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R E P O R T

on

FLOOD CONTROL & SHORE EROSION PROTECTION

of

CITY of NEW ORLEANS

from

FLOOD WATERS of LAKE PONTCHARTRAIN

for

BOARD of LEVEE COMMISSIONERS
of
ORLEANS LEVEE DISTRICT

BEDELL & NELSON
Engineers
840 Union Street, New Orleans, Louisiana

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REPORT
on
FLOOD CONTROL & SHORE EROSION PROTECTION of the CITY of NEW ORLEANS
from
FLOOD WATERS of LAKE PONTCHARTRAIN

I - SCOPE of SURVEY and REPORT

Lake Pontchartrain, like the Mississippi River, is one of the natural blessings enjoyed by the City of New Orleans, but like the Mississippi River it is also a threat to the safety of life and property. The River has been confined with levees; its floods bypassed thru spillways until it is no longer a menace, but only a part of this same safety program has been accomplished in protecting the City from the incursion of Lake waters. Levees and a concrete seawall, built to maximum practical height, still permit Lake water, driven by high northerly winds, to invade the City causing flood damage to public and privately owned property, and extensive erosion damage to the shore of Lake Pontchartrain and the seawall foundations.

It is, therefore, the purpose of this report to present the results of a survey for the determination of -

(1) Area of the City of New Orleans subjected to flood damage and shore erosion from the incursion of Lake waters;

(2) Value of land and improvements in the area subjected to damage;

(3) Climatology and storms of record;

(4) Estimated past and future damage from hurricanes;

(5) Recommendations for preventing flooding and shore erosion;

(6) Estimate of cost of recommended work.

II - AREA SUBJECTED to FLOOD DAMAGE

The immediate area of the City of New Orleans which is subjected to damage from the intrusion of flood waters from Lake Pontchartrain is indicated on the accompanying contour map of the City, Exhibit A. This area is bounded on the north by the south shore of Lake Pontchartrain; on the east by the Industrial Canal Levee; on the south by the embankment of Gentilly Road U.S. 11-90, Gentilly Ridge and the New Orleans Terminal Company's railroad embankment; and on the west along the Orleans Parish line by the levee of the 17th Street Canal. The area is further subdivided into six sections, running north and south, by the levees of existing drainage canals and bayous and the embankment of the New Orleans & Northeastern Railroad; namely, from west to east, the New Basin Canal, Orleans Canal, Bayou St. John, the London Avenue Canal, and the New Orleans & Northeastern Railroad embankment.

II - Area Subjected to Flood Damage (Cont'd)

The contour map of the City of New Orleans, Exhibit A, indicates that the ground surface of most of the City of New Orleans is below elevation +2.0 M.G.L., and further, extensive areas of the City, including the major portion of the area subjected to flooding, are below elevation 0.0 M.G.L. The highest natural ground in the City of New Orleans lies adjacent to the Mississippi River at an elevation of +14.0 M.G.L. From the river the ground surface recedes in a northerly direction towards Lake Pontchartrain terminating in elevations ranging from -2.0 to -4.0 M.G.L. in areas immediately south of the Lake Shore Development.

The original Lake Pontchartrain levees extended from the New Basin Canal along the approximate north side of Robert E. Lee Boulevard in an easterly direction to the embankment of the New Orleans & Northeastern Railroad and the Industrial Canal. Enabling legislation passed by the State of Louisiana in 1928 brought about the construction of the present concrete seawall and the lake shore development lying north of the line of Robert E. Lee Boulevard and extending from the New Basin Canal on the west to the east side of the New Orleans Airport. This development was undertaken by the State of Louisiana thru the agency of the Board of Levee Commissioners of the Orleans Levee District, and the work was completed in 1931. The top of the concrete seawall was set at elevation +9.6, and the area between Robert E. Lee Boulevard and its easterly extension and the seawall was hydraulically filled to a height varying from +8.0 at the seawall to +2.0 along the line of Robert E. Lee Boulevard and the original Lake Pontchartrain levee, all as indicated on the contour map, Exhibit A.

The east boundary of the area subjected to flooding, being the Industrial Canal Levee, is maintained at approximately elevation +9.6 The embankment of Gentilly Road U.S. Highway 11-90 with an elevation of +3.0 to +4.0 M.G.L. forms the part of the south boundary of the area subject to flooding extending westward from the Industrial Canal to the east end of Gentilly Ridge at the New Orleans & Northeastern Railroad crossing of Gentilly Road.

Gentilly Ridge, lying in a generally east-west direction and extending from the New Orleans Terminal Company railroad crossing at Gentilly Road at its western extremity to the crossing of the New Orleans & Northeastern Railroad and Gentilly Road at its eastern end, varies in height from elevation +3.0 to +4.0 M.G.L., thereby forming a part of the south boundary of the area subjected to damage from flood waters. The remainder of the southern boundary of this area is formed by the New Orleans Terminal Company's railroad embankment running in a generally east-west direction and extending from the 17th Street Canal levee at the Orleans Parish line on the west to its crossing of Gentilly Road on the east; this railroad embankment varies in height thru its length from +3.0 to +7.5 M.G.L.

II - Area Subjected to Flood Damage (Cont'd)

The west boundary of the area is the levee of the 17th Street Canal extending in a northerly direction from the New Orleans Terminal Company's railroad embankment to Lake Pontchartrain along the Orleans Parish line. This levee is maintained at approximately elevation +9.6 M.G.L.

The levees of the aforementioned New Basin Canal and Bayou St. John are maintained at elevation +9.6 M.G.L. to the locks which on each waterway are located approximately 1/2 mile from the Lake shore. The levees and sheet pile bulkheads of the Orleans Canal and London Avenue Canal are at elevation +9.6 M.G.L.

The embankment of the New Orleans & Northeastern Railroad varies from +8.0 M.G.L. along the south boundary of New Orleans Airport and the Lake Shore Development to +9.0 at its crossing of Gentilly Road at the south boundary of the area subjected to flooding.

The topographical features of the area subject to flooding, as hereinbefore described, are such that six separate natural basins for the ponding of flood water exist in the area, as indicated on the contour map, Exhibit A.

The approximate areas of these sections from west to east are -

A	-	582	Acres
B	-	1033	"
C	-	925	"
D	-	1110	"
E	-	1438	"
F	-	972	"

making a total area subjected to flood damage, lying between the Lake Shore Development and the south boundary of the area and extending from the 17th Street Canal on the west to the Industrial Canal on the east, of approximately 6060 acres.

The Lake Shore Development, as hereinbefore described and indicated on the map, Exhibit A, is subdivided into zones, the approximate areas of which are from west to east -

Zone 1	-	339	Acres
" 2	-	388	"
" 3	-	275	"
" 4	-	723	"

making the total area of the Lake Shore Development, extending from the New Basin Canal on the west to the Industrial Canal on the east, approximately 1725 acres.

II - Area Subjected to Flood Damage (Cont'd)

The Lake Shore Development is not subject to flood damage from ponding as described for the balance of the area, but is subjected to damage from the direct sheet flow of Lake waters over its surface as the water tops the seawall and flows into the ponding areas to the south.

It is, therefore, concluded that the area of the City of New Orleans, which is subjected to damage from the intrusion of Lake water during periods of high winds and hurricanes, is approximately 7785 acres.

The south shore of Lake Pontchartrain, extending from the New Basin Canal on the west to the Industrial Canal on the east, thereby forming the north boundary of the area subject to flood damage, is protected against normal tides by a concrete seawall constructed to elevation +9.5 M.G.L. which consits of 690 sections each 40 feet in length, making the total length of the wall and shore line 27,600 lineal feet.

The entire shore line and seawall are subject to serious erosion by the action of Lake waters which overtop the wall during high northerly winds and hurricane tides.

III - VALUATION of LAND and IMPROVEMENTS in the AREA SUBJECT to DAMAGE

The area subject to damage, as indicated on the Land Usage Map, Exhibit B, contains the last remaining and most important area for intermediate and high type residential development within the City of New Orleans.

Recreational facilities, both public and private, in this area consist of the following -

925 acres of City Park; approximately five miles of Lake shore parks extending from the New Basin Canal to the Industrial Canal; the Municipal Yacht Harbor; Pontchartrain Beach, a large public amusement park; the West End Country Club; and the Southern Yacht Club, all located in the area subject to damage.

These installations form the major part of all recreational areas and facilities serving the three-quarters of a million inhabitants of both the City of New Orleans and the adjacent residential areas of Jefferson Parish and St. Bernard Parish.

Located in the Lake Shore Development are four separate important military establishments.

III - Valuation of Land and Improvements in the Area Subject to Damage (Cont'd)

One large manufacturing plant is also located on the Lake front at Franklin Avenue.

Considering the areas A thru F, as shown on the Land Usage Map, Exhibit B, -

Area A, consisting of approximately 582 acres, contains 75 acres of developed and inhabited intermediate residential area located at the north end of the area. The West End Country Club, consisting of approximately 100 acres, is located near the south end of this area. The balance of this section, being approximately 407 acres, is undeveloped and partly drained and cleared;

Area B, consisting of 1033 acres, known as Lakeview, is a highly developed intermediate to high type residential area. In this section are located 36 commercial structures, which include restaurants, food stores, bakeries, hardware and appliance stores, drug stores and two theatres; public and institutional buildings consist of 1 fire station, 6 churches, 1 public school, 2 parochial schools and 1 public school under construction;

Area C, consisting of 925 acres of City Park, is a large partly developed recreational area. The developed area contains the City Park Golf Club, a lighted driving range, 5 large playing fields and several acres of landscaped picnic grounds. At the northeast corner of City Park is located the U.S. Department of Agriculture Research Laboratory, a one million four hundred thousand dollar investment;

Area D, a part of Gentilly, consisting of 1110 acres, contains 816 acres of highly developed intermediate to high type residential sections, as well as 2 large private multiple unit apartment projects. The remaining 294 acres of the area are partly drained and cleared but undeveloped;

Area E, the remainder of Gentilly, consisting of 1438 acres, is a highly developed residential section;

In areas D and E, the Gentilly Section, are located 23 commercial establishments of the types as described for Lakeview, Area B. Public and institutional buildings consist of 2 fire stations, 1 large public school under construction, Dillard University, Milne Boys Home, 4 churches and 2 parochial schools.

Area F, consisting of 972 acres is undeveloped with the exception of shipyard and other marine establishments located on the Industrial Canal. A relatively small area of apartment buildings, a Baptist Seminary under construction, and an abandoned temporary defense housing project is located adjacent to Gentilly Highway U.S. 11-90. Land has been purchased and plans are at present being prepared for the construction of a 30 million dollar private housing project to be located in this area.

III - Valuation of Land and Improvements in the Area Subject to Damage (Cont'd)

It is therefore concluded that of the 6060 acres in the area subject to flood damage lying south of the Lake Shore Development land usage is, as follows -

Residential and Commercial and Institutional	3400	Acres
Recreational	1060	"
Undeveloped	1600	"
Total	6060	"

Consideration of the population trend and growth in the area south of the Lake Shore Development, containing approximately 5000 acres after excluding parks and recreation areas, indicates that it has been the fastest growing residential area of New Orleans, particularly during the past ten years.

Previous census records and estimated present and future population indicate the following -

1920	1940	1945*	1950**	1975***
4380	17,487	28,450	41,340	78,215

* From unofficial census by Planning & Zoning Commission of the City of New Orleans

** Estimated on basis of 3.9 inhabitants/dwelling unit average for City of New Orleans (Figure reasonably agrees with unofficial 1950 estimates)

*** Estimated by Planning & Zoning Commission, City of New Orleans

Accordingly the census figures indicate an approximate 136% increase in population in the area during the past ten years.

This marked increase in population has been accompanied by a large residential and multiple dwelling unit construction program, made possible by installation of subsurface drainage and all utilities, as well as paved streets, sidewalks, clearing, site filling and other improvements throughout the area.

As of 1950, according to a field survey of the area, there have been constructed approximately 49 miles of paved streets, of which 23 miles are of a permanent type reinforced concrete with curb and gutter and subsurface drainage, or asphalt surface on a reinforced concrete base; the remaining 26 miles are asphaltic concrete or asphalt-surfaced shell streets. An additional 40 miles of streets in the area are unpaved shell-surfaced streets.

Subsurface drainage terminating in open channels conveys storm waters to pumping stations of the New Orleans Sewerage & Water Board which then lift these waters into the principal outfall canals draining by gravity into Lake Pontchartrain.

III - Valuation of Land and Improvements in the Area Subject to Damage (Cont'd)

Practically all of Lakeview and two-thirds of Gentilly are served by extensions of sanitary sewers of the New Orleans Sewerage and Water Board.

Based on recent sales, a fair average value of unimproved land in the area south of the Lake Shore Development is $3500 per acre.

A determination of the number of buildings in the area subject to damage was made from two principal sources, i.e., an aerial survey made in 1945 and a compilation of the building permits issued for the area by the Department of Regulatory Inspection for the years 1946 thru 1949. The aerial survey supplemented by ground inspection indicated a total of 6600 residences in the Lakeview and Gentilly areas as of the close of the year 1945. The compilation of residential building permits issued during the years 1946 thru 1949 indicated that 3988 residences were constructed in the area. During the same period a total of 9867 residences were constructed in the entire city. It is therefore evident that during the past four years residential construction in this area was equivalent to 41% of the total for the entire city thus indicating clearly the rapid residential growth of the area.

A comparison of the value of these residences with the residential construction of the entire city during this period indicates that altho the total value of residential construction for the city was $48,344,500, the value of the residential construction in the area was $21,640,300, showing that 44½% of the total value of residences is represented by the 41% of the dwelling units showing that the class of construction is slightly better than the average for the city as a whole.

The value of residential construction as indicated by building permits can be used for the purpose of comparison only, since prior to 1949 actual contract values were not recorded as the estimated value shown on the permit. Since February 1949 the estimated value as shown on the building permit is the actual contract price and therefore is a true value. A general comparison of recorded permit costs, both prior to and after February 1949 indicates that the previous recorded value was actually approximately one-half of the actual construction cost. A field survey of the residential construction in the area indicates an average cost per residential unit of $11,000, or 203%, of the values indicated in building permit records prior to 1949.

It is therefore evident that an analysis of the value of the residential construction in this area shows the value of residences constructed during the past four years to be $43,900,000.

III - Valuation of Land and Improvements in the Area Subject to Damage (Cont'd)

Further using the same basis of comparison, the value of the total residential construction in the area is approximately $116,000,000.

A field survey of all commercial and institutional buildings in the area indicates a value of approximately $6,400,000.

A large section of Area F has been purchased, plans completed and construction imminent, of a $30,000,000 privately financed residential housing development, which includes 3000 residential units.

The value of gas and electric distribution systems in the entire area, including the Lake Shore Development, is estimated at approximately $4,316,200.

Using an average fair value of $3500 per acre for undeveloped land as determined by recent acreage sales in the area south of the Lake Shore Development, extending from the Industrial Canal to the 17th Street Canal, the undeveloped land value of the 582 acres of Area A is $2,037,000. The value of streets and improvements other than buildings in the area is $175,000.

Using current sale prices of $100 per front foot on Canal Boulevard and $60 per front foot on other streets in Lake View, Area B, a value reflecting the improved rather than undeveloped land value, thereby including the value of streets, subsurface drainage and sewers, is estimated to be $15,080,000.

The portion of City Park, Area C, consisting of 925 acres, estimated at $3500 per acre for undeveloped land, has an undeveloped land value of $3,237,500 to which is added the estimated value of $575,000 for concrete drives, bridges, landscaping and other improvements.

Areas D, E and F, located between the Industrial Canal and Bayou St. John with an undeveloped land value of $3500 per acre and containing 3520 acres, have an undeveloped land value of $12,320,000 to which is added the value of streets, subsurface drainage, sewers, etc., estimated at $3,550,000.

The Lake Shore Development, bounded by Lake Pontchartrain on the north, the Industrial Canal on the east, Southline Drive, Hibernia Avenue and Robert E. Lee Boulevard on the south and the New Basin Canal on the west, is subdivided from west to east into four zones.

A part of Zone 1, extending from the New Basin Canal to Canal Boulevard, having a total area of 157 acres, is at present being subdivided and plans are prepared for the construction of four miles of paved streets with curb and gutter, sidewalks and subsurface drainage, as well as the installation of underground utilities. 800,000 sq.ft. of the west side of this area, bordering on West End Boulevard, was recently sold for commercial purposes at $1.00 per sq.ft. Fifty-one acres of this area are devoted to parks and playgrounds, and are

III - Valuation of Land and Improvements in the Area Subject to Damage (Cont'd)

valued at 50¢ per sq.ft., including landscaping, paving, etc., for a value of $1,110,780. Seventy-two acres of the area are being subdivided for private sale at an estimated value of 75¢ per sq.ft., including streets and utilities, having a value of $3,352,240.

The remainder of Zone 1, located between Canal Boulevard and the Orleans Canal, consisting of 182 acres, has a minimum undeveloped land value established by State law of 30¢ per sq.ft., or $2,378,376. Located on this acreage is the U.S. Naval Hospital, operated by the Veterans Administration, with an estimated value of buildings and improvements of $1,300,000.

Zone 2 of the Lake Shore Development is the Lake Vista Subdivision, one of the most highly developed subdivisions in the City of New Orleans, containing approximately seven miles of concrete streets and eight miles of interior 5' sidewalks. The entire area is fully improved and landscaped. Based on current sales of lots in this subdivision the value of improved residential property, excluding buildings, is estimated at $4,742,644. Residential construction to date consists of 459 units which include eight fourplexes, 30 duplex apartments and 421 residences. The average cost of the fourplex units is $45,000; of the duplex units $30,000; and of the residences $20,000, making the total value of residential construction $9,640,000. A large brick community center building, located in the subdivision, is valued at $400,000.

Zone 3, located between Bayou St. John and London Avenue, consists of approximately 275 acres of land which is either undeveloped or utilized as lake shore recreation area. The estimated value of this undeveloped acreage at 30¢ per sq.ft. is $3,593,700.

Zone 4, extending from the London Avenue Canal to the Industrial Canal, contains approximately 723 acres of land, valued at $9,448,164.

186 acres of this area are leased to the U.S. Navy on which is located the New Orleans Naval Air Reserve Station. The estimated value of buildings, equipment and runways, exclusive of aircraft, is $2,450,000.

Located at the end of Elysian Fields Avenue is the Pontchartrain Beach amusement park containing buildings, equipment and improvements valued at $1,200,000. Extending from the Lake front to Southline Drive on Franklin Avenue is located the 46-acre site and manufacturing plant of the American Radiator & Standard Sanitary Corporation, having an estimated value in buildings and improvements of $7,500,000.

Camp Leroy Johnson, a U.S. Army port of embarkation staging area, consisting of 168 acres, extends from Franklin Avenue to the Industrial Canal south of the Lake Shore Drive, with buildings and improvements valued at $4,500,000.

III - Valuation of Land and Improvements in the Area Subject to Damage (Cont'd)

The U.S. Naval Reserve Training Station located on the Lake front west of the Industrial Canal is a new installation valued at $600,000.

The Lake Shore Drive, a 30' concrete roadway paralleling the Lake front and extending from the New Basin Canal on the west to the Industrial Canal on the east for a length of some 7.5 miles, is valued at $715,000.

Arterial boulevards, including Canal Boulevard, Robert E. Lee Boulevard, Elysian Fields Avenue, Southline Drive, Beauregard Avenue and Franklin Avenue, having a total length of 5.2 miles, are valued at $746,000.

A concrete seawall extending along the entire Lake front from the Industrial Canal on the east to the New Basin Canal on the west was constructed in 1933 at an initial cost of $2,640,000. Reproduction cost of this wall, however, according to construction cost indices would be $5,940,000, which is considered a reasonable current value.

Located on the west side of the mouth of the New Basin Canal is the Southern Yacht Club, valued at $260,000, and the Municipal Yacht Harbor, valued at $300,000.

Summary of Value of Land and Improvements in the Area Subject to Damage

Areas A thru F, south of Lake Shore Development -		
Undeveloped Land (A)	$ 2,037,000	
Streets & Improvements (A)	175,000	
Land & Improvements including Streets, etc. (B)	15,080,000	
Undeveloped Land (C)	3,237,500	
Streets, Landscaping & Misc. Improvements (C)	575,000	
Undeveloped Land (D-E-F)	12,320,000	
Streets, Sewers, Drainage, etc. (D-E-F)	3,550,000	
Residential Construction (A thru F)	116,000,000	
Commercial & Industrial Construction (A thru F)	6,400,000	
Sub-total Value - Land & Improvements South of Lake Shore Development (A thru F)		$ 159,374,500

III - Valuation of Land and Improvements in the Area Subject to Damage (Cont'd)

Summary of Value (Cont'd)

Lake Shore Development - Zone 1 thru 4 -		
Undeveloped Land	$ 15,420,000	
Improved Land	9,006,000	
Residential Construction	9,640,000	
Community Center Building	400,000	
Pontchartrain Beach Amusement Park	1,200,000	
Federal Installations -		
U.S.Dept. of Agriculture Lab.	1,400,000	
U.S.Naval Hospital	1,300,000	
U.S.Naval Reserve Air Station	2,450,000	
U.S.Army Camp Leroy Johnson	4,500,000	
U.S.Naval Reserve Training Sta.	600,000	
Industrial -		
American Radiator & Standard Sanitary Corporation	7,500,000	
Lake Shore Drive	715,500	
Arterial Boulevards	746,600	
Concrete Seawall	5,940,000	
Sub-total Estimated Value of Land & Improvements - Lake Shore Development		$ 60,818,100
Gas & Electric Distribution System		4,316,200
West End -		
Southern Yacht Club	260,000	
Municipal Yacht Harbor	300,000	560,000
Total Estimated Value of Land & Improvements in Area Subject to Damage		$225,068,800

IV - CLIMATOLOGY and STORMS of RECORD

The New Orleans area has a mild sub-tropical climate due principally to the proximity of the Gulf of Mexico, Lake Pontchartrain, the Mississippi River and its Delta tributaries, and the sub-marginal swamps in the surrounding area which modify temperature conditions and changes.

The annual average temperature is 70°, and varies between an average summer temperature of 89° and an average winter temperature of 61°.

Annual rainfall varies considerably; however, the annual precipitation, based on 76 years of records, averages 60". Extreme recorded annual variations are 85.73" in the year 1875 and 31.07" in the year 1899. A maximum rainfall of 25" in one month has been recorded but

IV - Climatology and Storms of Record (Cont'd)

the average rainfall per month varies from 3.5" in October to 6.75" in July. Precipitation in excess of 2" per hour resulting from high intensity short duration thunder storms is not infrequent.

The precipitation during eight major storms of record was -

Date	Precipitation Inches
19-23 Feb. 1894	6.91
28-29 Sept. 1915	6.70
15-16 April 1927	14.01
1- 5 June 1928	9.04
2- 7 Sept. 1929	9.15
16-19 May 1932	10.5
1- 5 Oct. 1937	16.98
16-21 Sept. 1943	10.07

Average annual wind velocity prevailing from the southeast is 6.3 miles per hour.

The tabulation of average wind velocities and directions as recorded by the Department of Commerce for the period 1933 to 1940, is as follows -

	Velocities M.P.H.		
Direction	0-15	16-31	32-45
N	9.57%	3.49%	- %
NE	13.42	2.43	-
E	11.86	1.00	-
SE	10.19	1.00	-
S	15.00	1.66	-
SW	9.82	0.73	-
W	6.57	0.24	-
NW	10.35	2.33	0.34

Short duration thunder storms and minor cyclonic disturbances accompanied by gale force winds with an average velocity of 30 miles per hour and maximum velocities of 50-58 miles per hour occur locally in the Lake Pontchartrain area, as often as 16 times per year. These local squalls generally develop in the Northeast, North and Northwest and are therefore accompanied by northerly winds.

Severe hurricanes of record in the New Orleans area with such river and lake stage information as is presently available were, as follows -

Date	Rise in River Stage	West End Lake Stages
15 Aug. 1901	5.5'	--
27 Sept. 1906	3.0'	--
20 Sept. 1909	--	--
29 Sept. 1915	--	+5.0 MGL
19 Sept. 1947	3.3'	+5.4 MGL
3 Sept. 1948	--	+5.1 MGL

IV - Climatology and Storms of Record (Cont'd)

Available information on the 1915 and 1947 hurricanes indicates that they approached the City from a southeasterly direction thereby creating hurricane force winds from the northeast causing the increases in Lake Pontchartrain and Mississippi River levels as indicated above.

Since the construction of the Lake Pontchartrain seawall observations on the behavior of winds and tides have been taken and accurate records compiled. It has been observed that high winds from the East generally change to the Northeast, North and Northwest. The East winds, due to the formation of the Mississippi Sound at the junction of the Rigolettes outlet of Lake Pontchartrain, always create a rise in the Lake stage, the amount depending on the velocity and duration of the easterly winds. Northeast, North and Northwest winds of an intensity of 20 miles per hour or more quickly develop waves which to a variable extent overtop the seawall. Waves with a trough to crest of 6-8' make up quickly under the action of the northerly winds due to the relatively shallow depth, 14-16', of Lake Pontchartrain. Experience and observation indicate that whenever the Lake level is higher than +2 MGL and northerly winds are in excess of 20 miles per hour, waves make up quickly and break over the seawall.

As long as these breaking waves attain only such a magnitude from their wave height or tide level that only a small portion of the crest breaks over the wall, damage is limited to the erosion of the material along the face of the wall and the fill material directly behind the wall. However, when tide levels are in excess of elevation +3 and are accompanied by northerly winds in excess of 30 miles per hour, the waves not only break on the wall but the greater portion of the cap overtops the seawall and flows over the surrounding land.

The tropical hurricane of September 19, 1947, was the most severe storm experienced in the City of New Orleans since the construction of Lake Pontchartrain seawall. Accurate records of the performance of this storm were kept by the U.S. Weather Bureau, the Board of Levee Commissioners and the New Orleans Sewerage and Water Board. A combination of the data from the records of these three sources permits a comprehensive reconstruction of the conditions accompanying the storm.

The meteorological features and path of the September 19 hurricane are shown on Exhibit C, an official publication of the U.S. Weather Bureau. A composite graph of the hourly wind velocities, as measured by the anemometer located on the Huey P. Long Bridge, and the hourly Lake tide levels, as measured by tide gauges located at West End, Bayou St. John and the Industrial Canal, are shown on the Wind Velocity and Tide Graph of the 1947 Hurricane, Exhibit D. These records show that the 1947 hurricane approached the City of New Orleans from the southeast with a forward speed of approximately 18 miles per hour during the early morning of September 19. The center of the hurricane crossed the City of New Orleans south of Lake Pontchartrain at approximately 10:00 am and proceeded in a northwesterly direction inland over the State of Louisiana.

IV - Climatology and Storms of Record (Cont'd)

Northerly winds built up thru the night of September 18 and 19 reaching gale force of 50 miles per hour by midnight September 18 and increasing gradually until 2:00 am September 19 when the wind blew directly from the north, from which direction it continued to blow until the hurricane center arrived at New Orleans at 10:00 am.

These northerly winds increased rapidly between 2:00 and 3:00 am developing a velocity of 60 miles per hour at 3:00 am. A gradual increase in wind velocity from 60 miles per hour to 70 miles per hour occurred from 3:00 am to 7:00 am. By 8:30 am the wind velocity had increased to 80 miles per hour and by 8:45 to a maximum of 98 miles per hour. The wind velocity remained constant with gusts to 99 miles per hour until 9:40 am at which time it dropped back to 78 miles per hour for a short period, and immediately increased in velocity to 99 miles per hour, holding there until 10:00 am when the center of the hurricane arrived causing the wind velocity to drop off to 28 miles per hour.

As the center of the hurricane passed the City of New Orleans the wind shifted from north to northeast, to east, to southeast, to south, and increased in intensity from 28 to 40 miles per hour by 11:00 am, and further to 60 miles per hour by 11:20 am, thereafter maintaining the 60-mile per hour velocity until 11:50 am when winds gradually reduced in intensity to 40 miles per hour at 1:00 pm. At 1:30 pm the wind velocity had decreased to 30 miles per hour and remained constant during the remainder of the afternoon.

The strong northerly winds, as hereinbefore described, during the approach of the center of the hurricane created abnormally high tides in Lake Pontchartrain, as determined by gauge readings shown on Exhibit D. The Lake surface elevation of +2.6 MGL at 12:00 midnight on September 18 gradually increased to +2.8 by 2:00 am on September 19. Between 2:00 and 3:00 am a sharp increase to +4.8 with the wind velocity from a northerly direction at 60 miles per hour was experienced. The surface elevation further increased until it reached +4.9 at 7:20 am and a maximum of +5.6 at 9:00 am with a northerly wind velocity of 98 miles per hour. The Lake level then gradually decreased to +5.2 by 10:00 am and declined sharply to +1.9 at 11:00 am, remaining at that level until 12:00 noon September 19. The water level rose between 12:00 noon and 2:00 pm to +3.7 and with minor fluctuations continued to rise until 12:00 midnight September 19 when it reached an elevation of +4.6.

The abnormal rise in the Lake Pontchartrain tides was accompanied by surface waves of an estimated height from trough to cap of approximately 8', thereby causing Lake water to overtop the seawall in large quantities from 3:00 am to 10:00 am September 19.

The depression of the Lake water level coincident with the passing of the center of the hurricane and the change of wind direction from the north to the south at 11:00 am September 19 reduced the inundation to practically zero.

IV - Climatology and Storms of Record (Cont'd)

The U.S. Weather Bureau records show that the hurricane was accompanied by light rainfall commencing about 11:00 pm September 18 and continuing until 10:40 am September 19. Maximum rainfall in any hour during this period was 1/4" and the average precipitation was 0.218" per hour, making a total rainfall of 2.47" during the hurricane.

The City of New Orleans Sewerage and Water Board pumping records and observations for Pumping Station No. 4, give an excellent indication of the volume of Lake water removed from the inundated area of part of the Gentilly section. This station collects and removes water primarily from the area between London Avenue and Franklin Avenue, from Gentilly Ridge to the Lake front; however, under flooding conditions it also takes water from the area between Franklin Avenue and Peoples Avenue. The ponding area during flood conditions is then coincident with Area E of Exhibit A, consisting of 1438 acres. Station No. 4 is equipped with two centifugal pumps each having a rated capacity of 350 cu.ft. per second at a 10' effective head. This capacity reduces on a straight line to 0 cu.ft. per second under an effective head of 13.5'. The pumps were started at 1:15 pm September 19 and pumping was maintained continuously with both pumps, with the exception of a power cutoff of some 15 minutes, until 6:30 am September 21 when one pump was cut out; pumping then continued with one pump until the area was cleared by 4:30 pm of that date.

The log of this Pumping Station indicates that the total amount of water pumped from Area E was 56,016,000 cu.ft.

In order to determine the effect of rainfall in Area E on the operation of Pumping Station No. 4 a check was made of a precipitation of 2.24" occurring December 9 and 10, 1947, during which no Lake water reached the area. Calculations indicate that a total of 11,900,545 cu.ft. of precipitation occurred in the area. Pumping records indicate the removal of 3,060,000 cu.ft. of water by Station No. 4. It is therefore concluded that 8,840,545 cu.ft. of precipitation was absorbed by the ground, evaporated or handled by other pumping stations, thereby not reaching Station No. 4.

As hereinbefore stated the total water handled by Pumping Station No. 4 from Area E was 56,016,000 cu.ft. during the hurricane of September 18-19, 1947. The 2.47" of precipitation during the same period was calculated to account for 3,987,311 cu.ft. of the total water handled by Pumping Station No. 4. It is therefore concluded that the 52,028,689 cu.ft. of Lake water, which overtopped the seawall during the storm, flowed into Area E and was handled by the Pumping Station. It is readily determined that this volume of water applied to the 1438 acres of Area E was the equivalent of a 10" rainfall occurring over a period of less than seven hours.

IV - Climatology and Storms of Record (Cont'd)

A record of the water surface elevation on Prentiss Avenue near Pumping Station No. 4 indicated that 2-1/2 hours after the pumps were started the water level was at elevation -3.0 MGL. Information furnished by the City Engineer's Office indicates that the curb grades of the streets in Area E from Mirabeau Avenue on the south to Hibernia Avenue and New York Street, the north boundary of Area E, are an average elevation of -5.0 MGL.

A field survey of the area indicates that many house floors in the Area are between -3.0 and -4.0 MGL. It is therefore concluded that the floors of approximately 1908 residences in the Area were flooded by the 1947 storm, some to a depth of 1' or more for a period of about 12 to 14 hours. Personal observations of employees of the City of New Orleans, Orleans Levee Board, Red Cross and other relief agencies indicate that the degree of flooding in Areas A, D and F were similar to the inundation herein described in Area E. The southern section of Area C, City Park, and all of Area B, Lake View, have average street grades of from elevation -3.0 to -2.0, and therefore were not flooded to the same extent as the balance of the areas subject to damage. The approximate limit of inundation resulting from the Lake waters, as determined by field reports made during the hurricane of 1947, is indicated on Exhibit B.

The entire five miles of seawall was subjected to severe wave action during the hurricane. The Lake Shore Development area extending from the New Basin Canal to the Industrial Canal was subject to sheet flow to depths in excess of 2' at several points during the hurricane as the water from the Lake overtopped the seawall and flowed into the areas south of this high ground. Photographs furnished by the U.S. Navy and the Times-Picayune Publishing Company taken during the 1947 storm, Exhibits F thru K, show conditions which existed along the seawall and in the Lake Shore Development area.

It is therefore concluded that the 1947 hurricane subjected the entire Lake front seawall to severe buffeting and wave action, caused a sheet flow of Lake waters 2' or more in depth to cover the 1725 acres of the Lake Shore Development, and inundated 4000 acres, or approximately two-thirds of the area subject to damage south of the Lake Shore Development.

The tropical hurricane of September 3-4, 1948, approached the City during the night of September 3 from the southwest with a forward speed of approximately 18 miles per hour, creating maximum wind velocities of 78 miles per hour from the northeast during the early morning hours of September 4. The conditions as hereinbefore described for the 1947 hurricane were duplicated to a somewhat lesser extent. The seawall was severely buffeted and fill material directly in the rear of the wall was again washed out. Sheet flow of Lake waters occurred across the Lake Shore Development to depths as great as 2' during the storm.

IV - Climatology and Storms of Record (Cont'd)

As the hurricane passed the City the wind changed to southwest and flooding from the Lake subsided but with continuous pumping it was not until 2:15 am September 5 that flood waters were cleared from the low areas south of the Lake Shore Development.

The log of the Sewerage and Water Board Pumping Station No. 4 recorded a total of 33,433,000 cu.ft. of water pumped of which precipitation during the storm accounted for 6,800,000 cu.ft. It is therefore concluded that 26,633,000 cu.ft. of storm water originated from overtopping waves from Lake Pontchartrain.

From the information herein presented it is concluded that the frequency of minor squalls and gale force winds of local origin, creating erosion damage to the Lake bottom at the face of the seawall and causing minor damage to the fill immediately in the rear of the wall, is sixteen occurrences per year. The frequency of major hurricanes, causing shore erosion, seawall damage, sheet flow over the Lake Shore Development and inundation of large portions of the area subject to damage, is once each 8-1/3 years for the period 1900 thru 1950.

V - ESTIMATED PAST and FUTURE DAMAGE from HURRICANES and MINOR STORMS

Damages resulting from the action of hurricanes and minor storms are in three general classes -

(1) Erosion of the Lake bottom along the face of the seawall and erosion of fill material directly in the rear of the seawall, as well as damage to the Lake Shore Drive and its drainage system

(2) Damages resulting from sheet flow of Lake waters across the high areas of the Lake Shore Development

(3) Damages resulting from inundation of the areas south of the Lake Shore Development.

The frequency of minor storms of gale force and less has been shown to be an average of sixteen occurrences per year. These storms create local damage to the seawall and the Lake Shore Drive.

During these short-duration gales and thunder storms northerly winds quickly develop waves of 6' to 8' in height on the surface of Lake Pontchartrain. The winds also create a rise in the Lake stage to elevation +2 to +3 MGL.

Due to the irregular alignment of the seawall, waves strike the wall at an angle at various points thereby inducing lateral currents along the face of the wall. The disturbance of the Lake bottom caused by the wave action places Lake bottom material in suspension and the wave return eddy readily removes the suspended material from the toe of the seawall.

V - Estimated Past and Future Damage from Hurricanes and Minor Storms (Cont'd)

Whereas the Lake bottom on the completion of the seawall construction in 1931 had an average elevation of -0.6, or approximately 1' below the bottom step of the wall, subsequent investigations show a continuing erosion generally following a pattern of deep erosion where the convex curvature of the wall causes the maximum diagonal action of waves induced by northerly winds. Bottom erosion to a lesser extent has occurred where the northerly winds are more normal to the wall. The Lake bottom at the toe of the seawall now has an average elevation of -3.3 with many places reaching a depth of -6.0 to -7.0 MGL. This condition is shown on Exhibits E1 and E2 being the results of a survey by the Corps of Engineers made in October 1948. From these exhibits it will be noted that the points of deepest scour coincide with the points of maximum settlement of the seawall. At these points of maximum settlement openings have occurred in the sheet pile toe wall which in turn account for the maximum subsidence and erosion of earth from behind the seawall.

A portion of the crest of waves striking the seawall during minor storms overtops the wall and floods the area behind the wall and portions of Lake Shore Drive. The points of maximum flooding coincide with the points of maximum scour as hereinbefore described. This excess water is returned to the Lake thru the subsurface drainage system of the Lake Shore Drive and infiltrates thru the fill material in the rear of the wall andopenings in the sheet pile toe wall, thereby damaging the base of the Lake Shore Drive, overloading the subsurface drainage system and eroding large quantities of fill material from the rear of the seawall.

In addition to the physical damage to the seawall and Lake Shore Drive the local storms are responsible for considerable damages to commercial and pleasure craft which navigate on Lake Pontchartrain. The high winds and waves of the Lake render small craft and barge tows unmanageable, and when such craft are near the shore line, they are often driven onto the seawall and severely damaged.

The deeply eroded areas along the face of the seawall present a constant hazard to the thousands of people who congregate in the Lake shore recreation areas to fish and swim during the majority of the year. Loss of life by drowning has become such a serious matter that the City of New Orleans now maintains both a marine patrol and an emergency truck equipped with pulmotors and manned by trained crews who are prepared to rescue and resuscitate drowning persons. Available records indicate that for the periods June 1947 to August 1947, and May 1949 to July 1950, 18 persons were rescued and ten(10) others were drowned.

It is, therefore, estimated that in addition to the loss of life by drowning the annual damage caused by minor storms is -

V - Estimated Past and Future Damage from Hurricanes and Minor Storms (Cont'd)

Minor Storms - Annual Damage

1.	Seawall Erosion & Other Repairs	$ 22,000
2.	Lake Shore Drive	14,000
3.	Pleasure and Commercial Craft	12,000
	Total Estimated Annual Damage	$ 48,000

The frequency of major tropical hurricanes has been shown to be one occurrence each 8-1/3 years during the first half of the twentieth century. Damages resulting from these storms are extensive erosion of the face and rear areas of the seawall, inundation of the entire Lake Shore Development by sheet flow from waves overtopping the seawall and inundation of streets and improvements for longer periods in the low areas south of the Lake Shore Development.

The best available information on the extent and type of these damages is obtained from the records of the 1947 hurricane. During this hurricane extremely serious erosion occurred along the entire face of the seawall and along the rear of the seawall to such an extent that several thousand feet of sidewalks were destroyed, many joints of the seawall were opened and required resealing, and thousands of cubic yards of fill material were lost between the seawall and the Lake Shore Drive. The Lake Shore Drive was covered by 2' or more of Lake water for several hours as this water flowed across the Lake Shore Development into the lower areas of the City of New Orleans.

This excessive flooding of the Lake Shore Drive created severe damage to the pavement base and thereby required a major repair, undertaken by the State Highway Department, which included the leveling of existing paving slabs and the removal and reconstruction of extensive areas of paving along the entire 7-1/2 mile length of this drive. An additional 12 miles of concrete streets in the Lake Shore Development were flooded and damaged to a somewhat lesser extent than the Lake Shore Drive.

In 1947, 60 residences were located in Zone 2, Lake Vista; However, these buildings were high enough that they were not seriously damaged by sheet flow from the Lake. Residents in this area were marooned for a period of one day, however, due to water flowing to depths of as great as 2-1/2 feet to 3 feet thru the streets of the section.

Records show that water to depths of 2 feet flowed thru Camp Leroy Johnson, thereby causing its partial evacuation.

These same conditions occurred in Zone 4 at the Naval Air Station and Pontchartrain Beach, as shown on Exhibits F, G and H.

V - Estimated Past and Future Damage from Hurricanes and Minor Storms (Cont'd)

The U.S. Naval Hospital in Zone 1 was situated on slightly higher ground and was not evacuated. However, as shown in Exhibit I, streets in this area were flooded to depths of 2 feet and 2-1/2 feet as Lake water flowed into the Lake View section.

Many small pleasure craft docked in semi-sheltered areas of Bayou St. John were driven ashore and damaged, as shown in Exhibit K.

Information obtained from the American Red Cross, the Board of Levee Commissioners and the City of New Orleans indicates that flood waters from the Lake inundated extensive areas of the low lands south of the Lake Shore Development, as shown on the Land Usage Map, Exhibit B. It has been determined from aerial photographs and field surveys that in 1947 - 16.3 miles of concrete streets, 21.5 miles of asphalt streets and 32 miles of shell streets were flooded from a depth of one (1) foot to such depths that the use of motor boats and amphibious vehicles was required to evacuate inhabitants from their homes.

In Area A, as shown on Exhibit B, 178 residential and commercial units were flooded to such an extent that the occupants, together with removable furniture and fixtures, were evacuated, and extensive damage from flooding was suffered in the area.

In Area B, Lake View, 745 residential and commercial units were subjected to minor damage from inundation during the storm. Damages were less in Lake View because of the higher elevation of the area and the quicker runoff of storm waters.

Areas D and E, Gentilly, contained 1908 residential and commercial units located within the flooded area. Many sections of this area were flooded to such depths that water entered the buildings, damaging stock and furnishings, and residents were evacuated in small boats and amphibious trucks. Consequently the individual damage to structures and furnishings in the area was considerably greater than Lake View, Area B. All storm drains and sewers in the area were flooded, thereby endangering the public health and necessitating the boiling of all drinking water.

Records of the Red Cross show that 12,000 families were sheltered in Orleans Parish during the 1947 hurricane, and an additional 508 families were assisted. It is further estimated that of the total number of families assisted some 3000 were evacuated from the areas subject to damage.

Accordingly, it is estimated that the damage resulting from inundation during the 1947 hurricane is, as follows -

V - Estimated Past and Future Damage from Hurricanes and Minor Storms (Cont'd)

1947 Hurricane Damages

1.	Seawall, Erosion & Other Repairs	$ 300,000
2.	Lake Shore Drive	160,000
3.	Lake Shore Development - Concrete Streets - 12.2 miles	36,086
4.	Area A thru F - Concrete Streets - 16.3 miles	54,388
5.	Area A thru F - Asphalt Streets - 21.5 miles	28,743
6.	Area A thru F - Shell Streets - 32.0 miles	30,412
7.	American Radiator & Standard Sanitary Corp-Damage to RR Spur	6,700
8.	Camp Leroy Johnson	22,500
9.	Pontchartrain Beach	12,000
10.	U.S. Naval Air Station	12,250
11.	U.S. Naval Hospital (V.A.)	6,200
12.	Areas D and E, Gentilly - Residential & Commercial Units-1908	305,280
13.	Area A - West End - Residential & Commercial Units- 178	80,100
14.	Area B - Lake View - Residential & Commercial Units- 745	37,250
15.	Red Cross Expenditures	116,000
	Total Damage	$1,207,909

In order to determine a fair estimate of the extent of damage which would result at the present time from a hurricane of the intensity equal to the 1947 hurricane, a field survey was made of the entire area subjected to sheet flow and inundation in 1947. Based on the New Orleans average of 3.9 persons per dwelling unit, the population of the flooded areas in 1947 was 18,072. Estimated on the same basis the present population is 25,824. The total number of dwelling units in the area has increased from 4634 in 1947 to 6622 in 1950. Accompanying this increase in dwelling units has been the extension of utilities and the construction of new concrete and asphalt streets until as of 1950 there are 32.2 miles of concrete streets, 29 miles of asphalt streets and 40 miles of improved shell surfaced streets located in the area.

Real estate development has extended into the lower sections of the area, and the floor levels of the majority of the new residences, which are constructed on concrete slabs on the ground, are from elevation -3.5 to -4.0 MGL. It is reasonably estimated that the interiors of 1052 new residences constructed since 1947 would be flooded by an inundation to elevation -3.0 as was experienced in 1947. Such inundation undoubtedly would cause a much greater

V - Estimated Past and Future Damage from Hurricanes and Minor Storms (Cont'd)

damage to both the structures and furniture and fixtures of these residences than was experienced in 1947. New commercial establishments constructed since 1947 were built on concrete slabs and consequently have low floor elevations and would thereby be subjected to extensive damage of stock, fixtures and equipment.

Records of the 1947 hurricane indicate that some 3000 families were evacuated from the area. It is therefore estimated that based on the relative increase in population, a similar hurricane would require the evacuation of 4260 families. By assuming that similar damages, as described for the 1947 hurricane, would occur as a result of an equal extent of sheet flow and inundation, but taking into account new construction and improvements since 1947, it is estimated that the damages caused by a future hurricane would be, as follows -

Estimated Damage Resulting from Duplication of 1947 Hurricane in 1950 or Future

1.	Seawall Erosion & Other Repairs	$ 300,000
2.	Lake Shore Drive	160,000
3.	Lake Shore Development - Concrete Streets - 12.2 Miles	36,086
4.	Area A thru F - Concrete Streets - 20 Miles	67,985
5.	Area A thru F - Asphalt Streets - 29 Miles	35,929
6.	Area A thru F - Shell Streets - 40 Miles	38,016
7.	American Radiator & Standard Sanitary Corp. - Damage to RR Spur	6,700
8.	Camp Leroy Johnson	22,500
9.	U.S. Naval Reserve Training Station	6,000
10.	Pontchartrain Beach	12,000
11.	U.S. Naval Air Station	12,250
12.	U.S. Naval Hospital (V.A.)	6,200
13.	Areas D & E, Gentilly - Residential & Commercial Units-2949	1,033,980
14.	Area B, Lake View - Residential & Commercial Units-1193	104,450
15.	Area A, West End - Residential & Commercial Units- 193	86,850
16.	Red Cross Expenditures	211,000
	Total Estimated Damage	$2,139,946

VII - ESTIMATE of COST of RECOMMENDED WORK and ANNUAL CHARGES

COST ESTIMATE

Item	Quantity	Unit	Unit Price $	Total Price $
1. Off Shore Breakwater				
Steel Sheet Piling				
SP 4	25071.2	Ton	92.00	2,306,550
SP 4-Y	1646.3	"	172.00	283,163
SP 4-T	305.5	"	172.00	52,546
Pile Driving	1,679,708	LiFt	0.30	503,912
4" Channel Cap(In place)	123.85	Ton	300.00	37,155
Sand Fill	341,479	CuYd	0.80	273,183
Stone Rubble	43,248	"	5.00	216,240
Clam Shell Fill	21,646	"	2.25	48,703
Asphalt Surface	6,487	Ton	12.00	77,844
Navigation Lighting		L.S.		65,000
2. Filling at Seawall				
Sand Fill	185,141	CuYd	0.80	148,113
Total Construction Cost				$ 4,012,409
Contingencies - 5%				200,620
Engineering - 6%				252,782
Total Estimated Cost				$ 4,465,811

ANNUAL CHARGES

Interest at 3%	$ 133,974
Amortization at 3% for 40 Years	59,216
Maintenance at 1%	44,658
Total Annual Charges	$ 237,848

ANNUAL BENEFITS

Estimated Damage (Shore Erosion)	$ 48,000
Estimated Hurricane Damage $2,139,946 / Frequency-Yrs. 8.34	= 256,588
Total Annual Benefits	$ 304,588

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RATIO of BENEFITS to COST - $ 304,588 : $ 237,848

1.28 : 1

VIII - CONCLUSION

It is concluded:-

That the 5.3 miles of the New Orleans Lake front seawall are continually damaged by erosion caused by the wave action of short duration storms which occur approximately sixteen (16) times per year;

That hurricanes which occur with a frequency of once each 8-1/3 years create extensive erosion damage to the Lake front seawall and adjoining areas;

That during major tropical hurricanes 7785 acres of the highly developed residential area of the City of New Orleans, having a population of 41,340 and an estimated value of land and improvements of $225,068,800, are subject to inundation;

That the annual damages caused by shore erosion amount to $48, 000;

That the damage resulting from shore erosion and flooding during a hurricane equivalent in intensity to the 1947 hurricane would amount to $2,139,946;

That the annual estimated damage from both minor storms and major hurricanes would be $304,588;

That the cost of recommended improvements for the prevention of shore erosion and flooding would be $4,465,811; and

That the ratio of annual benefits to the annual cost of proposed construction would be $304,588 : $237,884, or 1.28 : 1.

Therefore, it is considered vitally important and economically sound to construct the off shore breakwater and fill the areas adjacent to the seawall in the manner described herein, thereby protecting the Lake shore from erosion and large areas of the City of New Orleans from inundation.

October 1950