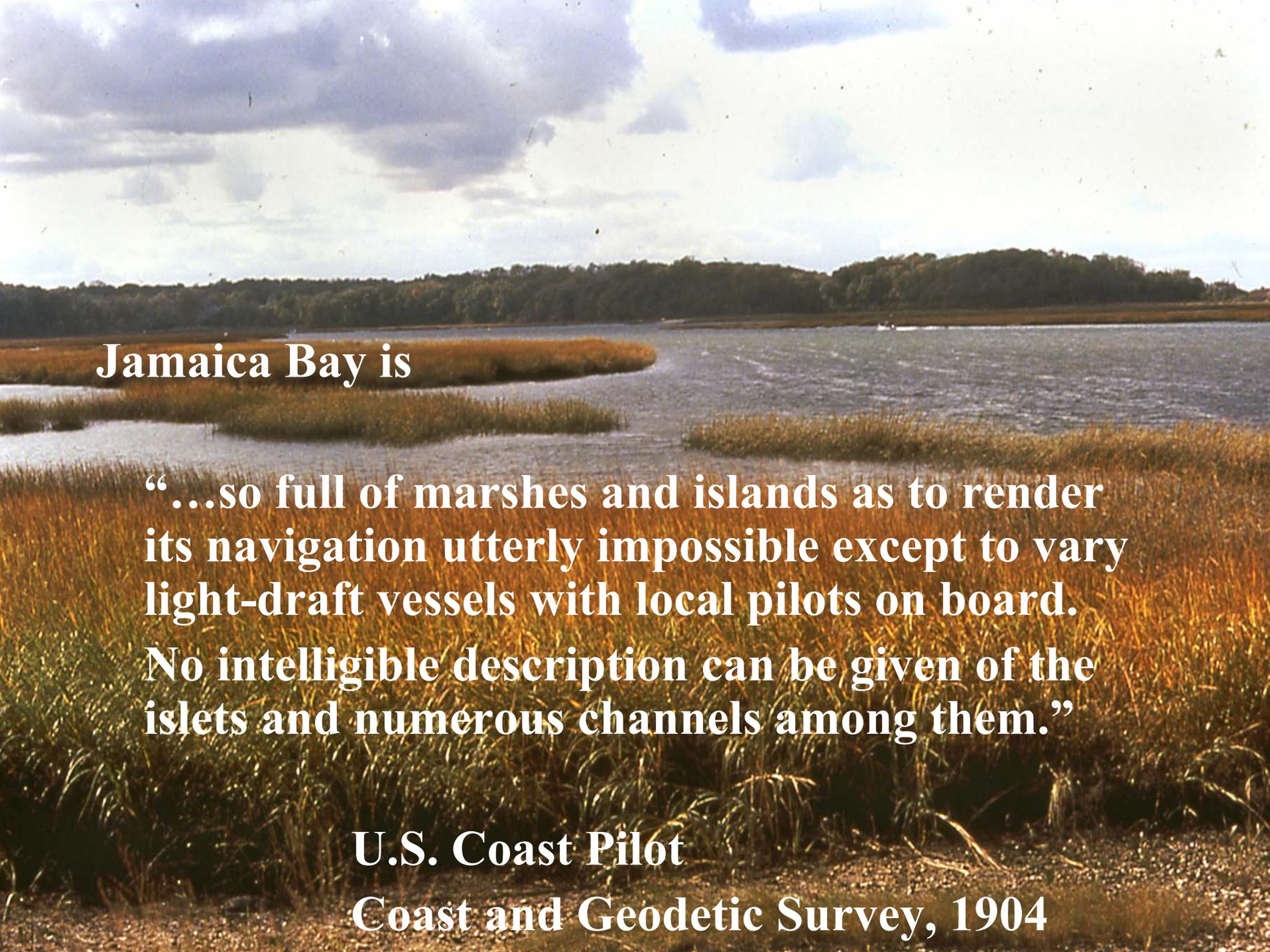
The background of the slide is a photograph of a city skyline, likely New York City, viewed from across a body of water. The sky is a mix of orange, yellow, and grey, suggesting a sunset or sunrise. The water in the foreground is dark and calm. The city buildings are silhouetted against the bright sky. The text is overlaid on this image.

**Increased Tidal Ranges
Coinciding with Jamaica Bay
Development Contribute to
Marsh Flooding**

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School of Marine and Atmospheric Sciences
Stony Brook University



Jamaica Bay is

“...so full of marshes and islands as to render its navigation utterly impossible except to vary light-draft vessels with local pilots on board. No intelligible description can be given of the islets and numerous channels among them.”

U.S. Coast Pilot

Coast and Geodetic Survey, 1904

Hypothesized Causes of the Jamaica Bay Marsh Loss

- **Sea level rise**
(Hartig et al., 2002)
- **Loss of sediment**
(Gordon and Houghton, 2004)
- **Pollution impacts**
(Kolker, 2005)
- **Physical alterations**



Major Dredging Activities in Jamaica Bay

Date	Activity	Location
1904	1.8 m deep x 15 m wide	to Canarsie Landing
1911	3.7 m deep	Broad Channel to Grassie Bay
1912-1930s	10 m deep x 300 m wide	Rockaway Inlet to Paerdegat Basin
1934	9 m deep	Broad Channel
1941	6 m deep	to Shellbank Basin

Natural and Anthropogenic Filling Activities

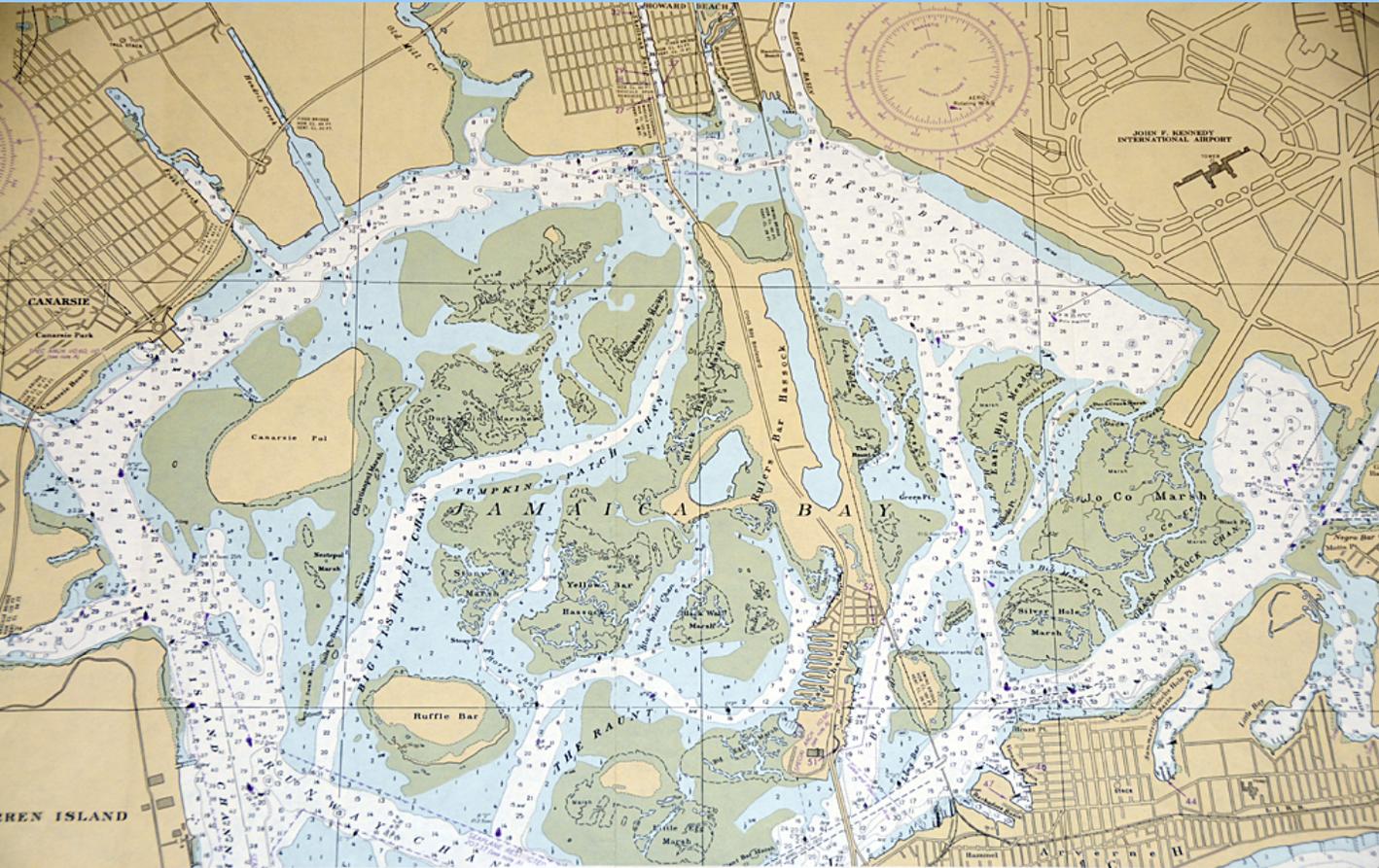


Date	Activity
1911-1941	1.4 km westward growth of Rockaway Pt.
1923	Cross Bay Boulevard completed
1931	Barren Island filled to complete Floyd Bennett Field
1962	Runway extension completed at J.F. Kennedy Airport by dredging and filling

Surface area of the Bay reduced from 101 km² in mid-19th century to 53 km² at present.

But . . .

the volume of the Bay has increased 350%.



***NYC DEP,
2007***

From 1974 – 1999

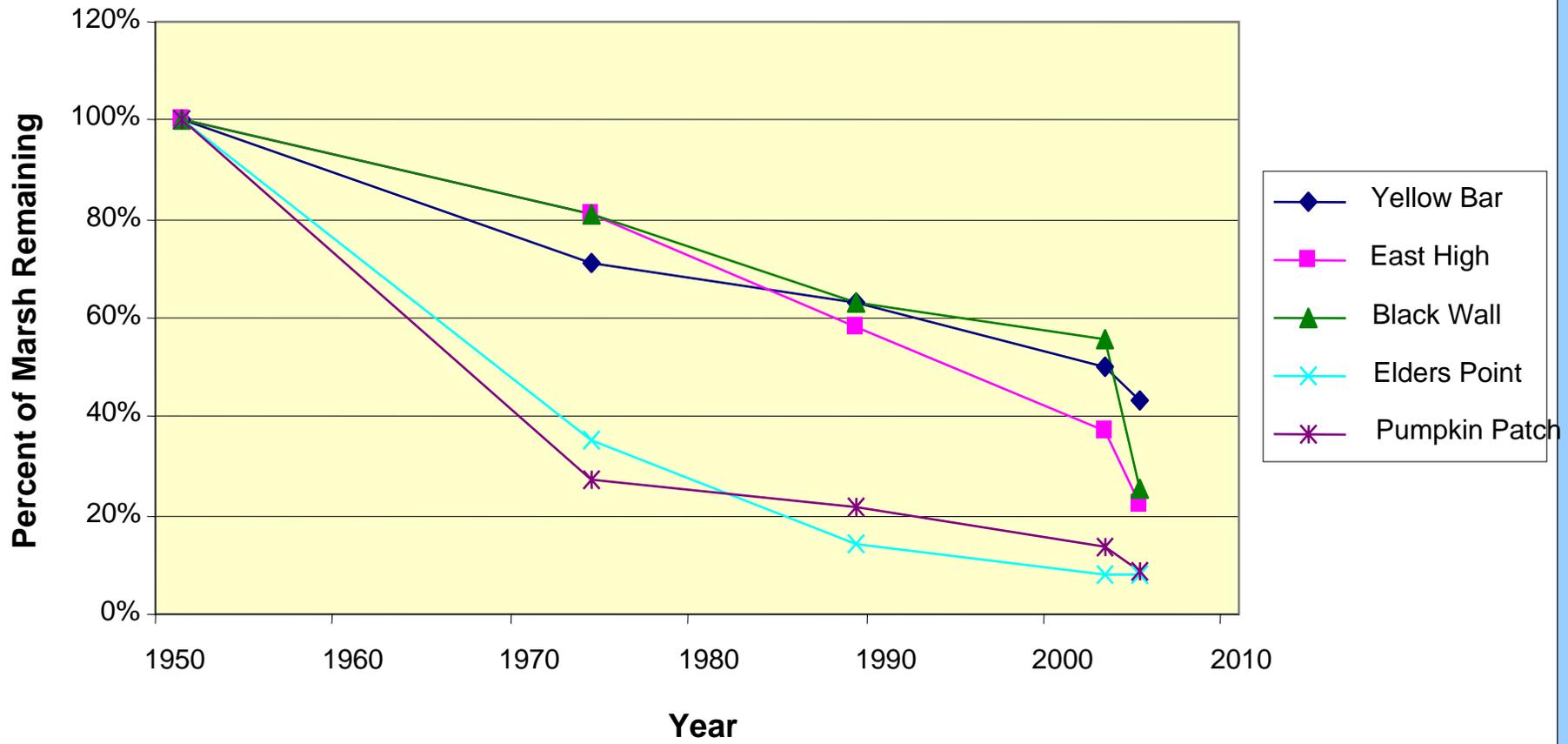
**2.5 km² (620 acres) of the marshes in
the interior of Jamaica Bay were lost.**

*Hartig et al.,
2002*



*JB Watershed Protection
Plan Advisory
Committee, 2007*

Vegetated Marsh Island Loss as a Percentage of 1951 Marsh Island Extent



Historic References



Tide Table B
1905
Lat. 40° 30'
Long. 73° 23'

TIDES SUMMARY

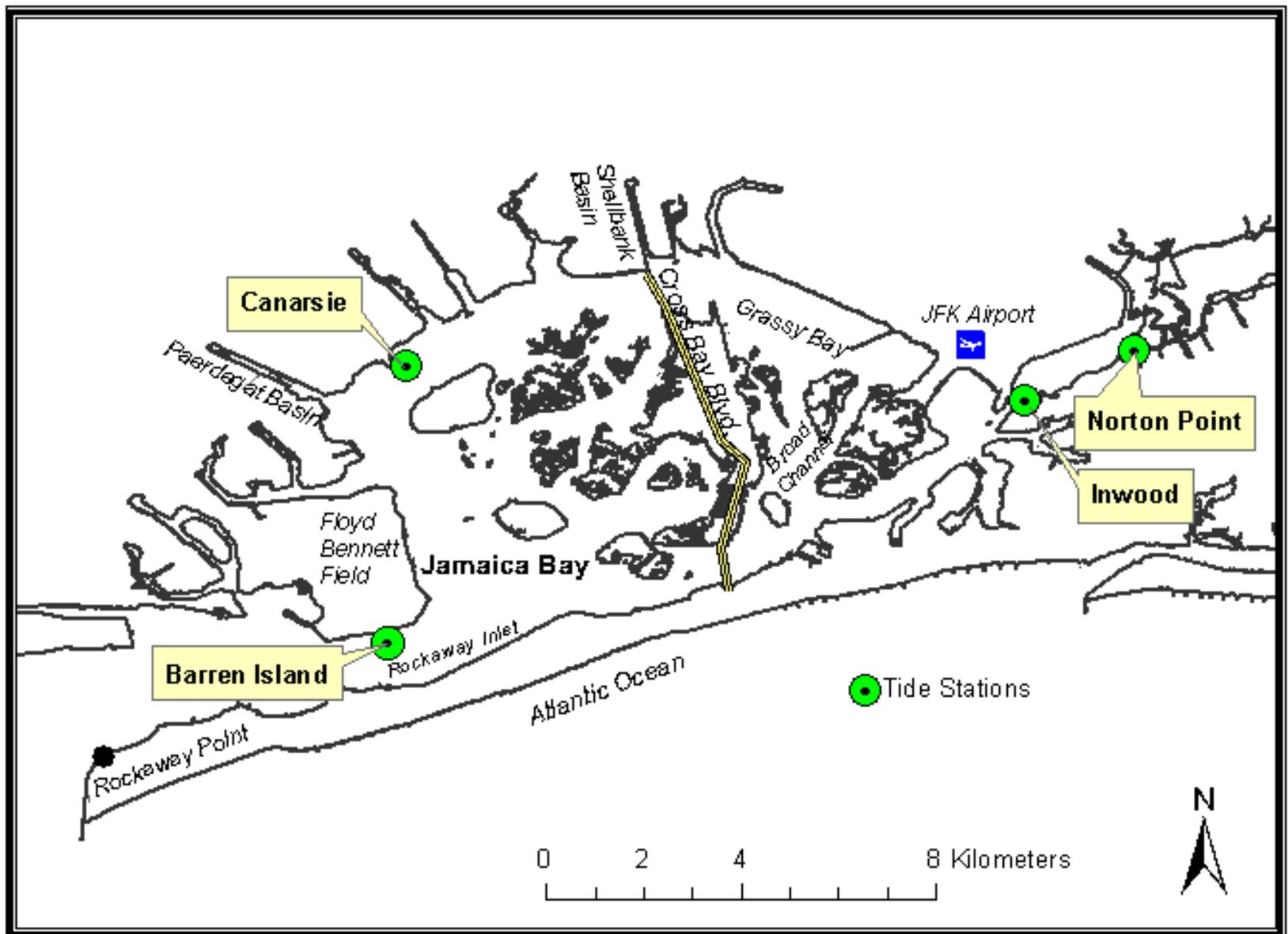
Station: *Barren Island, Rockaway Jct., Long. 73° 23'*

Year	Lat.	Long.	Mean High Water	Mean Low Water	Range	Remarks
1877	40° 30'	73° 23'	12.377	1.210	11.167	1st dist.
1878	40° 30'	73° 23'	12.310	1.210	11.100	2nd dist.
1879	40° 30'	73° 23'	12.243	1.210	11.033	3rd dist.
1880	40° 30'	73° 23'	12.176	1.210	10.966	4th dist.
1881	40° 30'	73° 23'	12.109	1.210	10.899	5th dist.
1882	40° 30'	73° 23'	12.042	1.210	10.832	6th dist.
1883	40° 30'	73° 23'	11.975	1.210	10.765	7th dist.
1884	40° 30'	73° 23'	11.908	1.210	10.698	8th dist.
1885	40° 30'	73° 23'	11.841	1.210	10.631	9th dist.
1886	40° 30'	73° 23'	11.774	1.210	10.564	10th dist.
1887	40° 30'	73° 23'	11.707	1.210	10.497	11th dist.
1888	40° 30'	73° 23'	11.640	1.210	10.430	12th dist.
1889	40° 30'	73° 23'	11.573	1.210	10.363	13th dist.
1890	40° 30'	73° 23'	11.506	1.210	10.296	14th dist.
1891	40° 30'	73° 23'	11.439	1.210	10.229	15th dist.
1892	40° 30'	73° 23'	11.372	1.210	10.162	16th dist.
1893	40° 30'	73° 23'	11.305	1.210	10.095	17th dist.
1894	40° 30'	73° 23'	11.238	1.210	10.028	18th dist.
1895	40° 30'	73° 23'	11.171	1.210	9.961	19th dist.
1896	40° 30'	73° 23'	11.104	1.210	9.894	20th dist.
1897	40° 30'	73° 23'	11.037	1.210	9.827	21st dist.
1898	40° 30'	73° 23'	10.970	1.210	9.760	22nd dist.
1899	40° 30'	73° 23'	10.903	1.210	9.693	23rd dist.
1900	40° 30'	73° 23'	10.836	1.210	9.626	24th dist.
1901	40° 30'	73° 23'	10.769	1.210	9.559	25th dist.
1902	40° 30'	73° 23'	10.702	1.210	9.492	26th dist.
1903	40° 30'	73° 23'	10.635	1.210	9.425	27th dist.
1904	40° 30'	73° 23'	10.568	1.210	9.358	28th dist.
1905	40° 30'	73° 23'	10.501	1.210	9.291	29th dist.
1906	40° 30'	73° 23'	10.434	1.210	9.224	30th dist.
1907	40° 30'	73° 23'	10.367	1.210	9.157	31st dist.
1908	40° 30'	73° 23'	10.300	1.210	9.090	32nd dist.
1909	40° 30'	73° 23'	10.233	1.210	9.023	33rd dist.
1910	40° 30'	73° 23'	10.166	1.210	8.956	34th dist.
1911	40° 30'	73° 23'	10.099	1.210	8.889	35th dist.
1912	40° 30'	73° 23'	10.032	1.210	8.822	36th dist.
1913	40° 30'	73° 23'	9.965	1.210	8.755	37th dist.
1914	40° 30'	73° 23'	9.898	1.210	8.688	38th dist.
1915	40° 30'	73° 23'	9.831	1.210	8.621	39th dist.
1916	40° 30'	73° 23'	9.764	1.210	8.554	40th dist.
1917	40° 30'	73° 23'	9.697	1.210	8.487	41st dist.
1918	40° 30'	73° 23'	9.630	1.210	8.420	42nd dist.
1919	40° 30'	73° 23'	9.563	1.210	8.353	43rd dist.
1920	40° 30'	73° 23'	9.496	1.210	8.286	44th dist.
1921	40° 30'	73° 23'	9.429	1.210	8.219	45th dist.
1922	40° 30'	73° 23'	9.362	1.210	8.152	46th dist.
1923	40° 30'	73° 23'	9.295	1.210	8.085	47th dist.
1924	40° 30'	73° 23'	9.228	1.210	8.018	48th dist.
1925	40° 30'	73° 23'	9.161	1.210	7.951	49th dist.
1926	40° 30'	73° 23'	9.094	1.210	7.884	50th dist.

TIDES SUMMARY

Station: *Fort Monmouth, New York*

Year	Lat.	Long.	Mean High Water	Mean Low Water	Range	Remarks
1843-1910	40° 25'	74° 16'	12.166	1.210	10.956	1st dist.
1843-1910	40° 25'	74° 16'	12.100	1.210	10.890	2nd dist.
1843-1910	40° 25'	74° 16'	12.034	1.210	10.824	3rd dist.
1843-1910	40° 25'	74° 16'	11.968	1.210	10.758	4th dist.
1843-1910	40° 25'	74° 16'	11.902	1.210	10.692	5th dist.
1843-1910	40° 25'	74° 16'	11.836	1.210	10.626	6th dist.
1843-1910	40° 25'	74° 16'	11.770	1.210	10.560	7th dist.
1843-1910	40° 25'	74° 16'	11.704	1.210	10.494	8th dist.
1843-1910	40° 25'	74° 16'	11.638	1.210	10.428	9th dist.
1843-1910	40° 25'	74° 16'	11.572	1.210	10.362	10th dist.
1843-1910	40° 25'	74° 16'	11.506	1.210	10.296	11th dist.
1843-1910	40° 25'	74° 16'	11.440	1.210	10.230	12th dist.
1843-1910	40° 25'	74° 16'	11.374	1.210	10.164	13th dist.
1843-1910	40° 25'	74° 16'	11.308	1.210	10.098	14th dist.
1843-1910	40° 25'	74° 16'	11.242	1.210	10.032	15th dist.
1843-1910	40° 25'	74° 16'	11.176	1.210	9.966	16th dist.
1843-1910	40° 25'	74° 16'	11.110	1.210	9.900	17th dist.
1843-1910	40° 25'	74° 16'	11.044	1.210	9.834	18th dist.
1843-1910	40° 25'	74° 16'	10.978	1.210	9.768	19th dist.
1843-1910	40° 25'	74° 16'	10.912	1.210	9.702	20th dist.
1843-1910	40° 25'	74° 16'	10.846	1.210	9.636	21th dist.
1843-1910	40° 25'	74° 16'	10.780	1.210	9.570	22th dist.
1843-1910	40° 25'	74° 16'	10.714	1.210	9.504	23th dist.
1843-1910	40° 25'	74° 16'	10.648	1.210	9.438	24th dist.
1843-1910	40° 25'	74° 16'	10.582	1.210	9.372	25th dist.
1843-1910	40° 25'	74° 16'	10.516	1.210	9.306	26th dist.
1843-1910	40° 25'	74° 16'	10.450	1.210	9.240	27th dist.
1843-1910	40° 25'	74° 16'	10.384	1.210	9.174	28th dist.
1843-1910	40° 25'	74° 16'	10.318	1.210	9.108	29th dist.
1843-1910	40° 25'	74° 16'	10.252	1.210	9.042	30th dist.
1843-1910	40° 25'	74° 16'	10.186	1.210	8.976	31th dist.
1843-1910	40° 25'	74° 16'	10.120	1.210	8.910	32th dist.
1843-1910	40° 25'	74° 16'	10.054	1.210	8.844	33th dist.
1843-1910	40° 25'	74° 16'	9.988	1.210	8.778	34th dist.
1843-1910	40° 25'	74° 16'	9.922	1.210	8.712	35th dist.
1843-1910	40° 25'	74° 16'	9.856	1.210	8.646	36th dist.
1843-1910	40° 25'	74° 16'	9.790	1.210	8.580	37th dist.
1843-1910	40° 25'	74° 16'	9.724	1.210	8.514	38th dist.
1843-1910	40° 25'	74° 16'	9.658	1.210	8.448	39th dist.
1843-1910	40° 25'	74° 16'	9.592	1.210	8.382	40th dist.
1843-1910	40° 25'	74° 16'	9.526	1.210	8.316	41th dist.
1843-1910	40° 25'	74° 16'	9.460	1.210	8.250	42th dist.
1843-1910	40° 25'	74° 16'	9.394	1.210	8.184	43th dist.
1843-1910	40° 25'	74° 16'	9.328	1.210	8.118	44th dist.
1843-1910	40° 25'	74° 16'	9.262	1.210	8.052	45th dist.
1843-1910	40° 25'	74° 16'	9.196	1.210	7.986	46th dist.
1843-1910	40° 25'	74° 16'	9.130	1.210	7.920	47th dist.
1843-1910	40° 25'	74° 16'	9.064	1.210	7.854	48th dist.
1843-1910	40° 25'	74° 16'	9.000	1.210	7.788	49th dist.
1843-1910	40° 25'	74° 16'	8.934	1.210	7.722	50th dist.
1843-1910	40° 25'	74° 16'	8.870	1.210	7.656	51th dist.
1843-1910	40° 25'	74° 16'	8.804	1.210	7.590	52th dist.
1843-1910	40° 25'	74° 16'	8.740	1.210	7.524	53th dist.
1843-1910	40° 25'	74° 16'	8.674	1.210	7.458	54th dist.
1843-1910	40° 25'	74° 16'	8.610	1.210	7.392	55th dist.
1843-1910	40° 25'	74° 16'	8.544	1.210	7.326	56th dist.
1843-1910	40° 25'	74° 16'	8.480	1.210	7.260	57th dist.
1843-1910	40° 25'	74° 16'	8.414	1.210	7.194	58th dist.
1843-1910	40° 25'	74° 16'	8.350	1.210	7.128	59th dist.
1843-1910	40° 25'	74° 16'	8.284	1.210	7.062	60th dist.
1843-1910	40° 25'	74° 16'	8.220	1.210	6.996	61th dist.
1843-1910	40° 25'	74° 16'	8.154	1.210	6.930	62th dist.
1843-1910	40° 25'	74° 16'	8.090	1.210	6.864	63th dist.
1843-1910	40° 25'	74° 16'	8.024	1.210	6.798	64th dist.
1843-1910	40° 25'	74° 16'	7.960	1.210	6.732	65th dist.
1843-1910	40° 25'	74° 16'	7.894	1.210	6.666	66th dist.
1843-1910	40° 25'	74° 16'	7.830	1.210	6.600	67th dist.
1843-1910	40° 25'	74° 16'	7.764	1.210	6.534	68th dist.
1843-1910	40° 25'	74° 16'	7.700	1.210	6.468	69th dist.
1843-1910	40° 25'	74° 16'	7.634	1.210	6.402	70th dist.
1843-1910	40° 25'	74° 16'	7.570	1.210	6.336	71th dist.
1843-1910	40° 25'	74° 16'	7.504	1.210	6.270	72th dist.
1843-1910	40° 25'	74° 16'	7.440	1.210	6.204	73th dist.
1843-1910	40° 25'	74° 16'	7.374	1.210	6.138	74th dist.
1843-1910	40° 25'	74° 16'	7.310	1.210	6.072	75th dist.
1843-1910	40° 25'	74° 16'	7.244	1.210	6.006	76th dist.
1843-1910	40° 25'	74° 16'	7.180	1.210	5.940	77th dist.
1843-1910	40° 25'	74° 16'	7.114	1.210	5.874	78th dist.
1843-1910	40° 25'	74° 16'	7.050	1.210	5.808	79th dist.
1843-1910	40° 25'	74° 16'	6.984	1.210	5.742	80th dist.
1843-1910	40° 25'	74° 16'	6.920	1.210	5.676	81th dist.
1843-1910	40° 25'	74° 16'	6.854	1.210	5.610	82th dist.
1843-1910	40° 25'	74° 16'	6.790	1.210	5.544	83th dist.
1843-1910	40° 25'	74° 16'	6.724	1.210	5.478	84th dist.
1843-1910	40° 25'	74° 16'	6.660	1.210		

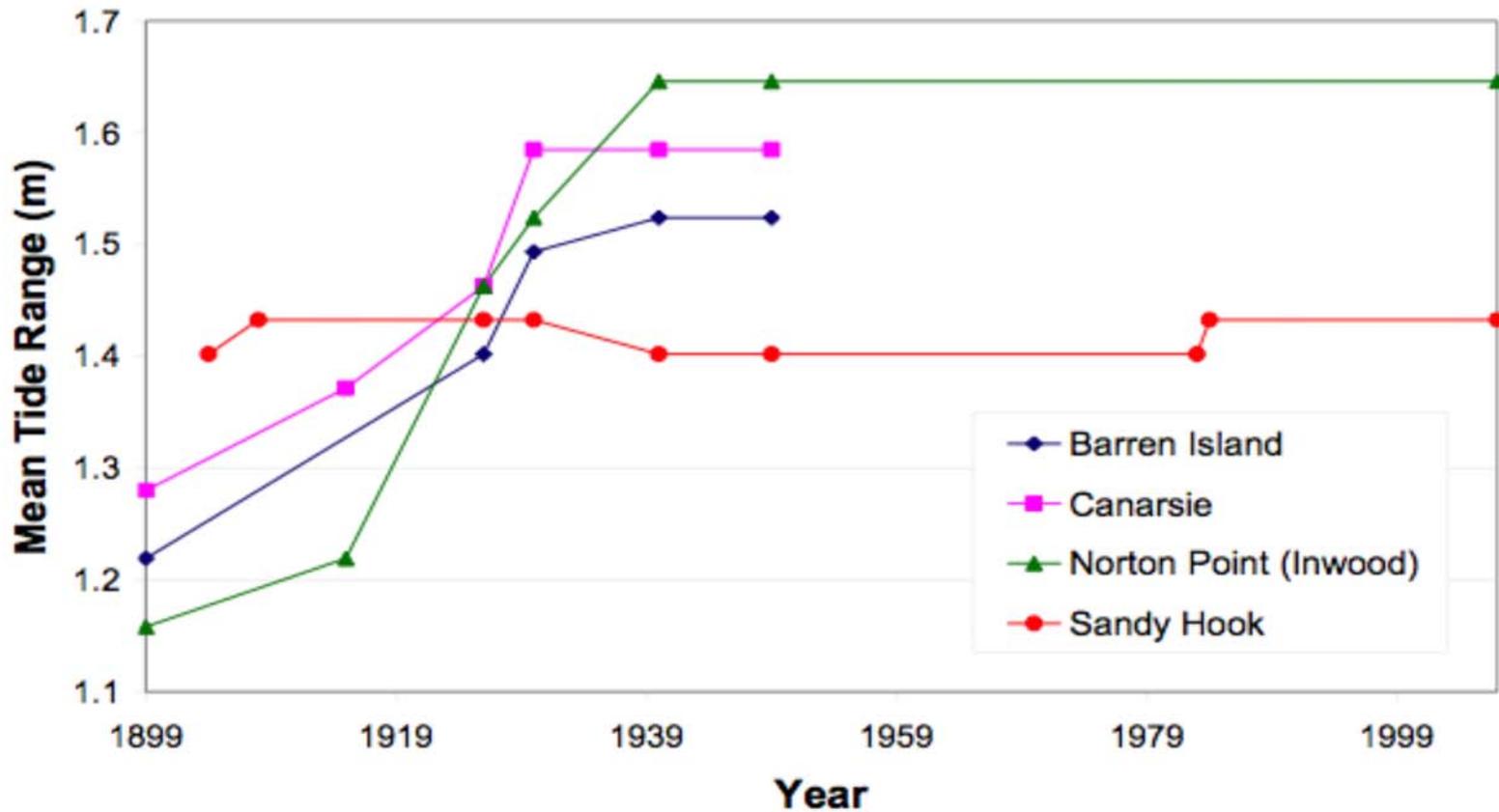


Locations of Tide Stations in Jamaica Bay

Historic tide stations in Jamaica Bay indicating change in tidal range and change in height () relative to Sandy Hook meters

	1899	1904	1912	1915	1926	1930	1940	1949	2007
Rockaway Inlet	1.22								
Barren Island					1.49 (-0.03)	1.49 (0.06)	1.52 (0.12)	1.52 (0.12)	
Canarsie	1.28			1.37	1.46 (0.03)	1.58 (0.15)	1.58 (0.18)	1.58 (0.18)	
Grassy Bay							1.58 (0.18)	1.58 (0.18)	
Norton Point	1.16			1.22	1.46 (0.03)	1.52 (0.09)	1.65 (0.24)	1.65 (0.24)	1.64
Sandy Hook		1.40	1.43		1.43	1.43	1.40	1.40	1.43

Change of Mean Tidal Range



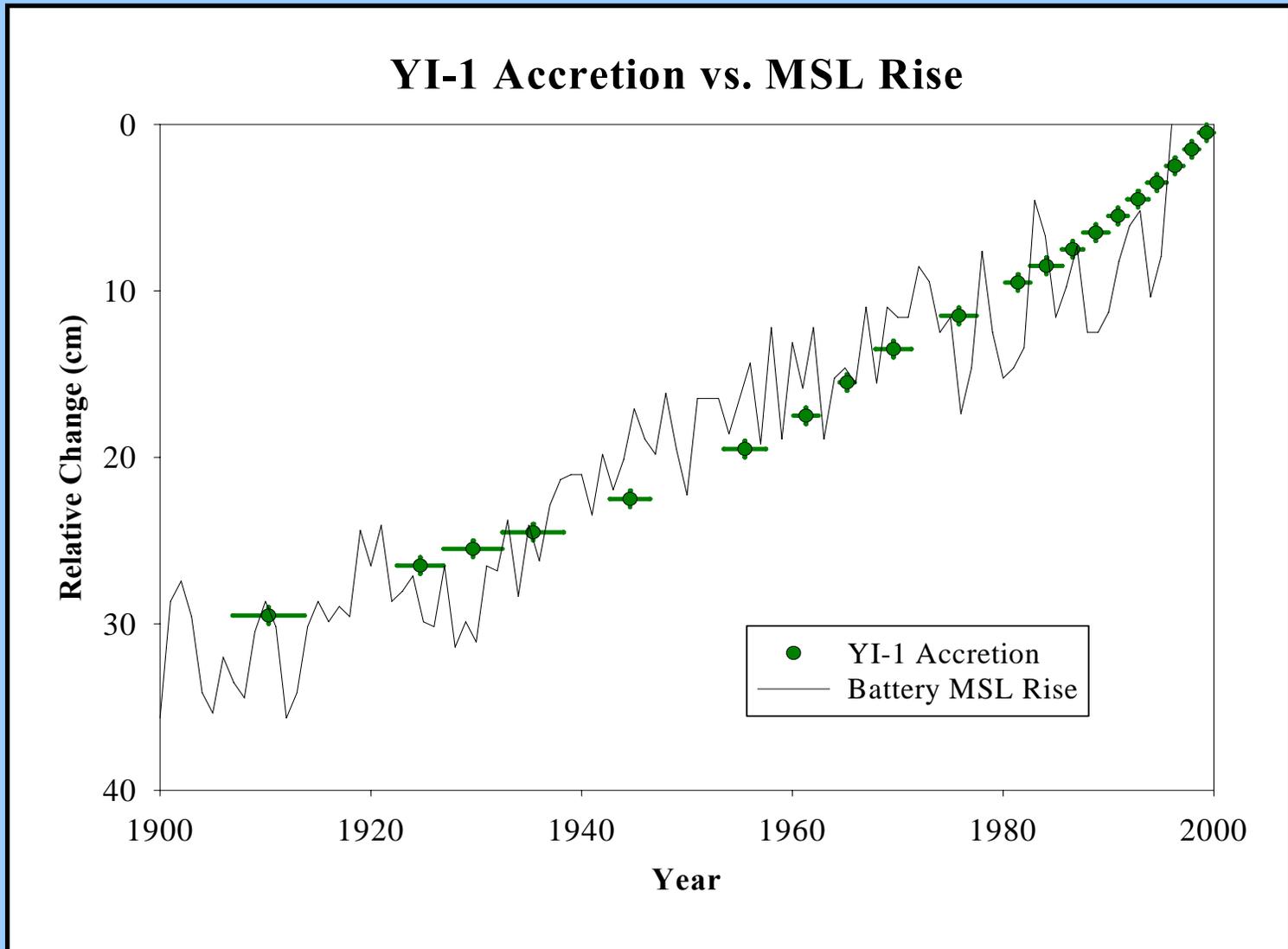
Today, Bay-wide



- spring tide ranges 20% > the means
- 50% of increased range in high waters
- 50% of increased range in low waters

Relative Sea Level Rise at the Battery

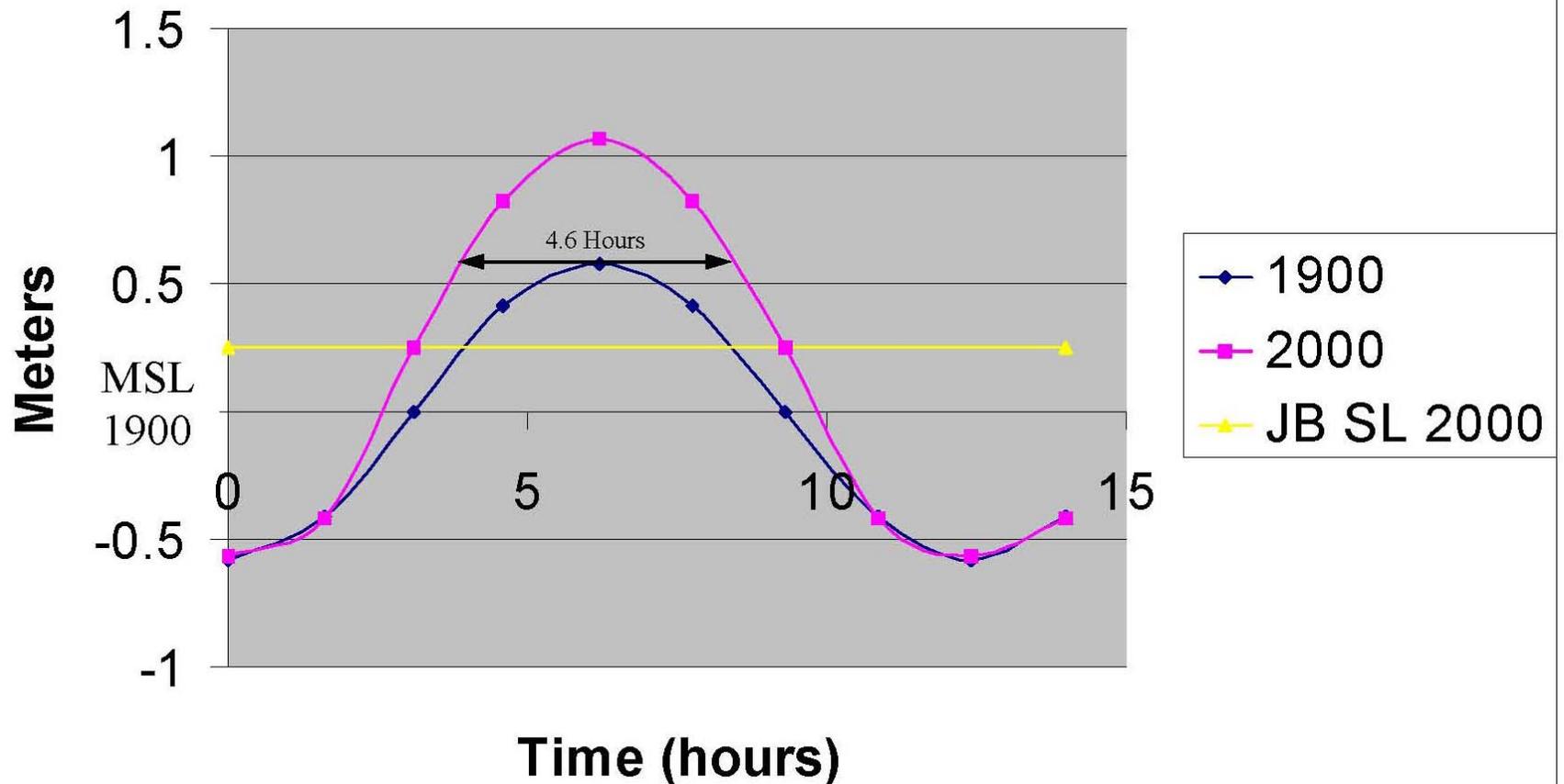
1900-2000



Increases in Head of High Waters in Jamaica Bay Since 1900 (meters)

	Δ Regional Sea Level	Δ Local Sea Level	Δ High Waters		Δ Total Head	
			Mean	Spring	Mean	Spring
Barren Island	0.28	-0.03	0.15	0.18	0.40	0.43
Canarsie	0.28	-0.03	0.15	0.18	0.40	0.43
Norton Point	0.28	-0.03	0.21	0.24	0.46	0.49

Comparison of Tide Curves at Norton Point 1900 and 2000



Conclusions

- **Reconfigurations of the Bay have altered tidal hydrodynamics including increasing tidal ranges and height of high waters**
 - Natural (barrier island) growth
 - Anthropogenic causes (dredging and filling)
- **Marsh flooding greater than previously documented**