Sedimentary Facies Map of Brooklyn and Queens

Uncovering Ancient Drainage Systems

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Project Objective

This research utilizes geologic data and historical maps to illustrate the historical distribution of streams and wetlands in Brooklyn and Queens (fig.1), aiming to identify connections between artificially filled floodways and current flood-prone areas. By creating sedimentary drainage facies maps, the study will enhance understanding of how historical drainage systems impact present-day flood risks, providing insights for urban planning and flood management strategies.

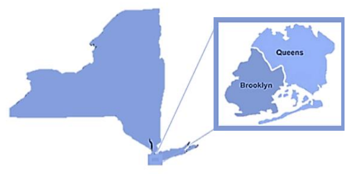


Figure1: Map of New York State and study area, Kings County (Brooklyn), Queens County (Queens).

Background and Geologic Setting

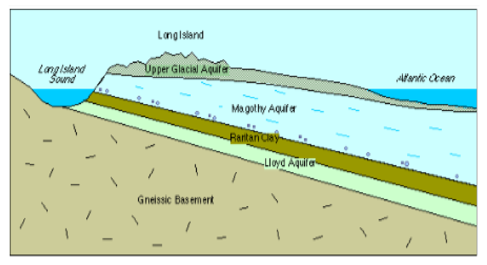


Figure 2: Subsurface geology of Long Island. Modified from the USGS Groundwater Survey (Long Island Groundwater geology)

Long Island primarily consists of unconsolidated sediments from the Cretaceous (145.5-66 mya), Quaternary (2.58 -0.012 mya)

Pre-Cambrian gneiss bedrock underlies these deposits.

Cretaceous lithologic units are part of the Northern Atlantic Coastal Plain Aquifer System (Eaten, 1995, (Frank and McClymonds, 1972).

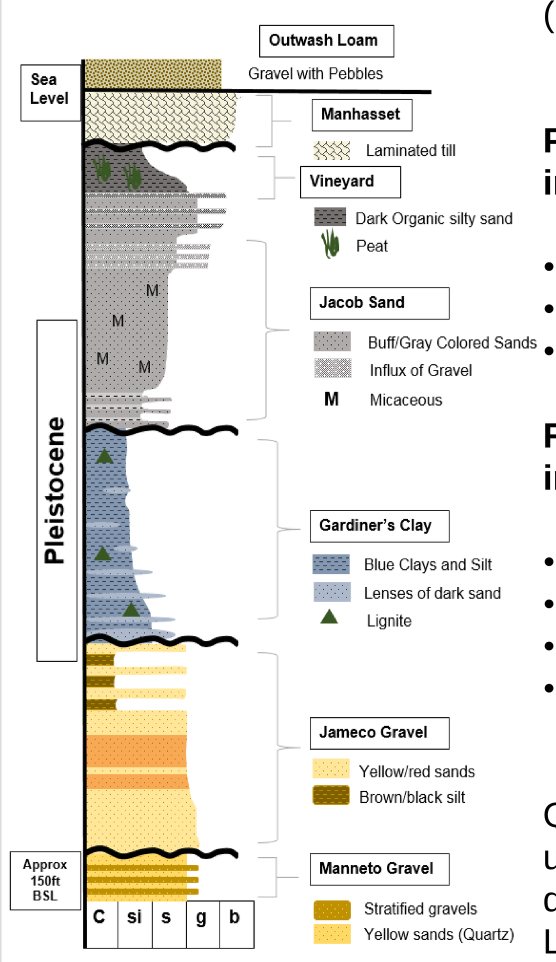


Figure 3: Generalized Stratigraphy of Long Island

Pleistocene stratigraphy represents glacial and interglacial periods. Formations represent:

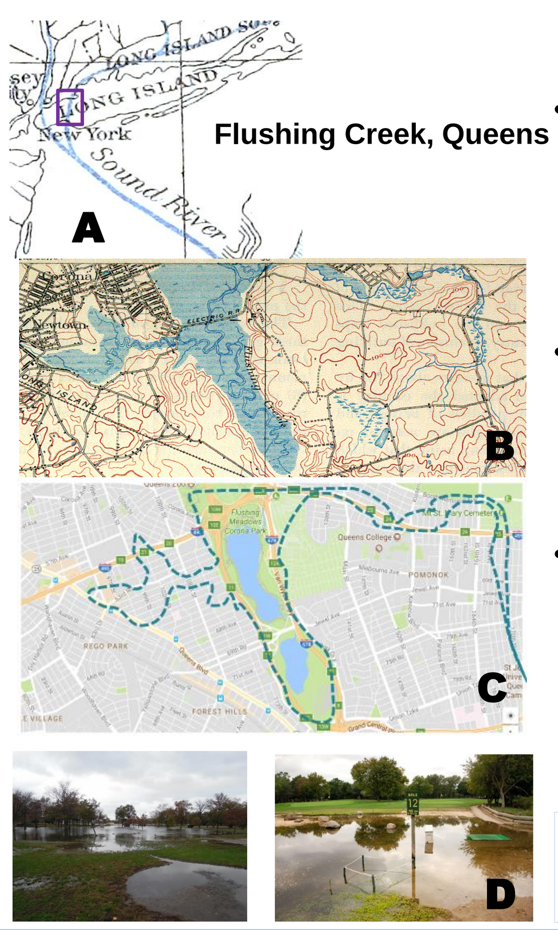
- Glacial outwash deposits
- Interbedded fluvial and deltaic deposits
- Transgressive tidal deposits

Recent Holocene deposits (11,650 kya - Present) include:

- Wetland soils
- Glacial outwash
- Fluvial deposits from meltwater channels
- Tidal channels from the retreat of the Laurentide ice sheet post-Wisconsin glaciation

Quaternary units (Pleistocene – Holocene) will be used for interpreting recent sedimentary facies, depositional environments, and geomorphology of Long Island.

Urban Development, Flooding and Mitigation



- Flooding in New York City affects both coastal and inland areas in Brooklyn and Queens (fig.4).
- Coastal flooding, especially after events like Hurricane Sandy, has been extensively studied. Limited research exists on the causes of frequent interior flooding in Brooklyn and Queens.
- Urban development has removed natural floodways, leading to increased flooding. Smith and Rodriguez (2016) identified the lack of permeable surfaces as a factor in flood patterns.
- Understanding ancient drainage systems in Brooklyn and Queens is crucial for floodplain management, as it provides insights into historical water flow patterns and could be utilized for developing modern strategies for mitigating flood risks and adapting to climate change.

Figure 4: (A) Confirmed channel floodway crossing Queens (NE/SW), Pliocene (Soren, 1987). (B) Historic Flushing Creek and (C) current Flushing Creek area [Modified from NY Public Library Map Archive] , (D) pictures of stream flooding in the developed Flushing Creek area

Research Approach

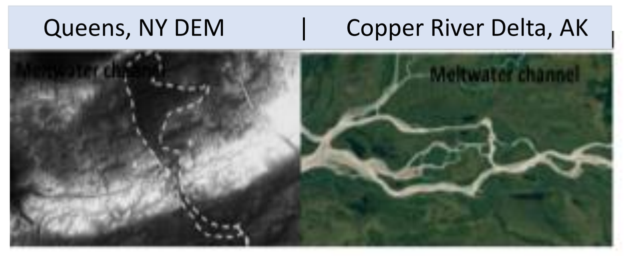


Figure 5: (Left) Digital elevation model of the meandering tidal zone of the study area (meandering channels outline in white) (Right) Meandering zone in the Copper River Delta Region, AK (meandering channels outlined in white) (Google Earth Image)

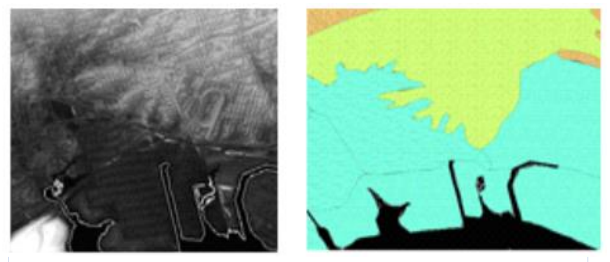


Figure 6: (Left): Digital Elevation Model of The study area (white areas represent higher topographic landforms such as alluvial lobes), (Right) Facies Map overlying the Digital elevation model of the study area (green = facies 2)

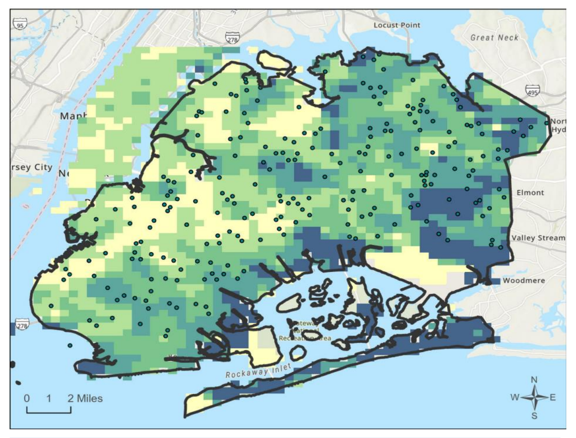


Figure 7 : Flood Density Map, modified from Smith and Rodriguez, 2016, With randomly generated sample points for flood facies statistical analysis.

I. Geologist's log reports and resistivity logs from various locations across the two boroughs in Long Island were retrieved from the US Groundwater Survey. These reports were digitized as point locations within Geographic Information Systems (GIS).

II. Sedimentology was coded, representing tidal to glacio-fluvial lithology, from fine-grained siliciclastic to coarse material. Modern environments like Alaska's Copper River Delta helped interpret the geomorphology of a glacially influenced estuary (fig.5).

III. Stratigraphic columns were created for each log and incorporated into the spatial dataset. The stratigraphy of the logs were analyzed to identify the primary sedimentary facies and depositional systems of the late Quaternary Period.

IV. Stratigraphic sections were correlated with neighboring locations to delineate the prominent sedimentary facies over space and time. Cross sections were created to determine the sequence stratigraphy of the core locations and surrounding areas. Four main sedimentary facies were identified (fig.6).

V. Interpolated predictions of geologic point data, Digital Elevation Model (DEM) and historical maps were utilized for terrain analysis and to identify major flood-originated sedimentary facies, depositional environments and paleo-drainage trends.

VI. Finally, paleo drainage trends were compared with modern flood hotspots identified from 311 flood complaint calls in New York City to determine if there is a correlation between flood-originated facies locations and modern urban flood trends (fig.7).

Results

Sedimentary Facies Map of Kings and Queens County

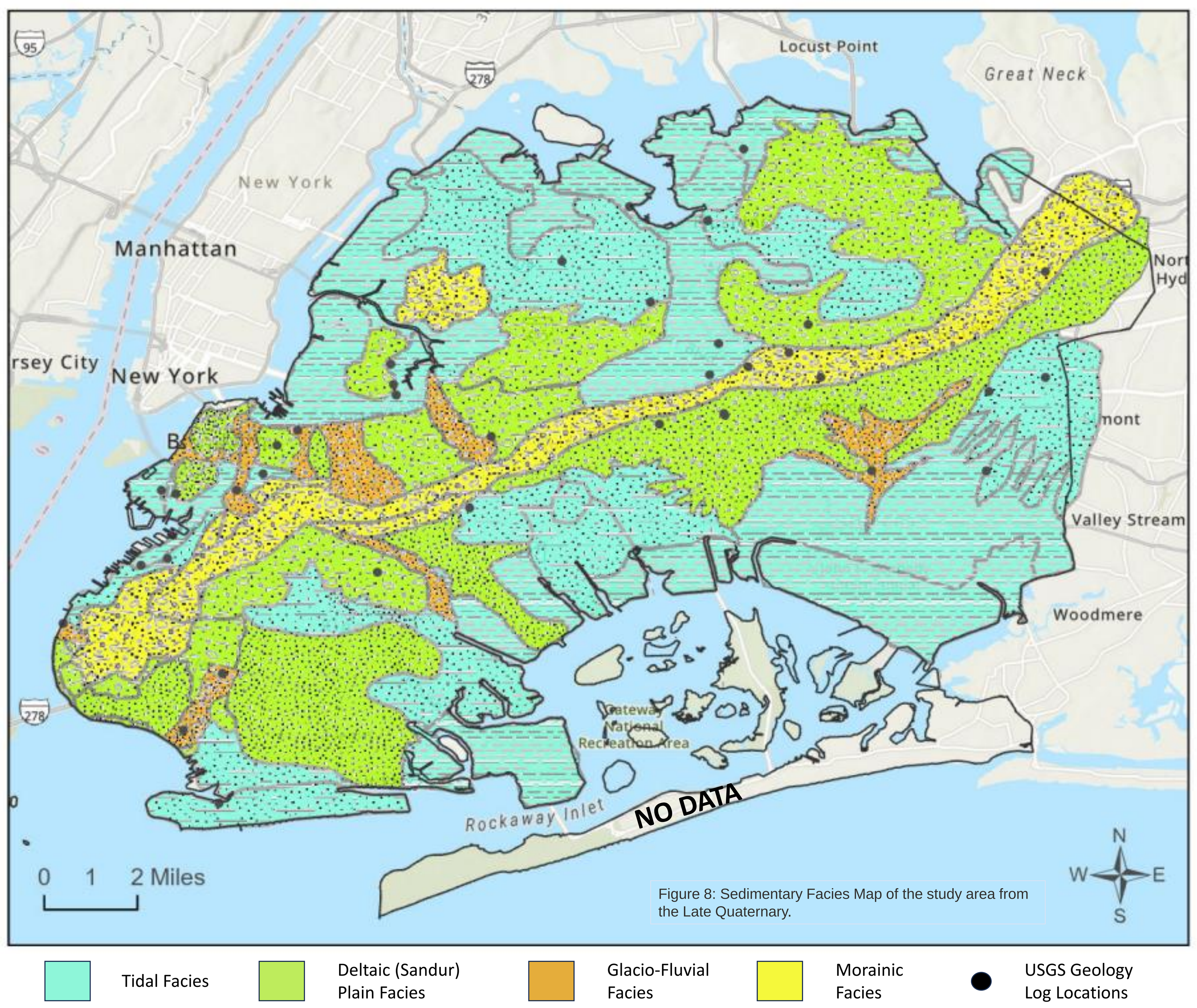
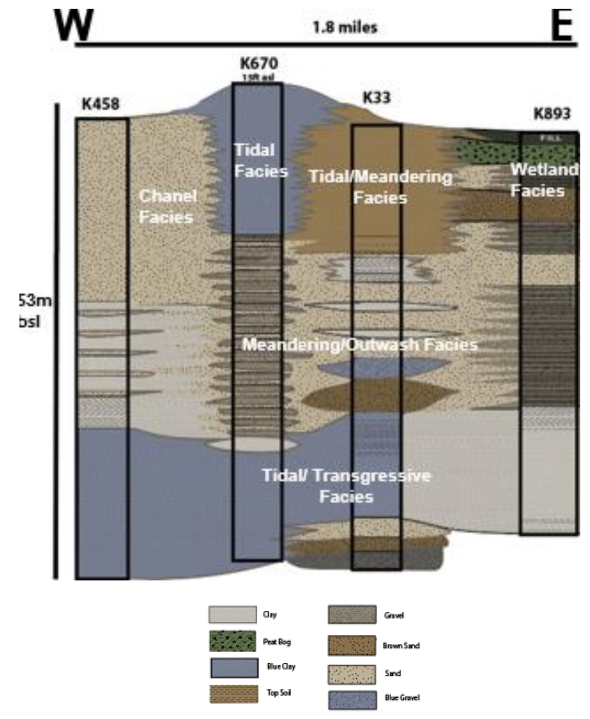
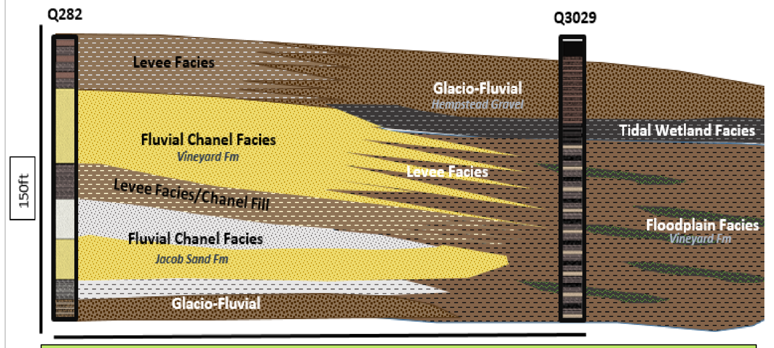


Figure 8: Sedimentary Facies Map of the study area from the Late Quaternary.

Discussion of Results

I. Facies Interpretations





Facies Type 2: Deltaic Flood Plain

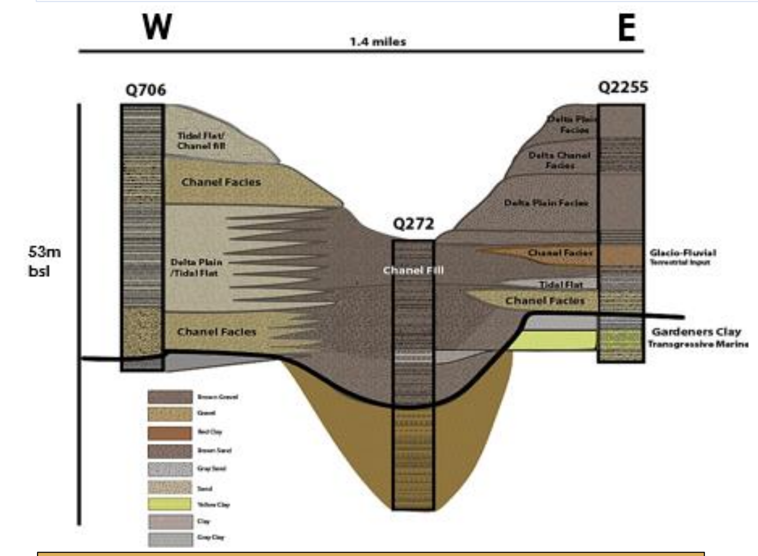
The Deltaic Plain Facies (facies 2) is located within meters of the Harbor Hill Moraine. It typically consists of coarse sands and gravels, found around 6 meters above sea level. Facies 2 is occasionally present in the drainage basins surrounding Jamaica Bay to the south and Long Island Sound to the north. Cores from these drainage basins show a gradational change in grain size, transitioning from massive sands and laminated gravel to silty-sands (similar to Facies 1) and gravel lenses throughout the basin.

Figure 10: Cross Section of Interpreted Deltaic Plain Facies in Queens County

Facies Type 1: Tidal Meandering Plain

The tidal/meandering sedimentary facies (facies 1) is predominant in southern Brooklyn and Queens around Jamaica Bay and near inlets in northern Brooklyn and Queens, such as Newtown Creek and Flushing Meadows. It is characterized by fine sand and silt throughout its stratigraphic sections, heavily influenced by tidal fluxes and coastal flooding. This facies typically occurs in drainage areas less than 6 meters above sea level. The uppermost sections often contain peat and lignite, followed by clay and silt deposits, reflecting sea level rises during the Pleistocene.

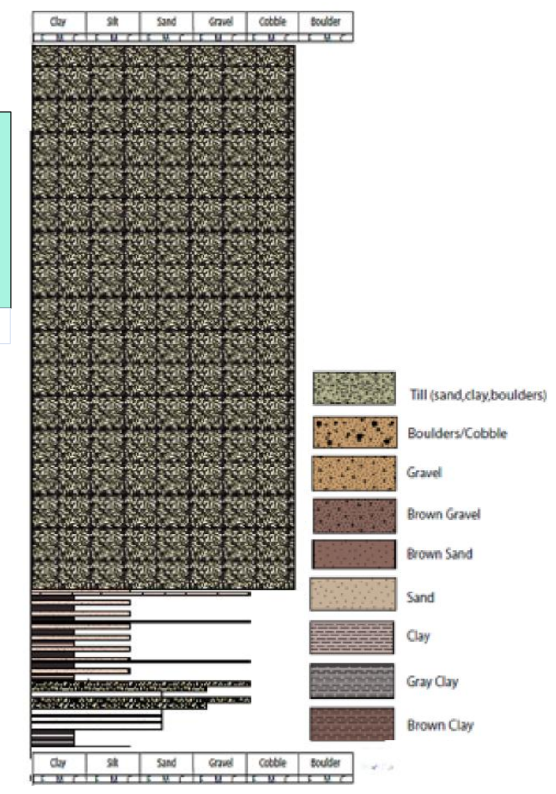
Figure 9 : Cross Section of Interpreted Tidal Facies in Kings County



Facies Type 3: Glacio-Fluvial

The Glacio-Fluvial Facies (Facies 3) is distinct in its lithology, differing from typical floodplain or estuary environments. It comprises a mixed composition of siliciclastic sediments ranging from course to fine sand. Iron-stained sediments from fluvial meltwater channels and varved sediments are common, especially in areas of decreased elevation near the Harbor Hill Moraine.

Figure 11: Cross Section of Interpreted Glacio-fluvial Facies in Queens County



Facies Type 4: Morainic

The Morainic Facies (Facies 4), consists of till deposits with unconsolidated sediments ranging from silt to boulder size, located along the terminal moraine. It is typically found at elevations over 100 feet above sea level. This facies is restricted to a longitudinal ridge that crosses northern Brooklyn and Queens. Terminal moraine deposits are present across northwest Brooklyn, including Sunset Park and Bay Ridge, extending east to Richmond and Cyrpris Hills in Queens. Additionally, smaller recessional moraines are situated north of the terminal ridge, formed by receding glaciers during climate changes.

Figure 12: A representative core stratigraphy of Facies 4 (Q306 core)

II. Statistical Analysis of Flood Density Variations Across Different Facies

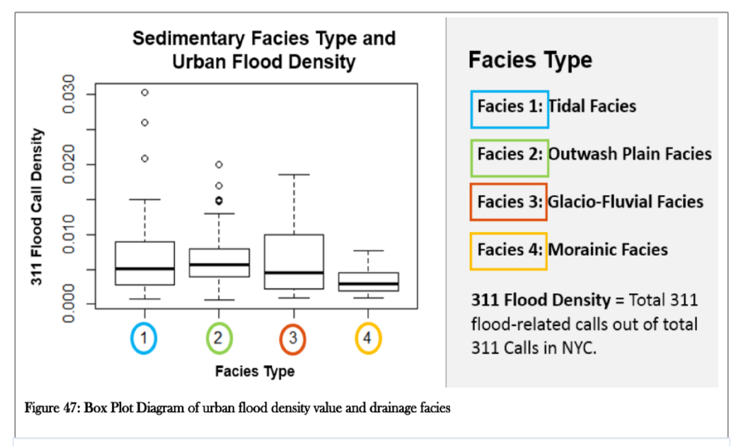


Figure 13: Box Plot Diagram of flood density values and associated facies

- Variable ranges of flood density values among the facies.
- Facies 1 ▯ wide spread of flood density values, including significant outliers.
- Facies 2 ▯ highest mean and median flood density value, indicating more frequent flooding compared to other facies.
- Facies 3 ▯ Highest maximum flood frequency and overall higher flood density values.
- Facies 2 and 3 ▯ higher median flood density values than facies 1 and 4.

Kruskal-Wallis Test: Chi Square = 7.5242 p-value = 0.02324

- Flood density distributions may be independent and not similar across facies.
- Findings support the assumption of significant variation in flood density values among facies, reflecting variable flooding severity associated with each facie.

Conclusion

Based on the results of the study, we conclude the following:

- Drainage facies models can be developed using subsurface geological descriptions, resistivity logs and geographic locations.
- Flood trends can be spatially represented using flood point location data.
- There is an association between the locations of paleo water channels (facies 1,3) and urban flood trends.

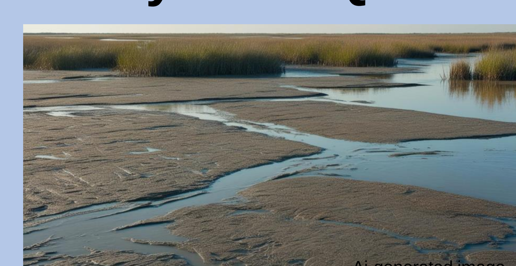
Evolution of Physical Geography of Brooklyn and Queens

Advancing glaciers collected sediments in the ice, depositing them as they retreated to form ridges called moraines. The terminal moraine marks the glacier's furthest reach, as seen in Brooklyn and Queens with the Harbor Hill Moraine and the terminal moraine.

Glacial retreat and rising sea levels during the warmer climate fluctuations of the Quaternary Period formed meltwater channels that carved through sediments and bedrock, shaping regional drainage and sediment distribution.

Meltwater from retreating glaciers deposited coarse sands and gravels across outwash plains, forming a gradational sedimentary structure with massive sands transitioning to silty sands and gravel lenses.

As glaciers advanced during warmer climate fluctuations, they transported and deposited sediments, forming Sandur Plains, while melting ice created kettle ponds.



The cyclical sea level changes resulted in the development of low-energy transgressive tidal sequences and the accumulation of organic materials, such as peat and lignite, in the upper layers, indicating periods of relative sea level rise.

As more people settled on the island, marshland was converted into farmland because of the nutrient-rich tidal soil.

Prospect Park Landfill 1867 Brooklyn, NY

As the boroughs became more developed through urbanization, landfilling became a common strategy for urban expansion.

Construction of the Brooklyn Bridge 1880 Brooklyn, NY

With the rapid development of NYC, natural landforms and streams were diverted and filled, replaced by impermeable streets and altered land cover.