937 The America of 1750: Peter Kalm's Travels in North America. Wilson Erickson, Inc., New York.
- Kardas, Susan and Edward Larrabee
1975 Historic Survey of Proposed US Routes 1 and 9 Corridor in Hudson and Bergen Counties, New Jersey Phase I .
- 1982 Cultural Resource Reconnaissance of Hackensack River Tidal Barrier Hudson County, New Jersey. Princeton, NJ: Historic Sites Research. Prepared for U.S. Army Engineer District, NY

- Kelso, Gerard K., Ph D.
1995 Palynology in Historical Rural Landscape Studies: The Pre-Clearance Forest Border at Great Meadows, Pennsylvania. Technical Report NPS/MARFONE/NRTR -95/067.
- Kelso, Gerard K., Ph D.
1994 American Antiquity, Volume 59, Number 2, Pages 359-372.
- Kelso, Gerard K., Dwyer Alison D. & Synenki Alan T.
1995 Northeast Historical Archaeology.
- Kaye, C.A., and Barghoorn, E.S.
1964 Late Quaternary Sea-Level Changes and Crustal Rise at Boston, Massachusetts, with Notes on Auto compaction of Peat. Geological Society of America Bulletin Feb., 1964, 75:63-80, Burlington, Vermont.
- Kellogg, Douglas C.
1988 Problems in the Use of Sea-Level Data for Archaeological Reconstructions. In Holocene Human Ecology in Northeastern North America, edited by George P. Nicholas. Plenum Press, New York and London. Pp. 81-94.
- Koehler, Francis C.
1940 Three Hundred Years: The Story of the Hackensack Valley, Its Settlement and Growth. Lew Biebigheiser, Chester, New Jersey.
- Kolker, Alexander S., Kroboth, Tamara, Goodbred, Steven and Cochran, J. Kirk
Sea Level History and Environmental Change in a Long Island Salt Marsh. Marine Science Research Center, SUNY at Stony Brook. Web abstract,
http://pbisotops.ess.sunysb.edu/lig/Conferences/abstracts_02/kolker.htm
- Kraft, John C.
1977 Late Quaternary Paleogeographic Changes in the Coastal Environments of Delaware, Middle Atlantic Bight, Related to Archaeologic Settings. Annals of the New York Academy of Sciences 288:35-69.
- Kraft, John C., Allen, Elisabeth A., Belknap Daniel F., John, Chacko J., Maurmeyer, Evelyn M.
1979 Processes and Morphological Evolution of an Estuarine and Coastal Barrier System. In Barrier Islands from the Gulf of St. Lawrence to the Gulf of Mexico (ed.) Stephen P. Leatherman, National Park Service Cooperative Research Unit University of Massachusetts.
- Lambeck, K. and E. Bard,
2000: Sea level change along the French Mediterranean coast since the time of the Last Glacial Maximum. *Earth Planetary Science Letters*, 175, 203-222.

Larrabee, Edward

- 1982 New Jersey's Cultural Resources: A.D. 1800-1865. In New Jersey's Archaeological Resources from the Paleo-Indian Period to the Present, edited by Olga Chesler. Pp. 220-240. New Jersey Office of Environmental Services, Department of Environmental Protection, Trenton.

Long, A.

- 2000 Late Holocene sea-level change, *Prog. Phys. Geogr.*, 24, 415-423.

Mathewson, Christopher C.

- 1988 Protection and Preservation of Archaeological Sites through Burial: A Multidisciplinary Problem Paer presented at the 1988 Society for Applied Anthropology Meeting. Paper on file at the Center for Engineering Geosciences, Texas A & M University.

Mathewson, Christopher C. (editor)

- 1989 Interdisciplinary Workshop on the Physical- Chemical-Biological Processes Affecting Archaeological Sites . Contract Reoprt EL-89-1, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg.

Mathewson, Christopher C. and Tania Gonzalez

- 1988 Protection and Preservation of Archaeological Sites through Burial. In, Engineering Geology of Ancient Works, Monuments, and Historical Sites: Preservation and Protection edited by Paul G. Marinos and George C. Koukis, pp. 519-526. A.A. Balkema, Rotterdam.

Mattson, Chester

- 1970 The Hackensack Meadowlands - An Ecological Perspective . Philadelphia, PA: Center for the Study of Federalism, Temple University.
McCormick, Jack & Associates, Inc.
- 1978 Full Environmental Statement for the Proposed Meadowlands Area at the New Jersey Sports Complex, Borough of East Rutherford, County of Bergen. Report prepared for the New Jersey Sports Exposition Authority, by Jack McCormick & Associates, Inc.

Maul, G.A. and Martin, D.M.

- 1993: Sea level rise at Key West, Florida, 1846-1992: America's longest instrument record? *Geophysical Research Letters*, 20, 1955-1958.

McCormick, Richard P.

- 1981 New Jersey: From Colony to State, 1609-1789. New Jersey Historical Society, Newark.

Meier, Mark F. and Wahr, John M.

- 2002 Sea level is rising: Do we know why?. *PNAS*/ May 14, 2002. vol. 99 no. 10.

Merley, M.M., Peteet, D.M.

- 2001 "Salt Marsh Formation in the Lower Hudson River Estuary" American Geophysical Union, Spring Meeting 2001, abstract #B41B-12. http://adsabs.harvard.edu/cgi-bin/nph-bib_query?2001AGUSM...B41B12M

Meadowlands References-2003

Joel W. Grossman, Ph.D.

- Meyer, Ernest L., and P. Witzel
1862 Topographical Map of Union County. On file, New Jersey State Archives, Trenton.
- Miller, Robert M.
1968 Hackensack Meadowlands Reclamation and Structural Development B.A. thesis, University of Virginia. Available at the New Jersey State Library, Trenton.
- Moore, J., Buchholtz ten Brink, M.R., and Mecray, E.L.
2001 Accumulation rates and sedimentary features from cores in the New York Bight [abs.] Geological Society of America, National Meeting, November 2001.
- Morrison, Charles C., Jr.
1961 The Hackensack Meadows - A Metropolitan Frontier. M.A. thesis, Columbia University, New York.
- Mortenson, Ray
1983 Meadowland. Lustrum Press, New York. Nelson William (editor)
- 1902 The New Jersey Coast in Three Centuries. Lewis Publishing Company, New York.
- Newark Evening News
1914 "Reclamation has Progressed Well: Work on Newark-Elizabeth Meadows Already Showing Results of City's Efforts," Newark Evening News, May 19, 1914. Newark Public Library, New Jersey Division, Clipping File (Meadowlands).
- 1940 "Tales of Kearny Forest: Interest in Tree Stumps Revived as Engineers Uproot Them in Meadows," Newark Evening News, March 29, 1940. Newark Public Library, New Jersey Division, Clipping File (Meadowlands).
- New Jersey Commission to Study Meadowland Development
1965 Final Report of the New Jersey Commission to Study Meadowland Development.
- New Jersey Turnpike Authority
1986 New Jersey Turnpike 1985-90 Widening, Technical Study Volume I: Natural Resources
- 1986 New Jersey Turnpike 1985-90 Widening, Technical Study Volume IV: Cultural Resources .
- Neumann, James E., Yohe, Gary, Nichola, Robert Manion, Michelle
2000 Sea-level rise & Global climate change: A Review of Impacts to U.S. Coasts. Prepared for the Pew Center on Global Climate Change.
- Nicholas, George P. (editor)
1997 Early Postglacial Land Use Patterns at Robbins Swamp, Northwestern Connecticut . Paper prepared for the Southeastern Archaeological Conference/ Eastern States Archaeological Federation Annual Meeting. (Charleston, South Carolina November 1987).

Meadowlands References-2003

Joel W. Grossman, Ph.D.

- 1988 Holocene Human Ecology in Northeastern North America. . Plenum Press, New York and London, 1988.
- Nichols, J., Robert
2002 Rising Sea Levels: Political Impacts and Responses. In Hester et. al, 2002. pp. 83-108.
- Nickens, Paul R. (editor)
1989 Laboratory Experiments to Study the Effects of Compaction and Pressure on Artifacts in Archaeological Sites. In, Archaeological Sites Protection and Preservation Notebook: Technical Notes Technical Report ASPPN II-5, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg.
- Office of New Jersey Heritage
1989 New Jersey and National Registers of Historic Places as of December 31, 1988 Trenton, N.J.: Office of New Jersey Heritage, Division of Parks and Forestry, Department of Environmental Protection.
- Oldale, R.N.
1985 Rapid Postglacial Shoreline Changes in the Western Gulf of Maine and the Paleoindian Environment. American Antiquity Volume 50 No. 1 Pp. 145-150. Jan., 1985. Washington, D.C.
- 1986 Late-Glacial and Postglacial Sea-Level History of New England: A Review of Available Sea-Level Curves. Archaeology of Eastern North America Fall, 1986, 14:89-99. New York.
- Peltier, W.R.
1996: Global sea level rise and glacial isostatic adjustment: an analysis of data from the east coast of North America. Geophysical Research Letters, 23, 717-720.
- Peltier W.R. and A.M. Tushingham
1989: Global sea level rise and the greenhouse effect: Might they be connected? *Science*, 244, 806-10.
- Peltier W.R., and X. Jiang
1997: Mantle viscosity, glacial isostatic adjustment and the eustatic level of the sea. *Surveys in Geophysics*, 18, 237-277.
- Quinn, John R.
a. Fields of Sun and Grass. An Artist's Journal of the New Jersey Meadowlands.
- Research and Archaeological Management, Inc.
1989 Cultural Resource Reconnaissance Hackensack Meadowlands District Hudson and Bergen Counties, New Jersey . Lyndhurst, N.J.: R.A.M. Prepared for the Hackensack Meadowlands Development Commission Comprehensive Master Plan Revision Program.

Reschke, Carole

Meadowlands References-2003

Joel W. Grossman, Ph.D.

- 1990 Ecological communities of New York State. New York Natural Heritage Program. New York (State). Dept. of Environmental Conservation.
- Righter, Elizabeth
ca.1978 Historical Background, Appendix XI. In Environmental Impact Statement on a Multipurpose Development Proposed on a tract of land in North Bergen and Secaucus, Hackensack Meadowlands District, Hudson County, New Jersey. Secaucus, N.J.: Hartz Mountain Industries, Inc.
- Rue, David J. and Traverse, Alfred
1997 Pollen Analysis of the Hackensack, New Jersey Meadowlands Tidal Marsh. *Northeastern Geology and Environmental Sciences*, v. 19, no. 3, 1997, p. 211-215.
- Rutsch, Edward S. et al.
1978 Stage IA Cultural Resource Survey for the Hudson County Sewerage Authority 201 Wastewater Facility Plan - District I Jersey City, North Bergen, Secaucus, and Kearny. Filed at ONJH in two parts: Appendix D Cultural Resources -- Survey of Designated Corridors; and Appendix C Cultural Resources -- Social and Physical Context. Newton, NJ: Historic Conservation and Interpretation, Inc. Prepared for Havens and Emerson, Inc. and Hazen and Sawyer.
- Salwen, Bert
1975 Postglacial Environments and Cultural Change in the Hudson River Basin. *Man in the Northeast* Fall, 1975 Volume 10 Pp. 43-40. Institute for Northeastern Anthropology, S.U.N.Y. at Albany, Albany, N.Y.
- Shennan, I. and P.L. Woodsworth
1992 A Comparison of late Holocene and twentieth-century sea levels from UK and North Sea region. *Geophysical Journal International*, 109, 96-105
- Shomette, Donald G.
1991 Archaeological Resource Potential in the Maryland Tidewater Resulting from Marine Transgressions during the Holocene Epoch. Paper presented at the Society for Historical Archaeological Conference Richmond, Virginia, January 1991.
- Schmid, J.A.
1987 Atlantic White Cedar in the Hackensack Meadowlands, New Jersey. In Atlantic White Cedar Wetlands Symposium, edited by Aimlee D. Laderman, pp. 315-322. Westview Press, Boulder, Colorado.
- Scholl, D.W., Craighead, F.C., and Stuiver, M.
1969 Florida Submergence Curve Revised: Its Relation to Coastal Sedimentation. *Science*, Volume 163, No. 3867, Pp. 562-564. Feb. 7, 1969. Washington, D.C.
- Shaw, William H.
1884 History of Essex and Hudson Counties, New Jersey. Philadelphia: Everts and Peck.

- Sipple, William S.
1971-72 The Past and the Present Flora and Vegetation of the Hackensack Meadows Bartonla No. 41:4-56.
- Sirkin, L.
1982 In Kardas and Larrabee Cultural Resource Reconnaissance of Hackensack River Tidal Barrier Hudson County, New Jersey . Princeton, NJ: Historic Sites Research. Prepared for U.S. Army Engineer District, NY
- Sloshberg, Willard
1975 "Archaeological survey of the area affected by the proposed new sewer lines in the Town of Secaucus, New Jersey".
- Snyder, John P.
1973 The Mapping of New Jersey: The Men and the Art. Rutgers University Press, New Brunswick NJ.
- Stanford, Scott D.
1989 Glacial Lake Levels and Drainage in the Hackensack and Lower Hudson Valleys, New Jersey and New York. In Abstracts with Programs - Geological Society of America, Northeastern Section, 24th Annual Meeting 21(2):68.
- Studley, Miriam V.
1964 Historic New Jersey Through Visitors' Eyes . Princeton, NJ: D. Van Nostrand Company, Inc.
- Stuiver M., and Daddario, H.J.
1963 Submergence of the New Jersey Coast. Science Volume 142 No. 3594, Pp. 951 Nov. 15, 1963. Washington, D.C.
- Thieme, Donald & Schuldenrein, Joseph
1996 Quaternary Paleoenvironments in the Hackensack Meadowlands: A Geological and Palynological Study of Borings for the Proposed North Arlington Force Main and Pumping Station, North Arlington, NJ.
- Thomas, E. and Varekamp, J.C.
1991 Paleo-Environmental Analyses of Marsh Sequences (Clinton, Connecticut): Evidence for Punctuated Rise in Relative Sea-level during the Latest Holocene. *Journal of Coastal Research* SI#11. 125-158.
- Thorbahn, Peter F., Cox, Deborah C.
1988 The Effect of Estuary Formation on Prehistoric Settlement in Southern Rhode Island, in Holocene Human Ecology in Northeastern North America, edited by George P. Nicholas. Pp. 167-180. Plenum Press, New York and London.

Meadowlands References-2003

Joel W. Grossman, Ph.D.

- 1989 Intentional Site Burial: A Technique to Protect against Natural and Mechanical Loss .
Archaeological Assistance Program Technical Brief No. 5, U.S. Department of the Interior,
National Park Service.
- 1991 Site Stabilization Information Sources . Archaeological Assistance Program Technical Brief
No. 12, U.S. Department of the Interior, National Park Service.
- Torrey, J. C. et al.
1819 A Catalogue of Plants Growing Spontaneously within thirty miles of the City of New York.
Websters & Skinners, N.Y. 100 p. (in Sipple 1972)
- Van Valen, J.M.
1900 History of Bergen County, New Jersey . New York: New Jersey Publishing and Engraving
Co.
- Van Winkle, Daniel, ed.
1924 History of the Municipalities of Hudson County, New Jersey, 1630-1923 .
New York: Lewis Historical Publishing Co., Inc.
- Varekamp, J.C. and Thomas, E.
1997 Ckunate change and the rise and fall of the sea level over the millennium. EOS, Transactions of
the American Geophysical Union 79:69 74-75.
- Varekamp, J.C., Thomas, E. and Van de Plassche, O.
1992 Relative sea-level rise and climate change over the last 1500 years. Terra Nova, 4, 293-304, 1992.
Global Change Spec. Issue (ed. By F. –C. Wezel)
- Vermeule, Cornelius C.
1896a Drainage of the Hackensack and Newark Tide Marshes. In Annual Report of the New Jersey
Geological Survey for 1896. MacCrellich and Quigley, Trenton.
- 1896b Map of Hackensack Meadows to Illustrate Report on Drainage. In Annual Report of the
New Jersey Geological Survey for 1896. MacCrellich and Quigley, Trenton.
- 1897 Drainage of the Hackensack and Newark Tide Marshes. In Annual Report New Jersey
Geological Survey for 1897. MacCrellich and Quigley, Trenton.
- 1899 Report on Reclamation of Hackensack and Newark Meadows. In Annual Report of the New
Jersey Geological Survey for 1899. MacCrellich and Quigley, Trenton.
- Waksman, S. A.
1942 The Peats of New Jersey and their Utilization. Part 1. Bulletin 55A, Geological Service, NJ
Department of Conservation and Development (in Sipple 1972).
- Warren, George M.
1911 Tidal Marshes and Their Reclamation. U.S. Government Printing Office, Washington, D.C.
- Warrick, R.A., Barrow, E.M. & Wigley(eds.)
1993 Climate and sea level change: observations, projections and implications. Published by
Cambridge University Press(England).

Meadowlands References-2003

Joel W. Grossman, Ph.D.

- Weiss, Harry B., and Grace M. Weiss
1965 Some Early Industries of New Jersey: Cedar Mining, Tar, Pitch, Turpentine, Salt Hay.
 New Jersey Agricultural Survey, Trenton.
- Westervelt, Frances A.
1923 History of Bergen County, New Jersey, 1630-1923. Lewis Publishing Co., New York.
- Widmer, Kemble and Daniel G. Parrillo
1959 Pre-Pleistocene Topography of the Hackensack Meadows, New Jersey.
 Geological Society of America, Bulletin 70(12):2.
- Winfield, Charles Hardenburg
1872 History of the Land Titles in Hudson County, New Jersey, 1609-1871. Wynkoop and
 Hallenbeck, New York.
- Wing, William G.
1960 Jersey's Unsung Meadows: The Pungent, Neglected Wasteland within Sight of Manhattan
 Contains a Wealth of Interest to Nature Lovers. New York Herald Tribune, July 3, 1960.
- Woodworth, P.L.
1999 a: High Waters at Liverpool Since 1768: The U.K. longest sea-level record, Geophysical Research
 Letters, 26, 1589-1592.
- Woodworth, P.L.
1999 b: A study of changes in high water levels and tides at Liverpool during the last two hundred and
 thirty years with some historical background. Proudman Oceanographic Laboratory Report
 No.56, 62 pp.
- Woodworth, P.L.
1993 *Sea Level Changes*, article in “ Climate and sea level change: observations, projections and
 implications.” (ed. By R.A. Warrick) Published by Cambridge University Press(England).
- Zelenak, Scott S.
2001 A Report on the Coordinate and Elevation Origins in the Greater New York City Area.
 Topcon-Point of Beginning Web Posting, January 1, 2001
 www.pobonline.com/CDA/ArticleInformation/features
- Zimmermann, G.L. and Mylecraine, K.A.
2003 Reconstruction of an Old-growth Atlantic White Cedar Stand in the Hackensack
 Meadowlands of New Jersey: Preliminary Results. In: Atkinson, R.B.; Belcher, R.T.; Brown,
 D.A.; Perry, J.E., editors, Atlantic white cedar restoration ecology and management,
 proceeding of a symposium; 2000 May 31-June 2; Newport News, VA. Christopher Newport
 University: 125-135.

A GIS-Friendly Definition for Archaeology

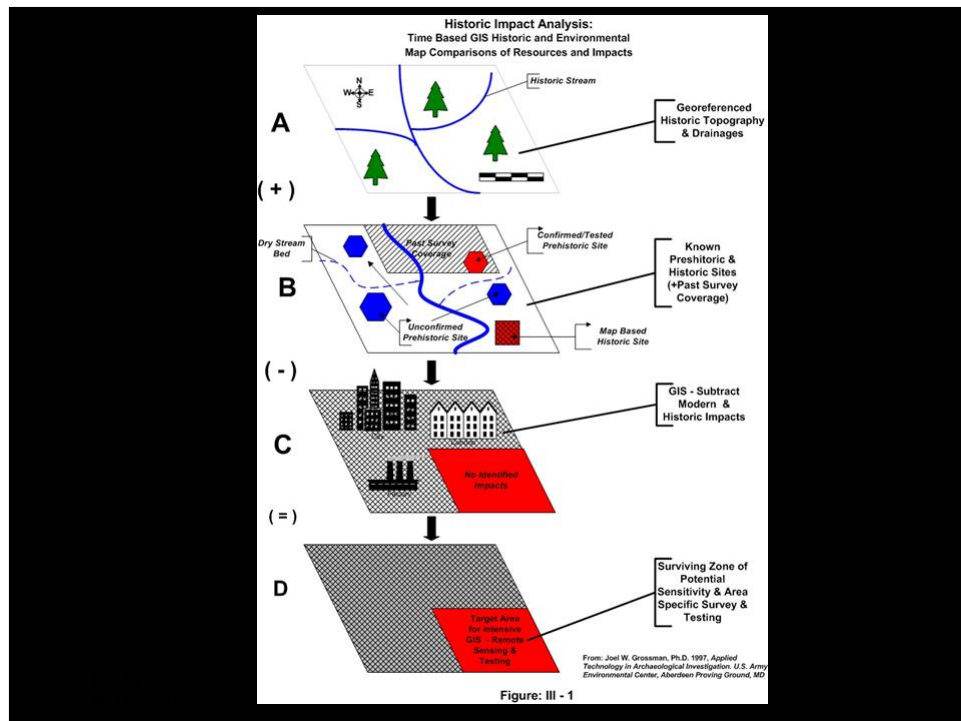
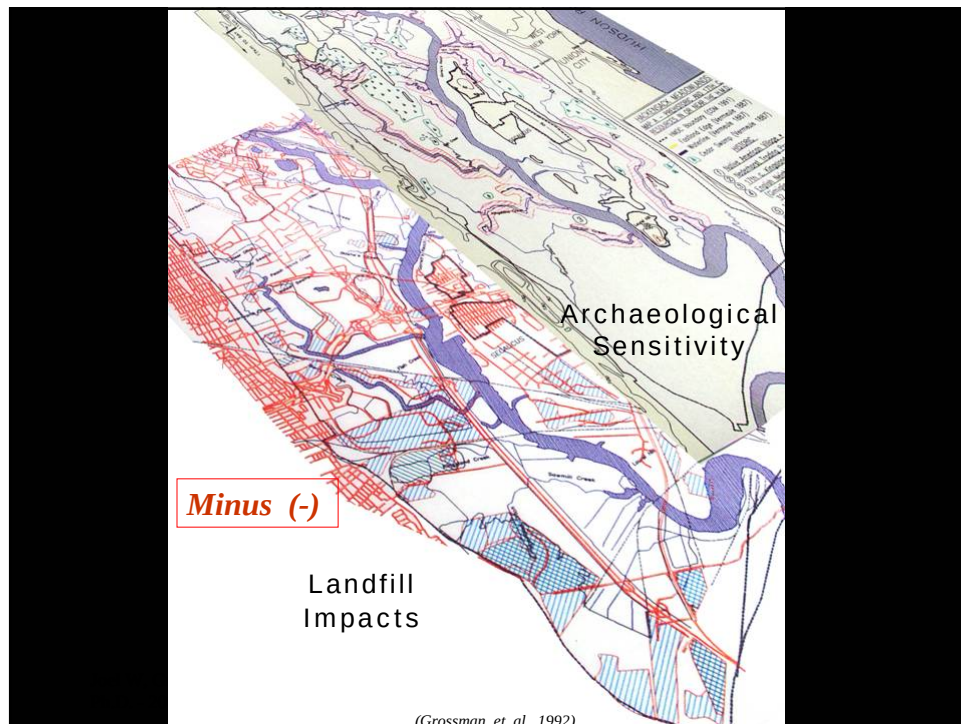
*“Quantified Three Dimensional Data
in a Stratified Series of Georeferenced
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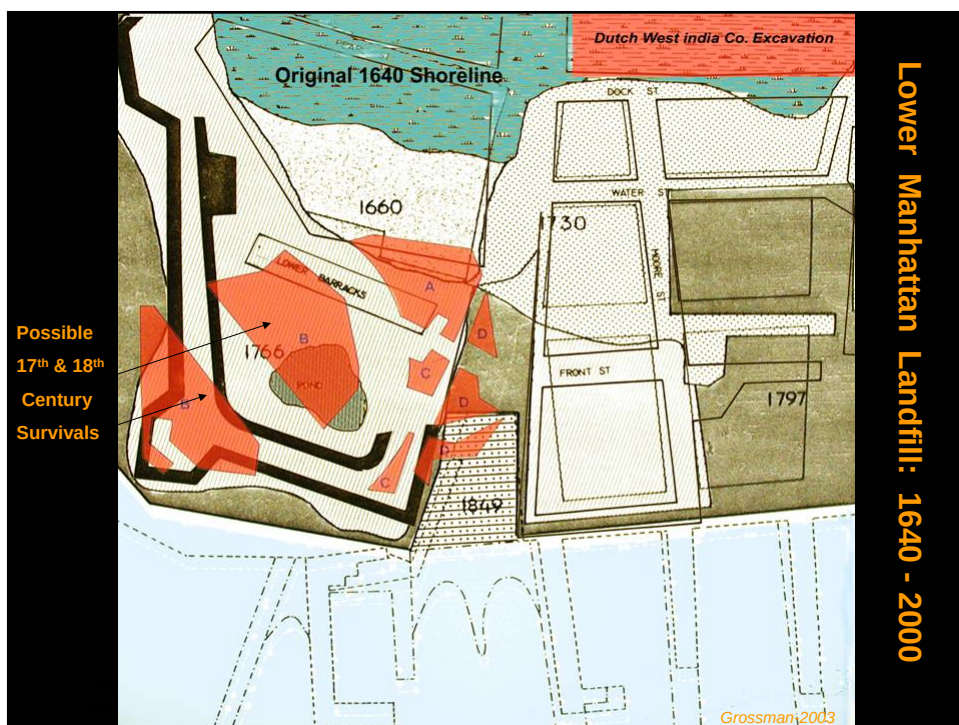
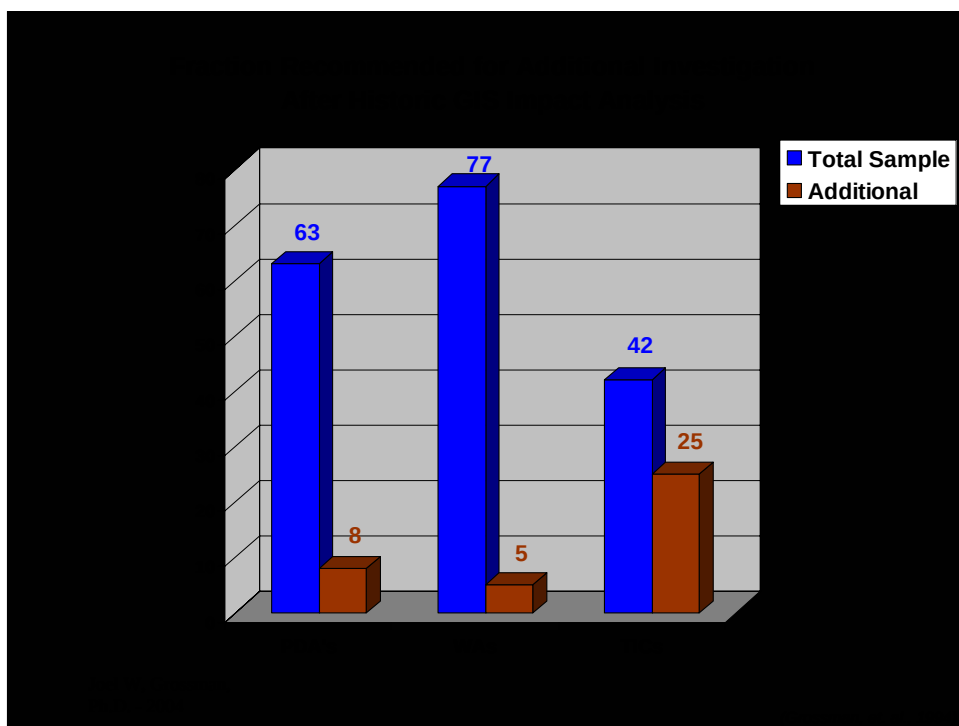
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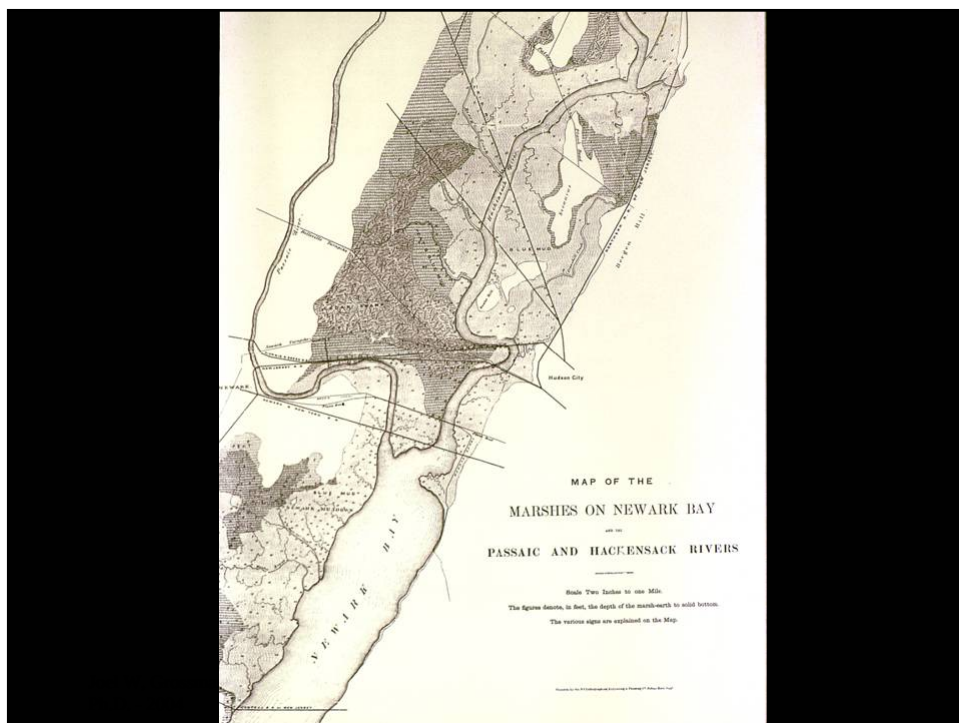
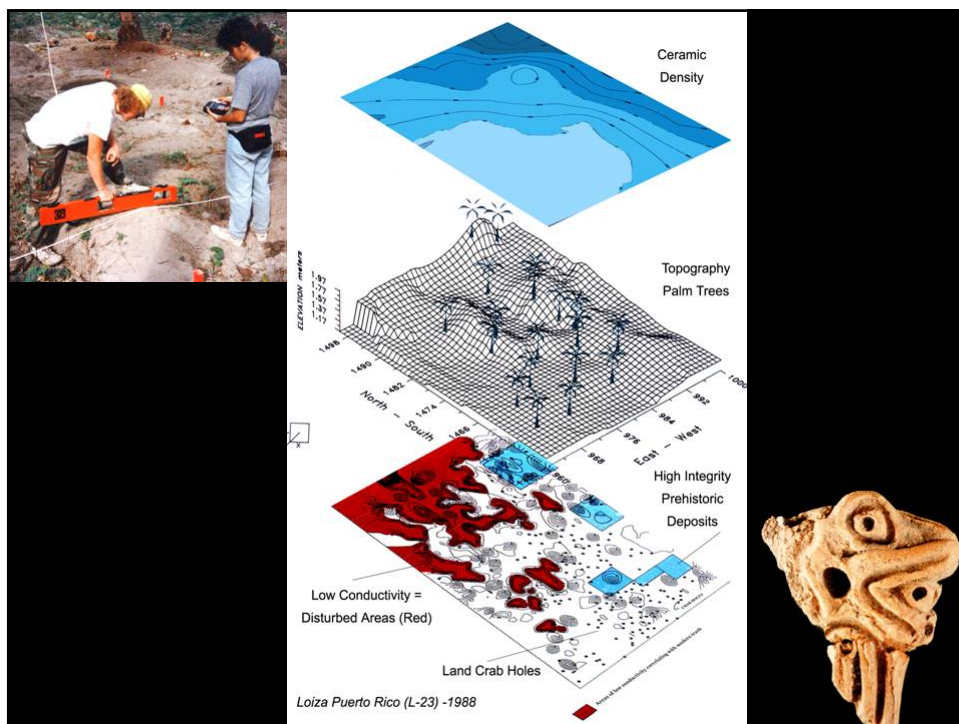
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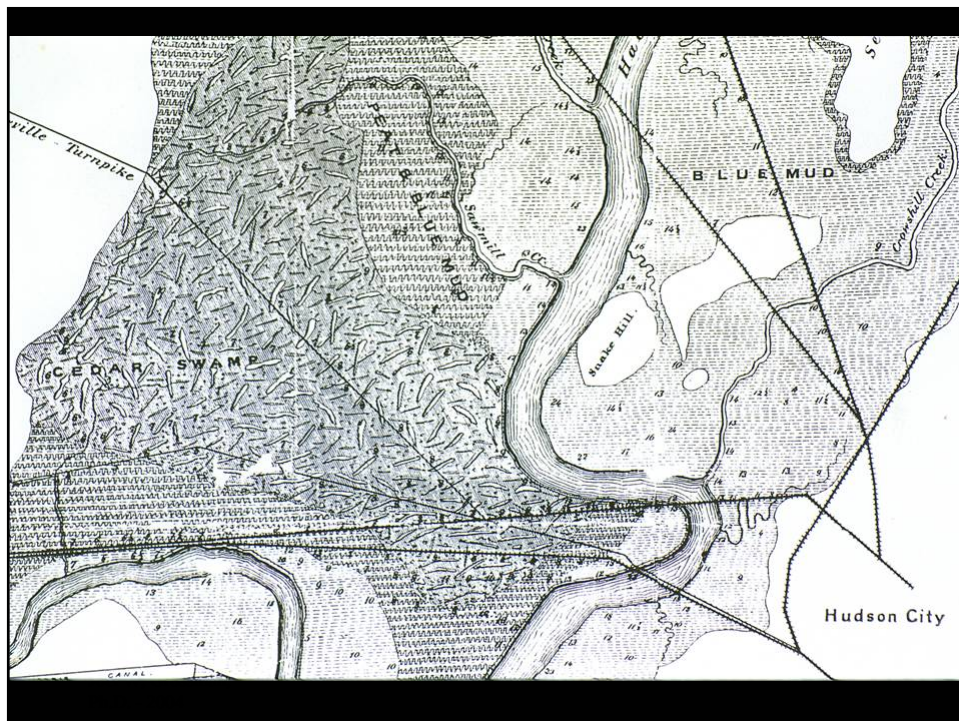
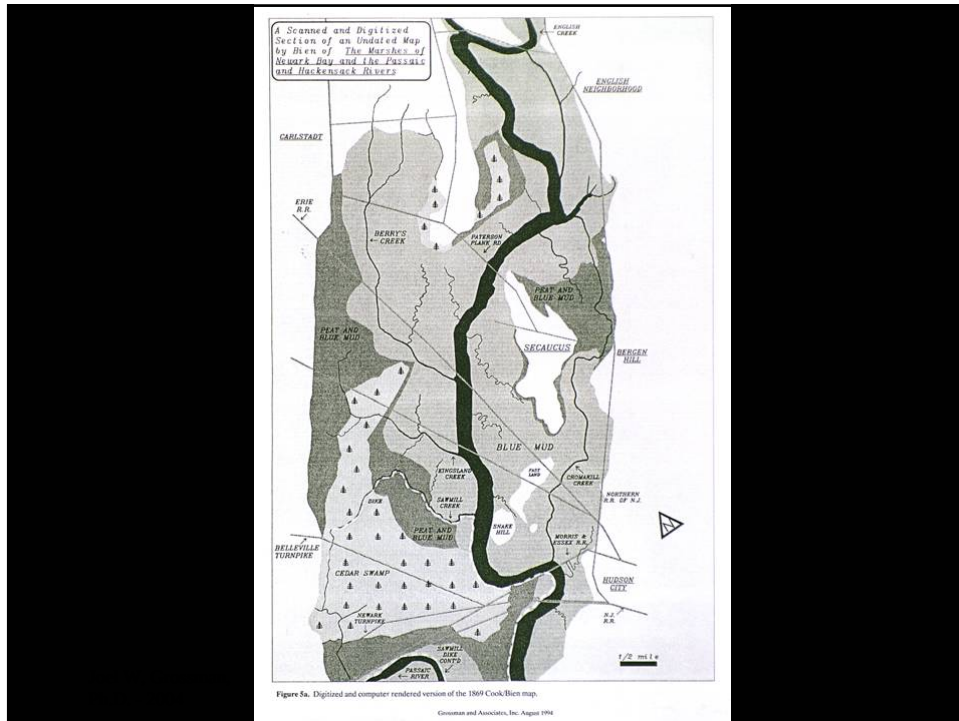
3D GIS in Archaeology

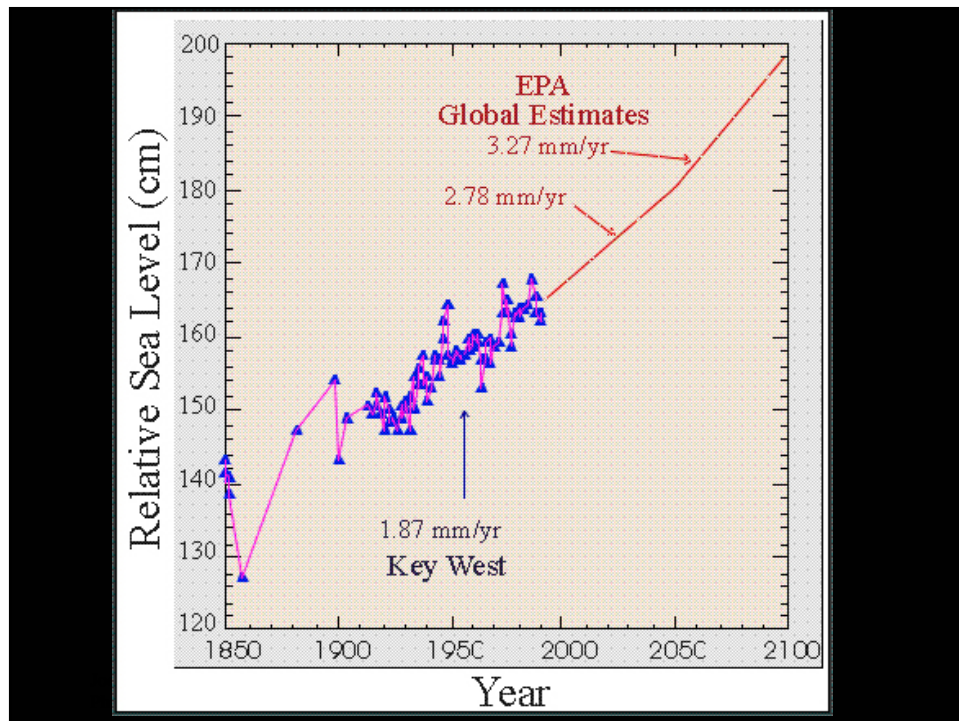
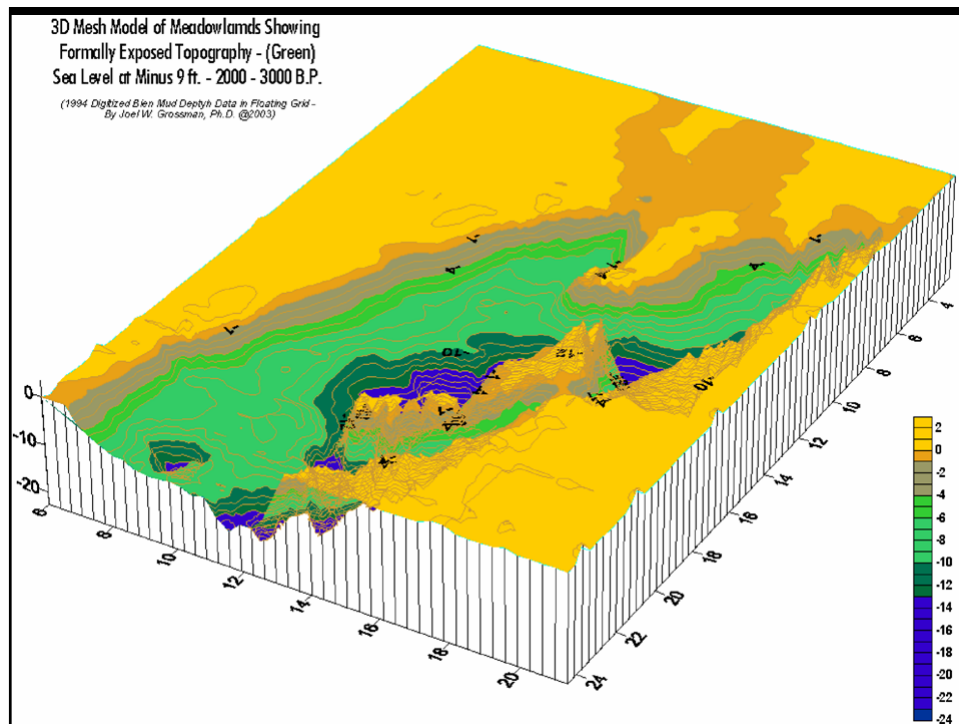
- I. Historic Impact Analysis*
- II. Paleo-environmental Reconstruction*
- III. Target-Specific Field Strategies*
- IV. Issues of Sea Level Rise*

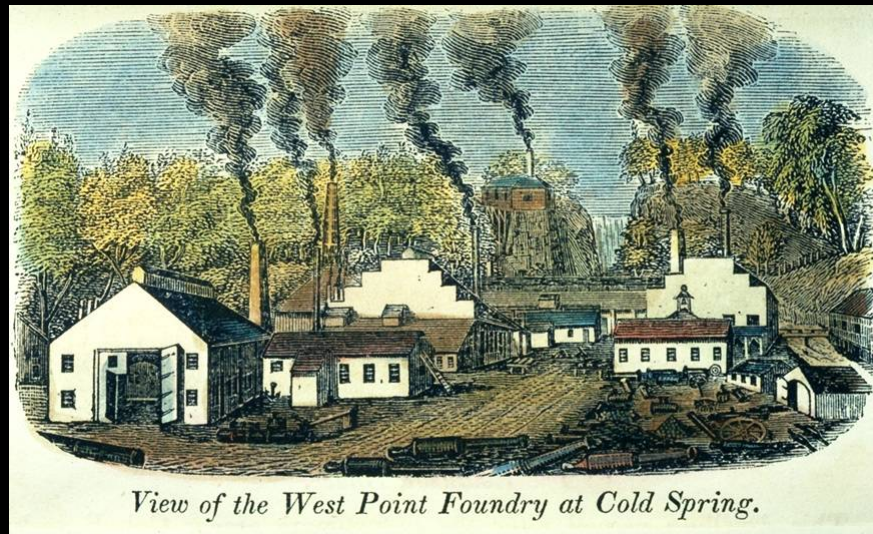
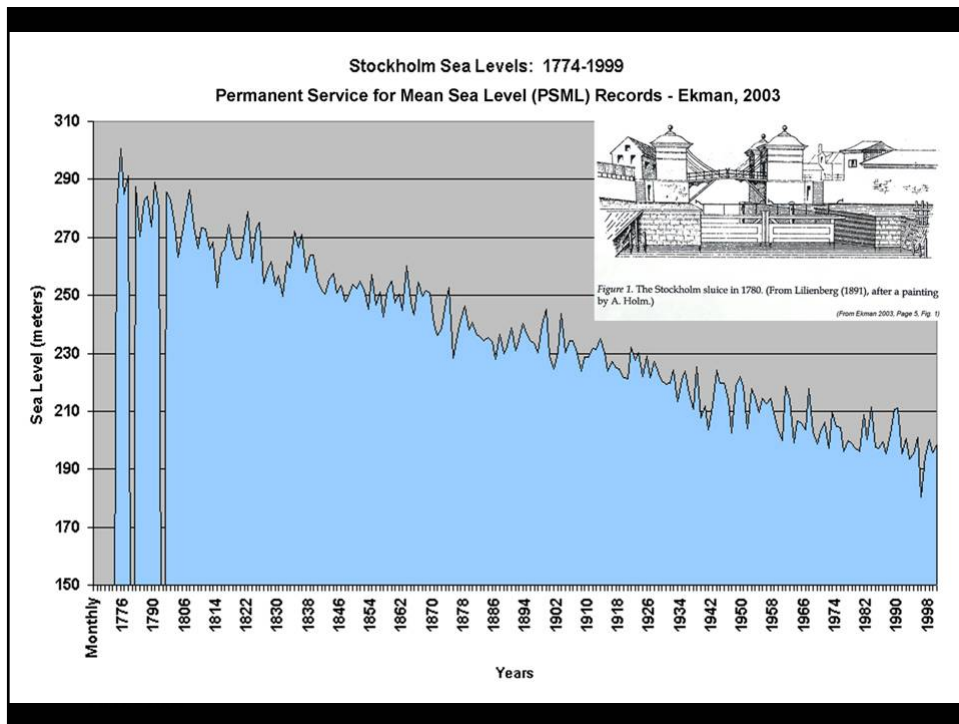


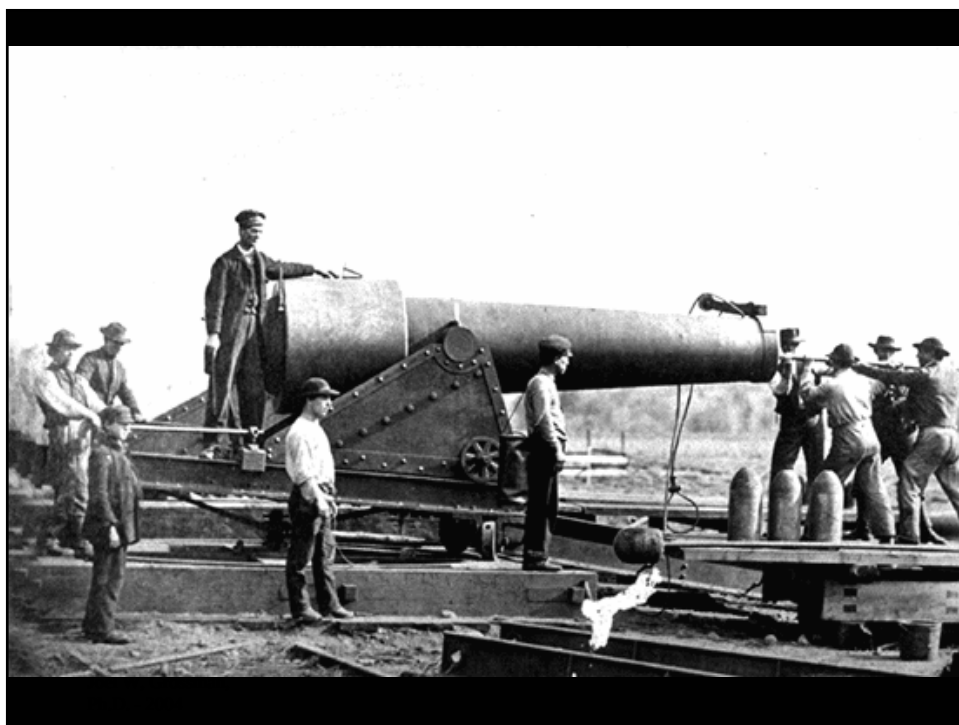
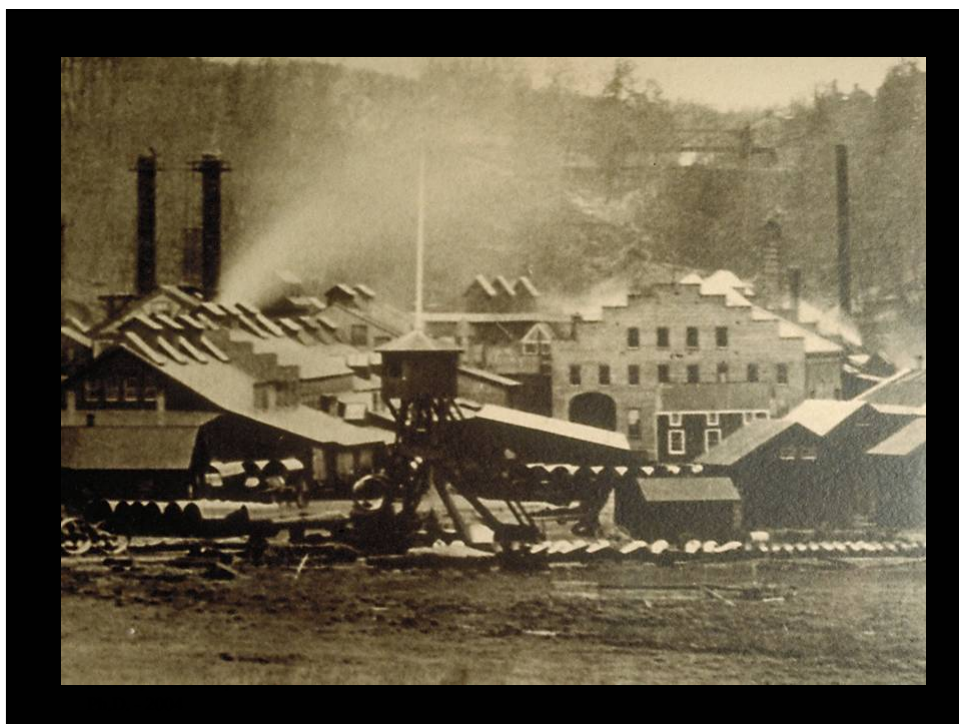


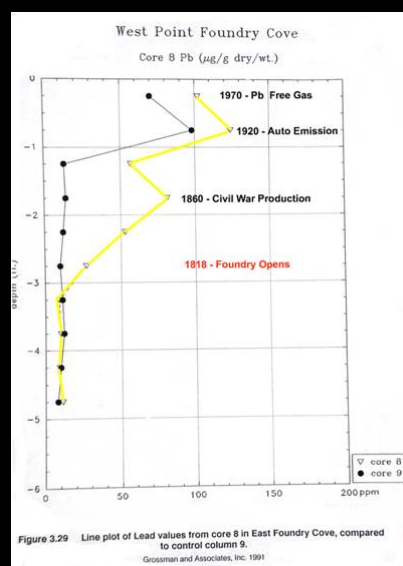
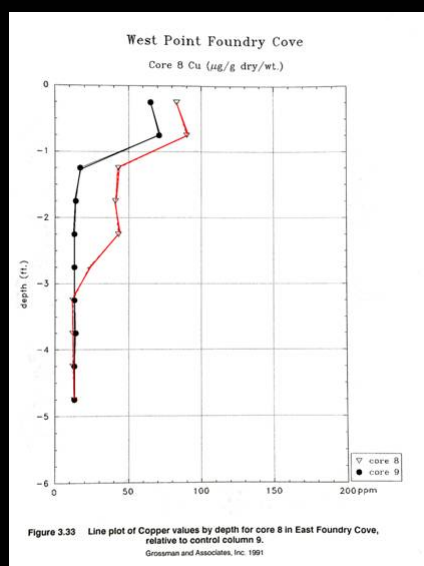


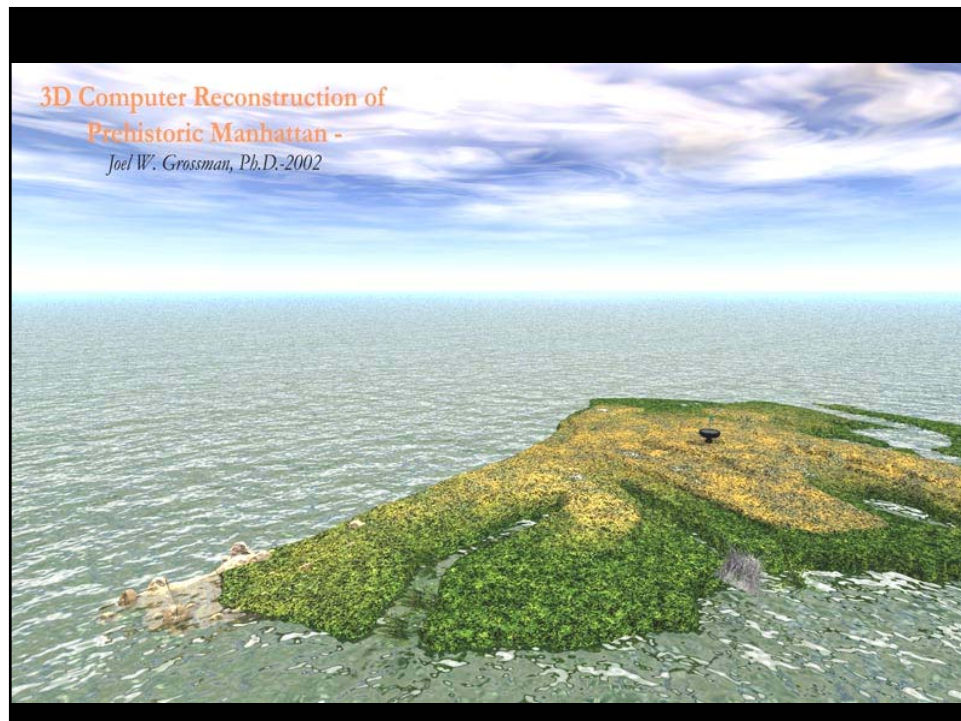
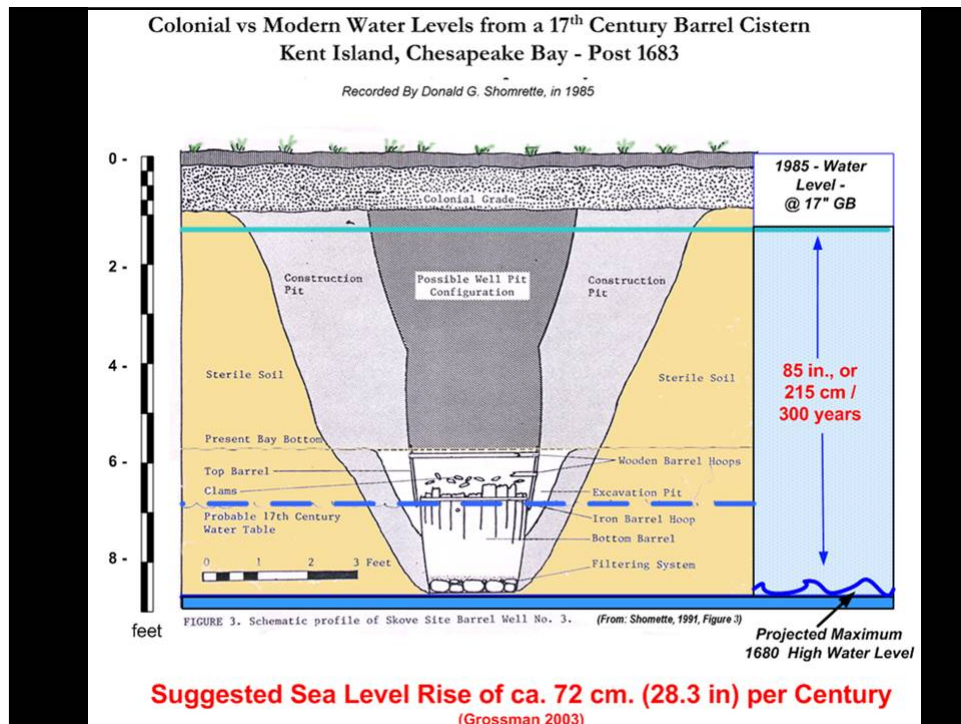
















19th Century Basement



*17th Century Cobble Floor
- Below it.*



