1. NAME OF PROPERTY

Historic Name: New Orleans Levee Breach Sites–17th Street and Inner Harbor Navigation Canals

Other Name/Site Number: Breach Sites of the 17th Street Canal (Metairie Outlet Canal/Upperline Canal)
Inner Harbor Navigation Canal (IHNC) Floodwall Breach (Industrial Canal)

2. LOCATION

Street & Number: 6900 block of Bellaire Drive, Lakeview Not for publication: N/A
2400 block of Surekote Road, Lower Ninth Ward

City/Town: New Orleans Vicinity: X

State: Louisiana Parish: Orleans Code: 071 Zip Code: 70124, 70117

3. CLASSIFICATION

Ownership of Property		Category of Property	
Private:	___	Building(s):	
Public-Local:	X	District:	
Public-State:	___	Site:	X
Public-Federal:	___	Structure:	
		Object:	

Number of Resources within Property

Contributing	Noncontributing	
___	___	buildings
2	___	sites
___	___	structures
___	___	objects
2	0	Total

Number of Contributing Resources Previously Listed in the National Register: N/A

Name of Related Multiple Property Listing: N/A

4. STATE/FEDERAL AGENCY CERTIFICATION

As the designated authority under the National Historic Preservation Act of 1966, as amended, I hereby certify that this ____ nomination ____ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60. In my opinion, the property ____ meets ____ does not meet the National Register Criteria.

Signature of Certifying Official Date

State or Federal Agency and Bureau

In my opinion, the property ____ meets ____ does not meet the National Register criteria.

Signature of Commenting or Other Official Date

State or Federal Agency and Bureau

5. NATIONAL PARK ~~SERVICE CERTIFICATION~~

I hereby certify that this property is:

___ Entered in the National Register
___ Determined eligible for the National Register
___ Determined not eligible for the National Register
___ Removed from the National Register
___ Other (explain):

Signature of Keeper Date of Action

6. FUNCTION OR USE

Historic: Government Sub: public works

Current: Government Sub: public works

7. DESCRIPTION

Architectural Classification: N/A

Materials:

Foundation:
Walls:
Roof:
Other:

7. DESCRIPTION

Current Description of Canal Breach sites

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Current Description of Canal Breach Sites:

On August 29, 2005, Hurricane Katrina passed to the east of New Orleans. The region's flood protection consisting of levees (sloped earthen walls) and concrete floodwalls embedded in the levees breached in more than 50 locations. The first priority of all government agencies was to plug the levee breach sites with fill material in order to pump water out of the flooded areas. Once this was accomplished agencies rebuilt the earthen levees and floodwalls to near the size and shape which had previously been at these breach sites which is about 15 feet high and 50 feet wide. At the 17TH Street canal and the Inner Harbor Navigation Canal (IHNC), the Army Corps of Engineers (Corps) replaced the failed I-walls with a different type of concrete floodwall – called a T-wall – which is similar in mass and scale to the older flood wall, but easily differentiated. A T-wall is a reinforced concrete structure supported by foundation pilings with a non structural steel sheet pile assembly beneath. T-walls are not earth supported, are a sturdier design and are more expensive to build than an I-wall.

At both breach site locations, for several blocks adjacent to the canal, the land is vacant of homes and buildings. In the vacant area, many foundations, called slabs, where homes once stood are all that remain. At both sites, all trees have been removed either due to the flooding or due to removal by the agencies post Katrina. At the 17TH Street canal, when the floodwall is viewed from the land side of the levee, the new T-wall is a different texture and a different color from the adjacent I-wall. From a birds'eye view, the new T-wall is two feet thicker in width. At the Inner Harbor Navagation Canal, when the floodwall is viewed from the land side of the levee, the new T-wall can easily be differentiated from the older I-wall because it is two feet higher. Like the 17TH street canal, from a birds'eye view, the new T-wall is two feet thicker in width.

Historic Description of Canal Breach Sites

The 17th Street Canal is the largest and most important drainage canal for the city of New Orleans and is capable of moving 9,200 cubic feet of water per second. The breach site of the 17th Street Canal, one of over 50 in Greater New Orleans that day, rendered the 17th Street Canal useless because floodwaters released by the breach rendered the canal's pump station ineffectual preventing it from pushing the storm surge waters back into Lake Pontchartrain situated north of New Orleans.

The Inner Harbor Navigational Canal (IHNC) (Industrial Canal) is a 5.5 mile (9 km) long navigation canal which connects the Mississippi River to Lake Pontchartrain allowing for the transit of large cargo ships and barges into the city. The IHNC from Lake Pontchartrain to the lock near the Mississippi River was constructed with dimensions of a 30 foot (9 m) depth, with a width of 300 feet (90 m) at the top of the canal and at least 150 feet (45 m) at the bottom. The original lock system to connect the river with the lake had gates, a width of 74 feet (23 m), and a depth of 50 feet (15 m), with a capability to function to up to 20 feet (6 m) in difference of levels between the river and lake.

The IHNC separates eastern New Orleans from the rest of the city of New Orleans. The IHNC also passes through the 9th Ward of the city separating the Lower 9th Ward from the Upper 9th Ward. Approximately half of the waterway's length, from the Industrial Lock on the Mississippi River to a point north of the Florida Avenue Bridge, is confluent with the Gulf Intracoastal Waterway.

Starting at the Mississippi riverfront, the IHNC constitutes the boundary between the Upper 9th Ward's Bywater neighborhood on the upriver (or west) side of the canal and the Lower 9th Ward neighborhood on the downriver (or east) side. Near where the IHNC enters Lake Pontchartrain is generally considered to be the eastern boundary of the Gentilly neighborhood and the western boundary of eastern New Orleans.

Pre-Katrina, the land immediately in front of both breach sites was a dense thriving neighborhood of homeowners. At the 17th Street Canal, homes filled the area right up to the canal floodwall. Huge oak and pecan trees graced the backyards of homes which abutted the flood walls, and throughout the neighborhood as well. The neighborhood was predominantly white middle to upper class homeowners.

At the IHNC, homes also filled the immediate vicinity. A dense early 20th century neighborhood of primarily African American lower to middle class homeowners was built right up to the navigational canal's walls. There were also huge trees – primarily oaks and cypress - in the back yards of the homes and throughout the neighborhood.

The floodwalls at both sites were made up of an I-wall configuration. It is designed to increase the flood protection height when additional real estate is difficult to acquire. The concrete and steel floodwalls were used to achieve increased crest height without the extra weight of additional earthen levee fill, and/or without the need to widen the earthen levee embankment section.

Introduction

In the early morning hours of August 29, 2005, the Inner Harbor Navigational Canal (IHNC) bounded on both sides by an earthen levee and reinforced with concrete I-wall floodwalls, breached catastrophically. This breach occurred as Hurricane Katrina's Category 3 winds pushed storm surge waters from the Gulf of Mexico and Lake Pontchartrain into the navigation canal filling it with water. The earthen levees on the canal edges were submerged and the concrete I-wall floodwalls failed. The east side, north breach in the concrete floodwall occurred before the storm surge water reached the top of the floodwall segments and was adjacent to the 2400 block of Surekote Road (parallel to Jourdan Road) in the Lower 9th Ward neighborhood of New Orleans. The initial breach soon expanded to a 90 foot breach releasing waters, that combined with a second 1,000 foot-wide breach along the IHNC about 6 blocks to the south, flooding the early twentieth century African-American neighborhood of primarily homeowners killing hundreds of residents, destroying hundreds of buildings and homes, and submerging the entire area of the Lower 9th Ward.

A short time later, a section of a concrete I-wall floodwall embedded in the eastern side of the 17th Street Canal earthen levee—the largest and most important drainage canal in the city of New Orleans— also breached catastrophically after storm surge water from the Gulf of Mexico and Lake Pontchartrain was pushed up the canal by the Category 3 winds of Hurricane Katrina. Just as with the situation of the IHNC, the storm surge water forced into the 17th Street Canal caused an initial breach in the floodwall when the surge was about 5 feet below the top of the concrete floodwall (pg 47, ASCE ERP 6-1-2007). As the storm surge water poured through this initial breach it weakened adjacent concrete floodwall sections and the breach quickly expanded into a 450 foot wide gap through which
storm surge water poured, carrying with it concrete floodwall sections and the earthen levee, destroying hundreds of residences, causing millions of dollars in property damage, killing hundreds of people, and submerging the main basin of Metropolitan New Orleans. The initial breach and subsequent floodwall gap of

the 17th Street Canal is adjacent to the 6900 block of Bellaire Drive in Lakeview, a predominantly white middle to upper class neighborhood in New Orleans.

These two breaches, triggered by Katrina's storm surge, were part of a pervasively flawed flood defense system for the Greater New Orleans area. The result was approximately 2,000 deaths (immediate, delayed, on-site, off-site) and total costs estimated to exceed U.S. $500 billion (direct, indirect, immediate, delayed, on- site, off-site). Currently, there are more than $2 trillion in Katrina flood damage claim lawsuits in New Orleans Federal District Court. (Bea and Cobos, 2008)

In January of 2008, federal Judge Stanwood Duval, of the US District Court, for Eastern Louisiana held the US Army Corps of Engineers responsible for defects in the design of the concrete I-wall floodwall in the 17th Street Canal which was constructed in the earthen levees in the period following Hurricane Betsy (1965).[1]

The IHNC and 17th Street Canal levee breaches and over four dozen others which occurred throughout metropolitan New Orleans on August 29, 2005, prompted a nationwide levee inventory project, recommendations for a national levee safety program, nationwide re-certification of levees and flood zones, changes to the National Flood Insurance Program, and passage of reform measures to the Army Corps of Engineers.

The following year, in November of 2009, Judge Duval, held the US Army Corps of Engineers responsible for the flooding from the two east IHNC levee breaches (and dozens of others) because the federal agency failed to properly maintain the Mississippi River Gulf Outlet (MRGO) a navigation canal which channeled storm surge from the Gulf of Mexico and Lake Pontchartrain into the IHNC which is part of the New Orleans Drainage System and commercial canal system constructed between the 1890s and 1920s.

20th century: Residential development of North of Metairie Ridge

When the Pumping Station 6 was constructed in 1899, it was at the "back" end of the developed part of town. As the area alongside the canal closer to the lake was largely undeveloped lowland, it was of little concern if waters pumped out of the city topped the 17th Street Canal and flowed into this area during heavy rains.

In the late 1920s and the 1930s, an Orleans Levee Board (OLB) project used dredged fill from the lake along the lakefront, to create new land in what had been Lake Pontchartrain and to create a sizable but somewhat low levee along the lake side. By this time, Pumping Station 6 at the 17th Street Canal and others had sufficiently

[1] **Prior to 1928, the US Army Corps of Engineers role in flood control among the major waterways of the United States was limited only to the construction of levees and other flood control structures which enhanced interstate commerce. In response to the Great Mississippi Flood of 1927, which had posed a direct threat to New Orleans, Congress passed the Flood Control Act of 1928 which authorized the Corps of Engineers to design and construct flood control structures, such as levees, on the Mississippi River to protect populated areas from floods. Under Section 3 of the Act once these flood control structures were built by the Corps of Engineers, it would be the responsibility of the local governments to maintain these structures. Also under Section 3 of the Act "no liability of any kind would attach or rest upon the United States for any damage from or by floods or flood waters at any place, provided that if on any stretch of the banks of the Mississippi River it was impracticable to construct levees."**

drained the land between the pumping stations and the new levees along the lake front to permit residential development. However minimal efforts were made at this time to raise the elevation of this reclaimed land between Metairie Ridge and the new lakefront fill.

The areas along the 17th Street Canal from Metairie Ridge to the Lake were substantially developed for residential use after World War II, and to protect these areas from storm surges from Lake Pontchartrain earthen levees along the "back" sections of the Canal farther farther from the Mississippi River and closer to the lake were raised. As a result, the water level of the 17th Street Canal could sometimes be higher than the surrounding residential areas and streets. Additional smaller pumping stations were built to add drainage water to the canal from areas along its length.

Historically, the Orleans Levee Board (OLB) designed, built and maintained the city's levees and floodwalls and shouldered 100% of the cost. In 1965, Hurricane Betsy caused severe flooding in portions of eastern New Orleans including the Upper Ninth Ward, Lower Ninth Ward, and Gentilly. Arabi and Chalmette flooded and so did neighboring St. Bernard Parish. For this reason, Congress voted to remove responsibility for designing and building the region's hurricane storm surge protection from the Orleans Levee Board (and other local levee boards) and give the responsibility to the US Army Corps of Engineers, with the passage of the Flood Control Act of 1965. From 1965 until today, the OLB are responsible for maintenance and for collecting taxes to pay the mandated 30% of the cost.

As a result, improved flood protection for the city and its drainage canals was implemented to cope with storm surge from hurricanes, resulting in increasing the size and height of the canal earthen levees and the installation of concrete I-wall floodwalls atop the earthen levees. In 1998 Hurricane Georges raised the level of Lake Pontchartrain, pushing lake waters into the 17th Street Canal. An upgrade of the canal levees, floodwalls, and bridges began in 1999. The canal was considered to be in good shape at the start of the 2005 Atlantic Hurricane Season.

Hurricane Katrina

After Hurricane Katrina struck New Orleans, the 17th Street Canal floodwall was breached over a two city-block wide length on the New Orleans side, contributing to extensive flooding in New Orleans' Main Basin, the area bounded by the Industrial Canal to the east and the 17th Street Canal to the west.

All investigative reports assert that the catastrophic breach at the 17th Street Canal was due to faulty design, rather than from conditions more severe than the levee and storm wall system of the canal was intended to survive. The Interagency Performance Evaluation Task Force (IPET), convened and managed by the Corps of Engineers in October 2005 confirmed that the canal floodwall failed at a significantly lower water level than the top of the floodwall due to faulty design. In 2007, the Corps announced the results of an engineering analysis applying more stringent and appropriate post-Katrina design criteria which showed the maximum safe water load on some of the surviving floodwalls is only 7 feet (2.1 m) above sea level, which is one-half the original 14 foot (4.3 m) design intent of these concrete floodwalls (New Orleans Times Picayune, Sunday August 5, 2007 by Sheila Grissett).

In January 2006 the Army Corps of Engineers announced it had finished the temporary repairs of the breached section of the levee, and construction of more permanent repairs would commence. The future of the 17th Street Canal is likely to see changes in design. While plans are not finalized, it is likely that

a new drainage pumping station will be constructed at the lake edge of the canal, which will serve not only to improve pumping capacity but also to act as a barrier to storm surge and lake flooding; the building would be constructed to act as a component of the system. As a temporary measure until such a new station can be built, the Corps of Engineers constructed storm surge barrier gates and interim pump stations at the lake end of the canal.

Integrity

The levee breaches at the IHNC (east side north) and 17th Street Canal were the sites of historical events when water seepage caused underground failures of the earthen levees and the embedded concrete I-walls failed. Following the events of August 29, 2005 government agencies immediately rushed in to plug the gaps in these levees with thousands of tons of fill material and began efforts to pump water out of the flooded sections of New Orleans. Once these emergency efforts were completed the earthen levees were rebuilt and eventually new concrete floodwalls (T-walls) were built in the areas where the breaches had occurred.

An examination of the areas of the breaches at both canals show that the work to restore the earthen levees have been rebuilt in a manner similar to that which existed prior to Hurricane Katrina. However, a new type of concrete floodwall (T-wall) has been built into the earthen levees in the areas of the two levee breach sites. These new concrete flood walls are designed in a different manner than the former concrete flood wall. This difference in design is clearly noted where the new designed flood walls abut with the older concrete flood walls based on an inspection performed and documented by the Louisiana SHPO office on September 29, 2010. According to that inspection 1) it is possible to clearly see which parts of the concrete floodwall at the two levee breach sites are original and which were replaced after Katrina; 2) the areas on the land side of the two levee breach sites have not be redeveloped and are essentially open land; and 3) the areas of the levee breach sites can be readily identified upon inspection.

The areas considered eligible for nomination to the National Register are the two levee breach sites along the 17th Street Canal and IHNC (east side north). The canals themselves are not under consideration for nomination. The 17th Street Canal was constructed along with Pumping Station No. 6 between 1897 and 1902. A US Army Corps of Engineers study of the pumping stations and drainage canals of New Orleans determined that Pumping Station Nos. 1, 2, 3, 6, and 7 all possess architectural and engineering integrity and were determined to be eligible for inclusion in the National Register. This report noted that "the major drainage canals have been modified within the past 50 years, so they only exhibit integrity of location" (1999: 96). As a result,

> "… none of the major canals in the drainage network (17th Street, London, and Orleans Canals) are in their original condition. All of the major drainage canals have been altered to some degree, by deepening, reshaping, redesign, covering, or re-covering since construction began on the system in 1897. This repair, redesign, and improvement of the drainage canals, which have continued up to the present will very likely continue into the future, have been a functionally necessary result of the increasing drainage demands of the city" [1999: 90].

No determination of eligibility study for the IHNC canal structure has yet been accomplished. The IHNC, constructed in the 1920s, like the 17th Street Canal has also undergone substantial changes to its dimensions since its construction. In addition, the alteration of the IHNC necessitated to make it part of a functional navigation canal and seaport by connecting to the GIWW and MRGO should be taken into account for any future determination of eligibility.

8. STATEMENT OF SIGNIFICANCE

Certifying official has considered the significance of this property in relation to other properties:
Nationally: X Statewide: _ Locally:

Applicable National Register Criteria: A X B _ C _ D _

Criteria Considerations (Exceptions): A _ B _ C _ D _ E _ F _ G X

Areas of Significance: Community Planning and Development

Period(s) of Significance: N/A

Significant Dates: August 29, 2005

Significant Person(s): N/A

Cultural Affiliation: N/A

Architect/Builder: US Army Corps of Engineers

Summary Statement of Significance

The two sites of the historic events of the levee breaches on August 29, 2005 at the 17th Street Canal and the IHNC are being nominated under National Register Criterion A at the local level of significance. In addition, because the historic events associated with these levee breach sites were of such a catastrophic nature and have resulted in a major policy changes regarding levees and floodwalls, not just in the New Orleans area, but throughout the nation, these two levee breach sites meet the Criterion Exception G for having obtained significance in less than fifty years.

Brief Description of the Event and its Impact

In the early hours of August 29, 2005, Hurricane Katrina, a Category 3 storm, came out of the Gulf of Mexico and passed east of the city of New Orleans, Louisiana. New Orleans was spared some wind damage as the storm did not directly hit the city. The wind driven storm surge created two separate hydraulic events; first, the wind pushed water from Lake Borgne (situated east of the city) into the IHNC contributing to the failure of the (earthen) levees and accompanying embedded (concrete) floodwalls, and, second, a bit later, the wind pushed storm surge water from the Gulf of Mexico and Lake Pontchartrain into the 17TH Street Canal. The affected flood areas contained residential and commercial areas which had been reclaimed from lowlands during the early twentieth century. Some of the area was several feet below sea level.

The City of New Orleans was protected by a series of levees along the shore of Lake Pontchartrain constructed at various times from the 1920s up to the 1960s, but this area was also bisected by a series of drainage and navigation canals constructed between the 1890s and 1920s. As noted above, the storm surge first contributed to the failure of the Industrial Canal levees and floodwalls, followed by the failure of the levees and floodwalls of the drainage canals. These canals (to pump rain and drainage water into Lake Pontchartrain and permit commercial shipping into the city) were lined on both sides with earthen levees and topped with concrete floodwalls (called I-walls) to protect the adjacent neighborhoods from storm surges. Storm surge from Katrina's winds funneled the water from the Gulf and Lake Pontchartrain into these canals precipitating the breach and collapse of the levees and floodwalls in nearly 50 locations in the Greater New Orleans area levee system, and flooding over 80 percent of Metropolitan New Orleans and 100% of nearby St. Bernard Parish.

Thirty-one (31) victims were recovered from areas directly flooded by breach in 17th street canal levee. Eight-four (84) victims were recovered from areas directly flooded by breach in INHC levee. (Boyd, E. (2010)

With regard to the loss of property and life only the Galveston, Texas Hurricane of 1900 and the San Francisco, California earthquake and subsequent fire of 1906 had suffered as much as New Orleans in 2005 (2006: 335).

The (two) levee breach sites, which are the subject of this nomination — the 17th Street Canal and the Inner Harbor Navigation Canal (IHNC), or Industrial Canal—flooded the residential areas of Lakeview and the Lower 9th Ward, respectively.

The breach of the 17th Street Canal, one of over 50 in Greater New Orleans that day was one of the most significant because it rendered the 17th Street Canal, the largest drainage canal in the city, useless. This

occurred because floodwaters released by the breach rendered the canal's pump station ineffectual preventing it from pushing the storm surge waters back into Lake Pontchartrain.

The breach of the IHNC (east side north) affected the adjacent neighborhood which, due to heavy media coverage, quickly became the "face" of the flooding event. In addition, due to the large size of the navigation channel, coupled with the very high level of storm surge, the resulting flooding was likely the most violent of the hurricane protection system failures.

The breaches which occurred at these two New Orleans canals taken together with the over four dozen other sites in New Orleans have led to a policy changes and reassessment of levee structures and their design throughout the nation. The policy changes driven by the events of August 29, 2005 has national implications for 55% of the American population which lives in counties protected by levees (request under FOIA, FEMA 09-325, Sept 18, 2009).

Although the areas of the levees where the (two) breaches occurred have been rebuilt following the events of August 29, 2005 it is still possible to determine where these (historic) events occurred due to the modifications of the floodwalls which are visible. These breach sites, and the nearly four dozen others have prompted a nationwide levee inventory project, recommendations for a national levee safety program, nationwide re-certification of levees and flood zones, changes to the National Flood Insurance Programs, and passage of reform measures by Congress to the Army Corps in the Water Resources Development Act (WRDA) of 2007 – all intended to prevent the engineering events of August 29, 2005 from ever occurring again.

The American Society of Civil Engineers Hurricane Katrina External Review Panel wrote in its January 2007 report that it "believes the failures in New Orleans' hurricane protection [system] constitute one of the worst catastrophes ever to befall this country. The flaws uncovered as a result of Hurricane Katrina must serve as a sobering reminder to engineers everywhere that their work has life-or-death implications. Whatever the constraints – whether related to cost, schedule, political resistance or inertia – engineers must continue to uphold the highest standards or their profession, knowing that peoples' lives are at stake."

Background History

New Orleans was established in 1718 about 90 miles up the main stem entrance of the Mississippi River into the Gulf of Mexico, on the eastern bank of the Mississippi River.[2] The intent was to have New Orleans guard the natural portage between the Mississippi River and Bayou St. John, leading to Lake Pontchartrain and secure France's claim to the Mississippi River Valley. The selection of the site of New Orleans as the capital of French Louisiana was chosen more with an eye to its strategic location which guarded the entrance to the Mississippi River and the interior of North America claimed by France and leading on to other French settlements in Canada. From a geopolitical view point New Orleans was the anchor for the encirclement of English colonies in North America, even though its

[2] Prior to the establishment of New Orleans as the anchor to France's colonial empire in the Mississippi River Valley, the French founded Fort de la Boulaye in 1700, located along the right bank of the Mississippi River about 30 miles south of present site of New Orleans, in Plaquemines Parish. Frequent flooding of that site led to its abandonment 1707 and the later founding of New Orleans. On October 9, 1960 the Secretary of the Interior designated the area of Fort de la Boulaye a National Historic Landmark.

location soon proved to be prone to hurricanes from the Gulf and TO diseases from the surrounding swamplands. One feature in favor of the selection of this site for the founding of New Orleans was a natural riverfront levee—built up by the historic spring inundation of the Mississippi River in this area—which appeared to offer some protection from annual spring flooding of New Orleans from the Mississippi River.

In April 1719 the town's founder Jean Baptiste le Moyne, Sieur de Bienville, reported that flood waters from the Mississippi River were regularly inundating the new settlement of New Orleans with half a foot of water each spring. This was due to the fact that the Mississippi River drains over 40% of the continental United States as part of the third largest watershed of any river in the world. A heavy winter snow fall in the northern latitudes would mean the next spring would see flooding in New Orleans as the Mississippi River would overflow its river channel and overtop the natural levees near the riverfront of the city.

Bienville recommended and began to require the colonists to construct man-made levees on top of the natural levees along the Mississippi riverfront and dig drainage canals from the town eastward into the back lowlands to drain water from the town during floods and heavy rains. In spite of these efforts, the annual spring flooding of the Mississippi River posed a repeated concern to the French colonial town. And in some exceptional periods of wet weather, the Mississippi River could remain high breaking through the natural and man-made levees and inundating New Orleans (Hewson, 1870).

The original French colonial settlement of New Orleans was laid out as 44 city blocks by 1721-23, with drainage ditches around each block to carry away heavy rain fall or heavy spring flooding from the Mississippi River. In addition to the riverfront earthen levees the town was surrounded by a defensive earthen wall and bastions in the classic French style, intended to reinforce the strategic importance of the settlement. The first man-made levee along the New Orleans' riverfront was allegedly erected in 1718 in recognition of the importance of protecting the new settlement from spring floods.

New Orleans' early history was typified by many natural challenges, some of which did not include flooding from the Mississippi River's spring inundations. The greatest threat to human life for much of the history of the town was the problem of disease as it has been estimated that more than 100,000 residents succumbed to yellow fever between 1718 and 1878. Twice in the colonial period, much of the city burned to the ground in 1788, and again, in 1794. As noted above, the settlement was also prone to periodic flooding by the Mississippi River between April and August – when melt water from the snows to the far north raised the level of the river. In addition, flooding and wind damage from hurricanes between June and October could threaten the community.

In the early years of the nineteenth century, New Orleans became less of a strategic settlement of empire and more a major port city as plantations upriver began exporting increasing amounts of produce through this city to the world. In order to protect their upriver plantations, many planters began building their own earthen levees and tied them into the city's levee system to keep the Mississippi's spring inundations off their lands. However, this could have adverse effect on New Orleans when one of these plantation levees was breached. On May 5, 1816 part of the Mississippi levee protecting New Orleans gave way at the McCarty Plantation, in present-day Carrollton, upriver of New Orleans and within a few day water filled the back portion of the city, extending from St. Charles Avenue to Canal and Decatur Streets, flooding the French Quarter. Eventually the area was dewatered when the

accumulated flood
waters drained away to the lowland to the east and into Lake Pontchartrain (Bea and Seed 2006:4-3).

On May 3, 1849 the Mississippi River levee broke at the Suavé Plantation at River Ridge, 15 miles upstream of New Orleans. Within four days this water reached the New Basin Canal, and within 17 days was flooding part of the French Quarter, flooding the area down slope (north of) of Bienville and Dauphine Streets. The 1849 flood waters rose at an average rate of one foot every 36 hours, which allowed residents ample time to evacuate. Uptown residents thought about severing the levee along the New Basin Canal to prevent water levels building up on their side, but those living on the opposite side of the canal threatened to prevent such measures using armed force.

The 1849 earthen levee breach, at Suavé Plantation was eventually plugged by driving a line of timber piles and piling up thousands of sand bags against these on the land-side of the pile wall. This work was of unprecedented proportions up to that time and took six weeks to complete before the river's waters were once again confined to their natural channel. Drainage trenches were then excavated through Metairie Ridge to channel the accumulated flood water north out to Lake Pontchartrain. By mid-June 1849 the water was finally receding and residents began re-entering their flooded homes, spreading lime to combat mold, mildew, and impurities.

Between 1849 and 1882, four major crevasses, or earthen levee breaches, occurred at Bonnet Carré, on the eastern bank of the Mississippi River, about 33 river miles upstream of New Orleans. The Bonnet Carré crevasses left a large fan-shaped imprint on the landscape. In fact, during the flood of 1849, a 7,000-foot-wide crevasse developed at Bonnet Carré which diverted flow from the Mississippi into Lake Pontchartrain for more than six months. This breach had to be filled so sufficient river discharge could flow down the main channel of the Mississippi to allow ocean going vessels to reach New Orleans. The 1849 floods were the last time the earth levees on the east bank of the Mississippi River were breached affecting what we now call the French Quarter or Vieux Carre (Bea and Seed, ILIT 2006:4-4).

In 1858, a New Orleans was again threatened when high water from the spring inundation lapped over the east bank riverfront earthen levee. A few days later there was a break on the west bank earthen levee of the Mississippi River at Bell Plantation, which drew down the high water threatening New Orleans. The Bell Plantation crevasse, or levee breach, remained open for six months to relieve pressure on the riverfront levees for New Orleans from the unusually heavy spring inundations. In 1859 the rear portion of New Orleans again flooded, between Carrollton and Esplanade Avenues, flooding one-third of the City between January and March, but it did not affect the French Quarter area (Bea and Seed, ILIT 2006:4-4).

During the steamboat era (post-1810), New Orleans emerged as the major trans-shipment center for river borne to seaborne commerce, vice-versa, and as a major port of immigration. By 1875 it was the ninth largest American port, shipping 7,000 tons annually. In 1880, after completion of the Mississippi River jetties (in 1879), New Orleans experienced a 65-fold increase in seaborne commerce, shipping 450,000 tons of goods, jumping it to the second largest port in America (New York then being the largest). New Orleans would retain its number two position until well after the Second World War, when Los Angeles-Long Beach emerged as the largest port, largely on the strength of its container traffic from the Far East. New Orleans remains the nation's busiest port for bulk goods, such as wheat, rice, corn, soy, and cement.

New Orleans has always been a high maintenance city for drainage. The city's residential district did not stray much beyond the old Mississippi River levee mound until after 1895, when serious attempts to bolster the Lake

Pontchartrain "back levee" and establish a meaningful system of rain water and flood water drainage were undertaken by the city. Most of the cypress lowland between Mid-Town New Orleans and Lake Pontchartrain was subdivided between 1900-1914, after the City established and funded a Drainage Advisory Board to prepare ambitious plans for keeping New Orleans dry all the way from the Mississippi riverfront to Lake Pontchartrain's shoreline. This real estate bonanza increased the City's urban acreage by 700% and their assessed property values by 80% during the same interim (Campanella, 2002). Most of these lots were developed after the First World War (1917-18). Another 1,800 acres was reclaimed from the south shore of Lake Pontchartrain in 1928-31, between the mouth of the 17th Street Canal on the west and the Inner Harbor Navigation Canal (IHNC) on the east. The entire area was subsequently built out following the Second World War, from 1945 to 1970.

At the beginning of the founding of New Orleans (1718) of the three major threats to the community the spring inundations of the Mississippi River and the fevers from the nearby swamps were by far more dangerous to residents of the Crescent City, than hurricanes. To a great extent hurricanes from out of the Gulf of Mexico usually lost much of their strength once they made landfall and their power was dissipated by the extensive cypress swamps south and east of the city.

By the mid-19th century massive earthen levees had been constructed along both the west and east banks of the Mississippi River which has protected New Orleans from spring inundation flooding – the last time the city was flooded in 1849. In addition, the creation of drainage canals – in the 19th century – extending eastward from the city and the construction of powerful pumping stations in the drainage canals – from 1897 to 1902 – to convey rain water and ground water toward Lake Pontchartrain and effectively dried out the lowland east of the city. This drainage had a twofold effect, in that it allowed the city to extend its residential areas into these former lowlands and become virtually free of diseases coming out of these areas.

Throughout the rest of the 20th century, however, the growth of the city of New Orleans, gas and oil development in the cypress swamp lands to the south, and creation of new navigation outlets for the Mississippi River all had the combined effect of causing a substantial loss of the delta and wetlands which once served to limit the impact of hurricanes coming out of the Gulf of Mexico. In particular, the construction of major riverfront levees to hold the river within its channel—encouraged before the Great Mississippi River Flood of 1927; combined with the construction of dams and navigation channels has reduced the amount of sediment load carried by the Mississippi from 550 to 750 million tons per year (before 1950) to about 220 million tons of sediment per year at present. This drop in sediment load has meant the Mississippi Delta south of New Orleans was not being replenished and has led to a massive loss of the wetlands sinking beneath the Gulf of Mexico. This in turn meant that a hurricane coming out of the Gulf could approach New Orleans with greater sustained winds and tidal surge than ever before, and these winds and surge enter the city by being funneled up the drainage and navigation canals or overtopping the levees.

The Geography and the Need for a Drainage System

Historically, the tendency for New Orleans to flood or be threatened by a flood annually from the Mississippi during late spring and summer runoff came to characterize the city settlement. Added to this was the poor drainage at New Orleans, created by deltaic topography, lying just a few feet above sea level, which did not help to drain an excessive rain or flood water from the inhabited areas. The natural

lowlands north and east of the original city were referred to as "back swamps" in the oldest maps, and "cypress swamps" on maps made after 1816.

By the early 1800s, New Orleans' role as a strategically placed town to protect the interior of the continent became less of a concern than its role in the economy of the young United States as a major port city through which goods produce in the mid-section of the continent flowed out to world markets

The New Basin Canal, also known as the New Orleans Canal and the New Canal, was a shipping canal in New Orleans, Louisiana from the 1830s through the 1940s. The New Basin Canal was constructed by the New Orleans Canal and Banking Company, incorporated in 1831 with a capital of 4 million dollars. The intent was to build a shipping canal from Lake Ponchartrain through the lowlands to the booming Uptown or "American" section of the city, to compete with the then existing Carondelet Canal in the Downtown part of the city. Work commenced the following year. Yellow fever ravaged the mainly Irish workers who constructed the canal. The Irish workers died in great numbers, but the Company had no trouble finding more workers to take their place, as shiploads of poor Irishmen arrived in New Orleans, and many were willing to risk their lives in hazardous backbreaking work for a chance to earn $1 a day. By 1838, after an expense of $1million, the 60 foot (18 m) wide 3.17 mile (5.10 km) long canal was complete enough to be opened to small vessels drawing 6 feet (1.8 m), with $0.375 per ton charged for passage. Over the next decade the canal was enlarged to 12 feet (3.7 m) deep, 100 feet (30 m) wide, and with shell roads alongside. No official count was kept of the deaths of the immigrant workers; estimates ranging from 4,000 to 30,000 have been published, with most historical best guesses falling in the 8,000 to 20,000 dead range. Many were buried with no marking in the levee and roadway fill beside the canal.

The canal joined with Lake Pontchartrain around the present day intersection of Robert E. Lee and West End Boulevards, but jetties were added on both sides extending into the lake, one with a lighthouse standing on the far end. From the lake the canal headed south through the lowlands (area at or slightly below sea level), cut through the high ground of Metairie Ridge, through the mid-city lowlands, into the city, then ended in a turning-basin at Rampart Street and Howard Avenue in what is now the New Orleans Central Business District.

The canal was commercially important through the 19th century, and served additional uses as improving drainage in nearby areas and being used to harvest the bald cypress trees in what is now the Lakeview neighborhood, which were brought in to the city near to a point the river via the canal and used to build many houses in the Uptown neighborhood.

The importance of the 17th Street Canal declined after World War I, especially with the opening of the Industrial Canal in 1923. In 1936 the Louisiana Legislature passed a state constitutional amendment to close the canal. In 1937-1938 the area back to Claiborne Avenue was filled in, but the rest of the length continued functioning on a more limited scale until after World War II. The rest was filled in by about 1950, except for a half mile long stretch at the lakefront by the lighthouse which was left as a small boat and yachting harbor and continues to exist. Much of the route became the Pontchartrain Expressway in the 1950s, which was incorporated into I-10 the following decade.

In 1965, Hurricane Betsy demonstrated that a major hurricane could overtop earthen levees and flood the residential and commercial areas of New Orleans in spite of the efforts of the pumping stations which had been continually increased in pumping capacity throughout the twentieth century. The U.S. Army Corps of Engineers determined that the existing local earth levees along the three outfall outfall canals in the main basin of New Orleans (including the 17th Street Canal) were not sufficient in either grade or stability to contain hurricane storm surge. (Woolley/Shabman, Hurricane Decision

Chronology, Page 2-47, April 2008).

The Army Corps working in consultation with the Sewage and Water Board (SWB) and the Orleans Levee Board (OLB) that had responsibility for interior drainage began to discuss two basic alternatives for providing hurricane protection at these canals. The Corps proposed raising the height of the canal walls (parallel protection) or installing floodgates, called butterfly gates, at the canal mouths at the lakefront (frontage protection).

For reasons unique to the 17th Street Canal, the Army Corps recommended a parallel protection plan. This was because with new sheet pile guidances and other factors, the cost difference between parallel protection and frontage protection was minimal for this particular canal. Furthermore, the local sponsors preferred parallel protection because "these local agencies [OLB and SWB] viewed the butterfly gates plan as incompatible with their interior drainage responsibilities, and they also questioned whether the gates would always work properly during storm events" (Woolley Shabman, 2-48).

Gates were considered the more economical option, but were not considered a more effective option for storm surge protection. There is no evidence in the project record that the Army Corps felt that there were differences between the approaches in providing reliable surge protection. (Woolley Shabman, 2-48) It is also important to note that the proposed gates did not include auxiliary pumps like the gates built after Hurricane Katrina.

In New Orleans, earthen levees were often supplemented and extended at many locations by means of more "structural" components comprised of concrete and steel. The concrete and steel floodwalls were used to achieve increased crest height without the extra weight of additional earthen levee fill, and/or without the need to widen the earthen levee embankment section to accommodate additional earthen levee fill in situations where the available "footprint" is limited.

In the forty years between Hurricanes Betsy (1965) and Katrina (2005) the outlying deltaic wetlands south and east of the city of New Orleans had become noticeably reduced in size. This was a significant factor in that these wetlands once acted as a natural brake on hurricanes and their storm surges which might be directed at New Orleans. With the destruction of these wetlands, hurricane storm surges could approach the city more easily and with greater force than ever before threatening the levees and potentially being able to push immense amounts of storm surge water into the city's drainage and commercial canals.

History of the Inner Harbor Navigational Canal (IHNC) (Industrial Canal)

The concept of a shipping canal connecting the Mississippi River to Lake Pontchartrain originated in the Spanish colonial period of Louisiana (1763-1803). The hand dug colonial-era Carondelet Canal connected the back side of the French Quarter with Lake Pontchartrain via Bayou St. John. The Carondelet Canal allowed small ships to approach close to the French Quarter from Lake Pontchartrain, but the canal was not extended to the river because of the differing levels of the river and the lake. Without the construction of canal locks, such a river to lake connection would be impractical and after some years, the Carondelet Canal silted up and was converted to drainage use. In the early nineteenth century, another navigation and shipping canal along the west side of the French Quarter was proposed but never built. However, the right-of-way for the proposed waterway gave its name to the city's Canal Street, which forms the western boundary of the French Quarter, a

National Historic Landmark.

In July 1914 the Louisiana State Government authorized the Port of New Orleans to build a deep-water shipping canal to accommodate ocean going cargo ships to navigate between the Mississippi River and Lake Pontchartrain. Considerable land was expropriated in the downriver (eastern) portion of the city for this project. Along the Mississippi riverfront, numerous buildings and homes were acquired and demolished to make room for the canal. The area toward Lake Pontchartrain was mostly little-developed swamp at this time so there was less need for developed private land to be acquired and buildings to be demolished.

Dredging of the 5.5 mile long navigation canal began on June 6, 1918. The dimensions of the IHNC from Lake Pontchartrain to the lock near the Mississippi River was constructed with a 30 foot (9 m) depth, with a width of 300 feet (90 m) at the top of the canal and at least 150 feet (45 m) at the bottom. The original lock system to connect the river with the lake had 5 gates, a width of 74 feet (23 m), and a depth of 50 feet (15 m), with a capability to function to up to 20 feet (6 m) in difference of levels between the river and lake.

The IHNC separates eastern New Orleans from the rest of the city of New Orleans. The IHNC also passes through the 9th Ward of the city separating the Lower 9th Ward from the Upper 9th Ward. Approximately half of the waterway's length, from Industrial Lock on the Mississippi River to a point north of the Florida Avenue Bridge, is confluent with the Gulf Intracoastal Waterway.

The opening dedication ceremony was presided over by Louisiana Governor John M. Parker on 5 May 1923. The cost for the construction of the IHNC was $19 million dollars.

After the opening of the IHNC, slips and docks were added along its length, allowing it to function as a harbor and industrial zone in addition to serving as a navigation canal. With the inauguration of the Gulf Intracoastal Waterway (GIWW) in the 1930s, the Industrial Canal served as a shipping channel linking the Lake Pontchartrain segment of the GIWW to its continuing segment, accessed via the Mississippi River. During World War II the GIWW was rerouted, and a newly-excavated segment extending through the marsh west from the Rigolets joined the Industrial Canal at its approximate midway point between the river and the lake. In 1944, the federal government leased the Industrial Canal lock and the southern 2.1 mile (3.4 km) section of the canal and took over its operation and maintenance. In the 1960s the Industrial Canal/Intracoastal Waterway junction was enlarged, in expectation of the anticipated increase in shipping traffic resulting from the completion (1965) of the Mississippi River Gulf Outlet (MRGO).

The MRGO is a 76 mile channel constructed by the Army Corps of Engineers in the mid-20th century that provided a shorter route between the Gulf of Mexico and IHNC via the GIWW.

Along both sides of the IHNC were also constructed earthen levees intended to protect the Upper and Lower 9th Ward neighborhoods – which are partially below sea level – that had developed since the 1920s, from storm surges which might rush into the canal and flow into these neighborhoods. A breach in the canal's earthen levees resulted in the flooding of the Lower 9th Ward after Hurricane Betsy in 1965. Subsequently, concrete I-wall floodwalls were constructed atop the earthen levees along both sides of this canal by the US Army Corps of Engineers.

On August 29, 2005, Hurricane Katrina's storm surge funneled by the confluence of the GIWW and MRGO submerged the earthen levees. Four breaches occurred in the Industrial Canal's concrete floodwalls, including the subject of this nomination as well as a failure of a quarter-mile length along the Lower 9th Ward (east side south), resulting in catastrophic flooding of the Lower 9th Ward. In addition to these breaches, there was also a breach on the west side.

An empty barge, the ING 472 owned by Ingram Marine which had been moored across from the breach site, came loose, and Katrina's winds and the eye had passed to Mississippi, the barge was pushed across the IHNC by west wind, floated through the east side south breach and was deposited in the Lower 9th Ward (Case 2:05-cv-05724-SRD-JCW Document 28). On the east side of the Industrial Canal, storm surge water poured through a breach near Florida Avenue. The canal lock on the riverfront side of the IHNC was functioning two days after Katrina hit, at first mostly for barges bringing in fill to repair the breaches along the navigation canal. A month later Hurricane Rita reflooded the recently drained areas along the canal by topping emergency fill at these breach sites.

In 2000, 2001 and 2002, an industrial complex was demolished adjacent to the levee and floodwall along the east side of the IHNC in the vicinity of the two breach sites. This complex, which consisted of maritime service businesses had been in place for over 40 years was situated along Surekote Road. The demolition was performed by contractors and was done to make way for a new navigational lock intended to replace the existing 1920's era lock located closer to the river in the IHNC. It is believed that the demolition of the businesses, buildings and improvements was performed in a manner, which compromised the stability of the flood protection components compared to the stability, which was available prior to 2000 ("Failure of the I-Wall Flood Protection Structures at the New Orleans Lower 9th Ward During Katrina, Robert Bea and Diego Cobos-Roa, 2008 EJGE).

History of the 17th Street Canal

The 17th Street Canal is the primary drainage canal in New Orleans, that in conjunction with Pumping Station 6 channels the most rainwater away from the city and into Lake Pontchartrain. The canal forms a significant portion of the boundary between the city of New Orleans and the adjacent suburb of Metairie, Louisiana. The canal has also been known as the Metairie Outlet Canal and the Upperline Canal.

The canal that was to become later known as the 17th Street Canal seems to have had its origin at the start of the 1850s as a hand dug drainage ditch, or barrow ditch, which was cut through swampy ground to raise a parallel right of way where the Jefferson and Lake Pontchartrain Railway was built. The railway, in business from 1853 through 1864, connected the town of Carrollton, Louisiana (along the Mississippi River front) with a shipping port on Lake Pontchartrain at what became Bucktown, Louisiana, a distance of about 5 miles (8 km). The drainage ditch and railway right of way, connecting Carrollton and Bucktown, cut mostly through land that was undeveloped lowland at that time.

In 1858, a secondary hand dug ditch was built to aid in drainage of the low area "back of town" from the town known as Carrollton, with its starting point at what is now the intersection of Dublin and Palmetto Streets, and connected to the Jefferson and Lake Pontchartrain Railway drainage canal a short distance on the south side of the Metairie Ridge. The Jefferson and Lake Pontchartrain Railway was discontinued on December 31, 1864 as competing rail lines between the river and lake were more successful. When the city of New Orleans annexed Carrollton, the railway drainage canal became the boundary line between Orleans and Jefferson Parishes. As the canal marked the new up-river limit of Orleans Parish, it became known for a while as the Upperline Canal.

The spur drainage canal at the north of Carrollton was beside a projected street numbered "17th Street" (although at the time there was little actual development in back of Claiborne Avenue), and that canal was thus the first to be known as the "17th Street Canal," a name which would later come to commonly

refer to the large canal which this is connected to.

By the 1870s, a steam engine powered pump known as the "Dublin Street Draining Machine" at the back of the Carrollton neighborhood was used to drain that neighborhood, pumping water out the Upperline Canal toward Lake Pontchartrain. Increased use of this canal to pump rainwater from the streets of the city into Lake Pontchartrain grew with the city. The Claiborne Canal connected with the 17th Street and Upperline Canal system via a canal along Dublin Avenue; thus the canal served to carry rainwater to Lake Pontchartrain from the greater part of Uptown New Orleans upriver of the New Basin Canal. Another canal, Hoey's Canal, was added connecting to the Upperline from up river to help drain the back of the Jefferson Parish communities along the riverfront, now known as "Old Jefferson." In 1894, 17th Street was renamed Palmetto Street (later redesignated Palmetto Avenue), but by this time the entire drainage canal was popularly known by the old street name – 17th Street Canal.[3]

In 1899 a new pumping station (Pumping Station 6) was opened in the 17th Street Canal a couple OF blocks north of Metairie Road. A few years later, in the early 20th century, new high-efficiency pumps designed by A. Baldwin Wood were installed at this pumping station, and remain in operation to this date. This was just one of a number of pumping stations along the three major drainage canals (17th Street, London and Orleans) which in the next decades would remove nearly all the rain water in the main basin from the Mississippi riverfront to the shores of Lake Pontchartrain. With this draining of the lowland and the construction of a levee along the shoreline of the lake (in the late 1920s) the area was soon parceled out for residential development although some of it was slightly below sea level.

By the year 2000, Pumping Station 6, in the drainage canal had 15 pumps capable of moving over six billion gallons of rainwater a day through the station toward Lake Pontchartrain. Rainwater runoff from substantial areas of Uptown New Orleans, Mid-City, Metairie, and surrounding neighborhoods drained into these canals and basins which pulled the water up into the 17th Street Canal which directed rainwater into Lake Pontchartrain.

Hurricane Katrina Chronology

The year of 2005 had been one of the more active hurricane seasons on record. By early August of that year eleven tropical storms had been plotted, but fortunately, most of these storms which became hurricanes had not made landfall and lost much of their strength over the cooler waters of the Atlantic. Then around August 15th the trade winds off west Africa "encountered the unstable air of a tropical wave moving west toward North America, approaching the Bahamas" (McQuaid 2006:159-60). Moving westward across the Atlantic Ocean over the next week this unstable air merged with the remnant of a deteriorating Tropical Depression on August 23rd which had formed off the same west African coast a week earlier (McQuaid 2006: 160). This merger of the two air masses produced a new

[3] As early as the late 19th century, New Orleans constructed separate systems of drainage to carry rain or storm water toward Lake Pontchartrain and discharge the daily sewage of the city into Lake Borgne. Only storm water was recommended to be discharged from the 17th Street, London, and Orleans Canals into Lake Pontchartrain based on the concerns of sewage pollution that might affect the shell fish and fish in that body of water (1999: 7). It may have seemed easier to pump storm water and sewage directly into the Mississippi River however, "with the ground sloping upward towards the river, this would have created impossibly high demands on any pumping equipment handling the high rates of flow produced in rainstorms" (1999: 81).

and strengthened Tropical Depression which the next day (August 24th) was designated Tropical Storm Katrina by the National Hurricane Center (McQuaid 2006: 162).[4]

At the time Katrina became the eleventh named tropical storm (August 24th) it only had top winds of about 40 mph, but as it moved west it was tracking to pose a threat to Florida and states fronting the Gulf of Mexico as well. The National Hurricane Center models showed that as it moved west toward warmer waters Katrina would become a hurricane. On Saturday night – August 27 – Katrina was a Category 1 hurricane, with winds between 74 and 95 mph (McQuaid 2006: 162).

Throughout Saturday night (August 27), Hurricane Katrina moved northwest through the Bahamas and then turned directly west toward Florida, its pressure kept falling and picking up strength from updrafts of hot ocean air laden with water vapor. A high pressure system was pushing the hurricane south so that it made landfall between Miami and Fort Lauderdale, Florida (McQuaid 2006:162-3). As the storm passed over the swamplands of the Everglades it weaken and was downgraded to a tropical storm with winds below 70 mph, but once it cleared the Florida peninsula and entered the warmer waters of the Gulf of Mexico Katrina quickly became a Category 3 Hurricane with top sustained winds of 115 mph (McQuaid 2006: 163, 170).

Sunday (August 28) as the storm moved northwest through the Gulf toward the general vicinity of New Orleans it became more powerful and doubled in size and became a Category 5 Hurricane with winds over 155 mph (McQuaid 2006: 170). Just after midnight of August 29th (Monday) Hurricane Katrina began to make landfall on the Mississippi Delta on a due north track that would take it east of New Orleans and over Lake Pontchartrain (McQuaid 2006: 187). According to McQuaid this

> … brought Katrina over cooler water, and it began to lose the terrifying strength it exhibited over the open Gulf. At the same time, a stream of dry air began to leach into its western rim, draining strength from bands of thunderstorms. The knot of winds around the eye lost speed, and the barometric pressure rose. The inner core of Katrina's eye wall — the continually regenerating heart of its convection engine — began to erode. The storm weakened like a deflating balloon, dropping from Category 5 to Category 3 in the space of twelve hours [2006: 187].

But with top winds of 127 mph, Hurricane Katrina began pushing a storm surge of seawater from THE Gulf of Mexico and Lake Borgne westward to the area's levees on the lake and the openings to the three drainage canals (17th Street, Orleans, and London) and the IHNC, or Industrial Canal. According to McQuaid,

> … seawater flowing in from the [lake to the] east had been filling the Industrial Canal [IHNC] for hours, along with a more modest influx from Lake Pontchartrain. As it rose, the water put mounting pressure on the canal's concrete I-walls and flowed through various gaps. Sections on both sides began breaking around 4:30 a.m., sending water streaming into [the Lower Ninth Ward of] eastern New Orleans …" (2006: 192).

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[4] Meteorologists classify storms using the Saffir-Simpson scale, developed by in 1969 by engineer Herbert Saffir and Hurricane Center director Bob Simpson. The scale ranked storms by their sustained wind speed: a tropical storm was defined as having winds of 39 to 73 mph; a Category 1 hurricane, 74 to 95 mph; Category 2, 95 to 110 mph; Category 3, 111 to 130 mph; Category 4, 131 to 155 mph. A Category 5 was anything over 155 mph (McQuaid 2006:163).

The Breach of the IHNC east side north

On August 29, 2005, at about 5 am, a section of the I-wall on the eastern side of the IHNC in the Lower Ninth Ward began to breach and catastrophically released storm surge from Hurricane Katrina. The breach occurred adjacent to the 2400 block of Surekote Road and failed before storm waters reached the top of the wall.

"Although it is clear that the walls were overtopped, and that their stability was compromised by the erosion that occurred, it is also clear that one of the east side breaches occurred before the wall was overtopped." Eyewitness reports indicate that the water level in the 9th Ward near Florida Avenue was rising as early as 5:00 AM, when the water level in the IHNC was still below the top of the floodwall. Stability analyses indicate that foundation instability would occur before overtopping at the north breach on the east side of the IHNC. This breach location is thus the likely source of the early flooding in the 9th Ward." (IPET, Vol. V)

Available evidence indicates the North Breach initiated before the wall was overtopped (about 5:00 am), with the breach fully developing between 6:00 and 7:00 am. Photographic evidence and post failure investigations indicate the North Breach was a narrow (250 ft., 76 m) movement that apparently started under the landside toe and progressed toward the waterside. All of this happened before this section of the flood wall was overtopped. The concrete I-wall failed and the steel sheet pile underneath the I-wall was stretched landward. The movement and resting place of the sheet pile indicates that the supporting earthen levee and foundation materials were washed away beneath the sheet pile and the water force pushed away the steel sheet pile and twisted them until a section of the sheet piles rotated 90 degrees – against the rising surge waters in the IHNC (INSERT Quote here supporting this information).

The east side, north breach is next to the Florida Avenue bridge. This breach took place in front of a Sewerage and Water Board pump station (PS#5). Other pump station operators elsewhere in the city listened to the PS#5 operators beg for help as the water flooded their station. (Bea and Cobos, 2008)

At approximately 7:45 am, a second breach began to occur a short distance away adjacent to the 1800 block of Surekote Road and eventually widened into a 1,000 foot gap. The failure mechanism of the second breach was due to a combination of overtopping, erosion and movement of the supporting levee as the I-wall shifted. Eighty-four (84) victims were recovered from areas directly flooded by breach in INHC levee. Floodwaters from the two breaches combined and destroyed buildings, homes and infrastructure. The water also flowed into the city of Arabi and Chalmette, Louisiana.

Before and during Hurricane Katrina's landfall, breaches in four I-walls developed – all before water levels in the adjacent canals overtopped them. They were the 17th Street Canal, the north breach of the Inner Harbor Navigation Canal and two breaches of the London Avenue Canal.

The Breach of the 17th Street Canal

As Hurricane Katrina was making its second landfall on the northern shores of Lake Pontchartrain and Lake Borgne, its Category 3 winds were pushing a storm surge of water into Lake Pontchartrain which flowed into the 17th Street Canal.

At about 6:30 am, a portion of the I-wall along the east side of the 17th Street Canal adjacent to the 6900 block of Bellaire Drive split open, sending torrents of water into New Orleans' Lakeview neighborhood. The water level in the Canal at the time of failure was about 5 feet lower than the top of the I-wall, well below the design water level. The breach released storm surge floodwaters that destroyed buildings, homes, and infrastructure. The initial breach expanded to a nearly 450-foot wide gap. Thirty-one (31) victims were recovered from areas directly flooded by breach in 17th street canal levee.

The 17th Street Canal levee and floodwall, at the breach site, was built over a layer of organic soil called peat or marsh, which, in turn, overlays a layer of very soft clay. A principal concern with levees founded on soft soil is the possibility that the entire levee might slide either into the canal or away from the canal because of the low strength of the soft soil. Indeed, the mechanism of failure at the Canal was the levee sliding away from the canal.

Those responsible for the design of the Canal levee and the I-wall over-estimated the soil strength-meaning that the soil strength used in the design calculations was greater than what actually existed under and near the levee during Hurricane Katrina. They made an unconservative (i.e., erring toward unsafe) interpretations of the data: the soil below the levee was actually weaker than that used in the I-wall design (ASCE: External Review Panel, pg 48).

Another critical engineering oversight that led to the failure of the 17th Street Canal involves not taking into account the possibility of a water-filled gap which turned out to be a very important aspect of the failures of the I-walls around New Orleans.

> "Analysis indicate that, with the presence of a water-filled gap, the factor of safety is about 30 percent lower. Because a factor of safety of 1.3 was used for design, a reduction of 30 percent would reduce the factor of safety to approximately one: a condition of incipient failure." (ASCE: External Review Panel, pg 51)

The Period Following Hurricane Katrina

Within a few days emergency crews had sealed the breach along the 17th Street Canal with 7000 sandbags, each weighing 10,000 pounds—for a total of 35,000 tons of sand, gravel, rocks and mashed up concrete (2006: 333). By early September a similar patch had been installed along the Industrial Canal and both the residential areas of Lakeview and the Lower 9th Ward were pumped dry (2006: 334). Unfortunately, the arrival of Hurricane Rita's storm surge approximately three weeks later washed out the patch at the Industrial Canal and reflooded the Lower 9th Ward, which was finally pumped dry again on October 14, 2005 (2006: 334).

In a postscript to the devastation caused during Hurricane Katrina, investigators with the Corps issued a preliminary report in March of 2006 that included a theory of why the IHNC and17th Street Canal concrete I-walls atop the earth levees had failed. It appeared that rising storm surge water had pushed the concrete floodwalls outward, opening a gap between the soil and the sheet pile foundation of the floodwalls. Water poured into the gap, weakening the entire structure, than a layer of soft clay underneath it suddenly slid away from the canal (2006: 342-3). Since then the Corps has rebuilt the levees and the agency has recommended providing permanent floodgates for the drainage canals where they enter Lake Pontchartrain and adding additional permanent pumping stations to the lake front. In addition some levees would be strengthened and armored with rocks (2006: 344).

Conclusion

In 1718, the French established the city of New Orleans on the east bank of the Mississippi, on a crescent shaped land area about ninety (90) miles north of where the river delta splits and flows to the Gulf of Mexico. The annual spring inundations of the Mississippi over thousands of years had deposited water borne sediment at this site building up a natural levee along the river and a slightly elevated area above the delta where the French would construct a town site on land a few feet above sea level. For most of the colonial period the main threats to the town was flooding from the Mississippi which could overtop its natural and man-made levees during the spring inundations of the river and disease from insect borne sources from the lowlands east of New Orleans which extended to Lake Pontchartrain. In spite of these problems, New Orleans was perfectly located to complete an encirclement of Great Britain's North American colonies. In this regard, geo-political and subsequently greater commercial needs dictated New Orleans's location rather than a safer or healthier environment.

Throughout the first half of the nineteenth century New Orleans increasingly changed in importance from an anchor to a colonial empire to a major port city exporting sugar and cotton from plantations up river. The attendant growth of New Orleans as a port city required the construction of large riverfront levees to protect the port city which were accomplished with the assistance of the federal government and the US Army Corps of Engineers to the point that 1849 was the last time the area of the original city—the Vieux Carre—was flooded by water from the Mississippi. At the same time, growth west, south and east of the old colonial town site required the construction of additional levees and drainage canals to drain the lowlands to permit building in these areas. These areas, however, were more exposed to disease from the lowlands and surges of water from Lake Pontchartrain resulting from hurricane activity, than the area along the riverfront.

By the 1890s, New Orleans faced three problems to its growth as a port city; 1) disease from the lowlands which annually was causing the deaths of hundreds; 2) the need for sewage and rainwater drainage away from the city; and 3) the need to permanently drain lowlands all the way to the shore of Lake Pontchartrain to permit expansion of the city. The answer to these needs was the construction of three major water drainage canals (17th Street, London, and Orleans) with massive new pumping stations, located a few miles from the shore of Lake Pontchartrain. By the 1923, a fourth canal (the IHNC or Industrial Canal) was completed to permit vessels to come into the city to take on and discharge cargo as a means of expanding the city's ability to handle bulk cargos. To protect the newly drained residential areas—some of which were below sea level—and these canals from hurricane storm

surges off the lake, earthen levees were erected along the shore of Lake Pontchartrain and the along both sides of the canals.

In New Orleans, the earthen levees were often supplemented and extended at many locations by means of more "structural" components comprised of concrete and steel. The concrete and steel floodwalls were used to achieve increased crest height without the extra weight of additional earthen levee fill, and/or without the need to widen the earthen levee embankment section to accommodate additional earthen levee fill in situations where the available "footprint" is limited.

In the forty years between Hurricanes Betsy (1965) and Katrina (2005) the outlying deltaic wetlands south and east of the city of New Orleans had become noticeably reduced in size. This was a significant factor in that these wetlands once acted as a natural brake on hurricanes and their storm surges which might be directed at New Orleans. With the destruction of these wetlands, hurricane storm surges could approach the city more easily and with greater force than ever before threatening the levees and potentially being able to push immense amounts of storm surge water into the city's drainage and commercial canals.

The breach of the 17th Street Canal, one of over 50 in Greater New Orleans that day was one of the most significant because it rendered the 17th Street Canal – the largest drainage canal in the city – useless. This occurred because floodwaters released by the breach rendered the canal's pump station ineffectual preventing it from pushing the storm surge waters back into the lake. In January 2008, the US District Court, Eastern Louisiana found the Army Corps of Engineers responsible for the defective I-wall design; however, the agency is protected from financial liability by the Flood Control Act of 1928. Since 2005, the Army Corps has discontinued the use of I-walls in the configuration at the 17th Street Canal breach site pre-Katrina.

The north breach of the Inner Harbor Navigation Canal I-wall in the Lower Ninth Ward of New Orleans was an excellent example of the sort of engineering failure mechanism which caused much of the flooding of New Orleans. The IHNC breach, like that of the 17th Street Canal, and others in the region breached before the water level reached the top. The IHNC east side north breach, the 17th Street Canal breach and others like it in the City of New Orleans prompted a nationwide levee inventory project, recommendations for a national levee safety program, nationwide recertification of levees and flood zones, changes to the National Flood Insurance Program and passage of reform measures by Congress to the U.S. Army Corps of Engineers in the Water Resources Development Act of 2007.

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Previous documentation on file (NPS):

__ Preliminary Determination of Individual Listing (36 CFR 67) has been requested.
__ Previously Listed in the National Register.
_X_ Previously Determined Eligible by the National Register. By letter from the Louisiana SHPO – July 29, 2010.
__ Designated a National Historic Landmark.
__ Recorded by Historic American Buildings Survey: #
__ Recorded by Historic American Engineering Record: #

Primary Location of Additional Data:

_X_ State Historic Preservation Office - Louisiana
__ Other State Agency
_X_ Federal Agency – US Army COE – IHNC Levee owner (?)
_X_ Local Government – Orleans Levee District – 17th Street Canal Levee owner
__ University
_X_ Other (Specify Repository): Dock Board (IHNC); Orleans Parish (17th Street)

10. GEOGRAPHICAL DATA

Acreage of Property: Less than a quarter of an acre.

UTM References: **Zone Easting Northing**

Verbal Boundary Description: The boundary for the levee breach site of the 17th Street Canal is the area immediately in front of the breach site which was 90 feet in diameter. The boundary chosen for the nomination is rectangular area 95 feet long and 6 feet wide or a surface area of 570 square feet.

The boundary for the levee breach site of the IHN Canal is the area immediately in front of the breach site which was _____ in diameter. The boundary chosen for the nomination is a rectangular area___feet long and ___ feet wide or a surface area of ____ square feet.

Boundary Justification:

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Date:

NATIONAL HISTORIC LANDMARKS SURVEY
February 9, 2019