Geology and Hydrogeology of the Crosswicks Creek Tidal Wetlands

Field Trip

September 17 (Saturday). Leader: Pierre Lacombe, U.S. Geologic Survey.
(Cosponsors with
Friends for the Hamilton-Trenton-Bordentown Marsh; Mary Leck
D&R Canal State Park,
Bordentown City Environmental Commission,
D&R Greenway Land Trust).

Introduction

The purpose of this Fieldtrip is to present an introduction to the geology that underlies and surrounds the Crosswicks Creek Tidal Wetlands (fig. 1). The geology is hard to see because it covered by lush vegetation or public, residential, and commercial properties. However, with exploration of some tidal shoreline outcrops, a few construction excavations, two geologic maps, accompanied by visits to some local buildings, one will see some of the in situ geology or will see the geology that has been mined and converted to building materials for homes and highways.

The bedrock (basement) consists of metamorphic rocks of Pre-Cambrian and lower Paleozoic age (Table 1). Overlying the basement is unconsolidated sand, silt, and clay of Cretaceous age. These unconsolidated deposits are 100 to 350 ft thick in the Marsh. Boulders, gravel, sand, sand, silt, and clay, of Pleistocene age; as well as sand, silt, mucks, and fill of Recent age overlie the Cretaceous sediments. The Pleistocene and Recent deposits range in thickness from a veneer to 50 ft. Geologic maps and sections show the relationship of the units in the marsh (fig 2, 6, 10).

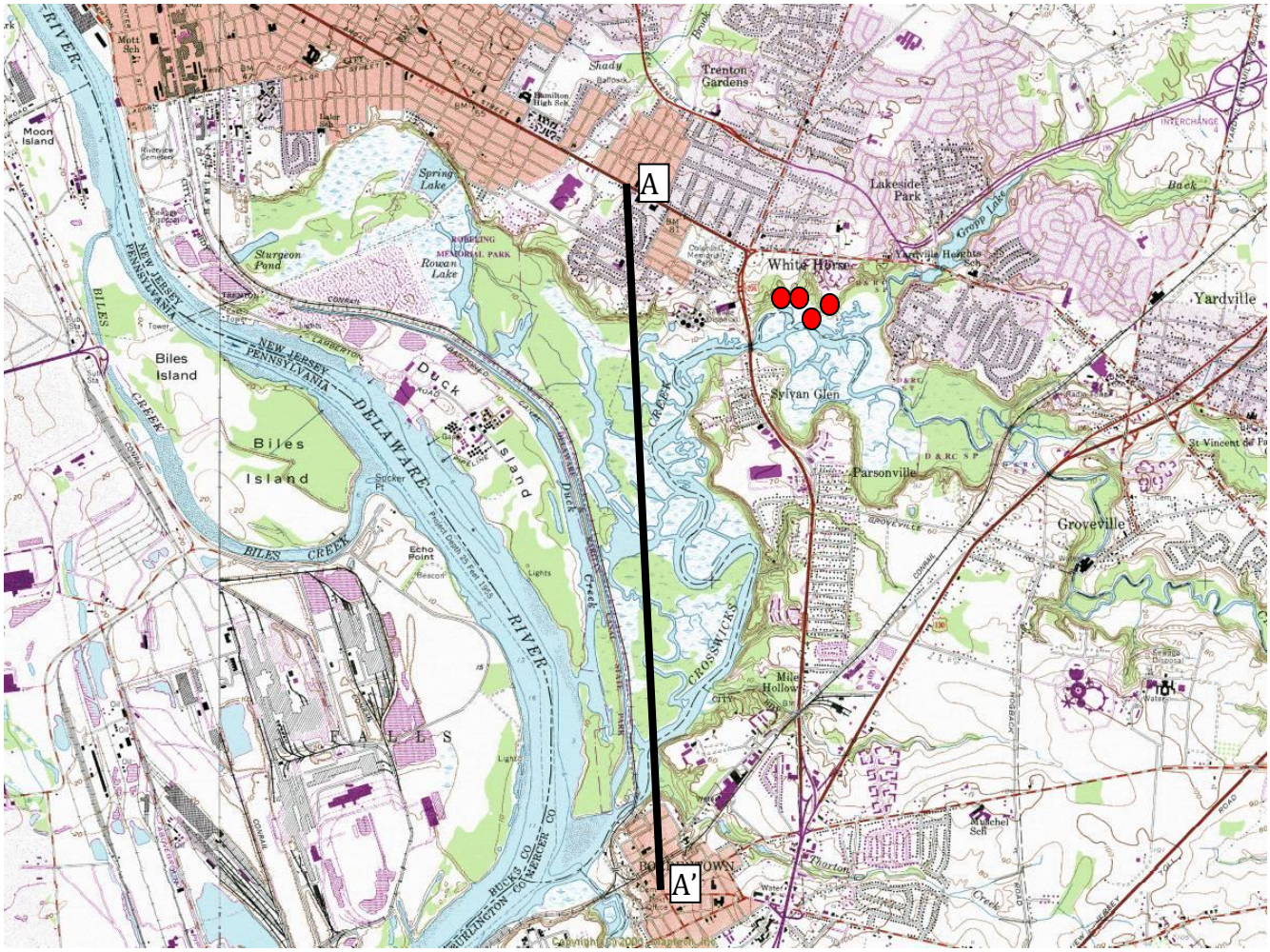


Figure 1 Topographic map of Marsh prior to construction of I 295 and 1 129 and Section A-A'

Cross section of Geology

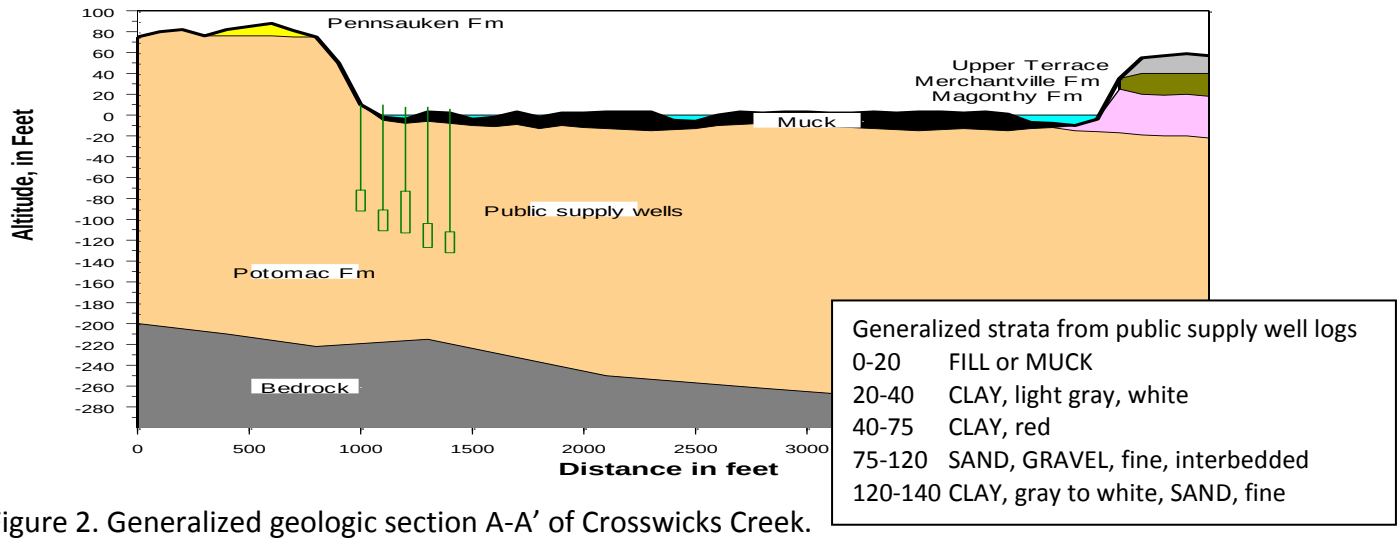


Figure 2. Generalized geologic section A-A' of Crosswicks Creek.

Table 1 Rock units of the Marsh and surrounding area

ERA	Period	Epoch	began in million years before present	Rock units	Major events in the Trenton Area
Cenozoic	Quaternary	Recent	0.01	Fill and alluvium	Humans mine, till, and otherwise transport sediment as well as erode hilltops.
		Pleistocene	2	Trenton Gravel Qtl, Qtf, Qwf, Qst	Glaciers form multiple times and extend from central Canada to about 40 miles north of Trenton. Trenton has permafrost, and heavy winds. As glaciers melt, Delaware River floods with 10 to 100 times more water than of the Recent epoch. Massive boulders, gravel, and sand are deposed in Trenton area.
	Tertiary		65		
Mesozoic	Cretaceous		136	Merchantville Fm Kmv Woodbury Fm Kwb Magothy Fm Kmg Raritan Fm Kr Potomac Fm Kp	Atlantic Ocean continues to open. Newark Basin and other areas northwest of Trenton rise and erode. Sediment is deposited in proto Atlantic in Bordentown area.
	Jurassic		190	diabase Jd	Rift basin opens southeast of Trenton. Igneous rocks intrude between around Pennington
	Triassic		225	Passaic Fm JTrp Lockatong Fm Trl Stockton Fm Trs	Newark Basin forms as Atlantic Ocean opens. Sediment eroded from Mountains and hills in the Trenton and more southeasterly area are deposited in the rift basin
Paleozoic	Permian		280		Mountains of Trenton area are eroded. Sediment is deposited in central PA area
	Pennsylvanian		325		
	Mississippian		345		Acadian Orogeny forming Pangaea
	Devonian		395		Mountains of Trenton area are eroded. Sediment is deposited in central PA area
	Silurian		430		
	Ordovician		500	Whissahickon Fm Czw*	Taconian Orogeny
	Cambrian		570	Chickies Fm Cc	Mountains west of Trenton erode mud, sand, clay, silt and lime deposited in deeper water
PreCambrian	Neo- & Meso-proterozoic			gneiss, Manhattan Schist Yg* CZm*,	Mountains west of Trenton erode. sand and gravel deposited in shore line of Iapetus Ocean
			1000	gabbro Ygb*	

* ages of these units are modified in Volkert's report

Precambrian and lower Paleozoic Metamorphic Rocks

The basement metamorphic rocks do not outcrop within the marsh. They are at an altitude of -100 to -300 ft and have only been detected in wells in the marsh. The only places one can see the gneiss and schist in the marsh is as cobbles along the Delaware River shoreline; on the exterior walls of the Isaac Watson house (fig. 3), and in the walls of a private residence on Farnsworth Ave., Bordentown.

Figure 3. Photograph of the Isaac Watson House. House is constructed of metamorphic rocks of the Trenton Prong (north side) and Stockton sandstone of the Newark Basin (south side).

Cretaceous Sediments

Much of the marsh is underlain by the **Potomac Formation** (Kp) (fig. 4). The Potomac Formation is predominantly clay to clay-silt, thinly laminated to thick-bedded, mottled red, white, and orange-brown, less commonly dark-gray and woody; interbedded with thin beds and lenses of very fine to medium-grained, massive, white to orange-brown, micaceous sand. Lithologies are typical of the shallow subsurface. Down dip, these lithologies interfinger with thin to thick beds of marine clay-silt, commonly glauconitic and locally shelly.

Ephemeral outcrops of this formation exist along erosion scarps of the marsh and the Delaware River and are best observed in Florence, NJ.

The source of these clays is the Triassic age Newark Basin sedimentary rocks.

The red clays of the Potomac formations were locally mined for the pottery industry and brick industry. Many of the red bricks in the historical homes of Bordentown were mined from clay outcrops in the marsh area (fig 5 and 6A).

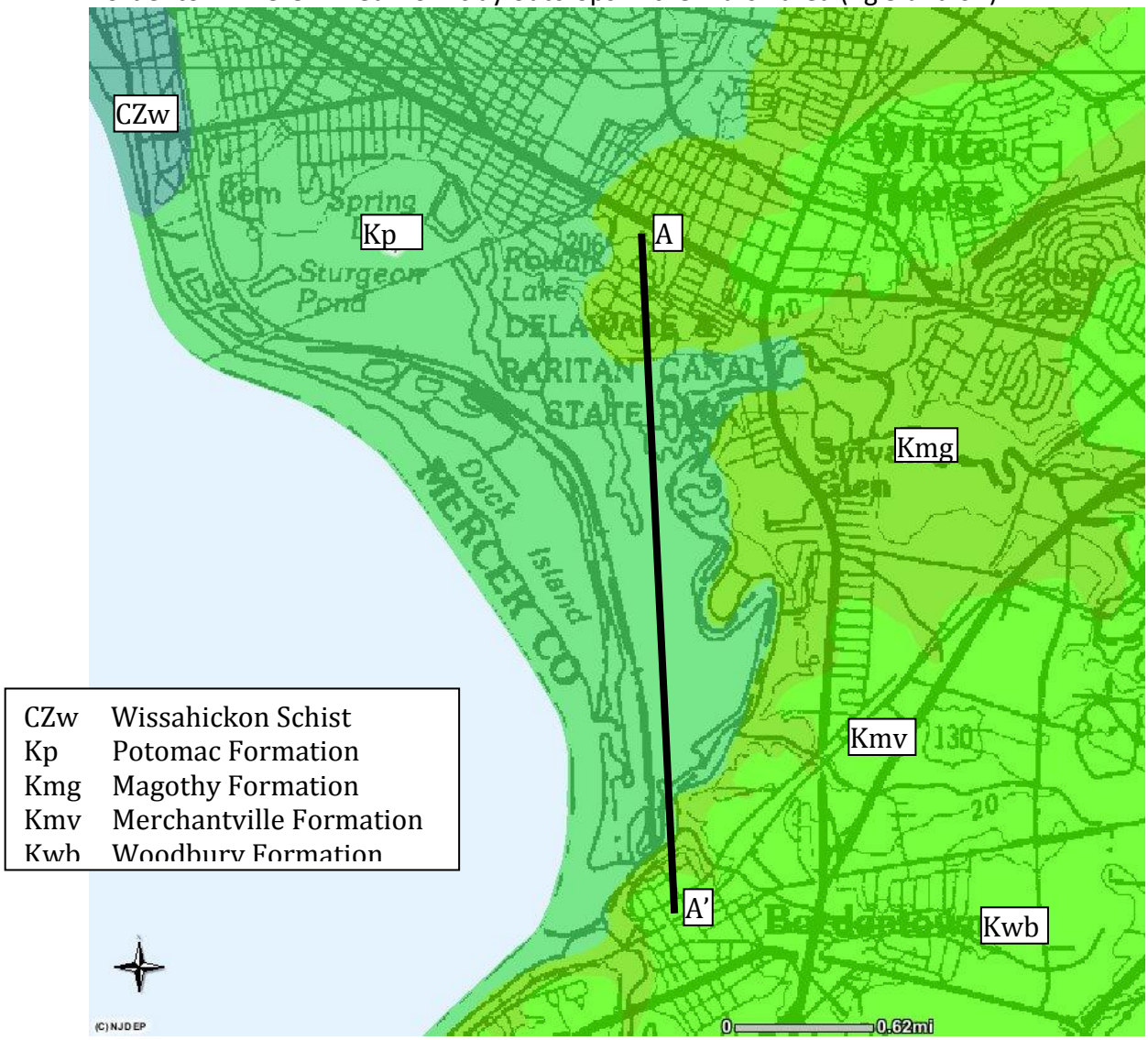


Figure 4. Geologic map showing the subcrop of Cretaceous age geologic strata.

Figure 5. Quaker Meeting House Bordentown, bricks are likely from local Raritan clay/sand deposits

The **Magothy Formation** (Kmg) overlies the Potomac Formation and it forms many of the hill slopes that surround the marsh. The Magothy Formation consist of sand, fine- to coarse grained, locally very gravelly (pebbles less than 1.3 cm (0.5 in) in diameter), typically cross stratified, massive, horizontally bedded, light-gray to white, carbonized wood (several centimeters long) and colorless mica scattered throughout. Black to dark-gray, very carbonaceous clay is locally interstratified with the sand. No calcareous fossils were recovered from the Magothy Formation in the shallow subsurface. The lower part of the formation above the gravel consists of thin-bedded white clay interbedded with fine- to coarse-grained, poorly sorted, thick bedded, light-colored, somewhat micaceous quartz sand. The interbedded clay becomes dark gray up section. Quartz is the major sand mineral. Siliceous rock fragments, mica, and feldspar are minor constituents. In general, this formation appears to be fluvial near the base (upper delta plain) and gradually becomes more marine upward (shelf). The overall sedimentologic pattern suggests a net transgression during deposition of the Magothy with shelf deposits overriding a nonmarine (probably deltaic) facies.

A dark-gray, carbonaceous clay unit outcrops in a streambed along the west side of Northern Community Park on Groveville Road.

The **Merchantville Formation** (Kmv) forms the uplands that surround the park. Merchantville Formation consist of sand, glauconite, locally has high quartz content, very clayey and silty, massive to thick-bedded, grayish-olive-green to dark-greenish-gray; weathers moderate brown or moderate yellow brown. Mica, feldspar, and pyrite are minor sand constituents. Very micaceous at base. Locally, has extensive iron incrustations in near-surface weathered beds. The Merchantville forms a continuous narrow to wide belt throughout the map area. The unit is about 20 m (66 ft) thick in the Trenton area. The formation is best exposed in the Trenton East quadrangle, mainly in

the tributaries on the western side of Blacks Creek and south of Bordentown, especially at Crystal Lake Park where the entire thickness of the formation can be seen in gullies (Owens and Minard, 1964b). The basal contact with the underlying Magothy Formations is sharp and disconformable. At most places, a reworked zone about 0.3 to 1 m (1-3 ft) thick is present at the base. This basal bed contains reworked lignitized wood, siderite concretions as much as 13 cm (5 in) in diameter, scattered pebbles and coarse-grained quartz sand and is burrowed. Most burrows project downward into the underlying formations. The Merchantville is the basal bed of a lower Campanian transgressive-regressive cycle that includes the overlying Woodbury and Englishtown Formations. Merchantville faunas were analyzed by Sohl (in Owens and others, 1977) who concluded that northern fauna represented deposition on a lower shore face or in the transition to an inner shelf, whereas the southern fauna was a deeper water assemblage, probably inner shelf.

A former clay mine for the brick industry is in Crystal Lake Park and the housing track on the east side of Crystal Lake is a former clay quarry for the brick industry.

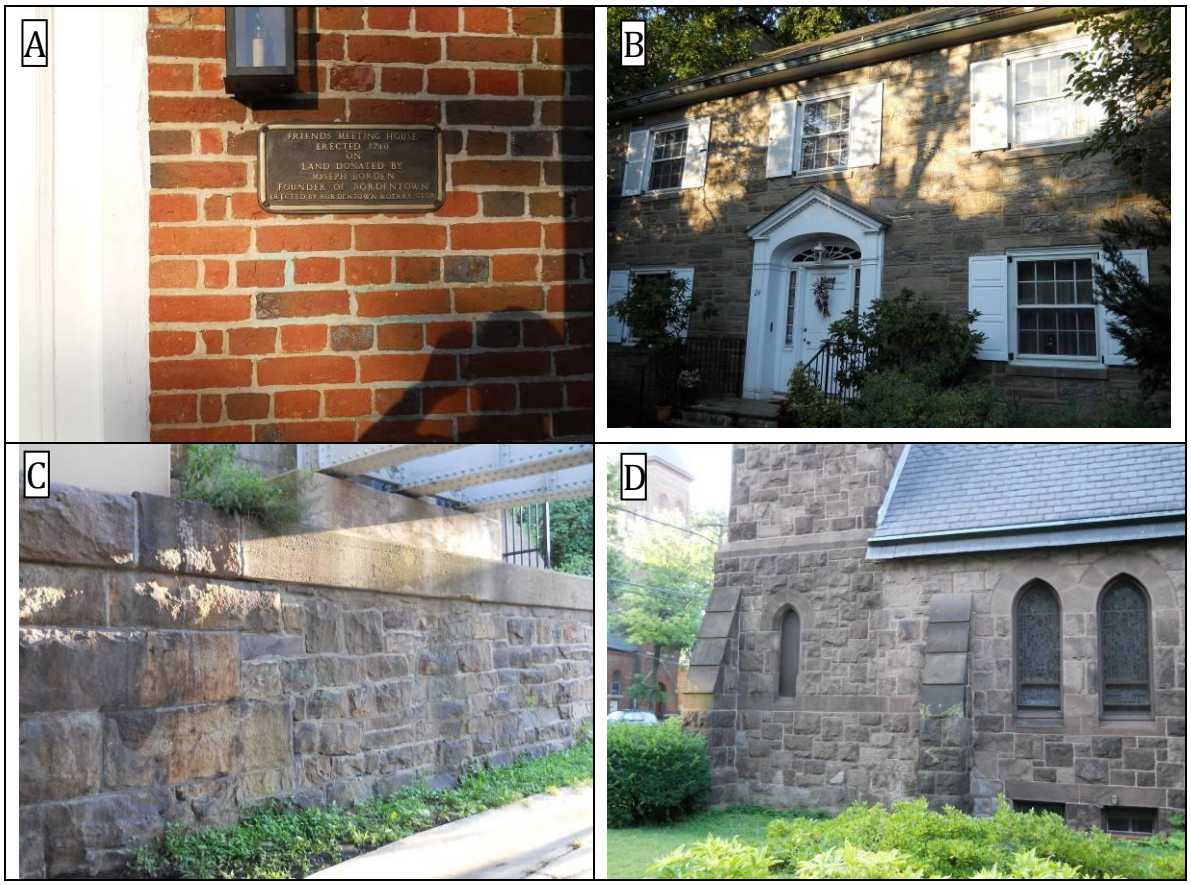


Figure 6. Source of sediments of Crosswicks Creek came from Triassic sedimentary rocks of the Newark Basin and metamorphic rocks of the Trenton Prong. The rocks and sediments are used for construction. (A) Brick from Raritan formation, (B) House made of metamorphic rock, (C) Train trestle foundation and (D) Church from Triassic Stockton Fm.

Cenozoic deposits

The Tertiary, Pleistocene, and Recent deposits (fig. 7) form the surficial geologic units within the marsh and covering the highlands that surrounds the marsh. Each unit is unconsolidated deposits of cobbles, sand, silt, clay, and/or organic muck as well as fill.

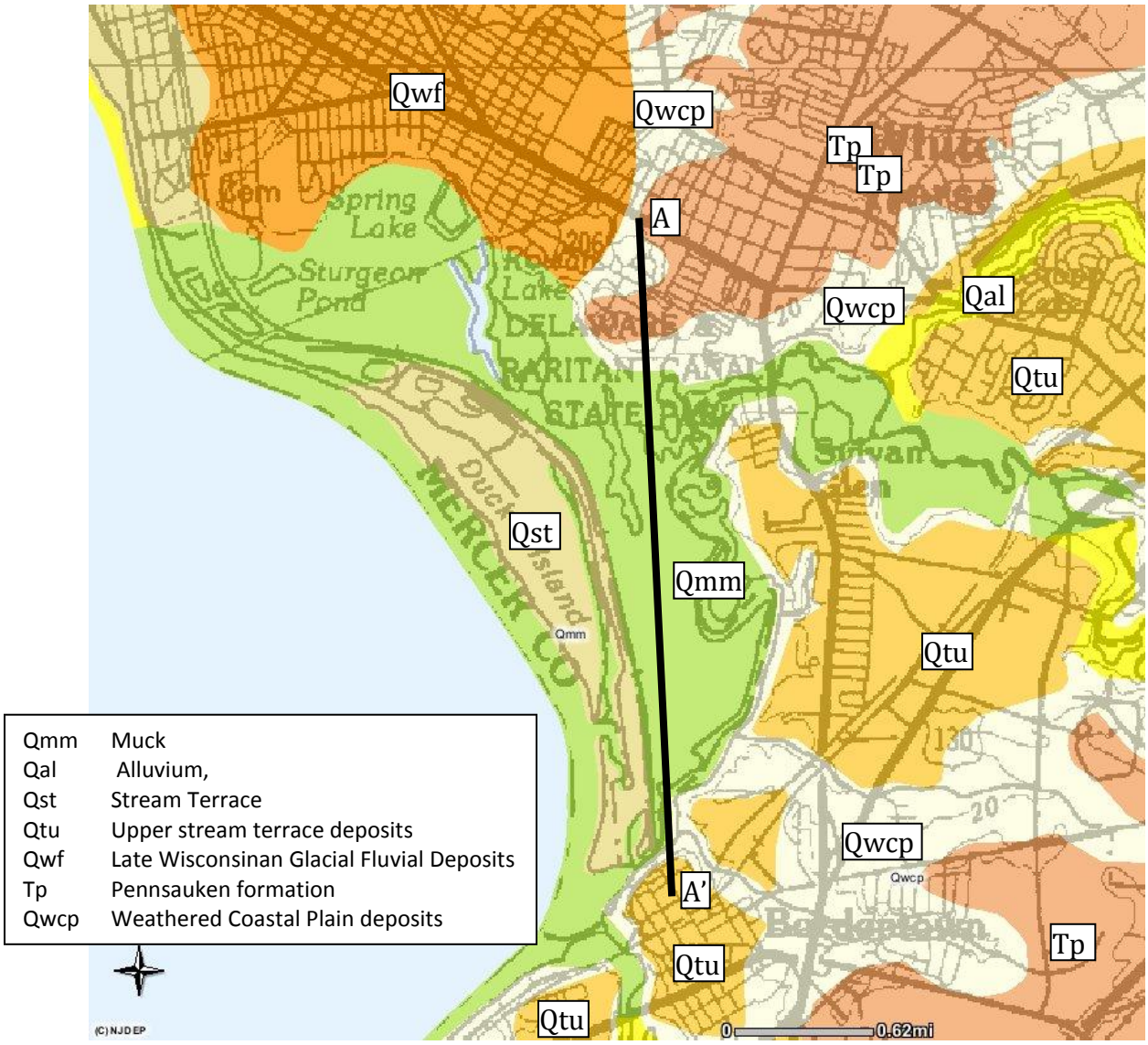


Figure 7. Surficial sediments that underlie and surround the Marsh.

Recent Deposits: muck, alluvium, fill

Recent sediments that underlie the wetlands (fig 1) consist of tidal marsh and estuarine deposits (Qmm), alluvium deposits (Qal) and fill. The Muck (Qmm) deposits consist of black, brown, and gray organic muck and peat composed of the remains of the marsh grasses. Generally, the muck is 1 to 2 meters thick. Alluvium (Qal) is composed of silt and sand and forms levee and crevasse splay deposits along tidal creek

margins. Deposits generally are transported as suspended sediment in turbid waters during high tide. The Alluvium is 1 to 2 meters thick.

Artificial Fill (af) covers much of native deposits along the I-295, I-195, Route 206 roadways; the Riverline rail tracks; the closed landfill (dump) north of I-195 and the industrial site of the Duck Island electrical generation plant, oil storage tanks and Hamilton sewer Plant and Trenton Sewer Plant. The sediments are widely variable, consolidated aggregate of excavated material that have been graded and compacted for site-specific engineering works. The thickness is highly variable ranging from less than a foot to 50 ft. Artificial fill is from areas as close as 100 ft away such as the banks of the canal to as far as from 15 miles away such as the railroad riprap.

Post glacial stream and terrace deposits

The postglacial deposits have multiple names depending on the location, and the time of geologic investigation. For the most part, they have a very similar sediment type (coarse gravel to sand) but the mode of deposition changes and therefore the names change. For the most part, they are subdivisions of the formerly named Trenton Gravel.

Postglacial stream terrace deposits (Qst) are early Holocene and late Pleistocene, late Wisconsinan. The deposits are compositionally similar to the fluvial deposits at Van Sciver Lake (Qvl) but with smaller scale, scoured and filled channels, point-bar deposits, and reworked finer grained material. The top of the unit originally included fining upward flood plain and overbank deposits. The deposit underlies Duck Island and other nearby low islands (less than 3 m altitude) downstream from the Trenton Falls. The Interpreted to be alluvium reworked from Delaware Valley outwash terraces (Qrdl) by meteoric discharges during the Holocene. Currently, deposits are flooded during major storm events and fine-grained sediments are veneered on surface. Much of Duck Island and other similar island have been excavated and used for landfill, dredge spoils, and industrial sites.

Uplands on the north, side of the marsh from Riverview Cemetery to about the Isaac Watson House are underlain by Late Wisconsinan Glacial Fluvial deposits (Qwf). From the Isaac Watson house to Gropp Lake on Back Edges Brook, the steep banks of the marsh are underlain by weathered Coastal Plain sediments (Qwcp). The top of the hill (Independence Mall area) is underlain by the Pennsauken Formation (Tp). The steep slopes along the east and south side of the marsh are underlain by weathered Coastal Plain sediments (Qwcp) and the more upland areas are covered by Upper Terrace deposits (Qtu). In Bordentown, the steep banks have been extended in many places by adding fill.

Flow of the Delaware River at Trenton and Crosswicks Creek at Extonville

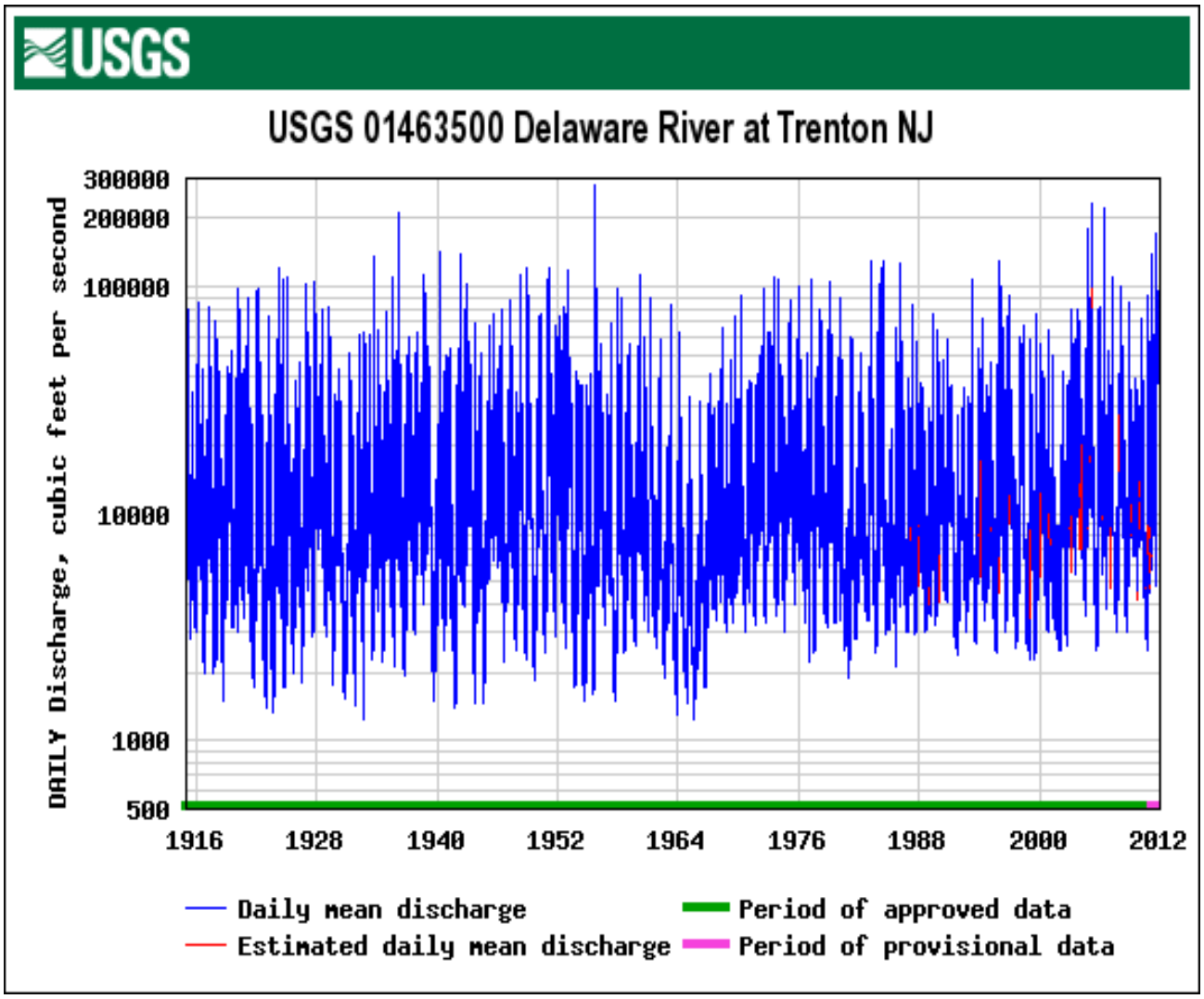


Figure8. Stream discharge of the Delaware River at the Calhoun Street Bridge.

A. Low maximum flow during the drought of the mid 1960s,
B. Increased base-flow after the construction of reservoirs in the upper basin to prevent saltwater intrusion in the Delaware River near Philadelphia area.
C. Flood stage discharge is about 125,000 cubic feet per second (cfs).
D. Record flooding occurred in August 1955, in the aftermath of the passing of Hurricane Connie and Hurricane Diane.
E. Recent severe flooding occurred along the river September 23, 2004, April 4, 2005, and June 28, 2006,

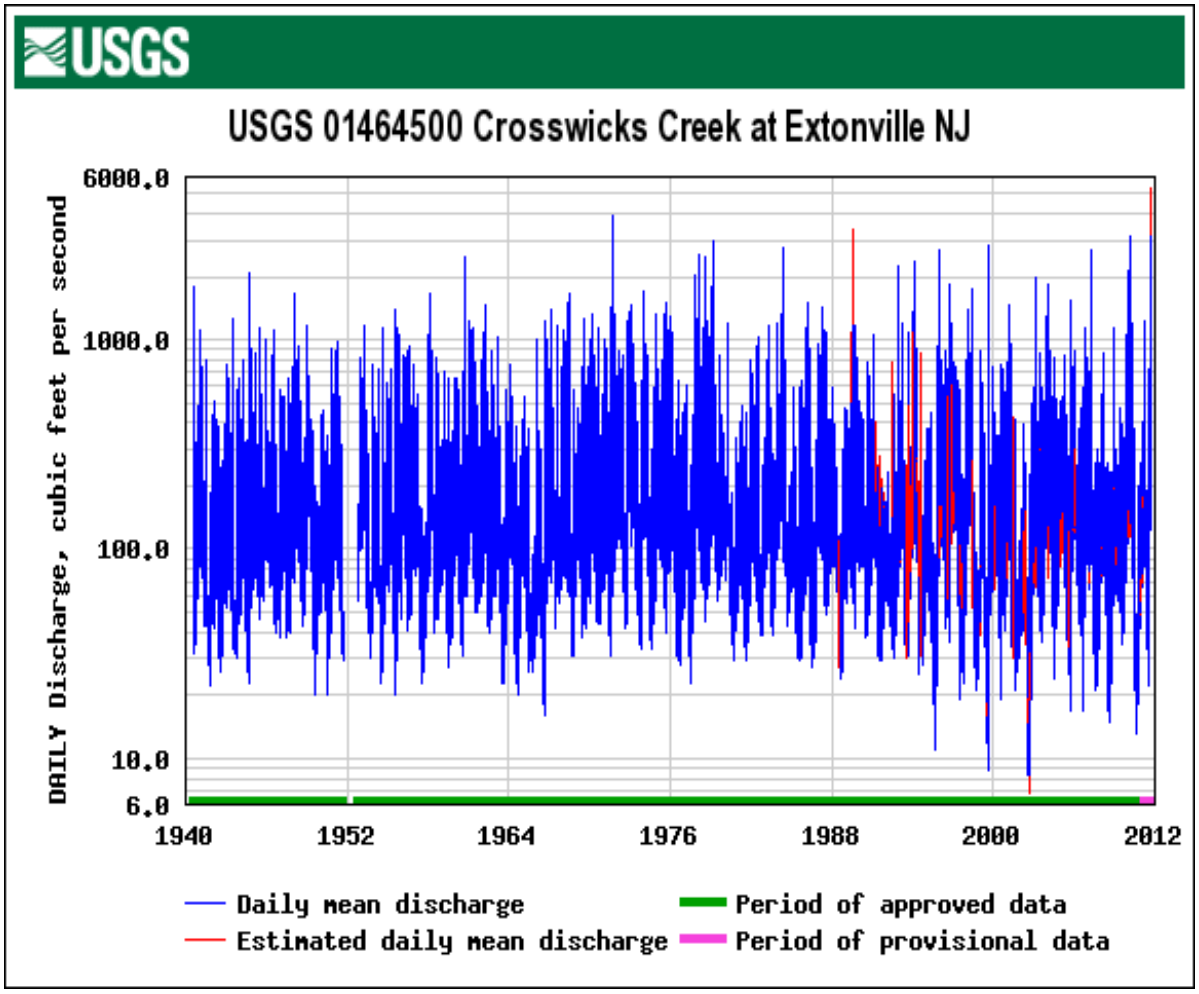


Figure 9. Flow of Crosswicks Creek at Extonville for period of record

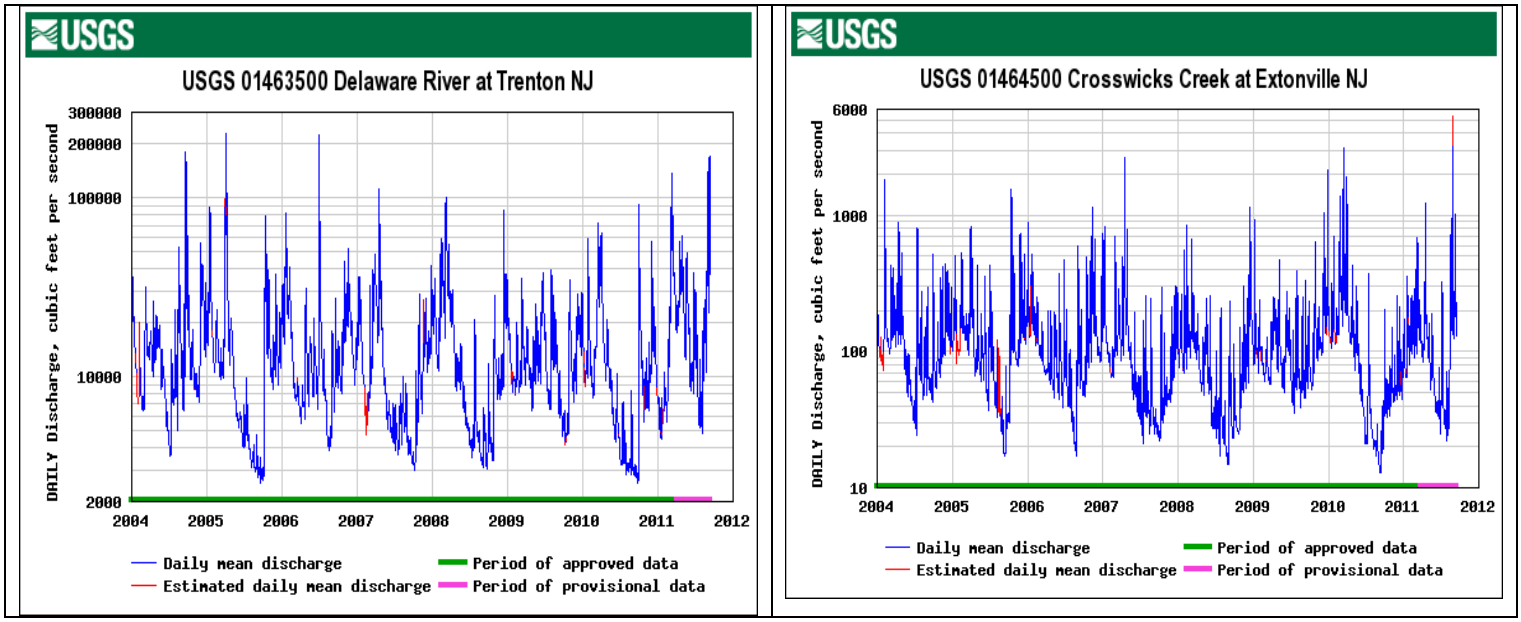


Figure 10 Flow of Delaware River at Trenton and Crosswicks Creek at Extonville 2000-2011

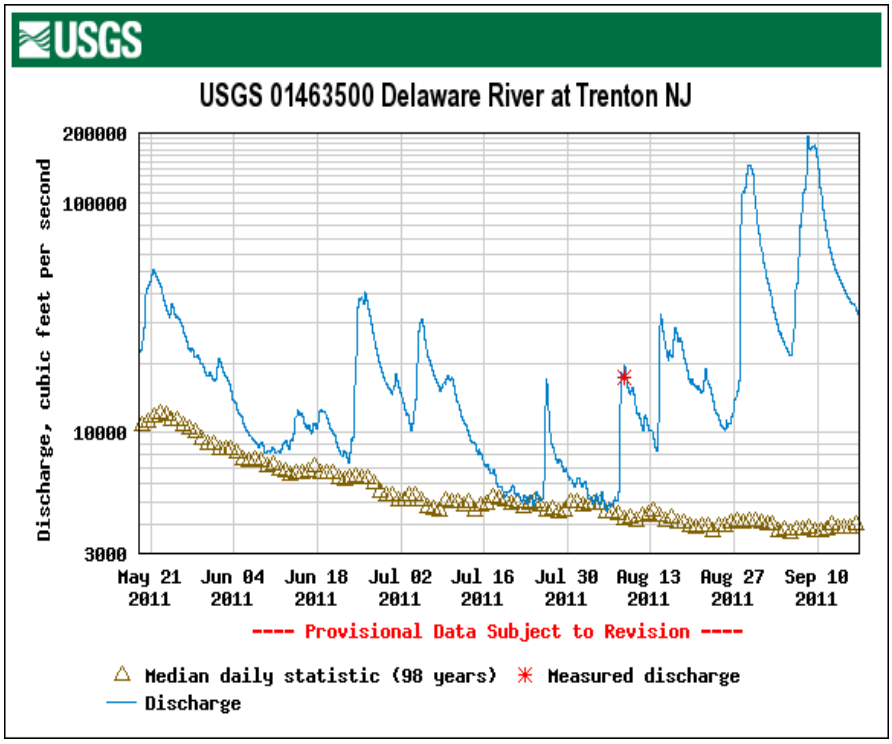


Figure 10 discharge of Delaware River at Trenton for the past 120 days

Water Supply of Bordentown

Bordentown City Water Department has four public-supply wells in the marsh and supplied about 900 million gallons per year of potable water to Bordentown Village and Fieldsboro during 2005-11. The public supply wells range in depth from about 110 to 130 ft below land surface.

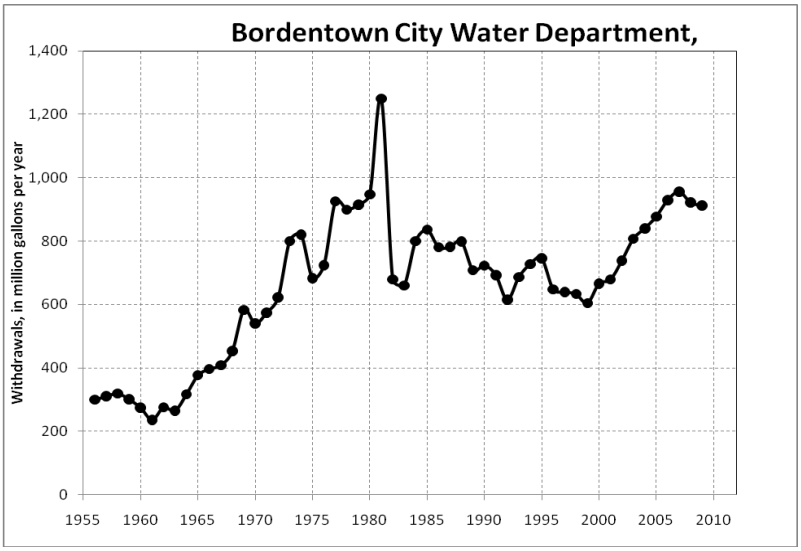
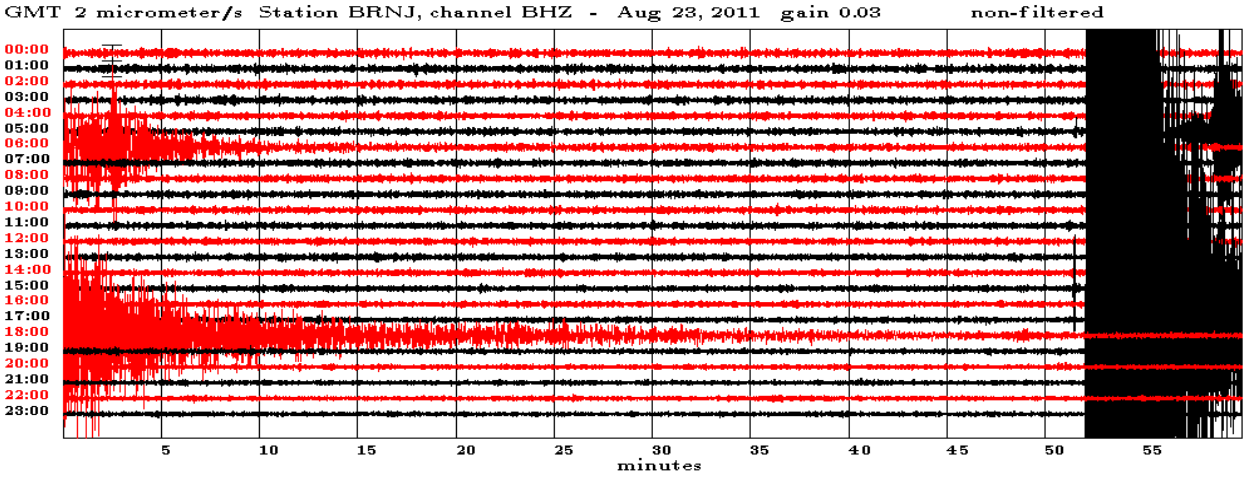
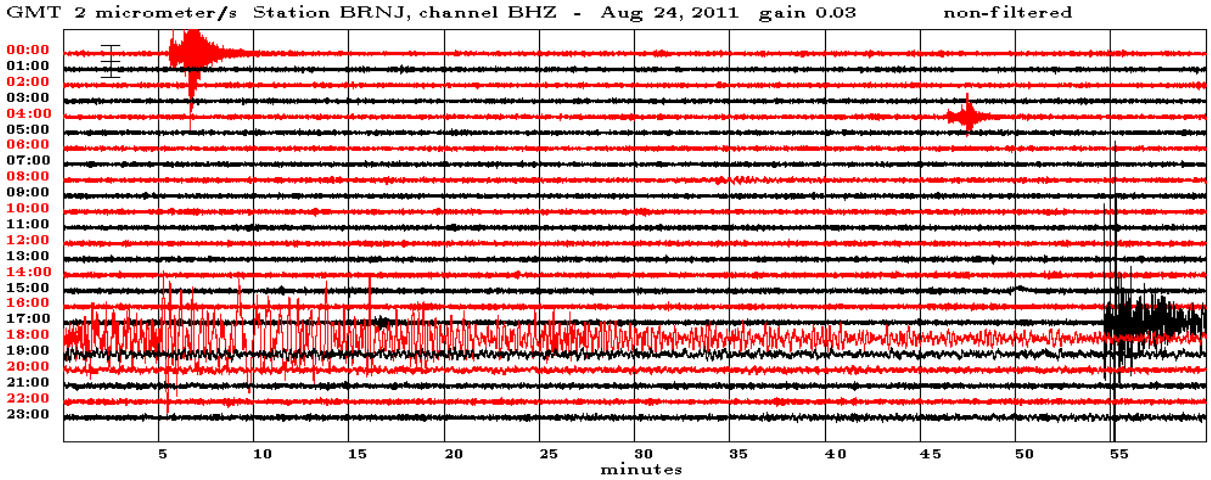


Figure 11. Reported annual groundwater withdrawal from the public supply wells by the Bordentown City Water Department.



On August 23 2011 at 1:51pm a 5.8 magnitude earthquake occurred in central Virginia about 225 miles from Trenton. The seismograph in New Brunswick recorded the signal and Greenwich Mean Time of 17:52. Nearly every body felt this earthquake

On August 24 2011 two smaller earth quake occurred at about the same place in Virginia



On Sunday, December 26, 2004, and earthquake of 9.1 in the Indian Ocean cause a major tsunami. Below is the seismic signal in New Bunswick

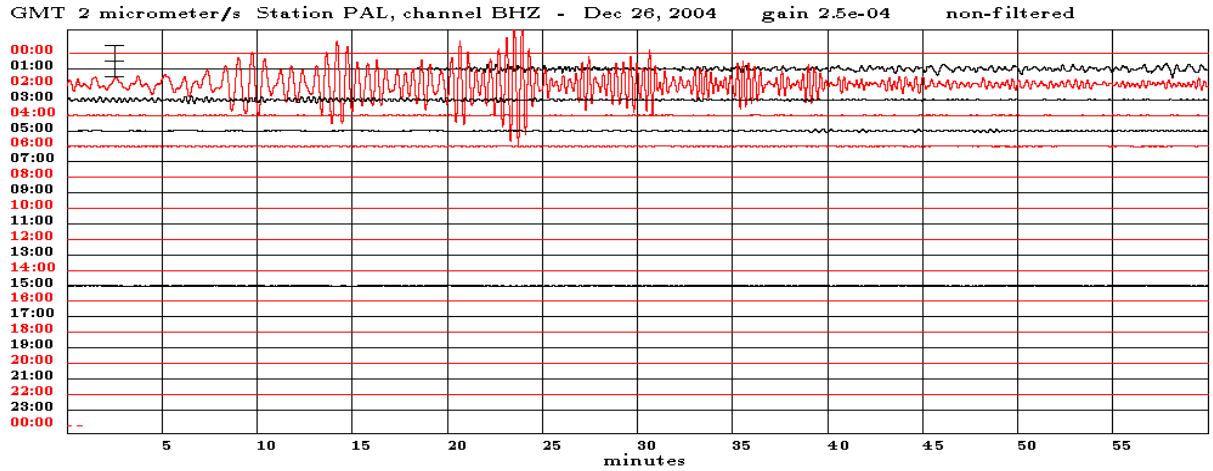


Figure 12. 2002-08 Air-photograph of northern Marsh showing (a) I-295, (b) I-129 (c) Duck Island electrical power plant, (d) Trenton landfill/dump, (e) Trenton sewage treatment plant, (f) Spring Lake, (g) artificial wetland (h) canal and light rail, (i) homes and residences south of Broadway and Laylor Streets.

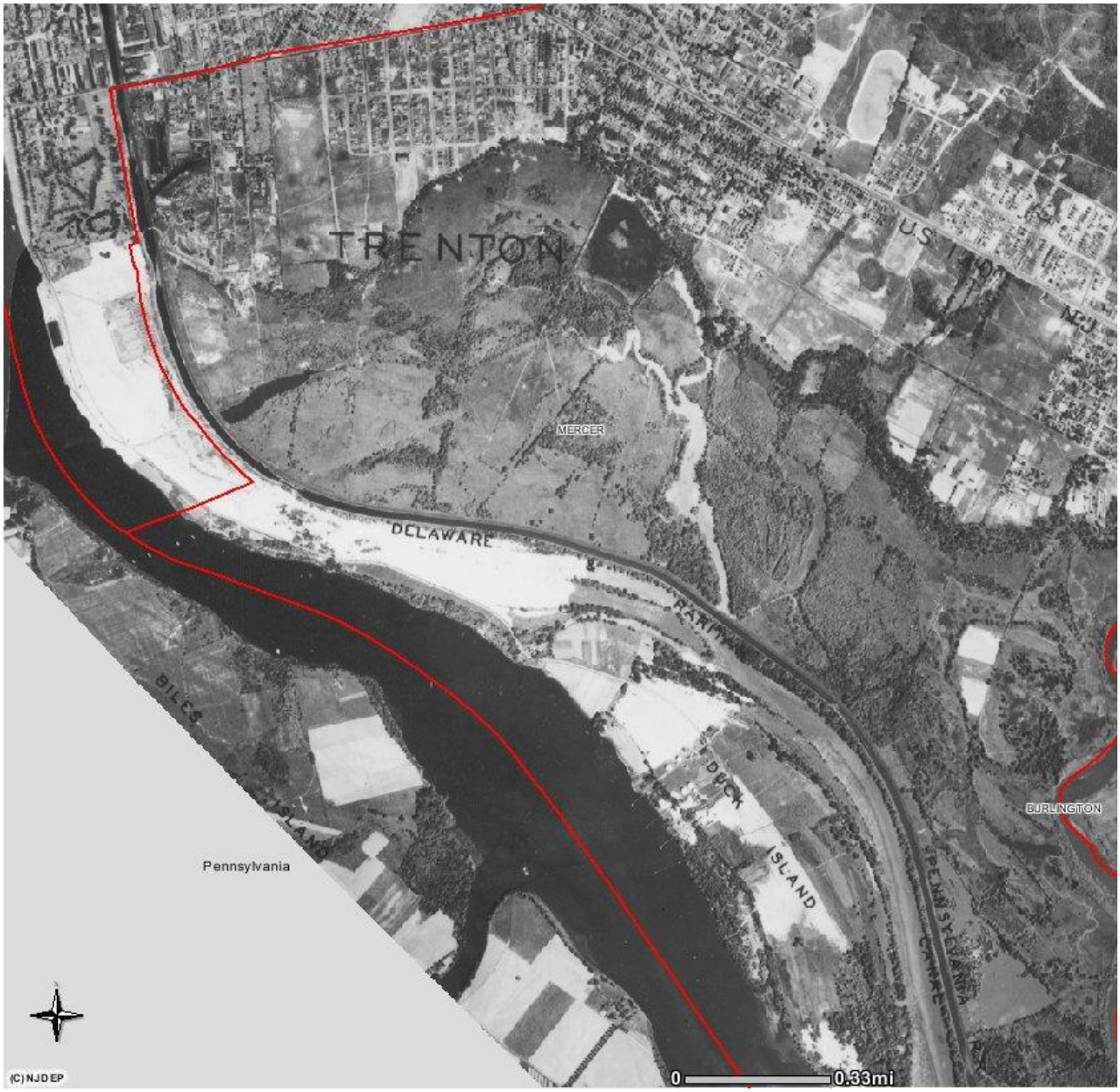


Figure 13. 1930s Air-photograph of Northern Marsh showing (a) Spring Lake, (b) Canal and rail line (c) Duck Island farm field (d) residences and farm fields south of Laylor and Broadway Streets

Figure 14. 2002-08 Air-photograph of southern Marsh showing (a) I-295, (b) I-129 (c) Duck Island electrical power plant, , (e) Hamilton sewage treatment plant, (g) artificial wetland, (h) canal and light rail, (i) residences and businesses along Route 206

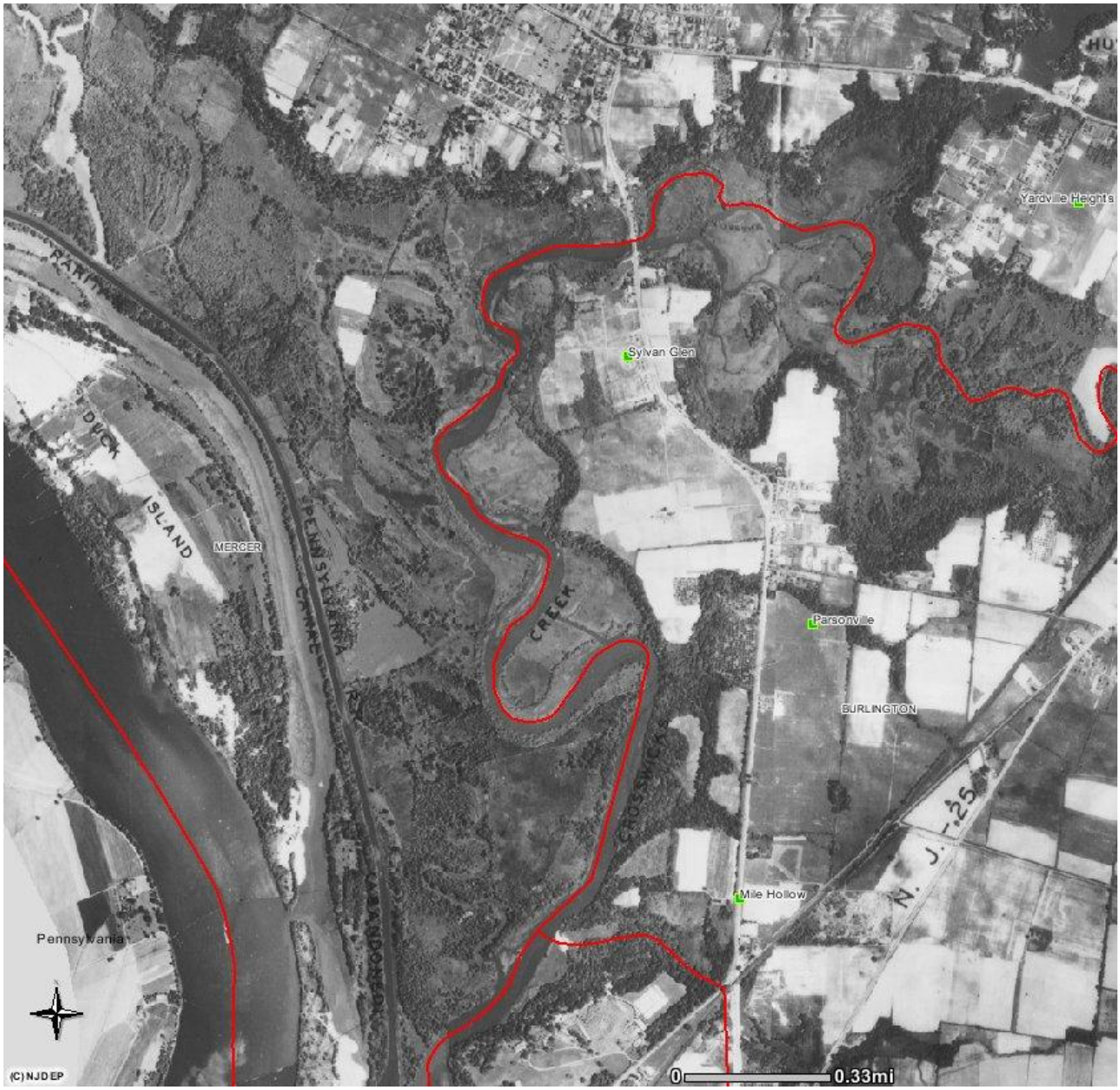
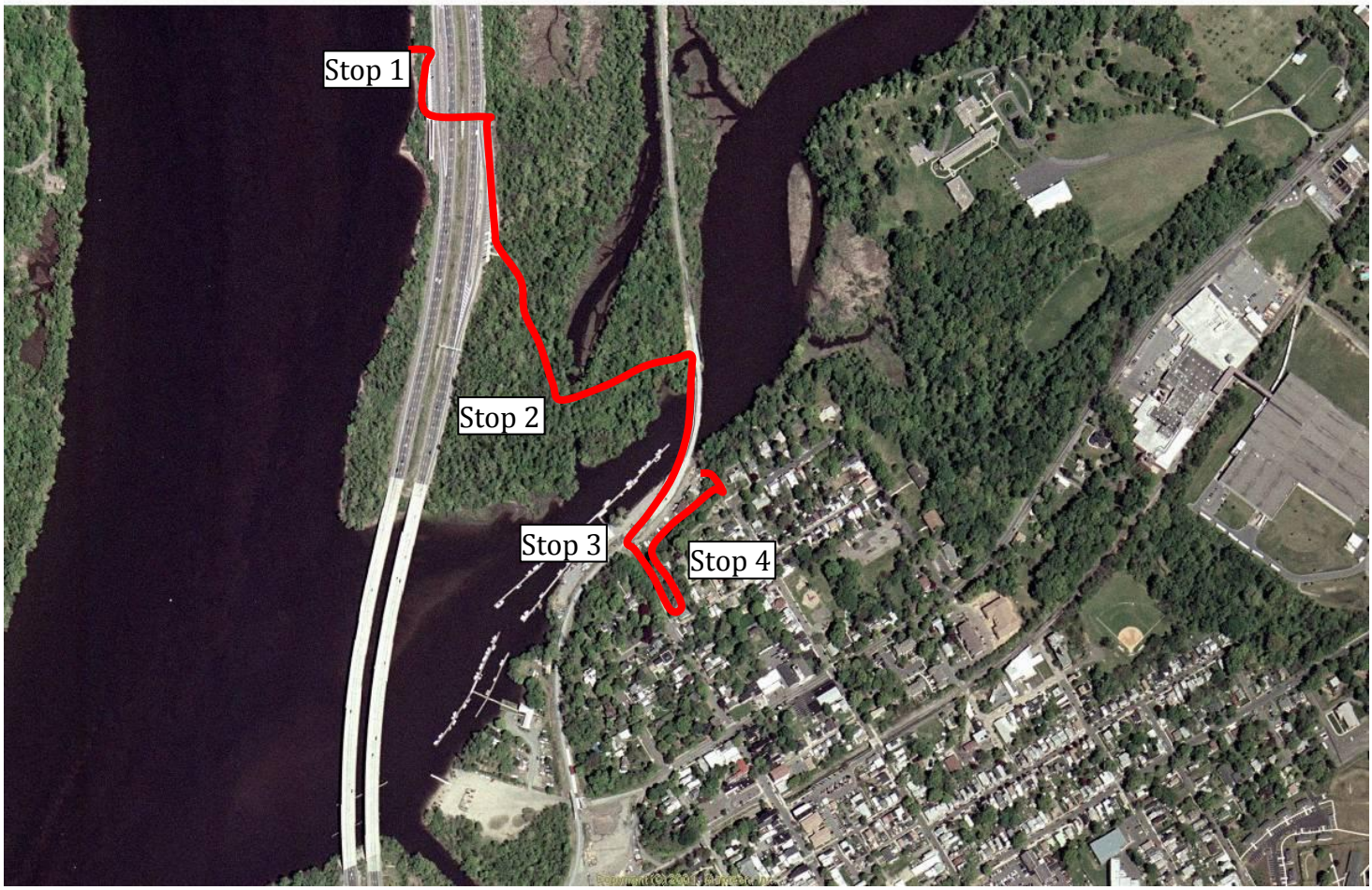


Figure 15. 1930s Air-photograph of Southern Marsh showing (b) Canal and rail line (c) Duck Island farm field (d) farms along Route 206



Field trip

Geology Field Trip

Stop 1 I-295 South bound rest stop just north of the Thomas Paine Bridge
Walk to Delaware River shoreline at low tide (Sept 17, 2011 low tide is 1:47 PM)

A: Cobble beach is a lag deposit caused by tidal washing of the Trenton Gravel.
B: Outcrops along the tree line are mixture of Trenton Gravel and fill.
C: Spring along the shoreline show boiling sand. 90% of flow of Delaware River groundwater discharge such as these springs.
D: Stream discharge hydrograph of Delaware River show five major flood and drought of early 1960's.
E: Dark gray angular riprap around rest stop is diabase form quarries north of Pennington and south of Lambertville.
F: Shore line erosion processes caused by old piers.

Stop 2 Walk across I-95 on walkway to Lock 1.

Discuss excavation of the canal and the spoils.

Discuss lining of the canal with Stockton sandstone to prevent erosion of banks by steamboat wakes

Discuss confluence of Crosswicks Creek and Delaware River

Discuss Delaware River dredging impacts on tidal flow.

Air photos of 1930 and 2010 show changes in land use of the marsh

Discuss Amusement park, landfill, clay mines, borrow pits, Water supply wells of Bordentown, Hamilton sewage disposal, farm fields,

Stop 3 Walk to Bordentown Yacht club

Discuss the geomorphology of the hill slope discuss hills (Mountains) of the NJ Coastal Plain other examples include: Mount Holly, Mount Laurel, Cherry Hill, and Arnie's Mount.

Stop 4 Wall up boat ramp to Bordentown Village

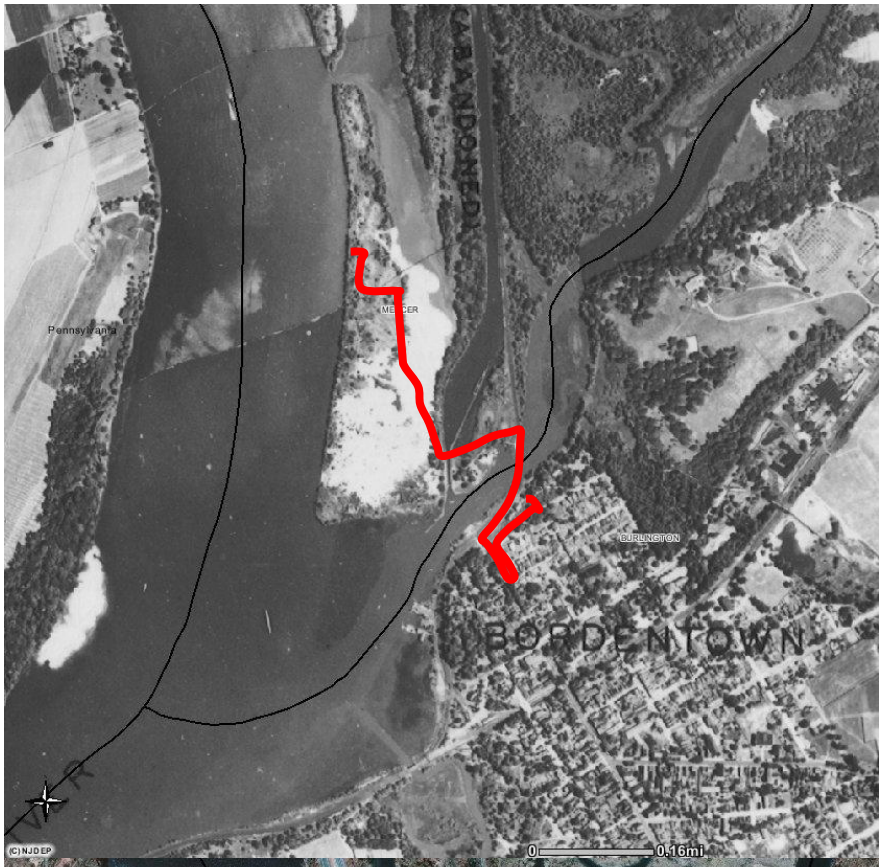
Look at home made of Wissahickon schist

Look at brick homes that were made with bricks of Raritan Clay and Magothy Sand

Observe mortar made of Oyster shells and Pennsylvanian Limestone

Discuss early 1900's plan to construct a sea level canal from Bordentown to Raritan Bay to compliment the Chesapeake Delaware Canal.

Walk to the Iris garden, down the stairs to the wharf and railroad tracks and back to the cars.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