

FOX POINT HURRICANE BARRIER

BY JOHN WM. LESLIE,* *Member*

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THE Narragansett Bay area of Rhode Island and Massachusetts, exposed as it is to the Atlantic Ocean on the south, has experienced very heavy tidal flood losses due to hurricanes. Hurricane tidal surges are funneled into the Bay and flood densely populated and developed areas especially in the vicinity of Providence, Newport, and Fall River. Recurring flood losses are estimated at approximately \$120,000,000 for the September 1938 hurricane, and \$92,000,000 for the August 1954 hurricane. Loss of life has been great with over 250 lives lost in Narragansett Bay and along the Rhode Island coast during the 1938 and 1954 hurricanes. The need for protection is urgent, particularly in Providence, the capitol city and chief commercial center of Rhode Island where a recurrence of the 1938 flood alone would cause \$42,000,000 of damages at today's pricing.

As a result of this serious problem of hurricane tidal flooding, the Congress in 1955 passed authorization permitting the Corps of Engineers to make a study of this heavy damage area to resolve the problem in the most expeditious and least costly manner. Operating on these instructions, the New England Division, Corps of Engineers, in 1957 submitted a report with its findings on the resolution of the problem. This report basically recommended two features (Figure 1): one, a proposed Lower Bay Barrier, and secondly, a local barrier at Providence. The Lower Bay Barrier was aimed at protection of the entire Narragansett Bay whereas the upper barrier at Fox Point was specifically directed toward reducing the damages to the City of Providence. The report was favorably acted upon in 1958 and at that time authority was granted for the design of the Fox Point project and continued studies on the Lower Bay Barrier. It is noted that the Fox Point Barrier was to cost in the neighborhood of \$16,000,000 whereas the Lower Bay Barrier would cost approximately \$80,000,000. It may

* Chief, Engineering Division, New England Division, Corps of Engineers.

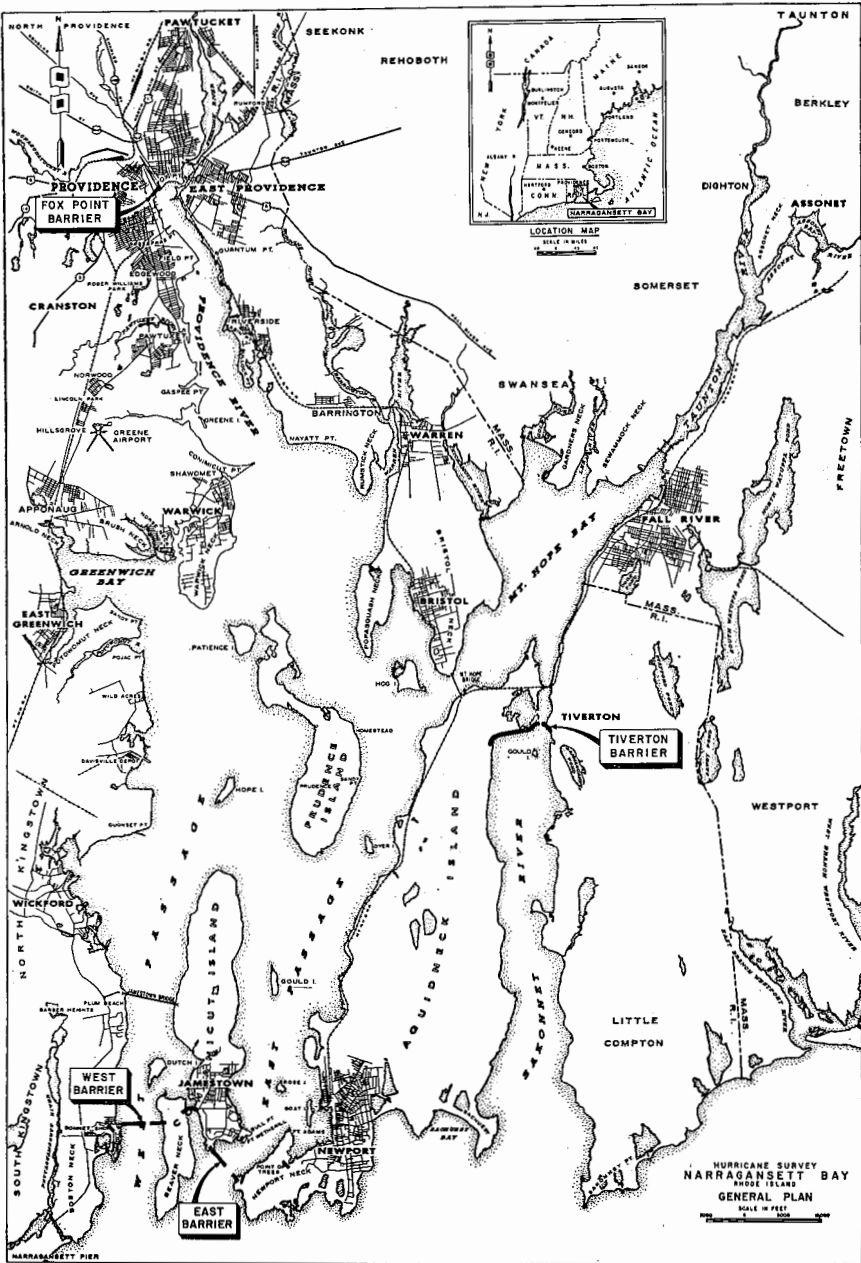


FIGURE 1.

occur to some what was the need of Fox Point if the Lower Bay Barrier plan was to be executed. The Fox Point Barrier is analogous to local protection in fresh water flooding whereas the Lower Bay plan is similar to a reservoir. Many times, local protection must supplement the reservoir as additional protection and in this instance the Fox Point project is necessary to supplement the Lower Bay plan to protect against residual conditions; in this case, the wave action due to wind effects of the long fetch of the bay. Again, the substantial amount of monies required to build the Lower Bay plan indicated that they might be long coming whereas the need for protection of Fox Point was necessary immediately.

Design against hurricanes is a brand new field of engineering and there is very little information upon which the designer may draw to produce his finished product. As a result, the Corps of Engineers, in attempting to develop criteria, worked along two major fronts. One, the creation of a physical scale model of the entire Narragansett Bay. This was done at the Corps of Engineers Waterways Experiment Station at Vicksburg, Mississippi. Here, a model was constructed that was of such magnitude that it required the majority of space afforded by an airplane hangar approximately $300' \times 300'$. Here all the tidal conditions and wind velocities that might occur in the Narragansett Bay were simulated and here was developed the data that would be needed for the design of both the Fox Point project and the Lower Bay Barrier. Secondly, a mathematical model was formulated at Texas Agricultural and Mining School where similar check data were made on a mathematical basis.

DESCRIPTION OF BARRIER

The Fox Point Hurricane Barrier is located just below the City of Providence. It crosses the bay of the Providence River and is composed of several features that I will describe in generalities. The total length of the hurricane barrier is just under 3000 feet. There are (a) 2,200 lineal feet of earth dikes, (b) 290 feet of a non-overflow concrete barrier, (c) 3 tainter river gates, $40' \times 40'$, with the sill at minus 15 feet MSL, (d) a pumping station $214' \times 91'$, with five 120-inch diameter pumps. The total pumping capacity of the five units is 7,000 cubic feet per second. The pumping station, incidentally, is to expel the inland run-off occurring during hurricane conditions from an approximate 77 square-mile drainage area, (e) three vehicular

gates totalling 125 feet in length, located at Allen's Avenue, Narragansett Electric Company and at South Main Street on the east side of the river. These features are clearly shown in the photograph of the proposed project (Figure 2).



FIGURE 2.—THE FOX POINT HURRICANE BARRIER, PROVIDENCE, R. I.

WORKING CRITERIA

a. The normal tide range at Narragansett Bay is plus 2.47 feet to minus 2.13 feet.

b. The stillwater elevation used in the design of the Fox Point Hurricane Barrier is elevation 20.5 feet mean sea level.

Surge at Newport	11.2 feet
Dynamic buildup	3.3 feet
Wind setup	2.9 feet
Coincident tide	3.1 feet

c. Freeboard of $4\frac{1}{2}$ feet was allowed for this project to take care of as much wave overtopping as was economical. This, therefore, establishes the top elevation of the barrier as 25.0 feet above mean sea level. It was not economically possible to take care of all over-

topping. We may expect as high as 350 cubic feet per second from wave overtopping. However, this is not serious inasmuch as it can be easily taken care of by the pumps in the pumping station which, as mentioned above, have a capacity of 7,000 cfs. It may be of interest to some, that the significant wave height was $6\frac{1}{2}$ feet with a period of 5.5 seconds.

COOLING WATER CANAL

Our early studies of the Fox Point project indicated that construction and later being of the barrier might cause trouble with the going plants of the Narragansett Electric Company. The excavation that would be needed in the channel in order to place the concrete structures is of an organic content and therefore could easily create a sulphide condition which could easily be taken into the plant through the cooling water intake pipes and cause pitting to the condenser tubes. This, of course, would be damaging and would result in damages that might be assessed against the Government and its contributing partners. Secondly, our studies at the Waterways Experiment Station indicated that there would be a rise in the temperature of the water impounded behind the barrier which would affect the efficiency of the generating units. In order to circumvent this, a cooling water canal was built along the pier of the Narragansett Electric Company. This permits the taking of the cooler bay waters into the plant at all times. As you may note on the photograph, the cooling water canal extends downstream of the barrier where it constantly takes its water from the bay.

The total cost of the Fox Point Hurricane project is now estimated at \$15,900,000, of which 30%, by law, is required to be paid by the local interests. In this particular instance it will be jointly subscribed by the City of Providence and the State of Rhode Island. This amount of 30% is approximately \$4,740,000. All Corps of Engineers projects and those of other Government agencies too, are evaluated on what is known as a B/C ratio, i.e., the ratio of the annual benefits to the annual costs. In order to be an acceptable project, this should exceed a ratio of one. In the instance of Fox Point, the annual benefits are \$1,786,000 and the annual costs \$732,500. This, therefore, gives the project a B/C ratio of 2.4 to 1 which is well above the criterion for an acceptable project.

The Fox Point project is now under construction and is expected

to be completed early in 1964. However, it will be operational in late 1963 should a hurricane occur. The project will be operated by the City of Providence with advice and guidance by the Corps of Engineers. Construction of the project as indicated above will forever free the City of Providence from damages resulting from forecastable hurricanes which, as stated previously, could exceed \$42,000,000.