Development of the New Orleans Flood Protection System Prior to Hurricane Katrina

J. David Rogers, Ph.D., P.E., P.G.
Missouri University of Science & Technology
for Technical Session #6 on Coastal and Flood Plain Processes
Annual Meeting
Association of Environmental & Engineering Geologists
New Orleans
Sept. 18, 2008
Online at: www.mst.edu/~rogersda
PART 1

ORIGINS OF
NEW ORLEANS
New Orleans is a deep water port established in 1718 about 100 miles up the main stem of the Mississippi River, on the eastern flank of the Mississippi River Delta.
New Orleans was established by the French in 1717-18 to guard the natural portage between the Mississippi River and Bayou St. John, leading to Lake Pochartrain. Note swamp contact, fresh vs brackish water.
The formal settlement was laid out as 14 city blocks in 1721, with drainage ditches around each block. The original town was surrounded by a defensive bastion in the classic French style.
The first levee was erected in 1722; and the tendency to flooding during late spring and summer runoff came to characterize the settlement. Note “Cypress swamps” north of the city.
During the steamboat era (post 1810), New Orleans emerged as the major trans-shipment center for river-borne to sea-borne commerce, and vice-versa, as well as a major port of immigration. It was the 9th largest American port by 1875.
PART 2
THE CORPS
‘LEVEES ONLY’ POLICY
The **Old Basin drainage canal** was excavated in the **1790s**. This shows the systems of drainage ditches and canals established by 1829, leading to Bayou St. John.
• The channel’s natural levees form the high ground
- Typical cross section through the sandy bank levees of the Mississippi River, illustrating how the river’s main channel lies above the surrounding flood plain, which were poorly drained swamp lands prior to reclamation.
- There is significant hydraulic sorting of materials deposited on either side of these levees, as sketched below.
Army Engineer A.A. Humphreys began studying the river in 1850, and virtually controlled it as Chief of Engineers between 1866-1879. He was the father of the Corps’ flawed “levees only” policy of flood control.
Levees were periodically raised between 1890-1960

- Typical levee cross section in New Orleans area

Louisiana levee topped out during the record 1973 flood
Why the ‘Levees Only’ policy failed

- The Mississippi channel is sinuous, and exhibits an asymmetric section
- It tends to migrate towards the outside of downstream bends through bank undercutting. Levees had to set back from these bends.
PART 3

NEW ORLEANS DRAINAGE CANALS
City Districts

- Prominent drainage features and neighborhoods of New Orleans
- Note Metaire - Gentilly Ridge distributary channel
Many Canals were filled or superseded by newer ones

- The **Old Basin, or Old Carondelet Canal** was excavated for drainage and navigation (row boats), between the City and Lake Ponchartrain. It ended at Basin Street, and was infilled in the 1920s, when it became railroad tracks and Lafitte Avenue.

- The **New Basin Canal** was excavated in the early 1830s in the American Sector, yellow fever killing 10,000 Irish immigrants. The New Orleans City Railroad paralleled this canal in post Civil War era.

- The **New Basin Canal** cut through Metarie Ridge; causing flooding of the downtown area in 1871.

- The portion south of Metarie Ridge was filled in the 1930s; and the remainder in the 1950s, with the Ponchartrian Expressway replacing the old canal.
Drainage Canal Chronology

- The **Orleans Canal** was excavated in **1833** to convey water from Bayou Metarie. The Turnpike Road ran along the west side of this canal.

- The **Upper Line/17\textsuperscript{TH} St. Canal** along the Orleans-Jefferson Parish boundary was excavated prior to **1849** – along the upper end of today’s **17\textsuperscript{th} St Canal**. The lower portion was excavated in **1857-58**, all the way to Bucktown, along Lake Ponchartrain.

- In **1853** the **Jefferson & Lake Ponchartrain Railroad** was built along the Upper Line Canal.
The 1878 Hardee drainage map was compiled after a yellow fever epidemic the previous year, which brought to City’s accumulated death toll to in excess of 100,000 people.
All 36 miles of drainage canals in the Lakeview and Gentilly areas are shown in 1878: 17th Street, New Basin, Orleans, Bayou St. John, London, and the Lower Line Protection Levee.
Drainage Canal Chronology

- The **1853** Ponchartrain Harbor Map shows brackish water tidal influx zone around the mouth of Bayou St. John, extending westward, to the New Basin Canal.

- The **Upper Protection Canal** was excavated around **1857-58** out to Lake Ponchartrain. This became the **17th Street Canal** (the street was renamed Palmetto Avenue in 1894)

- By **1863** there were a series of east-west **feeder canals** serving Bayou St. John from the west side

- By **1863** there were a series of NNE trending drainage canals in St. Bernard Parish
• Photo looking north along the eastern side of the New Basin Canal in 1890, when the levee was about 4 feet high, supporting a shell surfaced road. These embankments were raised in 1915 and again in 1947.
Drainage Canal Chronology

• The upper London Avenue Canal was constructed in the 1860s, north of Bayou Gentilly. A steam-powered draining machine near the intersection of London and Pleasure Street dumped this water into the cypress swamp near what is now Dillard University, north of Gentilly Ridge.

• The lower London Avenue Canal was extended out to Lake Ponchartrain sometime between 1873-78
PART 4
KEEPING THE CITY DRY
ORIGINS OF THE SEWERAGE & WATER BOARD
EARLY WARNINGS

• In **1871**, the New Orleans City Surveyor **W.H. Bell** warned of the potential dangers posed by the big outfall drainage canals.

• He told city officials to place pumping stations on the lakeshore, otherwise "**heavy storms would result in water backup within the canals, culminating in overflow into the city.**"
Much of New Orleans lies below sea level, Lake Ponchartrain, and the Mississippi River, making it particularly vulnerable to flooding. Mississippi levee 24.5 feet; Pontchartrain levee 13.5 feet.
Drainage Commission - 1896

- The Louisiana legislature created a drainage commission in **1896** to deal with drainage of New Orleans.
- This subsequently became the **New Orleans Sewerage and Water Board** in **1899**.
- By 1915 there were 70 miles of canals and three new pump stations in place. By 1926 the system cost $27.5 million.
- Eventually, this system has expanded to 172 miles of drainage canals, 90 miles of which are covered.
A. Baldwin Wood was a young S&WB engineer who designed the enormous screw pumps, 12 to 14 feet in diameter, which run on 25 Hz electric power using 20 ft diameter dynamos. The City began by installing 11 Wood pumps in 1915 for a cost of $159K. These replaced the old steam powered paddle wheel pumps.
This 1920s drawing shows the arrangement of a Wood screw pump, which uses a powerful siphon action to lift water into the drainage canals, where it flows by gravity to Lake Ponchartrain. The City’s 21 pump stations can lift 47,000 csf of water. Prior to Katrina it had only been overwhelmed on a few occasions, in 1978 and again, in 1995.
New Orleans also employs vertical pumps with impellers to lift water from subterranean storm drains to the drainage canals.
PART 5

1915 FLOOD ENTERED CITY VIA THE DRAINAGE CANALS

• In 1915 a powerful hurricane lifted the water level in Lake Ponchartrain to 6 feet above mean gulf level.

• The drainage canals were overtopped and much of the city flooded.

• The City’s new pump system was overwhelmed when the power stations were flooded.

• 275 people were killed in the flooding.
The political leadership of New Orleans dynamited the Mississippi levee downstream of New Orleans to save the city from being flooded. It was not necessary, but prompted by fear.
RESPONSE TO 1915 and 1947 OVERTOPPINGS

- After the **1915 flood**, Sewerage and Water Board General Superintendent George Earl ordered the levees along the drainage canals to be raised.

- After several of these heightened drainage canal levees were overtopped in **1947**, the state’s congressional delegation asked the federal government to assist in protecting the city.
Flooding of Jefferson Parish and Metairie was caused by a breach along the western side of the 17th Street Canal, across from site of the 2005 breach.
1947 Flooding Emanating from Inner Harbor Navigation Canal

- In the 1947 flood, a back protection levee broke at Tennessee Street, spilling 10 feet of water into the East Side.
- This was quickly cleaned up.
- Also, lots of flooding in Metairie and Jefferson Parish, through a breach in west side of the 17th St Canal.
- Flood inundation map published in the New Orleans Times-Picayune.
Hurricane Betsy clobbered New Orleans in 1965, with winds of up to 125 mph and a storm surge of 8 to 10 feet. It was the first hurricane to cause more than $1 billion in damages.
Flooding from Hurricane Betsy in 1965

- Both sides of the IHNC experienced breaks and overtopping during Hurricane Betsy in Sept. 1965.
- 6,560 homes and 40 businesses were flooded in water up to 7 ft deep on the west side of the IHNC.
- The east side of the IHNC also failed, flooding the west end of St. Bernard’s Parish.
Flood inundation caused by Hurricane Betsy - 1965
Flood inundation of New Orleans caused by Hurricane Betsy in September 1965.

Both internal levee failures and overtopping occurred along the Inner Harbor Navigation Canal, along both sides.

The triangles note depth of water above ground surface.
Betsy’s record damage was eclipsed by Hurricane Camille, which struck the Gulf Coast in August 1969. It’s eye made landfall about 60 miles east of New Orleans and went up the Mississippi Embayment, causing unprecedented levels of storm-related damage in Virginia, killing more than 300.
Recorded storm surge on Gulf of Mexico landfall of Hurricane Camille in 1969. Pass Christian recorded a storm surge of 22.5 feet, Bay St. Louis 20.2 feet, and Biloxi 16 feet.
Hurricane Georges Sept 1998

The 9 foot tidal surge caused by Hurricane Georges came within inches of overtopping the Lake Pontchartrain levees and drainage canal gates on September 27, 1998.
PART 6

Lake Ponchartrain and Vicinity Hurricane Protection Project

1956-2005
Federal involvement in the drainage canals began in 1955 with approval of the Lake Ponchartrain and Vicinity Hurricane Protection Project.

Clash of cultures and goals between local levee districts, the S&WB, and the Corps of Engineers ensued.

The Corps preferred gates at the mouths of the canals, but S&WB and many residents opposed, fearing they would malfunction, inhibiting outflow of storm water.
New Orleans is situated between Lake Ponchartrain and the Mississippi River.

After Hurricanes Betsy (1965) and Camille (1969) it was proposed that the Corps of Engineers construct a tidal gate across the outlet of Lake Pontchartrain to prevent potentially destructive tidal surges from entering the lake and impacting the back side of New Orleans. This would have the added benefit of protecting the causeways and viaducts leading to the city.
24 YEAR BATTLE

• The issue of how to address improvement of the drainage canals dragged on for almost 40 years.

• In the meantime, intense residential development encroached upon the drainage canals, beginning in 1955.

• The federal Court of Appeals decided the issue in 1979, ordering the Corps to go with heightened levees able to withstand a Category 3 storm with 12 ft tides and 130-mph winds.
Flood Walls were constructed on the crowns of drainage canals and the Inner Harbor Navigation Canal to accommodate functionality during high storm surges. The walls in the Lakeview and Gentilly Districts were supposed to be +14 ft above MGL (actually 12.1 ft).
Flood Walls

Prior to Hurricane Katrina, the drainage canals feeding into Lake Ponchartrain never exceeded a flow height of 7 feet above MGL.

This shows deflection of the western 17th Street Canal flood wall, opposite the August 29, 2005 break of the eastern wall, near the Hammond Highway Bridge.

The canal levee had previously breached at this position in 1947.
A complex network of levees protected the city from flooding, but it quickly failed on August 29, 2005, when water levels rose.
PART 7

HURRICANE KATRINA STRIKES NEW ORLEANS
AUGUST 2005
Hurricane Katrina swept across southern Florida and lost momentum, then gained speed and water, showing the second lowest barometric pressure ever recorded. The predicted storm surge was 18 to 28 feet; a record for New Orleans.
Katrina Landfall

- Historically, there haven’t been but a handful of Category 4 or 5 hurricanes that have ever been photographed making landfall.
Predicted water depth in New Orleans flood inundation area based on water level of 2.37 ft in Lake Ponchartrain on Sept 2, 2005. Overlay on 2002 5 m LiDAR DEM by USGS-MCGSC in Rolla. The dark red tones >9 ft.
This lecture will be posted at

www.mst.edu/~rogersda/levees

in .pdf format for easy downloading and use by others.

This lecture summarizes an article of the same name published in the May 2008 issue of ASCE’s *Journal of Geotechnical and Geoenvironmental Engineering*. It can be downloaded in pdf format with color graphics towards the bottom of the same folder.