MAPPING THE 20 – FOOT CLAY (WANTAGH FORMATION) IN QUEENS AND BROOKLYN, NEW YORK

Cheryl J. Moss, Mueser Rutledge Consulting Engineers, 14 Penn Plaza, New York, NY 10122 (cmoss@mrce.com)
Tony D. Canale, Mueser Rutledge Consulting Engineers, 14 Penn Plaza, New York, NY 10122 (tcanale@mrce.com)

Introduction

The Wantagh Formation, commonly known as the 20-Foot Clay, is an inter-glacial or inter-stadial marine clay of uncertain age. It is a discontinuous unit that was mapped in the subsurface along the south shore of Long Island by Doriski & Wilde-Katz (1983) (Figure 1). The stratum was identified in New York City, but not actually mapped there (Soren 1978, Buxton & Shernoff 1999). In 2015 data from the MRCE archives was used to show locations where the Wantagh was found in Brooklyn and Queens (Moss 2015). Hundreds of new borings made since then for Post-Sandy rebuilding and fortifying projects now allow a more detailed mapping of the Wantagh in New York City.

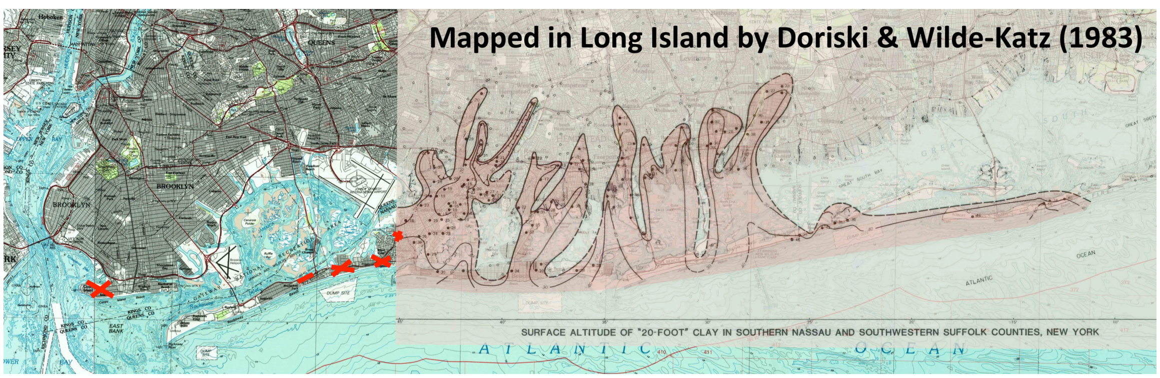

Figure 1 – Doriski & Wilde-Katz (1983) mapped the 20-Foot Clay in Suffolk and Nassau counties in Long Island, but the map stops at the county line. Data in MRCE archives was used to identify New York City neighborhoods (red Xs) where the stratum was also present (Moss 2015). (Modified from Doriski & Wilde-Katz (1983) and USGS Long Island West (1984) and Newark (1986) quadrangles.)

Stratigraphy Along the South Shore of Brooklyn and Queens

Along the south shore of Brooklyn and Queens Cretaceous coastal plains sediments were deposited above Paleozoic metamorphic bedrock (Figure 2). The basal Lloyd Sand is overlain by the Raritan Clay, which is in turn overlain by the Magothy-Matawan Formation. Subsequent erosion carved into the Cretaceous soil/bedrock surface leaving valleys and scattered depressions behind. Assorted Pleistocene glacial and inter-glacial sediments then filled in, and were deposited above, the older strata.

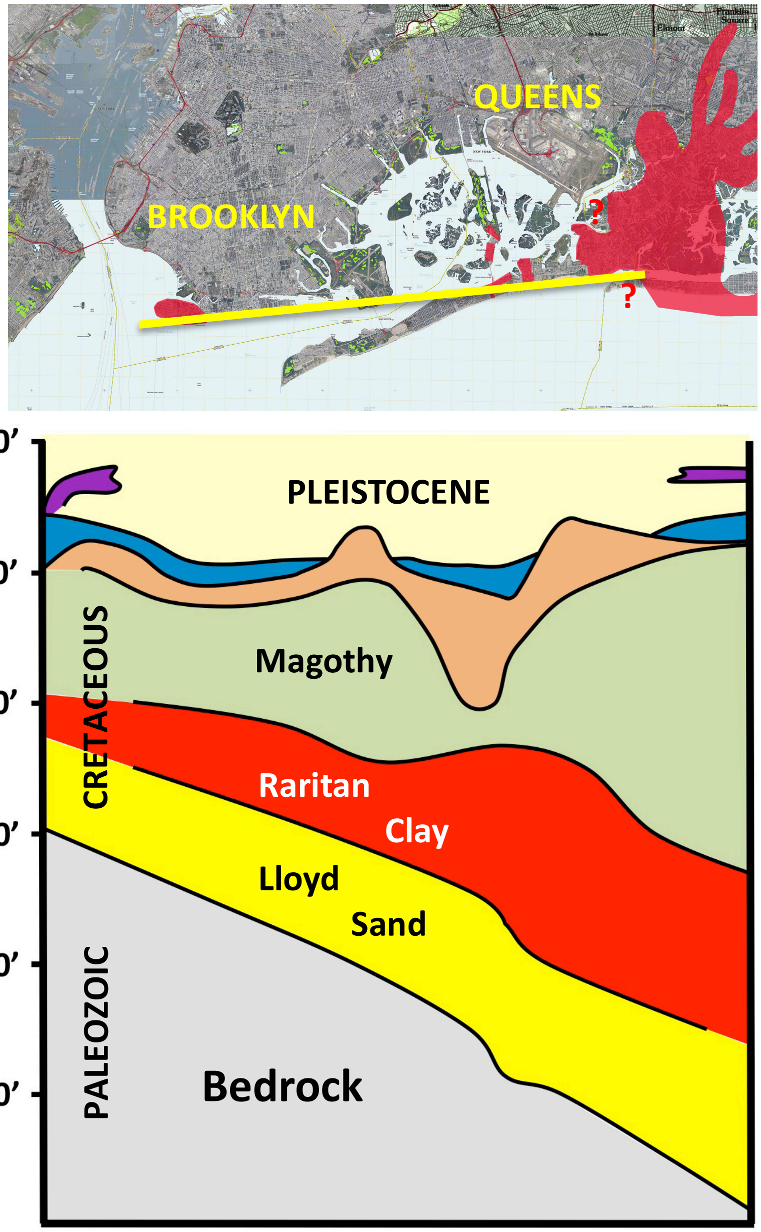

Figure 2 – Strata Along the South Shore of Brooklyn and Queens. Paleozoic metamorphic bedrock is covered with layers of Cretaceous coastal plains sand and clay. The regional bedrock/Cretaceous soil surface was carved by erosion, leaving behind valleys and scattered depressions that were filled and covered over with Pleistocene deposits. The cross-section is compiled from multiple U.S.G.S. map resources to reflect general stratigraphy along the southern edge of NYC (yellow line).

The ages of the Pleistocene strata are unclear, with different references assigning them to different glacial and inter-glacial events. The discrepancies are discussed in greater detail in Moss (2015). Along the south shore of NYC the Jameco Gravel lies above the Cretaceous sediments (Figure 3). It is a pre-Illinoian or Illinoian age outwash sand and gravel. The Gardiners Clay was deposited above the Jameco. The Gardiners is an inter-glacial marine clay of pre-Illinoian or Sangamon (Marine Isotope Stage 5) age that is mapped along much of the south shore of Long Island (Smolensky & Others 1989).

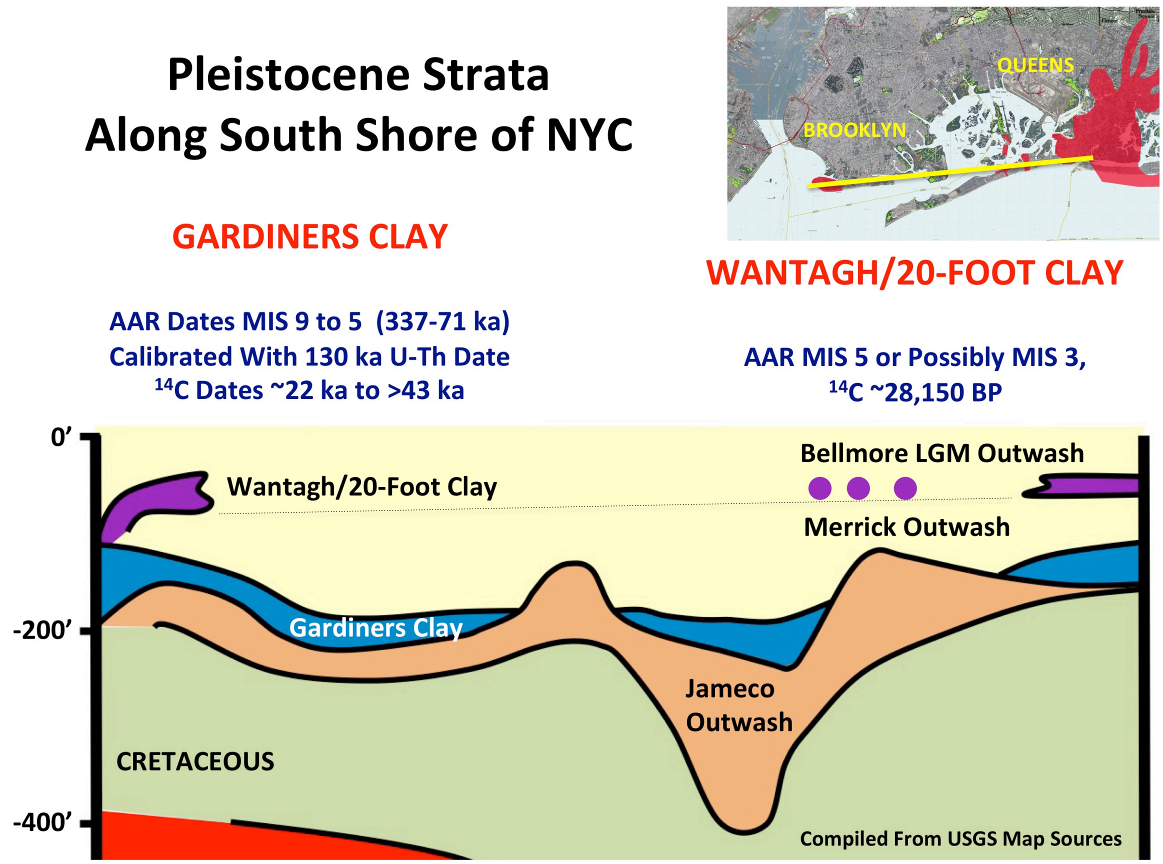

Figure 3 – Pleistocene Strata Along the South Shore of Brooklyn and Queens (yellow line). The ages of the units are uncertain, with amino acid racemization (AAR) dates typically much older than those obtained from ^{14}C testing. The Jameco Gravel is a pre-Illinoian or Illinoian outwash deposit. The Jameco is overlain by the Gardiners Clay, which is considered to be a pre-Illinoian or Sangamon marine clay. The Merrick outwash covers the Gardiners. The Wantagh Fm. is a Sangamon or pre-LGM marine clay present in places above the Merrick. It in turn is covered with the late-Wisconsinan Bellmore outwash from the LGM. An assorted mix of modern coastal sediments (not shown) is present at the surface.

The Pleistocene strata above the Gardiners were described and named in Rampino & Sanders (1981). The Merrick Formation is an Illinoian or Wisconsinan age outwash sand deposited over the Gardiners Clay. The Wantagh Formation, a marine clay similar to the Gardiners, lies above the Merrick. The Wantagh is commonly referred to as the 20-Foot Clay in older references, and is probably Fuller's Vineyard Formation (Fuller 1914, Perlmutter & Geraghty 1963). It was deposited during either the Sangamon (MIS 5), or an earlier Wisconsinan inter-stadial period (MIS 3) prior to the late-Wisconsinan Last Glacial Maximum (LGM). The Bellmore Formation, which is outwash from the LGM, covers the Wantagh. An assorted mix of modern coastal sediments caps the glacial deposits along the coastline.

Mapped Marine Clays

The Gardiners Clay is a stiff green gray organic clay and silt with some sand layers. It often contains shells and lignite. It is mapped in the subsurface along the south shore of Long Island from Quogue to western Brooklyn (Figure 4). It has also been found filling in depressions at scattered locations in New York Harbor and around the southern tip of Manhattan and the lower East Side.

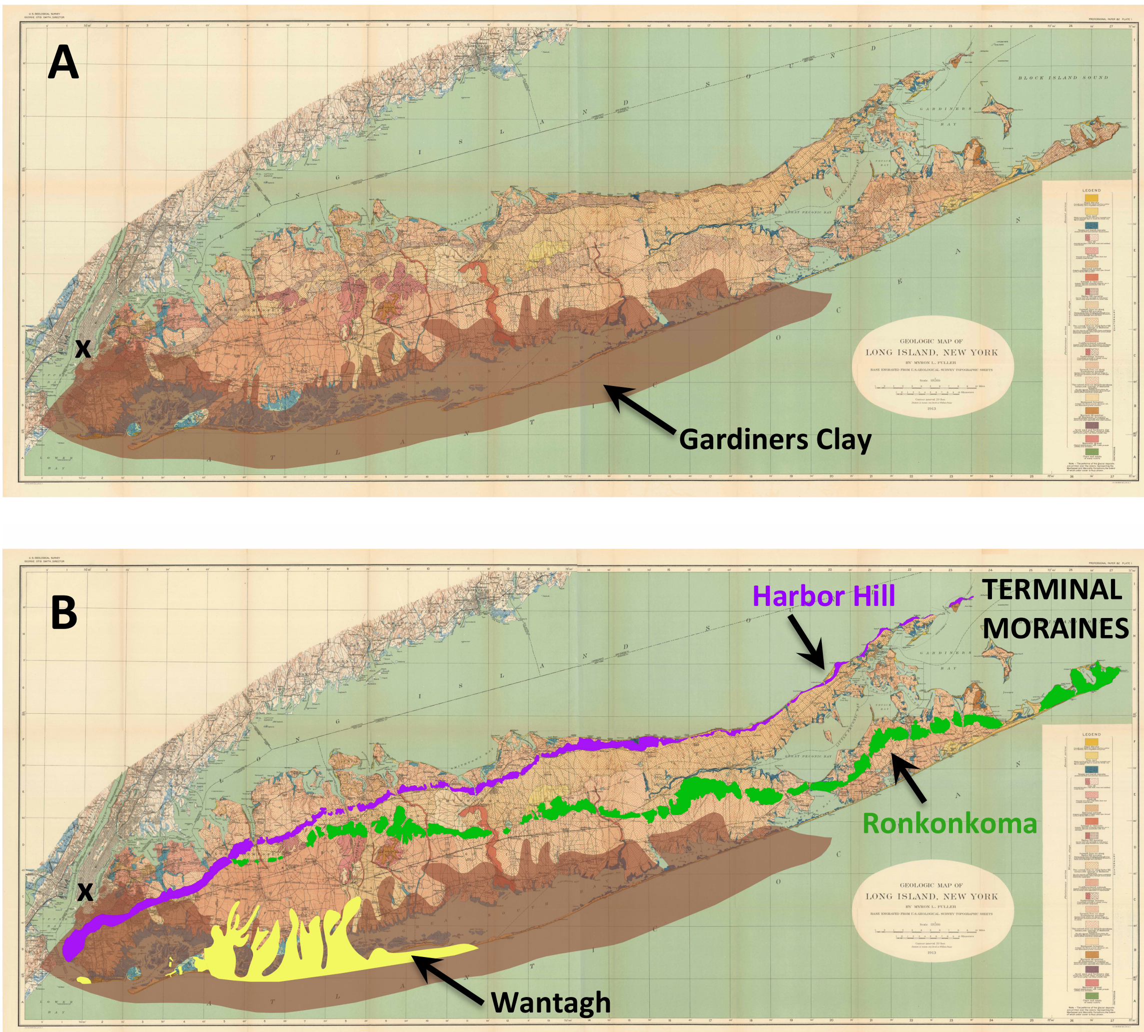

Figure 4 – Marine Clays Mapped on Long Island. (A) Map of Gardiners Clay (Smolensky & Others 1989) overlain on the Fuller (1914) map that shows Long Island's surficial glacial soils. The Gardiners is almost continuously present in the subsurface from Quogue to western Brooklyn. It has also been found filling depressions in scattered locations around New York Harbor, the southern tip of Manhattan and the lower East side (black X). (B) Wisconsinan age terminal moraines highlighted and map of Wantagh Fm. (Doriski & Wilde-Katz 1983 and this publication) overlain above the Gardiners on the Fuller (1914) map. The Wantagh is not nearly as extensive as the Gardiners. It is a discontinuous unit found in the subsurface between Kismet and western Brooklyn and has not been found in NY Harbor, Manhattan, or along the north shore of Jamaica Bay.

The Wantagh is typically a soft to stiff gray organic silty clay, with trace amounts of shells and peat. Peat layers, when present, are most commonly found at the base of the unit above the underlying sand. Sand layers and lenses are occasionally present within it. The younger Wantagh Formation is not as extensive as the Gardiners. It only stretches between Kismet (on Fire Island) and western Brooklyn, and in some places it does not reach as far inland (Figure 4). Unlike the Gardiners, it has not been identified in Manhattan, New York Harbor, or along the north shore of Jamaica Bay. It is unclear if this means the Wantagh was deposited at a lower relative sea-level than the Gardiners, and/or if it was subjected to more extensive erosion during the subsequent glaciation.

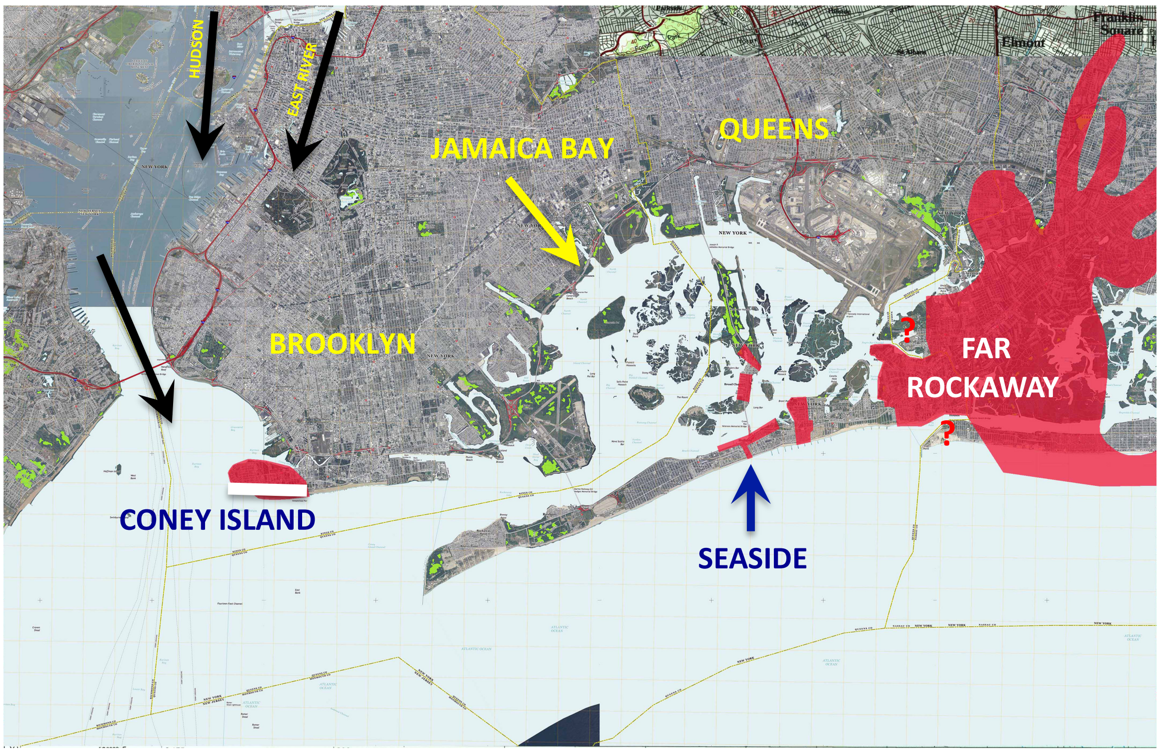

Figure 5 – Wantagh Formation Mapped in NYC. The Wantagh is present below the western 1/3 of Coney Island. The stratum drops off steeply at the western tip of Coney Island, along with the underlying sand. Flow of the Hudson and East Rivers projected southward or around Staten Island through the Narrows (black arrows) aligns with the drop in strata, suggesting the formations were scoured out by the Hudson and later filled in with younger sediments. The cross-section in Figure 6 is located along the white line. Heading eastward, the Wantagh quickly lenses out. It has not been found in the western Rockaways or along the north shore of Jamaica Bay. The Wantagh appears to be absent to around Broad Channel/Seaside where it reappears, initially lensing in and out. (Modified from Doriski & Wilde-Katz (1983) and USGS 7.5-Minute Series quadrangles.)

Mapped Wantagh in New York City

In order to produce a map of the Wantagh Formation in NYC, the MRCE archives were screened to identify projects in areas known to have the Wantagh, along with projects in surrounding neighborhoods. Boring data from each of these locations was reviewed and borings too shallow to encounter the Wantagh were eliminated from the data set. Many of the newer borings had surveyed coordinates in the NAD '83 New York State Plane system, with elevations referenced to NAVD 88. All of the borings considered deep enough to encounter the top of the Wantagh if it was present had their elevations converted to NAVD 88. Not all of the older borings had surveyed coordinates readily available. For each of those borings the accompanying boring location plan was layered onto Google Earth, the latitude and longitude was determined and then converted to the State Plane system. This allowed all of the deep borings, with and without the Wantagh present, to be plotted together, analyzed and placed on a map.

The Wantagh is a 20' to over 40' thick layer present below the western 1/3 of Coney Island (Figure 5). Its surface slopes westward from ~El. -40' to -60', then drops off steeply at the very western edge of Coney Island, as does the underlying sand (Figure 6). If you project flow of the Hudson and East Rivers southward, or their combined flow east of Staten Island through the Narrows, the paths line up with the drop in the strata. This suggests that the Wantagh and the underlying sand were both scoured out by the Hudson and later filled in with thicker layers of younger sediments. The Narrows is a breach in the late –Wisconsinan Harbor Hill moraine and it's not clear if there were any older features at the site that previously controlled flow through the Hudson. Lacking a barrier such as the Narrows, the mouth of the river might have been even wider and the extent of erosion even greater in the past. Due to the lack of deep boring data, it's not clear exactly where the Gardiners Clay is present below the younger strata, and the deep Wantagh may lie directly above it in places.

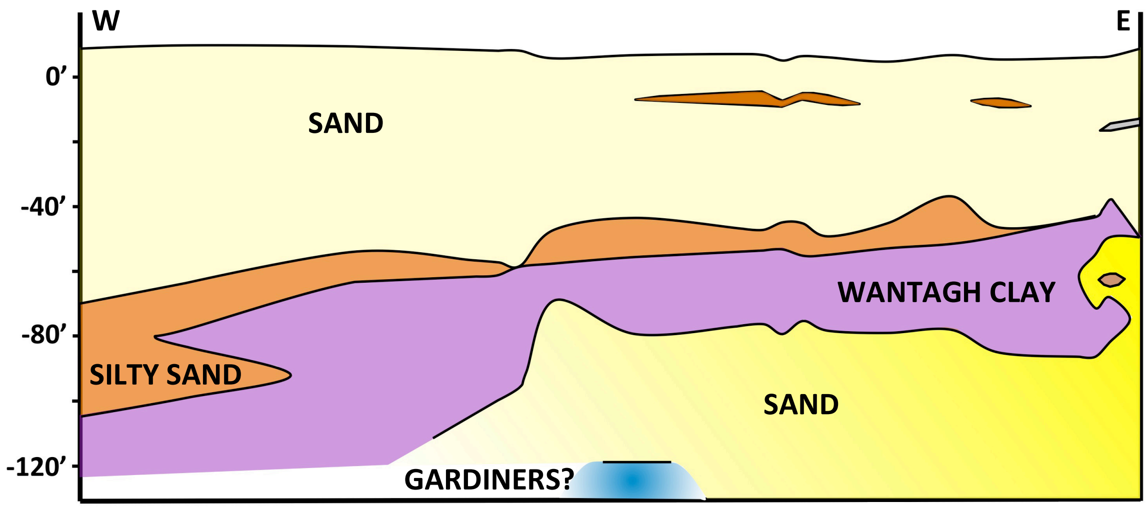

Figure 6 – East-West Cross-section at the Western 1/3 of Coney Island. The Wantagh is a 20' to over 40' thick layer below the western 1/3 of Coney Island. Its surface slopes westward from roughly El. -40' to -60', then drops off steeply at the very western edge of Coney Island, along with the underlying sand. It's not clear where the Gardiners Clay is present below the younger strata, and the deep Wantagh may lie directly above it in places.

Heading eastward, the Wantagh quickly lenses out. It has not been found in the western Rockaways or along the north shore of Jamaica Bay (Figure 5). There is little boring data from within Jamaica Bay, but the Wantagh appears to be absent to around Broad Channel/Seaside where it reappears, initially lensing in and out. The clay is discontinuous in both neighborhoods, possibly as a result of erosion from above.

Contours of the top of the stratum suggest that it may have been scoured away in Jamaica Bay along the western edge of Broad Channel.

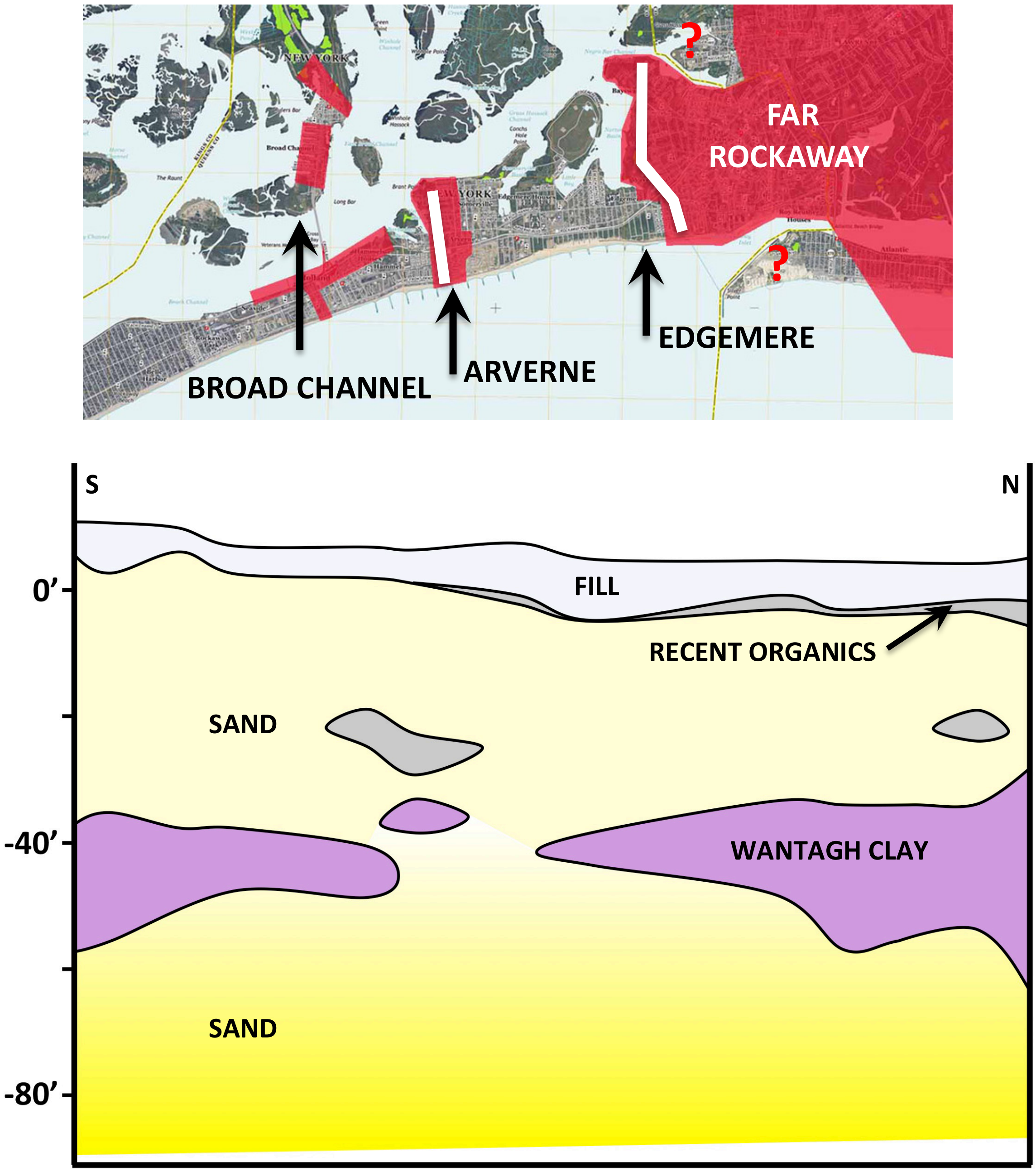

Figure 7 – North-South Cross-section at the Western Edge of Arverne. From Broad Channel/Seaside the Wantagh lenses in and out eastward to Arverne, where there is a continuous strip just east of this cross-section that mostly fills depressions in the underlying sand. The white lines show the locations of cross-sections at Arverne and Far Rockaway (Figure 8). The 2 red question marks cover areas in western Nassau county beyond data points on the Doriski & Wilde-Katz map and outside of the MRCE mapped area. The Wantagh may be continuous through the areas in question, but data is currently lacking.

The Wantagh lenses in and out eastward to Arverne, where there is a continuous strip that mostly fills depressions in the underlying sand (Figure 7). The unit appears to be missing along the barrier island between Arverne and Edgemere and becomes more continuous at the Far Rockaway mainland.

Heading northward at both Broad Channel and the Rockaways the Wantagh shallows slightly (Figure 8). In general, where the stratum is present in or around the eastern half of Jamaica Bay, it tends to be a 10' to 20' thick layer that is found somewhere between elevations -30' to -60' along the southern edge of the barrier islands and -20' to -50' at its northern landward edge. It appears to be absent in at least part, if not most, of Jamaica Bay between Broad Channel and the Rockaways. Contours suggest that it was scoured away at the southeast corner of Jamaica Bay (southwest corner of Far Rockaway).

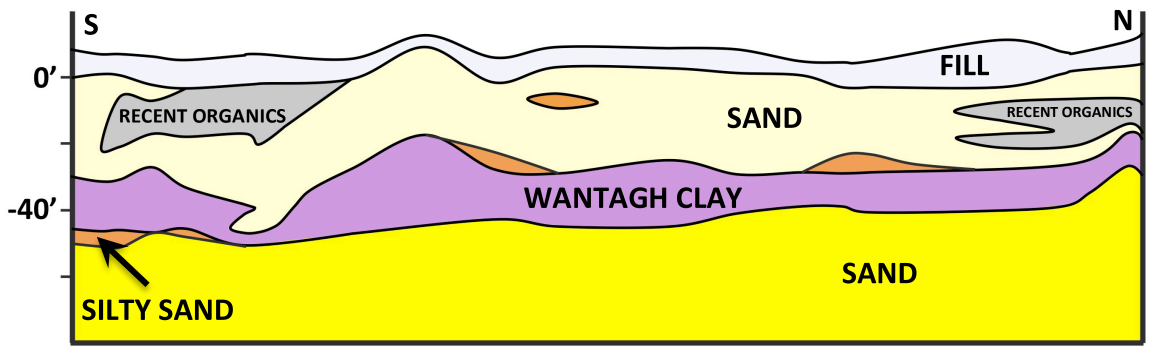

Figure 8 – North-South Cross-section at the Western Edge of Far Rockaway. Heading northward the Wantagh shallows slightly. In general, where the stratum is present it tends to be a 10' to 20' thick layer that is found somewhere between elevations -30' to -60' along the southern edge of the barrier islands and -20' to -50' at the formation's northern edge. There are often shallow organic layers and lenses above the Wantagh that are associated with more recent channel fill and marsh development.

The Wantagh often has shallow organic layers and lenses above it that are associated with more recent channel fill and marsh development. In some places the recent organics are directly above the Wantagh, and may involve some reworking of the underlying clay. The Wantagh is often a stiffer clay, reflecting consolidation and/or desiccation during the LGM sea-level drop. This is not always the case though, so in some places it may be difficult to differentiate the Wantagh from the younger sediments above.

Conclusions

The Wantagh Formation is a marine clay that was deposited along the coastline during a period of inter-glacial or inter-stadial sea-level rise. The organic clay filled depressions in the underlying sand and formed a fairly even layer over it. Its consistent presence at roughly the same elevation at the eastern, central and near western ends of Jamaica Bay suggests that it was originally a continuous stratum between Far Rockaway and Coney Island. Subsequent erosion, most likely during the LGM, scoured it away in many locations, particularly in the western half of Jamaica Bay.

Although there are coastal Brooklyn and Queens neighborhoods with no mapped Wantagh, finding remnant lenses of it between elevations -20' and -60', while unlikely, can't be absolutely ruled out. It may still fill the bottom of depressions in the underlying sand, and there may be strips of it that escaped erosion from above.

Acknowledgements

We would like to thank the partners at Mueser Rutledge Consulting Engineers for allowing us to publish information from the company archives. We would like to thank the many engineers at MRCE whose work on recent projects helped us locate the data. Also, many thanks to Stephanie Moss for her help with data entry.

References

Buxton, Herbert; and Shernoff, Peter, 1999, Ground-water resources of Kings and Queens Counties, Long Island, New York: U.S. Geological Survey Water-Supply Paper 2498, 113 p.

Doriski, T. P.; and Wilde-Katz, F., 1983, Geology of the "20-Foot" Clay and Gardiners Clay in southern Nassau and southwestern Suffolk counties, Long Island, New York, U.S. Geological Survey Water-Resources Investigations Report 82-4056, 17 p.

Fuller, M. L., 1914, The geology of Long Island, New York: U.S. Geological Survey Professional Paper 82, 231 p.

Merguerian, Charles; and Sanders, J. E., 1996, Glacial geology of Long Island: Guidebook for On-The-Rocks 1996 Fieldtrip Series, Trip 39, 01 + 02 June 1996, Section of Geological Sciences, New York Academy of Sciences, 130 p.

Mills, Herbert C.; and Wells, Paul D., 1974, Ice-Shove Deformation and Glacial Stratigraphy of Port Washington, Long Island, New York, Geological Society of America Bulletin, vol. 85, no. 3, p. 357-364.

Moss, Cheryl J., 2009, Boulder till filled plunge pools found at the World Trade Center site, NYC, NY, Geological Society of America Abstracts with Programs, v. 41, no. 3, p. 35.

Moss, Cheryl J., 2011a, Geotechnical Evidence of Multiple Glacial Advances in New York City's Subsurface, Geological Society of America Abstracts with Programs, v. 43, no. 1, p. 95.

Moss, Cheryl J., 2011b, Use of Engineering Properties to Identify Multiple Glacial Advances in New York City's Subsurface: in Hanson, G. N., Chm., 18th Annual Conference on Geology of Long Island and Metropolitan New York, 9 April 2011, State University of New York at Stony Brook, NY, Long Island Geologists Program with abstracts, 13 p.

Moss, Cheryl J., 2015a, New York's "20-Foot Clay" Conundrum: Which is Wrong – Published Dates, Presumed Glacial Events, or Strata Origins?, Geological Society of America Abstracts with Programs, v. 47, no. 3, p. 82.

Moss, Cheryl J., 2015b, The Problem Posed by New York's "20-Foot Clay": Which is Wrong – Published Dates, Presumed Glacial Events, or Strata Origins?: in Hanson, G. N., Chm., 22th Annual Conference on Geology of Long Island and Metropolitan New York, 11 April 2014, State University of New York at Stony Brook, NY, Long Island Geologists Program with abstracts, 13 p.

Moss, Cheryl J.; and Canale, Tony, D., 2017a, Mapping the Marine Wantagh Formation, Commonly Known as the 20-Foot Clay, in Queens and Brooklyn, New York, Geological Society of America Abstracts with Programs, v. 49, no. 2.

Moss, Cheryl J.; and Merguerian, Charles, 2009, 50 Ka Till-Filled Pleistocene Plunge Pools and Potholes Found Beneath the World Trade Center Site, New York, NY: in Hanson, G. N., chm., Sixteenth Annual Conference on Geology of Long Island and Metropolitan New York, 28 March 2009, State University of New York at Stony Brook, NY, Long Island Geologists Program with Abstracts, 19 p.

Perlmutter, N. M.; and Geraghty, J. J., 1963, Geology and Ground-Water Conditions in Southern Nassau and Southeastern Queens Counties Long Island, N.Y., Geological Survey Water-Supply Paper 1613-A, 205 p.

Rampino, Michael R.; and Sanders, J. E., 1981, Upper Quaternary Stratigraphy of Southern Long Island, New York, Northeastern Geology, vol. 3, no. 2, p. 116-128.

Sanders, J. E.; and Merguerian, Charles, 1994b, Glacial geology of the New York City region, p. 93-200 *in* Benimoff, A. I., *ed*., The geology of Staten Island, New York: Geological Association of New Jersey Annual Meeting, 11th, Somerset, NJ, 14-15 October 1994, Field guide and proceedings, 296 p.

Sanders, J. E.; and Merguerian, Charles, 1997, Geologic setting of a cruise from the mouth of the East River to the George Washington bridge, New York Harbor: New York, NY, American Rock Mechanics Association, NYRocks 97, hosted by Columbia University Field-Trip Guidebook, 147 p.

Sanders, John E.; and Merguerian, Charles, 1998, Classification of Pleistocene deposits, New York City and vicinity – Fuller (1914) revived and revised: p. 130-143 *in* Hanson, G. N., *chm*., Geology of Long Island and Metropolitan New York, 18 April 1998, State University of New York at Stony Brook, NY, Long Island Geologists Program with Abstracts, 161 p.

Smolensky, D.A.; Buxton, H.T.; and Shernoff, P.K., 1989, Hydrologic framework of Long Island, New York: U.S. Geological Survey Hydrologic Investigations Atlas HA-709.

Soren, Julian, 1978, Subsurface geology and paleogeography of Queens County, Long Island, New York: U. S. Geological Survey Water-Resources Investigations 77-34 Open File Report, 17 p.

Stanford, Scott D., 2010a, Onshore record of Hudson River drainage to the continental shelf from the late Miocene through the late Wisconsinan deglaciation, USA: synthesis and revision, Boreas, vol. 39, p. 1–17.

Stanford, Scott D., 2010b, Glacial Geology and Geomorphology of the Passaic, Hackensack, and Lower Hudson Valleys, New Jersey and New York, p. 47-84 in Benimoff, A. I., ed., New York State Geological Association 82nd Annual Meeting Field Trip Guidebook, Staten Island, NY, 24-26 September 2010, 190 p.

Stone, Byron D.; and Borns, Harold W. Jr., 1986, Pleistocene Glacial and Interglacial Stratigraphy of New England, Long Island, and Adjacent Georges Bank and Gulf of Maine, Quaternary Science Reviews, vol. 5, p. 39-52.

Stone, J.R.; Schafer, J.P.; London, E.H.; DiGiacomo-Cohen, M.L.; Lewis, R.S.; and Thompson, W.B., 2005, Quaternary geologic map of Connecticut and Long Island Sound Basin: U.S. Geological Survey, Scientific Investigations Map SIM-2784, scale 1:125000.

Suter, Russell; deLaguna, Wallace; and Perlmutter, N.M., 1949, Mapping of geologic formations and aquifers of Long Island, New York: State of New York Water Power and Control Commission with the U. S. Geological Survey, Bulletin GW-18, 211 p.

Swarzenski, Wolfgang, 1963, Hydrogeology of northwestern Nassau and northeastern Queens Counties Long Island, New York: U. S. Geological Survey Water-Supply Paper 1657, 88 p.

Wehmiller, John F.; and Pellerito, Vincent, 2015, An Evolving Database for Quaternary Aminostratigraphy, GeoResearch Journal, in press.

Wehmiller, John F.; and Pellerito, Vincent, 2015, Database of Quaternary Coastal Geochronologic Information for the Atlantic and Pacific Coasts of North America, Open File Report No. 50, Delaware Geological Survey.

Brooklyn Quadrangle, New York, 2013, 7.5-Minute Series, U.S. Geological Survey, U.S. Department of the Interior.

Coney Island Quadrangle, New York, 2013, 7.5-Minute Series, U.S. Geological Survey, U.S. Department of the Interior.

Far Rockaway Quadrangle, New York, 2013, 7.5-Minute Series, U.S. Geological Survey, U.S. Department of the Interior.

Jamaica Quadrangle, New York, 2013, 7.5-Minute Series, U.S. Geological Survey, U.S. Department of the Interior.

Jersey City Quadrangle, New Jersey-New York, 2014, 7.5-Minute Series, U.S. Geological Survey, U.S. Department of the Interior.

Lawrence Quadrangle, New York, 2013, 7.5-Minute Series, U.S. Geological Survey, U.S. Department of the Interior.

Long Island West Quadrangle, New York, 1984, 30x60 Minute Series, U.S. Geological Survey, U.S. Department of the Interior and National Ocean Service.

Lynbrook Quadrangle, New York, 2013, 7.5-Minute Series, U.S. Geological Survey, U.S. Department of the Interior.

Newark Quadrangle, New Jersey-New York, 1986, 30x60 Minute Series, U.S. Geological Survey, U.S. Department of the Interior and National Ocean Service.

The Narrows Quadrangle, New York-New Jersey, 2013, 7.5-Minute Series, U.S. Geological Survey, U.S. Department of the Interior.

Moss, Cheryl J.; and Canale, Tony D., 2017, Mapping the 20 – Foot Clay (Wantagh Formation) in Queens and Brooklyn, New York: in Hanson, G. N., Chm., 23rd Annual Conference on Geology of Long Island and Metropolitan New York, 8 April 2017, State University of New York at Stony Brook, NY, Long Island Geologists Program with Abstracts, 11 p.