GALVESTON'S BULWARK AGAINST THE SEA

history of the Galveston seawall

For Additional Copies:

Public Affairs Officer
Corps of Engineers
P. O. Box 1229
Galveston, Texas 77553

Rev: Oct. 1981

GALVESTON'S BULWARK AGAINST THE SEA

HISTORY OF THE GALVESTON SEAWALL

Foreword

Hurricane Carla struck Galveston on the 61st anniversary of the 1900 storm which killed 6,000 people and destroyed 3,600 homes at the island city. Although Galveston was partially flooded from the unprotected bay shore by high tides and suffered dramatic damage from tornadoes which struck after Carla, the seawall protected the city against the hurricane forces. In the area protected by the Galveston seawall, there were no lives lost and no homes destroyed by the surges and waves of Carla. The story of the seawall is particularly timely.

Galveston

Galveston Island, one of the long narrow barrier beaches that fringe the Gulf Coast of Texas, is a low, sandy formation about 28 miles long and from ½ to 3 miles wide. In its natural state the Gulf shore was bordered by an area of sand dunes rising to heights of 12 to 15 feet above the natural surface of the island. The availability of deep water along the bay side of the island led to the early development of the city of Galveston on the east end of the island. In its early days the city was protected from hurricane tides by the sand dunes along the Gulf front. The rapid development of the city in the latter part of the 19th century, especially its increasing importance as a summer resort, led to the removal of sand dunes along the beach front for fill and to permit easy access to the beach. Without the dunes the city was unprotected from the fury of the hurricanes. The danger to the city was realized by a number of persons, and several plans for storm protection had been developed; however, because of financing difficulties and general public apathy, none of these plans was carried out. (See Figure 1.)

1900 Storm

The resort city of about 38,000 persons was exposed to the havoc of the hurricane of September 8, 1900. The hurricane winds of this storm and accompanying 15-foot tide that swept the city caused property damages reported to be over $25,000,000, and a loss of more than 6,000 lives. Destruction along the Gulf front was complete: In about 1,500 acres along the Gulf front over 2,600 houses were demolished and up to 300 feet of land were lost by erosion of the shore.

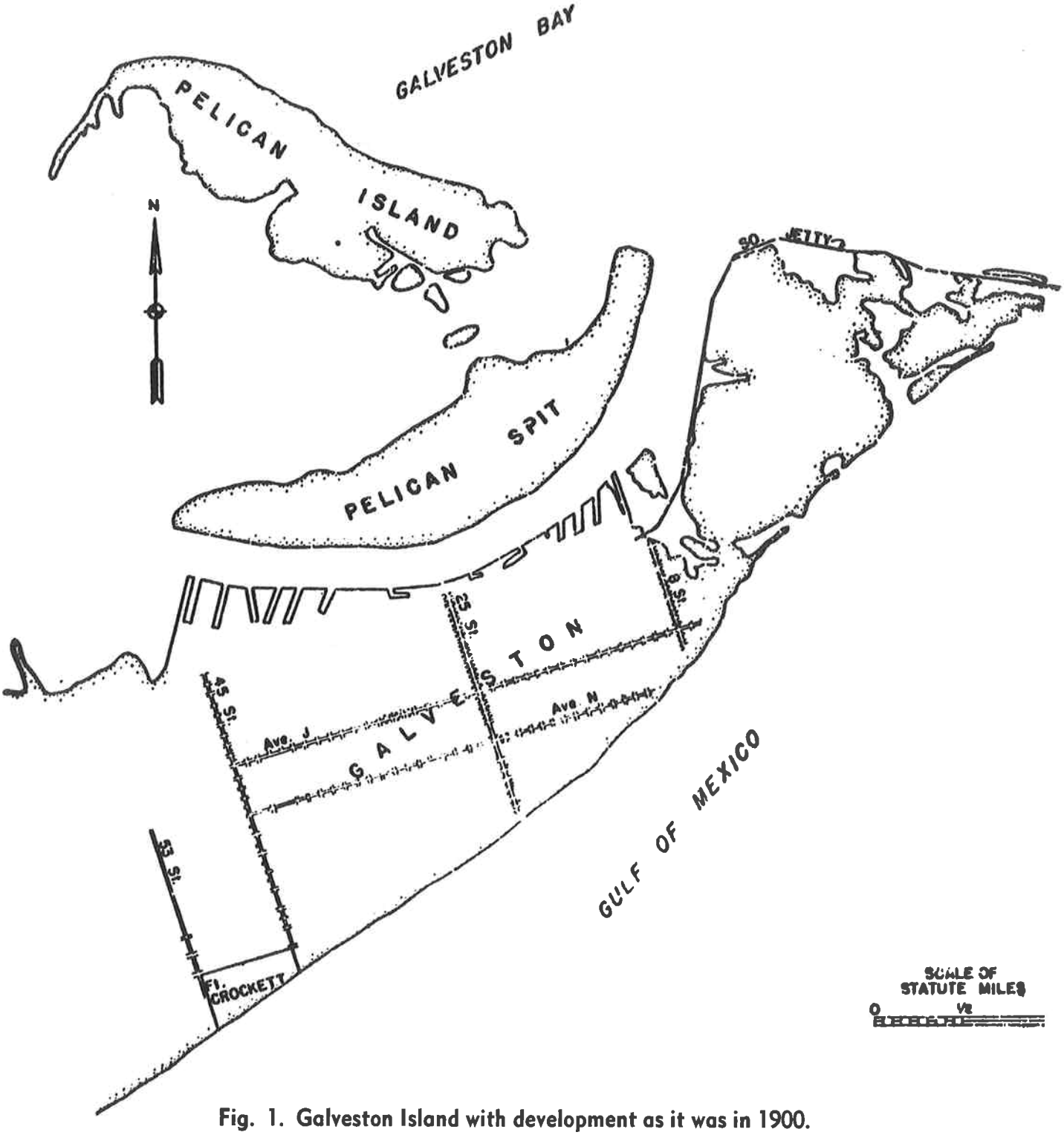


Fig. 1. Galveston Island with development as it was in 1900.

Original Seawall

The citizens of Galveston responded to the destruction of the city with remarkable energy and fortitude and within four years had erected a barrier to the sea that was to save the city from further devastation within fifteen years and which still makes Galveston a comparatively safe place in which to live.

About one year after the storm, the City Commission of Galveston and the County Commissioners Court of Galveston County appointed a board of engineers to report on means for protecting the city. The board was composed of Brigadier General H. M. Robert, former Chief of Army Engineers, retired, and Messrs. Alfred Noble and H. C. Ripley. The board was directed to report on the following:

1. The safest and most efficient way for protecting the city against overflows from the sea.

2. Elevating, filling, and grading the avenue, streets, sidewalks, alleys, and lots of the city so as to protect the city from overflow from the waters of the Gulf and to secure sufficient elevation for drainage of rain fall and sewerage.

3. A breakwater or seawall of sufficient strength and height to prevent the overflow of and damage to the city from the Gulf.

The Robert Board submitted its report on January 25, 1902, recommending in general the following plan for protection of the city:

a. A solid concrete wall, over 3 miles long, connecting with the south jetty near 8th Street; thence to 6th Street and Avenue D; and thence on 6th Street across the island to the beach and down the beach as far as 39th Street. The top of this wall to be 17 feet above mean low water.[1] The location of this seawall would be landward of the highwater line generally at about the 3-foot contour. (See Fig. 2)

[1]The Corps of Engineers mean low tide or mean low water datum plane is 1.40 feet below the Geodetic surveys mean sea level. Thus 17 feet MLW is the same as 15.6 feet MSL.

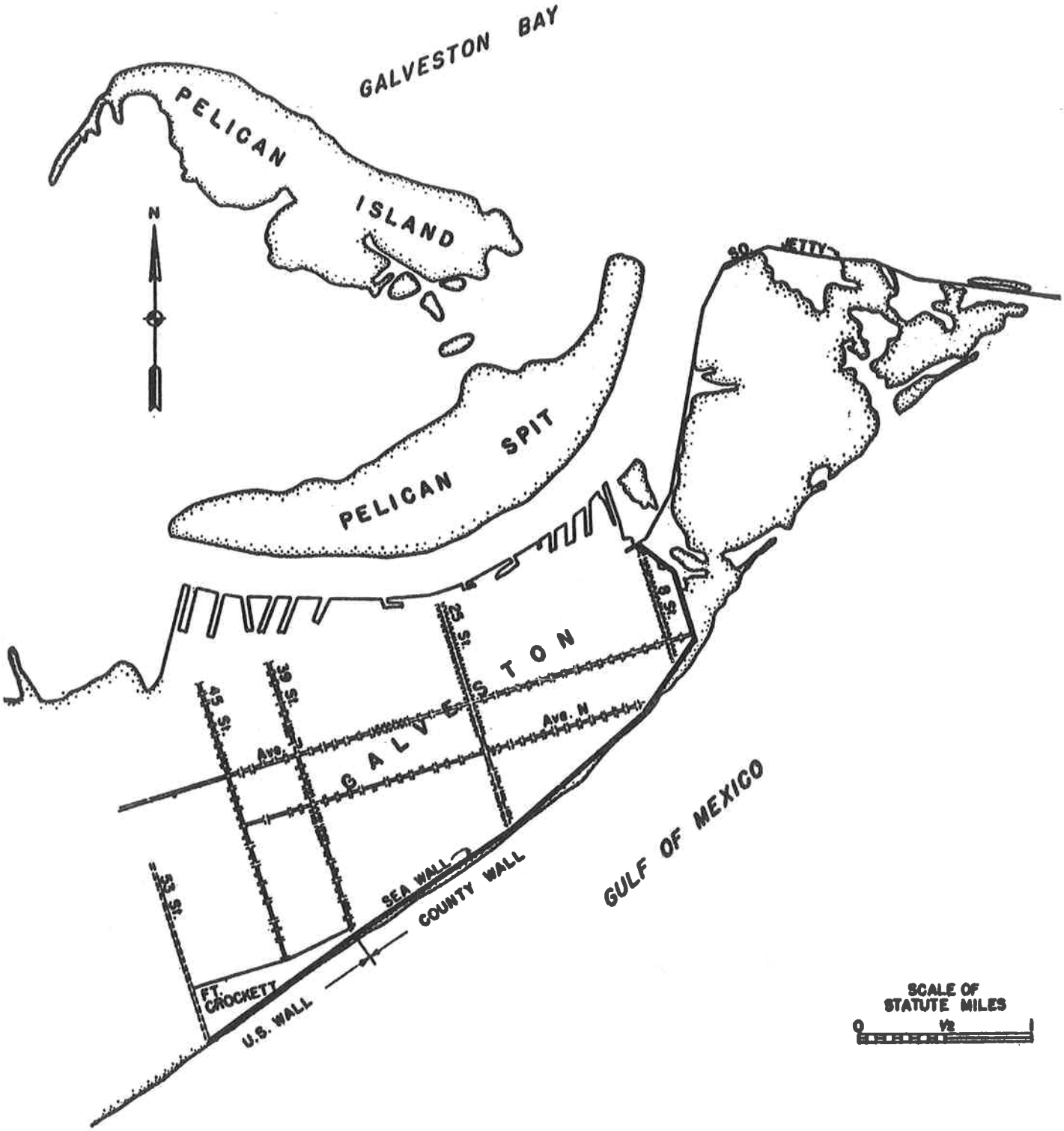


Fig. 2. Location of seawall as recommended by Robert Board in 1902.

b. The raising of the city grade to 8 feet at Avenue A, 10 feet at Broadway, 12 feet at Avenue P, and continuing this slope to the seawall, which corresponds to a rise of one foot in 1,500 feet from the bay toward the Gulf.

c. The making of an embankment on top of this fill adjacent to the wall, and rising to a height of 18 feet above mean low water at a distance of 200 feet from the wall, thence sloping down on a grade of 1 in 50 to the surface of the fill. The top of this embankment for 35 feet from the seawall to be protected by a brick pavement and 60 feet farther by Bermuda grass. (See Figure 3–a.)

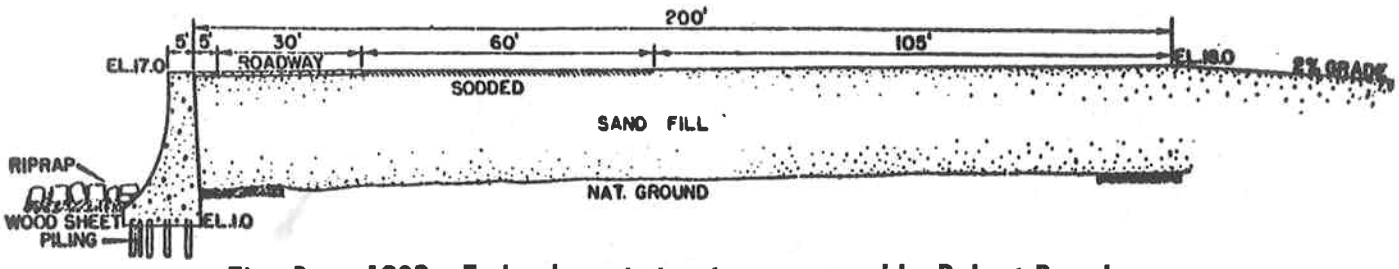


Fig. 3–a. 1902—Embankment structure proposed by Robert Board.

The design of the seawall provided for a concrete gravity section 16 feet wide on the base at elevation 1 foot above mean low water and 5 feet wide on top at elevation 17 feet above mean low water. The sea face of the concrete seawall to be curved so that its upper portion will be vertical, to give the wave an upward direction and prevent, to a great extent, its running up and over the embankment behind the wall. The wall would be founded on piles and protected from undermining by sheet piling and a layer of riprap 27 feet wide and 3 feet thick extending outward from the toe of the sea face of the wall. The riprap to be deposited so that when the work is

finished the larger stone will be on the surface with interstices closely filled with smaller pieces, the object being to present a surface as smooth and resistant to wave action as practicable without incurring great expense in placing the stone.

The cost of the seawall was estimated at a total of $1,295,000 for the 17,593 feet of seawall. This portion of the seawall was constructed by Galveston County, beginning in October 1902 and completed in July 1904 at an actual cost of $1,581,673.30. The structure was built generally in accordance with the plans of General Robert, except that the embankment behind the concrete section was built only 100 feet wide and to a maximum elevation of 16.6 feet. (See Figure 3–b.)

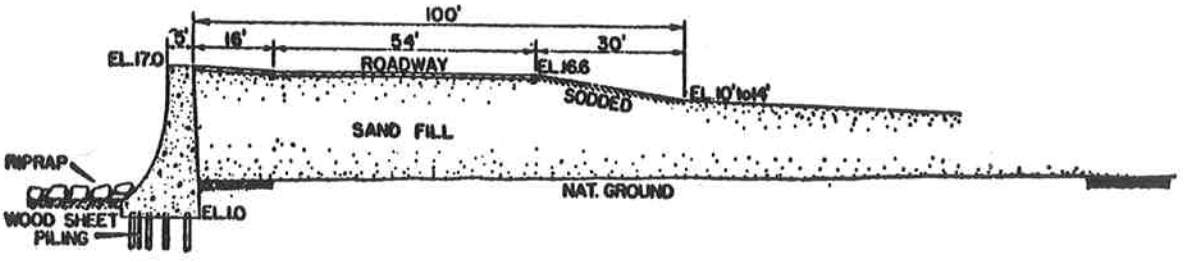


Fig. 3–b. 1904—Seawall as constructed.

Ft. Crockett Extension

While the county seawall was being constructed the U. S. Congress authorized the construction of a seawall of similar design along the front of the Fort Crockett Military Reservation. This reservation was located between 39th Street and 53rd Street, beyond the end of the county seawall. The Fort Crockett seawall is 4,935 feet long and ties in three concrete gun emplacements on the reservation. It was constructed

immediately following completion of the county wall at 39th Street, being started in December 1904 and completed in October 1905. The cost to the United States was $295,000, exclusive of the fill behind the wall.

The concrete section of the Fort Crockett wall is similar to the county wall as recommended by the Robert Board. Behind the wall the entire reservation was filled to a grade of 17 to 18 feet, and 34 feet of the fill adjacent to the concrete wall was protected with paving.

The 1909 Storm

The seawall was soon subjected to a minor test, when in 1909 an intense hurricane of small diameter crossed the Texas coast about 45 miles southwest of Galveston. The accompanying storm tide reached about 6.6 feet above mean low water. Considerable quantities of water were thrown over the seawall and drained across the fill into the city. The slope of the sand embankment behind the wall was considerably scoured by the flow of water and some of the raodway paving was undermined. The riprap along the toe of the wall was lowered somewhat and in a few places the wooden sheet pile cut-off wall was exposed.

The toe of the wall was repaired by placing sand and riprap to bring the riprap up to grade. As a result of the damage to the embankment caused by this storm it was decided to repair the embankment behind the wall and extend the fill to a crest elevation of 18 feet at a distance of 200 feet from the face of the concrete section as originally proposed. (See Figure 3–c.)

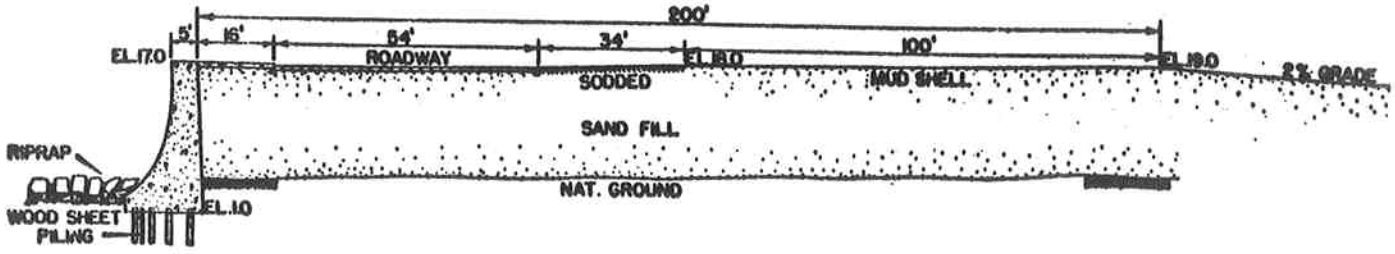


Fig. 3–c. 1909—Seawall repair and modification following storm.

Proposed Ft. San Jacinto Extension

In 1913 a report was prepared at the request of Congress by a special board of engineers for rivers and harbors, which considered the question of extending the seawall eastward from 6th Street to Fort San Jacinto in the east end flats. This report pointed out the danger of storm erosion cutting a channel across the island in this area, which would breach the jetty and result in extensive shoaling in the Galveston channel along the bay side of the island. The board considered this danger sufficient to warrant preventive measures and recommended that the seawall be extended across the east end flats to protect the harbor from blockage by storms and to permit expansion of the harbor facilities. The recommended extension from 6th Street to the first battery at Fort San Jacinto had a total length of 10,300 feet, of which 3,300 feet would be built by local interests, city or county, and 7,000 feet on the Fort San Jacinto Reservation would be built by the United States. (See Figure 4) The design of the seawall extension was the same as the completed seawall with the embankment behind the wall 200 feet wide from the edge of the wall to the crest of the fill.

The 1915 Storm

In 1915 the seawall was subjected to its first severe test, for the tropical cyclone that crossed the Texas Coast on August 16, 1915, about 30 miles southwest of Galveston, was a major hurricane fully as severe as the storm of 1900 that wreaked such havoc in the city.

The seawall proved the adequacy of its design in protecting the city from a repetition of the damage it had experienced in 1900. In Galveston the loss of life in 1915 was only 12 and the total property damage was estimated at $4,500,000, both many times less than that caused by the 1900 storm.

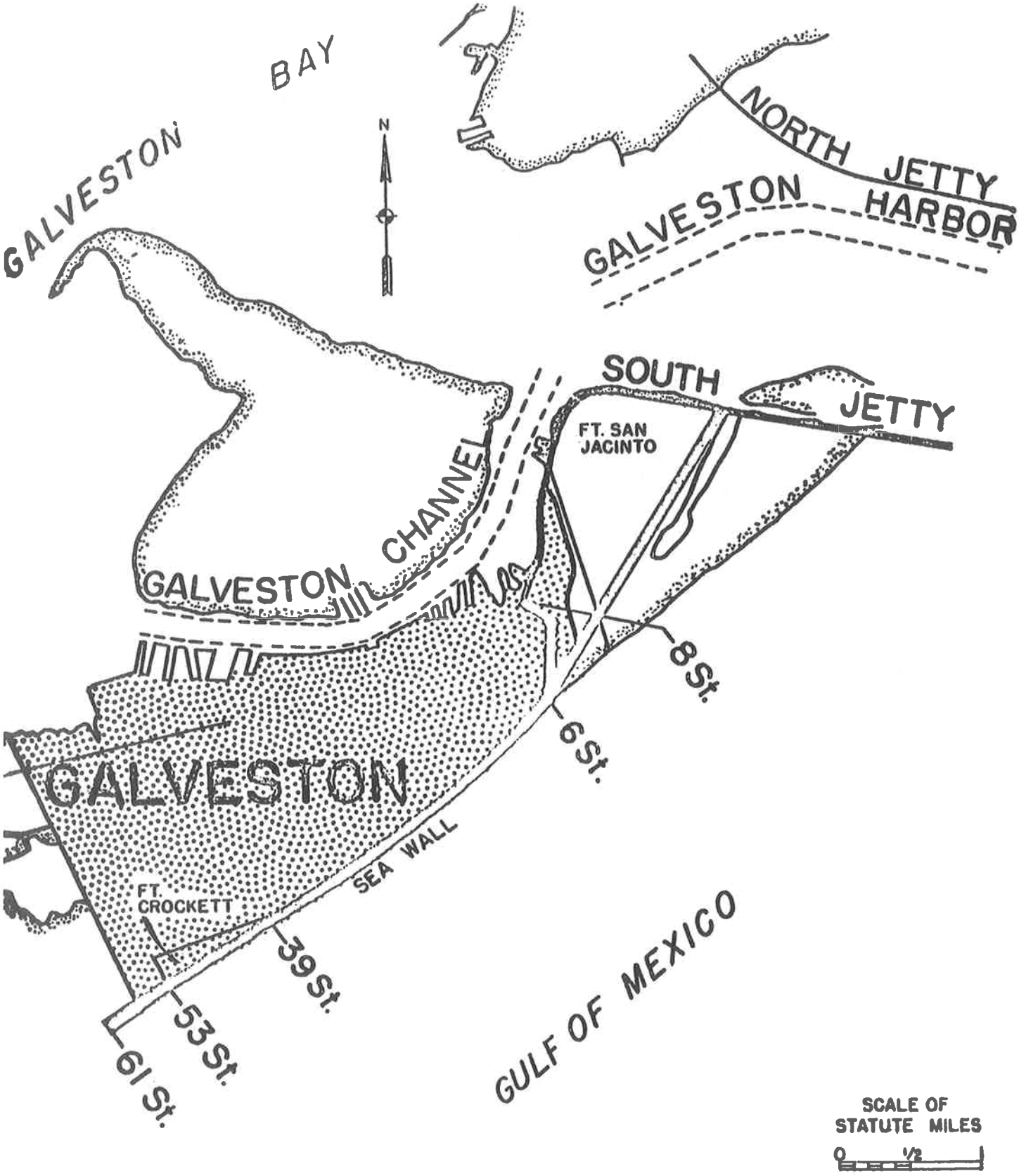


Fig. 4. 1913—Seawall extension from 6th Street to Fort San Jacinto proposed.

The 1915 storm was accompanied by a tide that reached nearly 14 feet above mean low water and wave crests that are estimated to have reached a maximum height of about 21 feet. The storm was of particularly long duration, being several times that of the 1900 storm, and the storm tides inundated the city for over 40 hours.

The heavy waves caused considerable scour along the foot of the seawall. The riprap apron was undermined in many places, dropping as much as 3 feet below the toe of the wall, and exposing the timber sheet pile cut-off wall. This was of particular concern since the untreated timber was exposed to teredo damage. The exposed reaches were filled with sand and riprap as rapidly as possible. Over 24,000 tons of riprap were placed along the toe of the wall to repair the storm damage.

The most extensive damage to the seawall was the erosion of the embankment back of the wall by the great quantity of water that was thrown across the wall. One observer reported that water appeared to be coming over the wall in a continuous sheet about two feet deep. The embankment was scoured out and the pavement destroyed completely from 6th Street to 18th Street. Several houses and buildings near the seawall were undermined by the scour and destroyed. Between 18th Street and 21st Street the embankment was protected from scour by buildings. West of 21st Street the embankment was washed down from 7 to 8 feet and the brick paving was damaged, and from 39th Street to 43rd Street, in front of Fort Crockett, the embankment with road and sidewalk was washed back into the city. There was considerable scour from 43rd Street to the end of the wall at 59th Street.

The concrete section of the seawall was damaged to the extent of two small chips of about two cubic feet each near 39th Street. This was caused by a four-masted schooner which was blown over the wall during the height of the storm while dragging two anchors. The anchors caught on the toe of the wall and the schooner pounded to pieces on top of the wall. Fragments of the hull, masts, and cargo were scattered over the west end of the town.

GALVESTON TRIBUNE.

Vol. XXXV GALVESTON, TEXAS, WEDNESDAY, AUGUST 18, 1915. No. 227

GALVESTON'S SEAWALL STANDS SUPREME TEST; LOSS OF LIFE LESS THAN SCORE

Mayor Fisher stated this morning that he has decided to have the city placed under soldier patrol and he would take such action before night. It is not actually martial law.

Numerous additional instances of looting were reported this morning and appeals for assistance in safe-guarding unprotected property were many at the police station. In as many instances as possible regular officers were dispatched in response to these appeals and in addition scores of private citizens were sworn in as special officers. Entrusted with this duty, City Secretary J. D. Kelley remained at the city hall throughout the forenoon.

Mayor Fisher said that a meeting of the citizens' advisory committee, appointed yesterday afternoon and composed of representatives of all the city's principal interests, had been called for 3 o'clock this afternoon, at the Cotton Exchange.

The water situation remained unchanged this morning, although Commissioner Shay and others connected with the department were actively at work in efforts to relieve this situation, and it was said that a [illegible] water for drinking purposes [illegible] obtained by all who [illegible] for that purpose to the city waterworks station at 30th and Ave. H.

Both the Sealy hospital and St. Mary's infirmary have been supplied with adequate drinking water, it was announced this morning.

City Engineer Dickey this morning began assembling teams and men for the purpose of cleaning the streets of debris left by the storm.

The entire west half of the business block facing on twenty-third street between Avenues A and B was destroyed by fire which was discovered shortly after 5 o'clock today. The loss includes 2302 Ave. B, a three-story brick building occupied by J. E. Seinsheimer [illegible] and others, and owned by the City National Bank; 2304 Ave. [illegible] occupied and owned by Fred Pab[illegible], a [illegible] story brick building, 2308 Ave. B occupied by the Blum Notion Co., and owned by Mrs. Jules Muller, a three-story [illegible] building [illegible] twenty-third street [illegible] the [illegible] & Co., and 230[illegible] end lost [illegible] by the Swift Pa[illegible] Co. [illegible] had [illegible]

The Gulf Fisheries Company, at the foot of Twenty-Second Street, have an artesian well, 14[illegible] feet deep, which furnishes a steady stream of pure water. The company announces that everybody is welcome to as much as they desire.

Before the storm there was a beach generally along the Gulf side of the wall, as much as 300 feet wide in places. After the storm the beach had completely disappeared and there was a depth of 3 to 4 feet at the toe of the riprap. The beach sand was in a bar deposited several hundred feet off-shore from which a large quantity gradually moved in-shore, but the beach has never built up above low tide to any extent since the storm.

Seawall Improved

Because of the extensive damage to the seawall, the county requested General Robert to review the problem and report on a plan to furnish further protection against hurricanes. His recommendations were that the paving on top of the embankment be extended to a width of 100 feet; that a reinforced concrete sheet pile bulkhead be placed along the land side of the pavement, with a top elevation of 18 feet; and that the embankment rise in another 100 feet to an elevation of 21 feet at 200 feet from the wall.

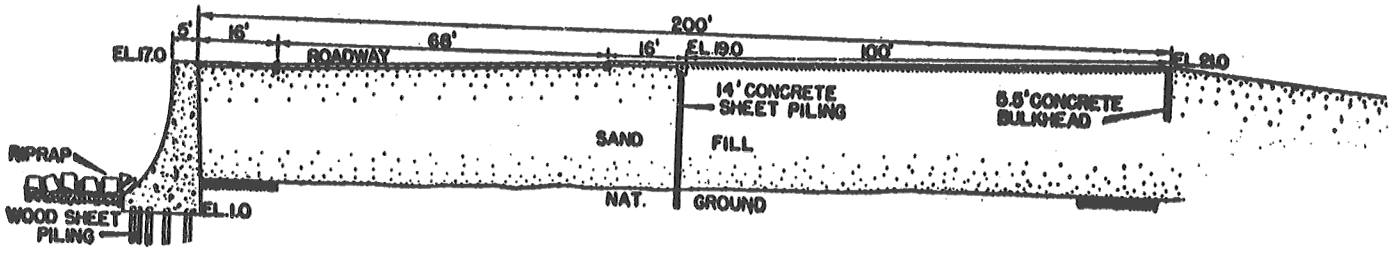
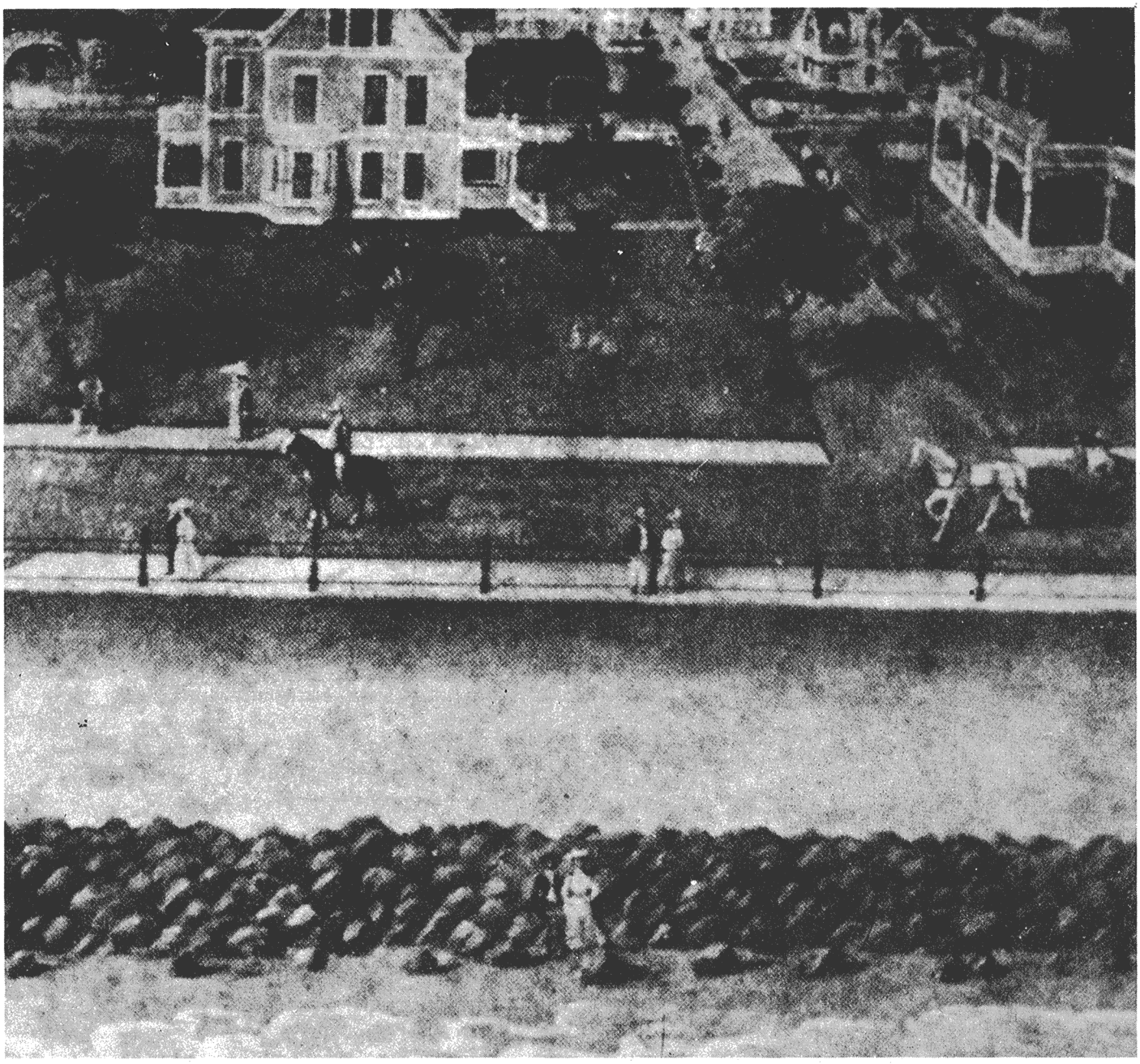
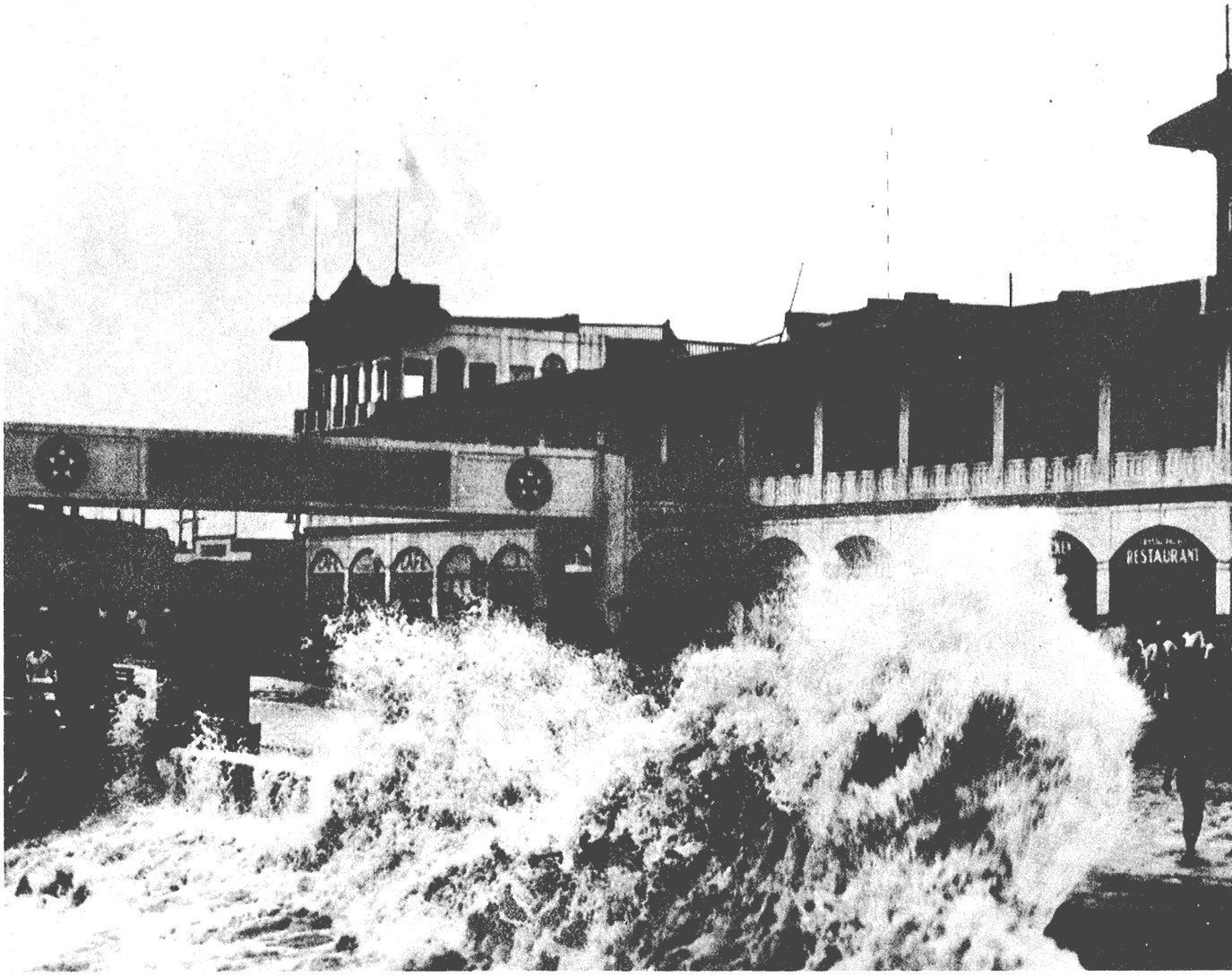


Fig. 3–d. 1915—Improvements to seawall following storm.

This work was done immediately and, in addition, a small concrete bulkhead, 1 foot thick and 5 feet high, was constructed at the crest of the embankment. The sand fill beyond the paving was protected by sodding or by a cover of shell. (See Figure 3–d)



Beach Boulevard residential area, about 1904.



High waters lash Galveston during 1933 storm.

The 1919 Storm

On July 27, 1916, Congress authorized the east extension of the seawall from 6th Street to Fort San Jacinto as recommended by the board of engineers in 1913. (See Figure 4). Work on this extension was begun on June 20, 1918. The work was very much delayed by wartime labor shortages and lack of materials because of embargoes on railroad cars. The extension was about half completed, having reached the edge of an old borrow pit about 300 feet wide and 2-1/2 feet deep, from which about 3,000,000 cubic yards of material had been removed for the Galveston grade raising, when the severe hurricane of September 13-14, 1919, occurred. The borrow pit had been closed with a wood sheet pile bulkhead and the work of constructing the seawall across the area was in progress when the storm occurred. This storm passed about 180 miles south of Galveston but it caused a tide of 9.0 feet above mean low tide and winds of about 60 miles an hour at Galveston.

The high tide covered the east end flats with several feet of water and caused strong currents around the end of the completed wall that scoured the borrow pit to a width of about 2,000 feet with a maximum depth up to 19 feet and an average depth of about 8 feet. It was necessary to place about 250,000 cubic yards of sand fill in the scoured channel. The fill was slow in draining and considerable difficulty was experienced in constructing the wall across this reach.

The volume of water thrown over the seawall during this storm was not large and there was little damage behind the wall except in the section at the Fort Crockett Reservation that had been washed out in the 1915 storm. Here the embankment had been replaced but had not been paved and sodded. The sand fill was scoured to depths of 2 feet to 12 inches behind the wall and the sheet pile bulkhead 100 feet from the wall.

West of 39th Street the riprap at the toe of the wall was deficient in quality and quantity, being small in size and partly of sandstone. This rock was scattered and lowered for a distance of several hundred feet and in places the wood sheet piling was exposed. About 6,000 cubic yards of rock were required to repair this section of the wall.

The east extension of the wall to the battery at Fort San Jacinto was completed in March 1921. In the last 4,660 feet of this wall reinforced concrete sheet piles were used for the cut-off wall under the toe of the concrete wall, and the riprap apron was omitted because of the protection afforded by the wide foreshore in front of the wall.

A somewhat different design was used for the embankment behind the seawall across the San Jacinto Reservation. Here the embankment behind the wall has a 10-foot walk and 50-foot roadway that slope up on a 2 per cent slope and then the embankment rises on a 20 per cent slope for 40 feet to a crest of the fill at elevation 26 feet above mean low water. The crest is 8 feet wide and there is a concrete cut-off wall along its landside that extends one foot above the top of the fill. Behind the cut-off wall the fill has a 1 on 6 slope to the natural ground at a distance of about 250 feet from the face of the concrete wall. The front slope and crest of the embankment are paved. This embankment is designed to prevent any over-topping of the fill by storm waves. (See Figure 3–e)

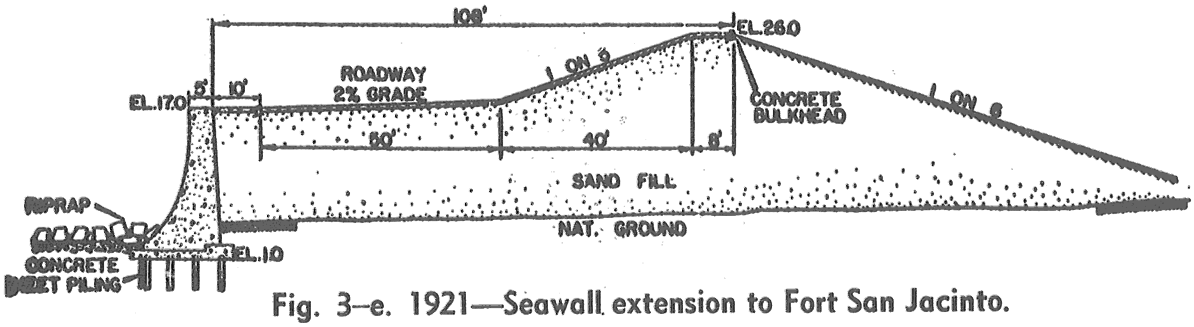


Fig. 3–e. 1921—Seawall extension to Fort San Jacinto.

A further extension of the seawall eastward across the Fort San Jacinto Reservation to the south jetty was authorized by Congress in 1922, and was constructed between May 1923 and January 1926. This extension of 2,860 feet in length was of the same design as the completed wall on the reservation.

In 1926, Galveston County constructed a west extension of the seawall from 53rd Street to 61st Street. This section, 2,800 feet in length and of the same design as the county wall in front of the city, was completed in June 1927.

West Extension

The protection that the seawall afforded the city of Galveston encouraged development of the city, and the protected area became densely occupied with houses until there was little undeveloped land, protected by the seawall, available for expansion of the city. Development had taken place toward the southwest beyond the end of the seawall at 61st St., despite the danger of destruction by hurricanes. In order to afford protection to this area, Congress, in 1950, authorized construction of a 16,300-foot southwest extension of the seawall from 61st street. The design of this extension is similar to the later sections of the existing wall. The riprap at the toe of the wall is 40 feet wide and the embankment behind the wall rises to an elevation of 21 feet at a distance of 155 feet from the face of the wall. The top of the wall is reduced to a width of 3 feet and concrete sheet-piles are used in the toe cut-off wall. (See Figure 3–f)

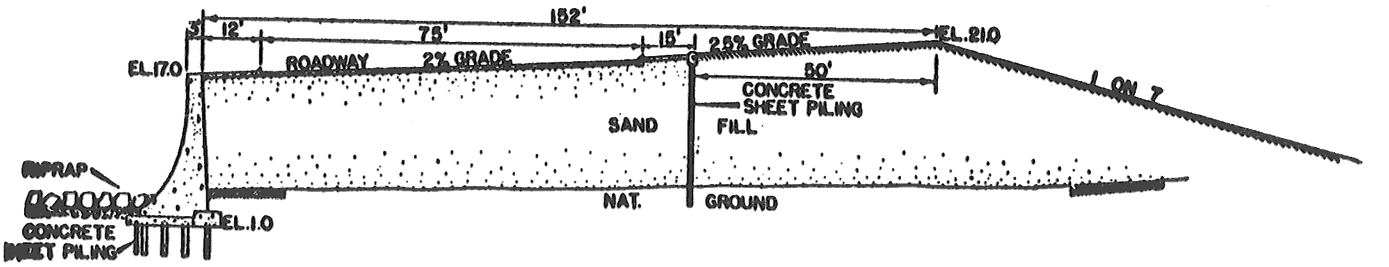


Fig. 3–f. 1953–63—Three-mile west extension of seawall.

The Korean War delayed Federal construction of this 3-mile extension so Galveston County undertook construction of the first mile of seawall, completing it in 1953. The final two miles were constructed by the Federal Government between 1958 and 1963. The three-mile extension cost a total of $9,335,000 of which $6,465,000 was Federal funds and $2,870,000 was contributed by Galveston County.

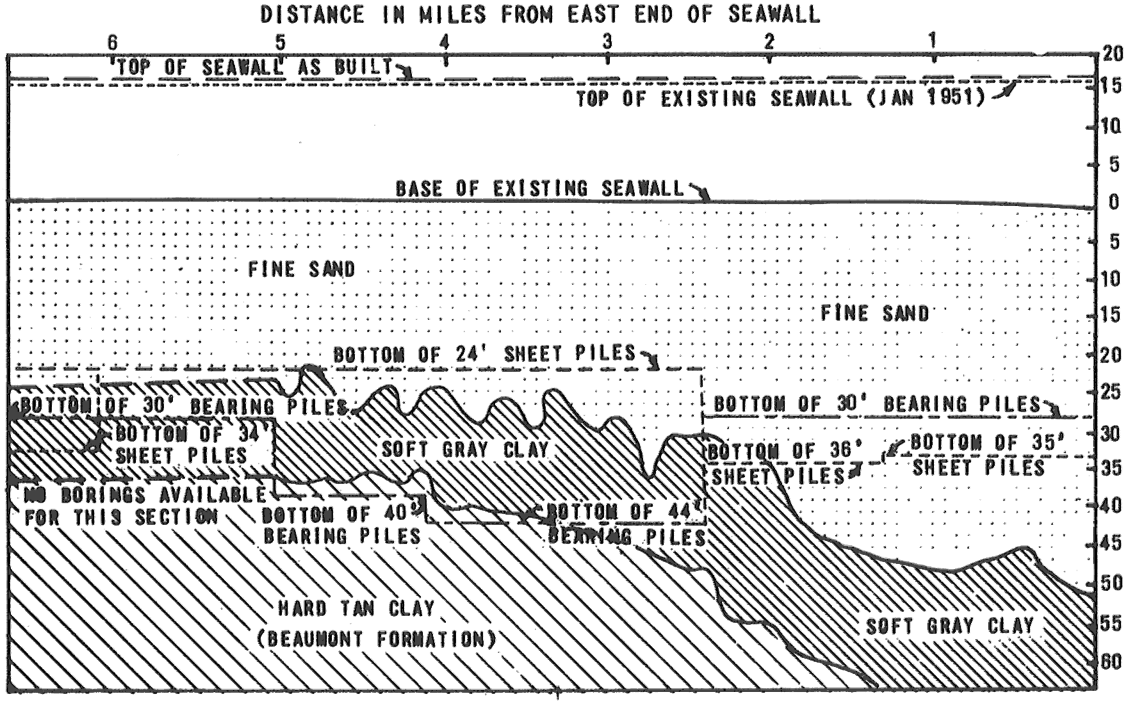
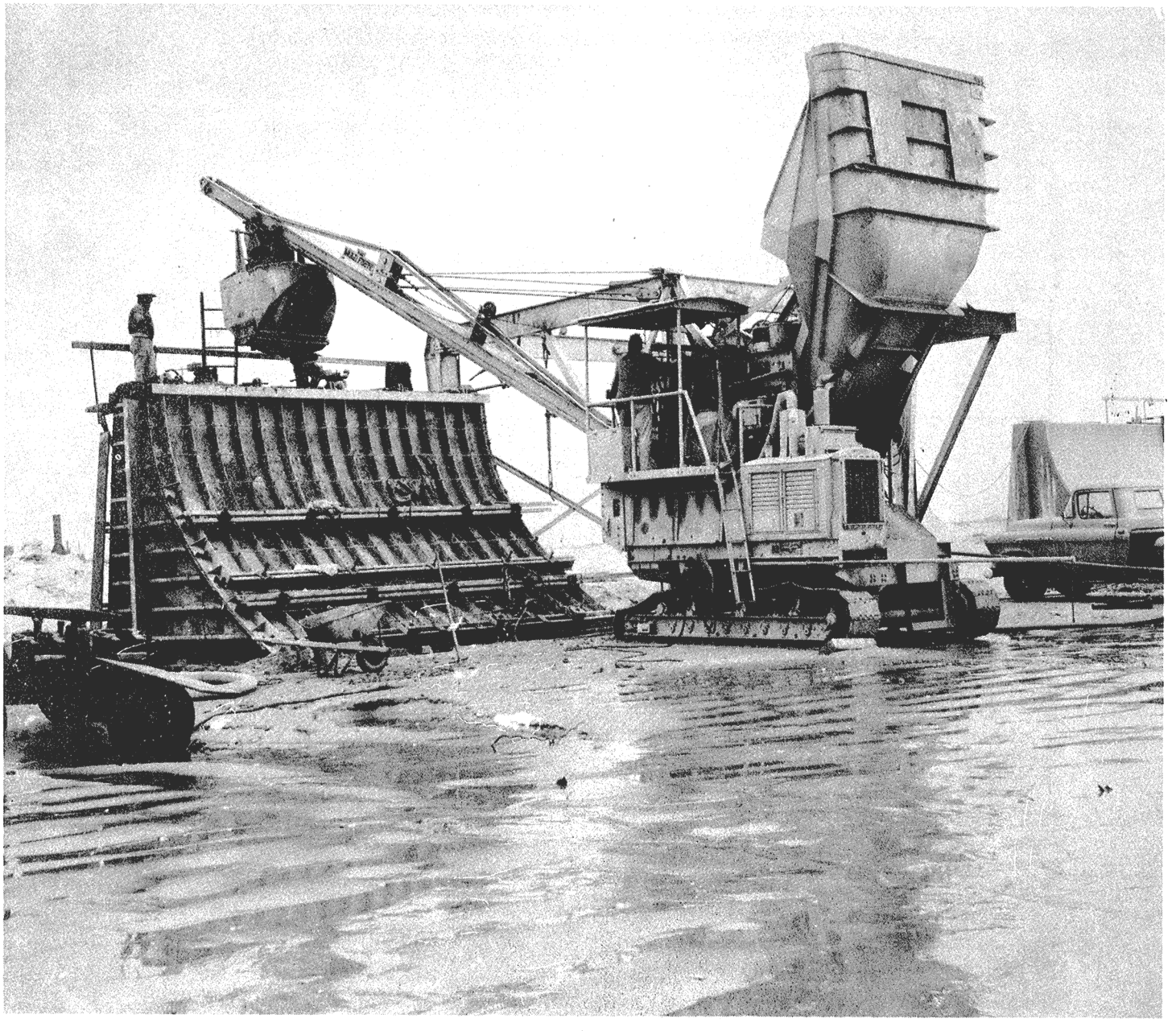


Fig. 5. The profile of the seawall from 61st Street to the south jetty shows the subsurface strata consisting of about 25 feet of sand, underlain by 10 feet of soft clay below which is the heavy clay of the Beaumont Clay formation. The east end of the profile shows erosion forming the gorge of Galveston Pass. Bearing piles under the wall are generally seated in the clay strata, except in the east end where the depth of clay is too great, and the section west of 39th Street where short piles were used.



Concrete pouring during 1959 seawall extension.

Riprap is placed at toe of seawall extension.

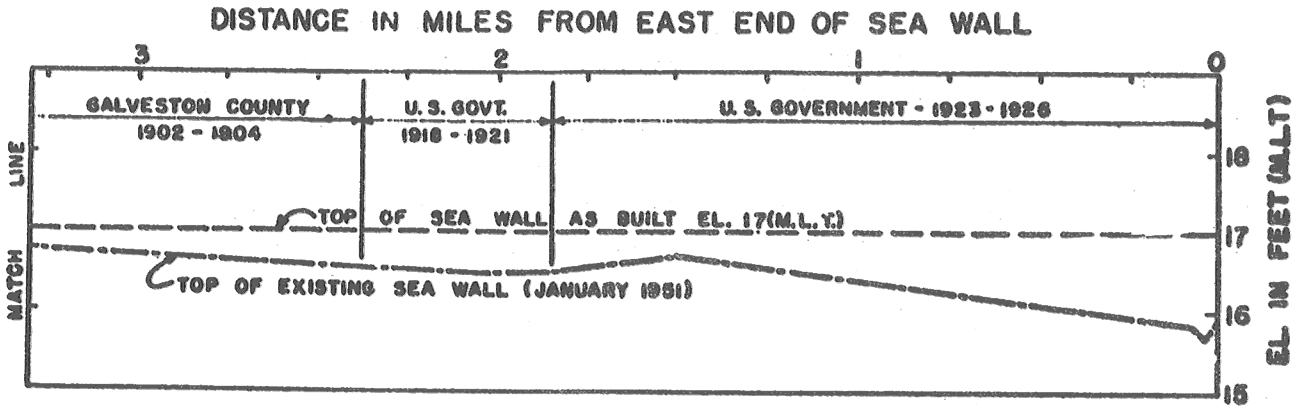
The completion of this section brought the seawall to its present condition. The total length of seawall constructed is 54,790 feet, or 10.04 miles, of which 28,755 feet was constructed by Galveston County and 26,035 feet was constructed by the Corps of Engineers. The effective length of seawall along the Gulf front is 9.74 miles. The cost of the seawall totaled $15,465,000, and the cost per foot varied from $90. a foot for the first construction in 1902, $200. a foot for the construction in 1926, and $570. a foot in 1963.

Hurricane Carla

In September 1961 a major hurricane swept across the Gulf of Mexico and crossed the coast near Pass Cavallo, Texas. This hurricane, called Carla, was extremely slow moving and covered almost the entire Gulf of Mexico. The storm center passed about 120 miles west southwest of the city of Galveston causing a maximum tide at Galveston of 10.7 feet above mean low tide. Although Galveston was partially flooded from its unprotected bay side by the high tides and suffered a traumatic experience from the damage from tornadoes in the storm fringes, the seawall protected the city from storm wave damage. No homes were destroyed and no deaths were caused by the storm surges. The completed portion of the seawall weathered the storm without significant damage. However, there was extensive erosion at the west end of the wall which was just being completed. The unsodded slopes of the landside fill were washed down and a portion of the road pavement was undermined. A section of pre-cast concrete block toe protection was undermined and damaged.

Settlement of Seawall

The profile of the top of the wall, (Figure 6), shows the extent of settling that has occurred in the wall. The oldest part of the seawall has settled least because of the use of longer bearing piles, the tips of which extend into or near the Beaumont Clay formation. Settlement of the wall has been caused, mainly, by consolidation of the soft gray clay beneath the tips of the piles that do not reach the Beaumont Clay.



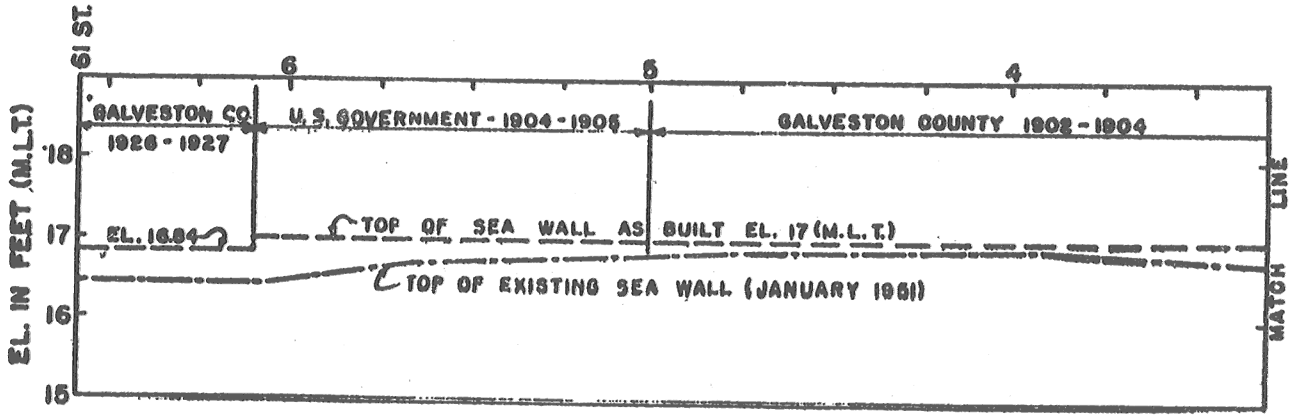


Fig. 6. Settling of seawall is shown in profile of top of wall.

Settlement has been very uniform at any one locality along the seawall and no cracking or shifting of the monoliths is evident. Settlement has been continuous since the seawall was constructed and apparently is continuing. The greatest settlement occurred in the east end of the wall which was constructed over recent deposits. Here the soft gray clay layer is much thicker and it appears that this area was the entrance to Galveston Bay until the last few centuries. Settlement ranges from 1.45 feet near the east end of the wall to a mere 0.1 foot near the central portion of the county wall at about 27th Street, which was built in 1902-04.

Grade Raising

Concurrently with construction of the county seawall the city of Galveston undertook extensive grade raising in the city behind the wall. This work started in 1903 and continued at intervals through 1948, at which time all of the area within the city except a 10,200-foot section north of Broadway and a narrow strip along the west city limits had been filled. The present grade of the city slopes uniformly from an elevation of 14 feet on Avenue T behind Fort Crockett, to 10 feet at Broadway and 8 feet along the channel. The cost to the city for grade raising amounted to about $6,000,000, of which about $4,000,000 was received from state taxes remitted to the city for this purpose. The Fort Crockett Military Reservation was filled at the time the seawall was constructed. The San Jacinto Military Reservation has been filled to a considerable extent with spoil from channel dredging.

From the 1919 storm until 1969, six storms at Galveston caused tides of between 6.0 and 10.7 feet above mean low tide. The only damage to the seawall from these storms was loss of beach sand and a slight lowering of the riprap at the toe of the wall. The roadway ramps at the south jetty, 6th Street, and 61st Street were usually damaged and there was generally some erosion around the west end of the wall. Repairs consisted of rebuilding the ramps and replacing riprap as required. Normal maintenance other than repair of storm damage has consisted principally of repairing and repaving the roadway on the embankment behind the wall.

Beach Erosion

The seawall between 10th Street and 53rd Street as originally constructed was located so that there was an appreciable beach, up to 300 feet wide in places, on the seaside of the wall. The storm of 1915 washed away practically all of this beach. Some of the beach materials were returned to the beach within a short period; however, several succeeding cycles of erosion and accretion resulted, in 1934, in lowering the beach and in recession of the shore line until it generally coincided with the toe of the riprap along the seawall. There was danger that further loss of sand from in front of the seawall would expose the untreated wooden piling under the seawall to destruction by teredo.

Groin System

A cooperative beach erosion control survey, made in 1934 by the Beach Erosion Board, Corps of Engineers, concluded that the seawall could best be protected and a beach for recreation be provided by the construction of a system of groins from 12th Street to 61st Street. The Board further concluded that a groin system might not be filled by natural action and that artificial replenishment of the beach materials might become necessary. Construction of the proposed groin system was authorized by Congress in 1936, and a system of 13 groins, each 500 feet long and 1,500 feet apart, between 12th Street and 59th Street, was constructed from 1936 to 1939. The groins consisted of steel sheet piles with timber wales and support piles. The groins have accumulated considerable quantities of beach materials, most of which is below mean low tide, and have kept the toe of the seawall well protected. Excess loss of beach materials during hurricanes has prevented accumulation of sufficient materials to provide a suitable beach for recreation.

Groin Rehabilitation

The timber piling in the groins gradually deteriorated under attack by marine borers and the steel sheet piling succumbed to oxidation combined with the corrosive action of sea water and sand abrasion, until the structures were no longer functional and rehabilitation became necessary. The rehabilitation consisted of rubble mound groins instead of the steel sheet-pile

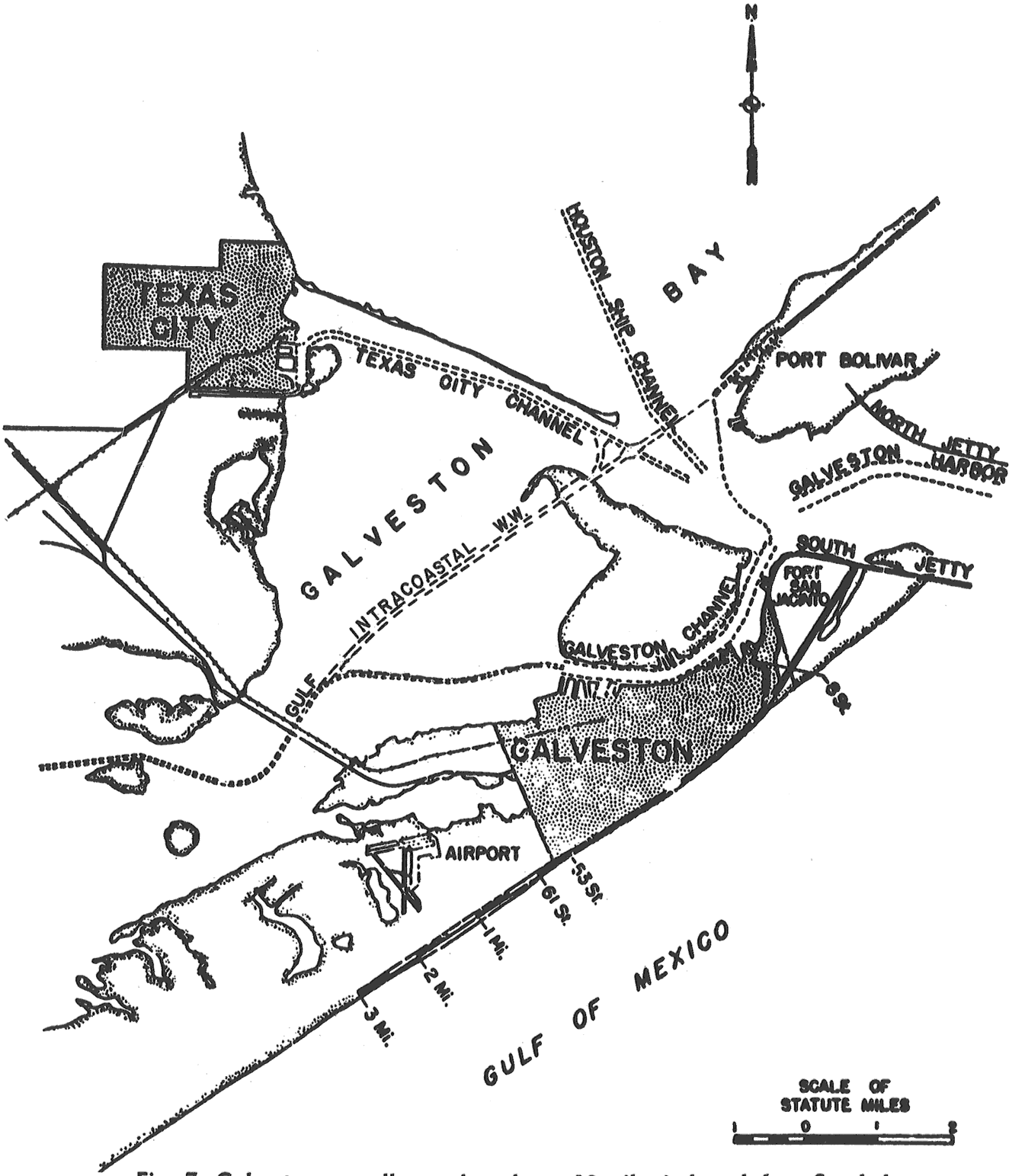


Fig. 7. Galveston seawall stretches almost 10 miles in length from South Jetty.

groins. Four rubble mound groins previously constructed by Galveston County as fishing piers were incorporated in the groin field. The rehabilitated groin field consists of 15 groins between 10th Street and 61st Street. The rubble mound groins eliminated the severe hazard to bathers caused by the scour and undertow currents which characterized the sheet-pile structures. The large evenly placed cover stones in the mounds permit access by sightseers and fishermen. Rehabilitation of the groins was completed in June 1970.

Conclusion

Today, Galveston's bulwark against the sea extends for nearly 10 miles across the Island City (Figure 7), protecting life and property against destructive forces of tide and wave that accompany tropical hurricanes. The seawall and the groins also provide a facility that is widely used by fishermen and sight-seers and adds materially to Galveston's attractiveness as a vacation area.

U. S. ARMY CORPS OF ENGINEERS

P. O. BOX 1229

GALVESTON, TEXAS 77553