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The Friends of Lafitte Corridor [FOLC] formed in early 2006 by those who were concerned about post-Katrina planning, neighborhood revitalization, and open space development and alarmed about short-term political decisions being made without benefit of long-term planning vision. Since then, FOLC has built a network of diverse constituents who share its vision of developing the Lafitte Corridor as a greenway that encourages active living, facilitates economic development, and links adjacent neighborhoods, cultural features, historic sites, retail areas and public spaces. We envision a public trail that will:

- increase transportation options by providing a safe, non-motorized path of travel;
- enhance recreational opportunities and add useful community open spaces to the City’s green space inventory;
- generate economic recovery among residents of adjacent neighborhoods;
- demonstrate best practices in environmental sustainability; and
- educate residents and visitors about the city’s cultural and economic history and its relationship to the larger environment.

Post-K recovery has allowed residents of New Orleans to re-imagine what our city should be. Grass-roots efforts such as ours have been generously supported by visionary community organizations such as the Greater New Orleans Foundation, and their encouragement has allowed us to explore innovative concepts and environmental strategies that, prior to Katrina, would not have been possible or even conceivable. We feel now, more than ever, that the Lafitte Corridor is an ideal platform in which to demonstrate innovative concepts of environmental management and sustainability.

Communities rarely get an opportunity such as this one to radically re-imagine drainage, water management, and environmental sustainability. This investigation demonstrates that the Lafitte Corridor offers a unique opportunity to re-envision what an urban green space for our community could be.

We sincerely appreciate the confidence in our initiative and the support shown by the GNOF for our efforts. Thanks to GNOF and the innovative strategies presented here, residents of New Orleans now have an opportunity to discuss the concepts and strategies outlined in this study. FOLC membership looks forward to engaging residents of New Orleans in that important discussion. We encourage everyone in our community to examine this report and give it the consideration it deserves.

Friends of Lafitte Corridor
July 2010
Copy of a 1798 Spanish map of New Orleans. Lafitte Corridor location outlined in red.
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PROJECT SCOPE

Initiated by the Friends of the Lafitte Corridor and made possible by a Greater New Orleans Foundation Environmental Fund grant, this report presents strategies for sustainable water design within the Lafitte Greenway redevelopment. The study was divided into three sections: historical research, data collection and analysis, and the development of illustrative water design potentials for the Lafitte Greenway.

The Lafitte Greenway is a linear open space that connects historic neighborhoods in the heart of New Orleans. The proposed 3.1 mile long, bicycle and pedestrian parkway begins at Armstrong Park at the French Quarter, runs through the Tremé, Faubourg St. John, Mid-City and Lower Mid-City neighborhoods and ends at Canal Boulevard. The Bayou St. John, which intersects the corridor at Jefferson Davis Parkway, is the historical entry to New Orleans from Lake Pontchartrain and was connected to the French Quarter via the Carondelet Canal. Now filled and ignored, the former navigation canal and an abandoned railway remain as a public right-of-way. The Lafitte Greenway traces the pathway of a historic maritime and rail transportation corridor. With its connection to one of the city’s few open waterways and its prominent role in the city’s drainage system, this greenway corridor can provide the community unique urban amenities with ecological, economic, and social value and benefits.

New Orleans’ existing drainage network is overburdened; frequent street flooding occurs during severe rain events in significant part because the closed, subsurface drainage network has little capacity for water storage. Increasing pumping capacity or conduit size has been, and remains, the typical approach to improve the current system. As a consequence of constant pumping, groundwater is removed from the porous, organic soils. Subsidence results, through oxidation processes, with significant consequences to subsurface and surface infrastructure. Additionally, storm water runoff is not mitigated and pollution is flushed directly into Lake Pontchartrain. As a result, traditional infrastructural approaches to address these problems require constant maintenance and therefore have become economically and ecologically unsustainable.

Facing similar pressures of rising sea level, resource depletion, and threat of increased flooding, the Dutch have developed fundamentally different approaches to water management. They recognize that it is more cost effective and feasible to employ
diverse, small scale strategies rather than relying solely on large scale infrastructure projects for water management. Their strategies demonstrate that water sensitive urban design begins with an understanding of subsurface soil and water conditions, followed by adjustments to infrastructure, land uses and spatial planning. Available water - surface water, groundwater, storm water, drinking water and wastewater - is used intensively as a resource. Consequently, urban vulnerability to flooding, drought, extreme heat and land subsidence is reduced through intelligent, water-wise design, efficient operation and effective management. The goal of these principles is to produce a “Water Sensitive City” that is robust, resilient and sustainable. Currently a “Drained City,” as defined by the Urban Water Management Transitions Framework, New Orleans has several steps to take before it can attain this goal.

Influenced by this Dutch approach to water sensitive design, Waggonner & Ball Architects developed recommendations for surface water, storm water and groundwater interventions for the Lafitte Greenway that utilize the following sustainable water design principles:

- Alleviate load on pumping system, reduce street flooding, and increase safety by providing space for water storage and retention;
- Minimize subsidence with balanced groundwater;
- Improve water quality by mitigating runoff;
- Promote resilience to climate change, including flood, drought and heat;
- Reconnect neighborhoods and individuals to healthy water network, providing urban amenities and value.
Based upon these principles and addressing unique conditions along the length of the Lafitte Greenway, we developed three distinct areas of hydrological identity:

**Water Identity 1: Fresh Water** begins at the former Carondelet Canal turning basin at the French Quarter and runs to Pumping Station #2 at Broad Street. A well pressurized by the Mississippi River, will provide a constant flow of fresh water into a meandering channel. This water course will provide space for water storage and balance groundwater, thereby reducing subsidence rates. Measures to filter and slow storm water runoff from the corridor and the neighborhood, such as rain gardens and bioswales, are recommended for all three hydrologic zones.

**Water Identity 2: Brackish Water** is an extension of Bayou St. John to the Pumping Station #2 at Broad Street and would be a primary demonstration project for water sensitive design. This surface channel will provide an outlet for the currently stagnant bayou and will create space for water storage to alleviate flooding in the Hagan Street Basin. Two options for covering the existing and dangerous, open concrete box canal that runs along this section of the corridor, either with the bike path or the new canal, have been illustrated. A re-imagined intersection at Jefferson Davis Parkway, Bayou St. John and the Lafitte Greenway will celebrate and beautify this historic location, identified by all previous planning efforts as a unique urban design opportunity.

**Water Identity 3: Filter** describes the stretch of railway corridor that runs north of Bayou St. John to Canal Boulevard. This narrow zone captures and mitigates runoff from the corridor and the lower surrounding neighborhoods.

The suggestions presented herein provide a vision and framework for rethinking urban space with sensitivity to sustainable water design. As such, they should not be viewed as final or definitive plans. Community engagement and participation during the future master planning efforts will determine the extent and formal arrangement of these water identities within the Lafitte Greenway.

Managing storm water, balancing groundwater, and introducing and celebrating surface water will result in a more resilient and viable city, leading to economic and social value through the creation of a vibrant, ecologically sensitive Lafitte Greenway.
Plan and section on New Orleans, 1828
Guided by the native inhabitants in 1718, French Colonist Jean-Baptiste Le Moyne de Bienville founded New Orleans at its present location on the relatively high natural levee along the Mississippi River. Convenient and strategic access through Bayou St. John and Lake Pontchartrain to the Gulf of Mexico meant that New Orleans could receive ocean-going commerce while all river trade funneled past its banks. Although the area was predominantly marshland and prone to river flooding and intense storms, a city at the mouth of the greatest water highway on the continent was essential. According to historical geographer Richard Campanella, “the site [Bienville] finally selected represented the best available site within a fantastic geographical situation.”

Governor Périer initiated the construction of a navigation and drainage canal to connect the nascent city directly to the Bayou St. John in 1727, but the project was halted shortly thereafter. In 1794, under Spanish authority and with slave labor, New Orleans Governor Francisco Luis Hector, Baron de Carondelet, successfully completed a six foot wide, one and a half mile long canal from Bayou St. John to a turning basin at its terminus at what is now Rampart and St. Peter streets. After the Louisiana Purchase, this canal was widened and deepened by the New Orleans Navigation Company beginning in 1805, with the canal fully realized by the 1820’s. The Carondelet Canal was 30 feet wide with a 64 foot wide embankment on each side known as the Carondelet Walk, and an enlarged turning basin at its terminus. By the time the citizens of New Orleans approved the creation of a new and revolutionary sewerage and drainage system in 1899, the Carondelet Canal was already in decline. By then commonly referred to as the Old Basin canal, supplanted by the wider and deeper New Basin Canal in the 1840’s it became silted, polluted, and choked with weeds, with its commerce reduced to shallow draft oyster boats. P&J’s Oyster Company, located at the corner of Rampart and Toulouse Streets, one block away from the Carondelet Canal turning basin, is a physical reminder of the waterway.

The introduction of efficient rail freight made both Old and New Basin Canals obsolete by the early part of the 20th century, and they were decommissioned and filled in 1927 and 1950 respectively. Much of the New Basin Canal right of way provided a corridor for the I-10/Pontchartrain Expressway while the Carondelet Canal footprint remains as a fallow strip of land, a former railroad right of way now mostly vacant, publicly owned.
Early colonial map of New Orleans with modern street grid and buildings overlaid. Bayou St. John and other waterways dissipate into the landscape. 
and pregnant with potential for redevelopment. This is the Lafitte Corridor.

While the Carondelet Canal’s main purpose was navigation, it also served as a drainage conduit. The natural slope of the Mississippi levee was created by the river’s sediment as it overflowed its banks during spring floods. Heavier river sands were deposited close to the river, while lighter clays and silt were deposited farther away. New Orleans was founded upon this elevated ground, 15 feet above sea level at its highest near the river, sloping gently downhill towards the back swamp with a former distributary of the river forming a stable ridge of relatively high ground midway between the river and Lake Pontchartrain. The Bayou St. John snaked through the swampy terrain at the level of the tidal Lake Pontchartrain and the saturated land adjacent to it was near sea level. The Carondelet Canal communicated with the lake via the bayou and its level fluctuated with the tide. As storm water runoff flowed downhill from the high ground near the river, it drained into the canal, bayou and back swamp. Relying on the shallow natural slope of the landscape, this early drainage system was wholly inadequate and easily overwhelmed, especially during high tide. Sanitation was rudimentary, while some property owners built cesspools on their properties, most sewage flowed into the open street gutters and stagnated. Early in the 1900’s, Sewerage and Water Board Superintendent George W. Earl described the challenges of draining the city:

First of all, New Orleans had to face the problem of overflows from the Mississippi River and from tidal waters in Lake Pontchartrain, and the construction of levees, first along the river bank, because high water in the river was above the level of even the highest land in the city, and later, in the rear, to prevent high lake tides from backing into the lower part of the inhabited area, followed. Then came surface ditches and canals to drain the storm water into the tidal bayous, which often rose to a level which precluded much relief by such method, since only a small area of land along the river bank in New Orleans is higher than the high tides of the lake, and the ditches and canals were more or less filled by tidal water and gave very inadequate drainage even for the highest portion of the city. Rainfalls of great intensity were of frequent occurrence, and these falling on a ground which was always saturated made the need for better drainage imperative.

In the 1820’s, state engineer George Dunbar proposed an ambitious system of underground canals beneath the streets and mechanical pumps that would drain water into the low-lying swamps. His plans were never realized, due to the Panic of 1827 as well as insurmountable technical challenges. As the century progressed and the city grew, gravity-fed, surface canals were
1892 Rand McNally Atlas Map of New Orleans showing surface canals (blue) and streetcar lines (red) \textsuperscript{10}
dug, expanding the network begun with the Carondelet Canal. By the 1890’s, major canals were located at Broad, Orleans, London, 17th Street, Melpomene, Poydras, Claiborne, Carrollton, Dublin, and Florida. Four drainage machines were built to push water towards the Lake, including one at Bienville and one at Orleans at the end of the Carondelet Canal and Bayou St. John. These machines were fashioned from steamboat paddle wheels and lifted water four to five feet, albeit inefficiently and insufficiently, into the outfall canals that drained to the lake. The canals were often choked with vegetation, trash and sewage and due to the low slope, and they were rarely flushed. Rainwater frequently flooded the streets from curb to curb and remained for many days as illustrated by the Alexander Allison photo at left.

For the duration of the 18th and 19th centuries, the drainage and navigation canals also served as the primary sewage system. Drinking water was provided by rainwater stored in typically open cisterns and waste was collected in cesspools or deposited directly on the street. These two practices, combined with the standing water in the streets and gutters, resulted in contaminated drinking water and noxious odors and provided the ideal environment for mosquitoes to breed. Before Dr. John Snow’s theory that cholera was spread by water tainted by human waste was conclusively proven in the 1870’s and Dr. Walter Reed proved that mosquitoes transmitted yellow fever in 1900, miasmas (foul air or “mal aria”), and fomites (transmission through contaminated objects or people) were blamed for the deadly epidemics. The continuing epidemics and frequent flooding depressed business and investment. Once it was understood that the lack of drainage was not only inconvenient but deadly, the citizens of New Orleans demanded a new system to provide clean drinking water, remove sewage and drain the city.

In 1893, the Drainage Advisory Board was established and careful consideration of New Orleans drainage and sanitary problems commenced. Transects of the landscape were measured from river to lake and the first detailed topographic map of the city was drafted. The existing drainage system, rainfall measurements and settlement patterns were documented, and a plan was developed that would dramatically change the landscape of the city. In 1899, a bond measure was approved by the citizens of New Orleans to construct a comprehensive drinking water, sewerage and drainage system.

Improved pumping technology allowed greater lifting capacity and the drainage canals were deepened to be ten to fifteen
Patent diagram of the Wood screw pump and the early engineered drainage system it enabled. 14

Above and left: first measured contour map and drainage proposal for New Orleans in anticipation of a mechanical drainage system, 1895. 15, 16
feet below grade. The primary canal was installed along Broad Street, running west to east between the Gentilly and Metairie Ridges through the lowest point in the city to the Bayou Bienvenue and Lake Borgne. The system was designed so that the first flush of runoff would carry polluted water to the marshes around Lake Borgne through the Broad Street canal and the subsequent storm water would flow to Lake Pontchartrain through the improved Metairie (now 17th Street), Orleans, London Avenue and Lafayette (now Peoples) outfall canals. The planners recognized that the health of the lake front was critical for the success of the resorts at the ends of the New Basin Canal, Bayou St. John and at Milneburg. The navigation canals and Bayou St. John were no longer used for drainage as their tidal based water level was well above the elevation of the new system.

A separate system for sewage was developed that pumped effluent into the Mississippi down river from the city, while a massive water treatment plant brought in fresh water above the city, replacing mosquito breeding rain cisterns with metered potable water. The terracotta pipes of the sewerage system were loose fit to provide flexible joints. As a result, additional groundwater was drawn out of the saturated soil by continual pumping to the river. Highly efficient screw pumps were invented by in 1913 Albert Baldwin Wood, a young Sewerage and Water Board engineer and local resident, and installed at the outfall canals. With the deployment of these powerful pumps, the New Orleans drainage system was the most technologically advanced system in the world. Due to their efficiency, this pump design became internationally recognized and was used the Dutch to drain the Zuider Zee and tame their own landscape.

Lowering the level of the canals drained groundwater and pumped water out of the swamps and marshes. The immediate effect was the desaturation of the typically water-logged New Orleans soil, providing increased runoff rates during rain events, enabling a previously wet, swamp and marsh landscape to be developed. The city expanded north into the drained lowlands from its densely populated sliver by the river. With confidence among most that this mastered landscape could be developed, residential construction ensued. Structures from the 1920s and 1930s were often raised, with lower areas used for garages, storage or rental units, but post-World War II development abandoned the traditional raised housing type and ranch-style, slab-on-grade houses dominated the new landscape. Ironically, the newly available land was well below sea-level, and
Maps of the Carondelet Canal from the Robinson Atlas of 1883 and the Sanborn Map of 1909.\textsuperscript{21,22}
continually lowering in elevation due to subsidence caused by the removal of groundwater from the porous, oxidizing, organic soils. Throughout the 20th century, the drainage infrastructure of pipes and pumps was expanded and fortified. Pile-supported box culverts remained high while adjacent land fell away. Concrete floodwalls were erected along the outfall canals, still open to Lake Pontchartrain, to prevent storm surges from flooding the city. While routine drainage may have been improved, the frequency of street flooding during intense rain storms increased due to a combination of reasons, including greater areas of hard surfaces that created more run-off, and perhaps more importantly, the system’s inherent inability to store or retain water. The Sewerage and Water Board’s advertised capacity to drain and pump the city is a storm event of one inch of rain per hour over a twelve hour period. With the increasing frequency of severe rainfall that exceeds this capacity, new approaches to drainage must be explored.

Hurricane Katrina revealed the folly of the levee and drainage strategy and the hubris of the City’s reliance upon this flawed defensive system. The floodwalls were not overtopped, rather they were undermined by water moving through the soil below inadequate sheet piles. Post-Katrina, the US Army Corps of Engineers reassessed the external flood protection of the metro-area and have been upgrading it to meet the 100 Year Flood Protection status. New closure and pumping structures are being built at mouths of the outfall canals, without holistic or systematic consideration of internal drainage. A new effort to study the city’s relationship to water that considers soils, groundwater, water retention and storage capacity in addition to drainage is necessary for the long-term sustainability of New Orleans. The Lafitte Corridor has a vital role to play in the water system of the new city, as the Carondelet Canal had in the old one.
The Lafitte Greenway Master Plan, developed by the Friends of Lafitte Corridor (FOLC) and BROWN+DANOS landdesign, inc. in 2007, proposed to reclaim the Carondelet Canal and former railroad right of way and convert it into a linear park for recreation, bicycle transportation as a catalyst for redevelopment. Opportunities for restoring the Old Basin Canal as a water feature and to use the Lafitte Greenway as a water retention, detention and bio-filtering zone have been promulgated through the Dutch Dialogues (see Appendix) and many student theses, planning projects. These previous efforts were considered in our analysis of the Greenway.

Data collection is a necessary first step in the development of a new water sensitive design framework. Geographic Information System (GIS) mapping of the corridor overlaid critical data such as topography (at 3” contours), subsurface infrastructure, FEMA flood zones, and blighted and adjudicated housing. On the ground surveys of existing conditions, including photography and detailed measurements of surface features, allowed the creation of base maps to illustrate the context of the Lafitte Greenway. The installation of groundwater monitoring stations and soils testing for hazardous materials are necessary next steps to gauge current and future subsurface conditions of the landscape.

The corridor has four distinct, existing physical identities over its length herein designated as Spatial Zones. Typically, the surface elevation of the corridor’s cross section is higher than the surrounding landscape due to the elevated railway and the filled canal and its modest levee. The Carondelet Canal was close to sea level and the current Lafitte Corridor remains fairly flat over its length with higher ground in Zone 1 and at the Metairie Ridge in Zone 4. The LIDAR elevation map at left indicates topography above (red) and below (blue) mean sea level (yellow). During the flooding caused by the levee failures after Hurricane Katrina, most of the corridor remained high and dry. Above ground, the right-of-way is easily understood as a linear empty space and as an interruption of the street grid. Below grade, infrastructure is organized around and adjacent to the corridor, where the former canal and railway lines were an impediment. Street and infrastructure crossings occur only at a select locations, a rare opportunity that provides continuous space for surface water management and greenway interventions.
The first distinct zone begins across Basin Street from Armstrong Park on the north edge of the French Quarter and runs to Claiborne Avenue. The former canal right-of-way is roughly 200 feet wide while the railroad corridor is another 300 feet. Much of the landscape consists of impervious parking for the abandoned Winn-Dixie grocery store, the recently renovated Basin Street Station Visitors Information Center and an RV Park. For the purpose this study, the entire width of the former corridor, including the grocery store and RV Park, were considered. It is noteworthy that at Basin Street, named for the turning basin that defined this place in the urban network, the corridor connects to historic Congo Square.
ZONE 2: CLAIBORNE AVENUE TO BROAD STREET

The second zone starts at Claiborne Avenue and runs to the pumping station at Broad Street. The width of the corridor tapers from approximately 450 feet to 150 feet at Broad. The former railroad corridor is currently vacant and a large parcel was recently acquired by the City of New Orleans. The Sojourner Truth Community Center and the only open, public NORD swimming pool in the city are important community assists located within the former canal right of way. Tennis and basketball courts, playing fields and playgrounds in need of restoration are also located in the corridor. A large mixed-income and mixed-use HUD housing redevelopment project is currently under construction at the directly adjacent Lafitte Public Housing site, demolished after Hurricane Katrina. These new houses are being constructed on raised fill and though the project has its own internal drainage system, its runoff will potentially have an impact upon the adjacent neighborhoods, street system and the Lafitte Corridor.
Crossing Broad Street, the character and topography of the narrow corridor, 200 feet wide at this point, changes. A concrete, open outfall canal, 25’ wide and 15’ feet deep runs from Pumping Station #2 north to Jefferson Davis Avenue where it disappears and splits underground into two separate culverts that continue up Orleans Avenue to Pumping Station #7 and Lake Pontchartrain. The drainage canal is a barrier and a hazard, blocking the street grid and the flow of water across the Lafitte Corridor. Occasionally, ducks and fish occupy the deep culvert, but trash and debris are more typical. The drainage channel was installed during the last century as the new citywide drainage plan developed. It coexisted with the Old Basin Canal which was at a substantially higher elevation. Sandwiched between was the railway. Municipal storage buildings and yards and a former brake tag inspection station fill most of the Carondelet Canal right-of-way today.
HAGAN STREET BASIN

Underground drainage system near Bayou St. John.

Sections through the corridor at Bayou and near Broad Street, 10x vertical exaggeration.

Rain Water Impounded by Concrete Drainage Canal

Subsidence at Hagan & Lafitte

Subsidence at Drainage Canal and Jefferson Davis Parkway

Top of buried canal exposed behind post office
The neighborhoods on either side of the Lafitte Corridor in this stretch are substantially lower in elevation due partially to subsidence caused by the drainage system. Street drainage on the west side of the canal either flows directly into it or is pumped back to Broad Street. The eastern side has significant street flooding issues, in an area referred to as the Hagan Street Basin, defined by the naturally high Esplanade Ridge and Orleans Avenue to the east, the Bayou St. John levee to the north and Broad Street to the south. During intense rain events, runoff flows towards the Lafitte Corridor and is impounded by high ground. The subsurface storm drains and catch basins are undersized and ironically flow opposite the natural slope of the landscape towards the canal under Orleans Avenue and back subsequently to the main canal under Broad Street. An extensive hydraulic analysis of the area was completed in 2004 by Brown Cunningham Gannuch and Integrated Logistical Support, Inc. It was determined that the lowest cost and most effective solution for improving drainage was to provide an outlet directly into the outfall canal in the Lafitte Corridor in addition to reworking subsurface drainage. Alternates were more expensive and deemed less feasible due to the simple fact that the Broad Street canal’s 10-year flood elevation is higher than the area, plus the installation of larger diameter pipes was required for water storage capacity.iii

At the intersection of Jefferson Davis Parkway and Bayou St. John, the Lafitte Greenway has great potential to transform, reveal and celebrate a currently obscured, historically significant landscape. Bayou St. John once trailed off into the marshes, but is now truncated at a concrete lined embankment that resembles a boat launch while the connection to the Old Basin Canal is forgotten. A manhole cover in the middle of the Bayou provides access to a valve that can be opened to drain into the Orleans Canal like a bathtub. This reach of the Bayou is relatively stagnant with limited tidal action and an outflow into City Park creating circulation. Currently, water testing stations at this end of the Bayou and at several other locations are monitoring its ecology to determine how to improve its health. Providing better communication with Lake Pontchartrain and a constant flow through an outlet at the end of the Bayou would have positive benefits. One of the underground canals is revealed on the north side of the Post Office. With its concrete cover indistinguishable from the surrounding streets, it is used as an alley and for parking. The derelict Lindy Boggs Medical Center provides a prime site for redevelopment facing the Bayou, Jefferson Davis and the Lafitte Corridor. A public place of prime import for ceremonial functions and urban legibility can be readily imagined at this critical historic and physical hinge point.
ZONE 4: BAYOU ST. JOHN TO CANAL STREET

The fourth zone has a significantly different character, width and potential. Running from Jefferson Davis Parkway to Canal Boulevard along St. Louis Street, the future Greenway will exist along a former railroad corridor. Adjacent industrial buildings confine the corridor for most of this stretch with a few residential blocks mixed in. The high railway bed sheds water to the neighborhoods, and there has never been subsurface drainage in the zone. Large empty lots and vacant or under-utilized buildings alongside the corridor provide opportunities for intelligent redevelopment.
LAFITTE GREENWAY
Retain, Store, Drain, Replenish, Balance
LAFITTE GREENWAY SUSTAINABLE WATER DESIGN

WATER IDENTITY 1: FRESH WATER + RAINWATER COLLECTION

WATER IDENTITY 2: BRACKISH WATER + RAINWATER COLLECTION

WATER IDENTITY 3: FILTER ON-SITE RUNOFF CAPTURE TO LONDON AVENUE CANAL TO ORLEANS AVENUE CANAL

MISSISSIPPI
FRESH WATER
BAYOU
ST. JOHN
BRACKISH WATER
HAGAN STREET DRAINAGE AREA

Neighborhood runoff flows toward Lafitte Corridor into curbside rain gardens and overflow compartments to mitigate localized flooding.

LAFITTE HOUSING DEVELOPMENT

New development built on raised fill will channel additional rainfall onto surrounding streets. The Laffite Greenway will alleviate increased runoff.

PERMEABLE EDGES

All along the corridor - and potentially throughout surrounding neighborhoods - curb cuts and rain gardens filter and detain water during rain events.

FRESH WATER WELL

The fresh water system beginning at the old turning basin can be charged with aquifer water or pressurized groundwater from the Mississippi.

PUMPING STATION #2

Fresh and brackish water mix and enter existing drainage systems.

GROUNDWATER MONITORING STATIONS

An array of monitoring stations will collect groundwater data for design development and ongoing management.

FRESH WATER WELL

The fresh water system beginning at the old turning basin can be charged with aquifer water or pressurized groundwater from the Mississippi.

BAYOU BASIN

Enlarged bayou terminus provides attractive public space, habitat, and room for bio-filteration zones.

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THREE WATER IDENTITIES

Three distinct water identities for the Lafitte Greenway have been developed. The first hydrologic identity extends from Basin Street to the pumping station at Broad Street (Zones 1 and 2), the second continues to the Bayou St. John (Zone 3), and the third extends to Canal Street (Zone 4). Water strategies are proposed for the Lafitte Greenway that address or mitigate the shortcomings of New Orleans’ current drainage model and look forward to a city-wide, sustainable water system.

Existing Water System
- An overburdened drainage system results in flooding on a regular basis
- Closed subsurface piping and canals have limited capacity for storage
- Pumping to the outfall canals is the only discharge path for storm water
- Continuous pumping lowers the water table and causes subsidence
- Untreated urban runoff is flushed directly into Lake Pontchartrain
- Sewerage and Water Board has the largest carbon footprint in New Orleans due to high energy use and damaged, inefficient systems
- Ambient air temperatures increased when open waterways were replaced with covered canals and groundwater level was lowered
- Divisive and unattractive drainage features are physical and social barriers
- No amenity from or value derived from hidden drainage infrastructure or forgotten historical waterways

Sustainable Water System
- Alleviate load on pumping system, reduce street flooding, and increase safety by providing space for water storage and retention
- Minimize subsidence with balanced groundwater
- Improve water quality by mitigating runoff
- Promote resilience to climate change, including flood, drought and heat, by increasing waterways and green space that create micro-climates and act as heat sinks
- Reconnect neighborhoods and individuals to healthy water network, providing urban amenities and ecological, economic and social value
Fed by a well source near the Carondelet Canal turning basin charged with deep aquifer water or shallow groundwater pressurized by the Mississippi River, a meandering channel will carry water north through and alongside the bike path, recreational areas, playing fields, urban gardens, and other community assets to be designed during the Lafitte Greenway design development. The water course will have additional capacity for storm runoff storage and will help to balance and replenish the groundwater in the adjacent terrain by slowing, filtering and detaining water. A continuous flow, with aerators and fountains, in addition to beneficial, natural predators, such as birds, fish and frogs, will limit the development of mosquitoes. Curb cuts and rain gardens will create a permeable edge to the Lafitte Corridor that will collect, filter and drain adjacent street runoff.
Potential section through Water Identity 1. In this wide zone, many programs are compatible with water management strategies.
Fazenda, Sao Paulo, Brazil. Cascading Water and Plantings

Example of Curbside Rain Garden in Portland, Oregon
An extension of Bayou St. John into the Lafitte Corridor provides the identity for the second, brackish water zone. A new, surface canal will carry brackish water from the Bayou south to the pumping station where it will be sent to on to the Orleans and London Avenue canals. This new water system proposed during the Dutch Dialogue III charrette in April, 2010 would continually circulate brackish water from Lake Pontchartrain at an elevation of one foot below mean sea level to the drainage canals at an elevation of minus five feet. By providing an outlet for the Bayou, it can once again communicate freely with Lake Pontchartrain, improving its ecology. Two options were developed during the charrette regarding the existing drainage canal in the zone. One scheme proposes covering it and locating a bicycle and pedestrian path atop it while providing a second surface waterway adjacent to it. The second scheme proposes creating a double decker canal with the brackish water on top. In either case, space for storm water would be provided with wide and shallow zones alongside the main channel with a few feet of available freeboard that is safe to flood. Wetland zones would provide habitat, storage capacity and a filtration zone for street runoff. Brackish water is not a favorable environment for mosquitoes, and therefore the flow of the water can be gentle. To alleviate the Hagan Basin flooding, new drainage conduits would transfer street runoff across Lafitte Street and into the greenway filtration and storage areas. Due to the high elevation of the corridor, substantial excavation will need to occur in this zone.
Aerial perspective of the Lafitte Greenway from Bayou St. John looking towards downtown New Orleans
The intersection of Bayou St. John and the Lafitte Corridor would be celebrated and expanded in this vision, which appropriately reflects the prime importance of this juncture, not only in the Lafitte Greenway but also the city as a whole. In the scenario below and rendered at left with an aerial perspective, the short length of Lafitte Street at Moss Street would be removed and Jefferson Davis Parkway would be realigned northward towards the American Can Company. Simplifying the street grid will reduce crossings for the bicycle path and provide more area for water and green space. An island in the middle and increased parkway area alongside the Bayou would provide new and expanded performance, gathering and recreation space. The suburban US Postal Office currently existing in the footprint of this re-imagined landscape could be relocated to the Lindy Boggs Medical Center site and provide a ground floor, community oriented, retail anchor for the redevelopment. While this reordering of streets and public space is an ambitious vision that exceeds the boundary of the Lafitte Greenway project, the proposed water system is not dependent upon it to be successful.
Existing:
Section through Water Identity 2 at N. Gayoso Looking North
LAFITTE STREET

Filled Canal and Railway Corridor Impede Storm Water from Low Lying Surroundings

Former Carondelet Canal (Filled)

Subsurface Storm Water Drainage to Orleans Avenue is Undersized
Westerpark, Amsterdam, NL

Water storage area with hydrophylic tree plantings
Option 2
Potential Section through Water Identity 2. Covered canal improves safety and provides level, elevated bike path while a new waterway in the former Cardondelet Canal right-of-way provides an outlet for Bayou St. John, water storage, and a wetland zone.
Hemradsingel, Rotterdam NL. Soft edged canal

Westerpark, Amsterdam, NL
North of the Bayou, just as the spatial character changes significantly, so too do the requirements for water management and the opportunities for its articulation. The challenge in this narrow zone is to capture surface runoff and to filter it through vegetation and soils into the groundwater. Along the length of the relatively high corridor, a series of bio-swales and rain gardens would detain, filter and drain water from the Greenway and adjacent street runoff. Underground drainage infrastructure does not currently exist in this narrow zone, and therefore a new, permeable conduit for water would collect and conduct overflow to the nearest, existing drainage features while infiltrating soil and replenishing groundwater. Currently a broken asphalt and gravel hardscape with opportunistic weeds provides minimal greenery, however, the future artery would become lush with water-loving vegetation that provides visual interest, wildlife habitats, and with appropriate planting, shade to pedestrians and bicyclists using the Greenway.

Potential section through Water Identity 3. Even narrow spaces can accommodate paths, plantings, and water storage.
A comprehensive and fine grained understanding of soil and groundwater is vital.
In addition to those illustrated in the Water Identity section, the following steps are needed to advance design for a responsive and resilient Lafitte Greenway:

- Testing of soils used to fill canal and in adjacent former railroad right-of-way to determine level of pollutants and hydropedological characteristics.
- Map quality and fluctuating level of groundwater
- Continuous monitoring of surface water and groundwater dynamics using observation wells with deep filters. These monitoring stations would study the rate of seepage or infiltration of surface water into soils and would help determine the effects of re-introducing surface water into the landscape
- Soil movement monitoring to study the effect of the water system upon subsidence
- Discussion and determination of water quality objectives for surface water is needed. Are water features for habitat creation and groundwater balancing or also for recreation and swimming?

Soil boring in the Netherlands

Deep soil section through Elysian Fields
Diagram illustrating the connection of the French Quarter to Lake Pontchartrain via the Lafitte Corridor and Bayou St. John with the potential water network and significant urban nodes highlighted.
Redevelopment of the Lafitte Greenway provides an opportunity to enhance two historically significant urban public spaces:

- Congo Square and the Turning Basin
- Jefferson Davis Parkway and Bayou St. John

The progression of hydrological areas identified here in the Lafitte Corridor will give scale and interest to this linear green space, reflect unique hydrological conditions and educate the public on issues related to ecology and water management. Of the three hydrologic zones described in this study, we recommend Water Identity 2, the area between Jefferson Davis Parkway and Broad Street, as the likely location for a future demonstration project. It is key to addressing the multiple ecological and infrastructural issues this study identifies:

- New Orleans’ Water System
- Health of Bayou St. John
- Hagan Street Drainage

An analysis of the street network and vehicular rights-of-way throughout the Greenway is warranted. This should be coupled with redevelopment plans and strategies for adjacent parcels. Improvements to the Lafitte Corridor Greenway offer substantial potential to spur investment and economic recovery, particularly when coupled with proposed redevelopment of Claiborne Avenue.

The integration of water sensitive design into the redevelopment of the Lafitte Greenway will offer multiple benefits to the surrounding neighborhoods and the city as a whole, including:

- Large areas of storm water storage and retention will alleviate loads upon pumping station and reduce street flooding;
- Incidences of flooding will decrease, reducing flood and homeowners insurance rates for local residents;
- Visual and recreational amenities will be enhanced and the community's inventory of green space will be increased;
- Property values will increase through access to water;
- Subsidence will decrease with balanced groundwater;
- Urban runoff will be mitigated, resulting in the improved health of Lake Pontchartrain;
- Trees and vegetation will increase, nourished by adjacent waterways;
- Ambient air temperature
- Habitat for diverse, beneficial species of fish, amphibians and birds

Water-sensitive design must be integrated at every level of architectural and urban planning, from measures to reduce and detain runoff from individual houses, commercial and public properties to large scale water retention, and storage intervention opportunities, such as the Lafitte Greenway.

In summary, sustainable design, including water management, must be a priority for future design teams, together with community discussions about such strategies and policy changes among city agencies. Such engagement among community constituents and elected officials is vital in determining the water and landscape identity of the Lafitte Greenway. Through intelligent, water-wise design, a landscape can be re-created that celebrates the aesthetic qualities of the region, harnesses the potential benefits of existing environmental amenities and cultural resources, and protects against potential environmental dangers of living below sea level.
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APPENDIX A
Dutch Dialogues
LIVING WITH WATER

With crisis comes opportunity. After a total disruption of day-to-day life, possibilities for change and re-ordering of priorities arise. In post-Katrina New Orleans, we have seen, however, that needed changes do not necessarily result. A traumatized population sought to re-establish itself in ways and places like before. Without guidance, financial inducement or compensation this response is understandable, if unwise.

A challenge as large as redefining an established city’s relationship to the base layer of ground and water, and developing an infrastructure appropriate to this re-envisioned layer is in any case difficult. This is compounded by a lack of post-disaster resources and a fractious political context with limited leadership. In this situation, Dutch Dialogues aspires to create a vision of a different, more desirable city and to educate not only the politicians, but also the populace.

No place is more in need of a transformative vision and process for water management than New Orleans and the Mississippi Delta. Long bound by a regime of levees, pumps, and pipes, the city has turned its back on its prime asset, water, and exacerbated its subsidence. After decades of levees and drainage for flood protection and navigation, with channels cut through the marsh for commercial purposes, the wetlands in south Louisiana, now buffeted by the great oil calamity of 2010, are receding at an alarming rate.

A shift in paradigms is fortunately underway. Large scale diversions of the river’s flow and sediment can revive coastal wetlands downstream. Plans and initiatives to speed and increase these diversions are in progress. The perimeter defense system built by the Corps of Engineers around the city, though more robust than before Katrina, not only provides a lower level of protection than the urban area needs for safety and re-investment, but also is less flexible than would be desired. It is nonetheless a base line that must be amplified, supplemented and built upon in the years and decades ahead.

The third component of the storm defense and water management system is the urban water system. Here the balances between existing and envisioned, man-made and natural can be explored. Implementing the idea of living with water instead of fighting against it, the urbanized settlement can over time be transformed. Instead of wasting soil and ignoring water, a
shift to cherishing earth and the root it provides, and revealing and revering water is needed. Crucial balances in process of re-evaluation include land and water; habitation and infrastructure; buildings and open spaces; hard and permeable surfaces; fresh and salt water gradients; levees, perimeter defense structures, and storm surge; and the effect of variable “sea level” and higher limits on operating levels for the urban water system.

Adaptations are fundamental, but conceivable and ultimately achievable. The planning time frame needs to shift from a five year horizon to fifty years. A vision-driven, learning-based approach is nascent, and with nurture can bear fruit. A consensus-based water strategy just commenced is a key step in this transformative process. To succeed, an integrated approach developed from a multi-level perspective is required. Change must encompass the whole system, with targeted starting points. To succeed, focus should be on windows of opportunity instead of barriers. Non-interactive models, like that of the Corps need to be supplemented. Ecological memory, learning from the past, is instructive and should be recalled.

Several principles and ideas have risen in consciousness. Lessons are learned. We must make space for water. Landscape is not a secondary idea but a prime contributor to the health and sustainability of the settlement. Trees and plant materials are vital to the livability of this sub-tropical area. Specific attention must be paid to the underlying layers of soil and groundwater. Hydrological units or sub-basins, perhaps developed into polders, are the district level structure of the city. Planning for transportation, infrastructure, and water management should be integrated with spatial planning. There is an existing urban form with and from which we build. At the larger public scale, a circulating water system is essential, multi-purpose infrastructure. Private as well as public property must contribute to the water storage solution. Biological as well as human diversity and healthy development should be encouraged. Alternative funding strategies, like awards and incentives for citizens and developers, or credits to offset energy or utility use should be developed.

New Orleans is inevitably an ecological borderland. With engaged citizens providing specific knowledge, a flexible planning culture and a commitment to learning, through innovation and feedback using a science-based, place-based approach, an adaptable and highly desirable water city of an expanded, productive garden type can be sustained in the Mississippi Delta.

Two similar Dutch Dialogue proposals for the Lafitte Corridor.
Proposed water system that provides internal storage and integrates neighborhoods with fresh and brackish water at multiple scales.

Exaggerated Section Illustrates Groundwater and Soil Strata
To this end, a series of multi-disciplinary, cross-cultural and inter-generational workshops known as Dutch Dialogues has been organized in New Orleans. The first of the Dutch Dialogues was held in March 2008 to explore if, where and how Dutch approaches to water management, landscape architecture, flood protection and urban design are relevant to New Orleans as it recovers from Hurricane Katrina. Dutch Dialogue 2 was held in October 2008, bringing together 60 experts to develop illustrative solutions and design approaches at regional, sub-basin and neighborhood scales that could make New Orleans more flood-proof, sustainable, resilient, and attractive from both urban design and economic perspectives. Dutch Dialogue 3 gathered 70 participants in New Orleans in April 2010 in conjunction with the American Planning Association 2010 National Planning Conference. During this workshop, a proposal for a circulating water system that could serve as the framework for sustainable development was outlined along with related, transformative ideas for City Park, the Lafitte Greenway, and a residential district between the London Avenue and Orleans Avenue outfall canals that encompass City Park.

It should be understood that the problem, as well as the solution, of living in a Delta City is fundamental. Without taking account of the relationship with water, disaster at one scale or another will recur. Without making visible this element, it remains out of mind, and land and water become out of balance. Maladies like subsidence and flooding recur. By taking advantage of the opportunities the physical situation presents when managed intelligently, when designed with function and aesthetics in mind, benefits accrue and prosperity ensues.
APPENDIX B

Rebuilding the Carondelet Canal in New Orleans?

Roelof Stuurman, Deltares
Rebuilding the Carondelet Canal in New Orleans?

Introduction

Large parts of the filled Old Carondelet Canal strip are now unused. During the Dutch Dialogues meeting in October 2008 the forum questioned the lack of surface water canals in the city of New Orleans. Urban surface water systems can improve the quality of life (recreation, view), but also increase economy (tourism). In the Netherlands many urban canals were also filled in during the 19th and 20th century. These canals were changed into roads, tram rail lines and parking lots. At the last decades of the 20th century and the beginning of the 21st century a process of reopening and restoration of canals and filled harbors started. The most important objectives of these restoration activities were (1) increase urban quality in the center of cities and (2) increase surface water storage capacity in cities.

From a Dutch perspective and experience, where should we think about planning the restoration of the canal?

“With water life returns”. Temporary artist impression of canal restoration in the city of Drachten.
History of the Carondelet Canal

The canal was built at the end of the 18th century to connect the Bayou St. John with the Vieux Carre (Old Quarter) of the city. The restoration possibilities of the Carondelet Canal cannot be studied without taking into account the interaction with Bayou St. John.

17-18th Choctaw Indians introduced the four mile water route (Bayouk Choupic, later Bayou St. Jean, Bayou St. John) to the new settlers (‘muddy stream barely ten feet deep’). The Bayou was surrounded by cypress swamps;

1701 The French built Fort St. Jean at the confluence of the Bayou and Lake Pontchartrain;

1718 New Orleans was founded;

1727 Governor Périer initiated push for canal. Work commenced but was abandoned;

1794 The Canal was built during Spanish administration by convicts and 150 slaves; a shallow ditch, 2 miles long, 15 feet wide and six feet deep. The canal connected the city with Lake Pontchartrain;

1796 Canal was improved (wider and deeper) and six floodgates were built to divert floodwaters. The canal was used for drainage and shipping;

1799 Renovation of Fort St. Jean renamed Spanish Fort;

1809 President Thomas Jefferson & Congress spent $25,000 to lengthen the canal and to deepen the Mississippi channel. The Orleans Navigation Co. cleared and widened the canal, improved the turning point (turning basin, 7400 m²) and dredged the Bayou (costs $375,000). After construction ONC offered poor canal management. Around 1820 some 70-80 ships sailed every day. Along the Bayou bank people lived in house boats;
1838 After construction of New Basin Canal the Carondelet Canal lost its commercial value. Only small rowing boats and canoes remained;

1875-1900 Rail line along the canal connected the city with the lake (Bayou St. John Railroad). Resorts and amusement parks emerged on the lakeshore;

1900 Massive reclamation project instituted against flooding and epidemics; swamps and marshes drained;

1927 The Carondelet Canal was declared not navigable;

1938 The canal was filled in and later the ground was used for rail lines

*The Old Basin harbor near the French Quarter (1900s)*
A generalized geological profile between Mississippi and Lake Pontchartrain.

**Geomorphology, Geology and hydrogeology**

The Carondelet Canal was built perpendicular to the Mississippi River bank deposits (point bar). The Old Turning Basin was constructed at the northern edge of this point bar. The bottom of the point bar deposits is situated at approximately 100 feet below MSL. Especially the deeper parts of this point bar consist of permeable sands that are connected to the Mississippi River gully. This is important for groundwater flow. Most parts of the Carondelet Canal were built in an area of soft peat and clay deposits. The deeper parts of the soil consist mainly of clay and silt with some sand lenses and will act as an aquitard for groundwater flow. It is possible that the shallow deposits (peat, artificial fill) have a higher permeability for groundwater flow.

Surface water level in the Mississippi fluctuates, rising 20–0 feet above MSL (NGVD) with a mean level of 11 feet above MSL. In the past the water level in the canal was approximately sea level. It is presumed that there was a significant groundwater flow component from river gully to the Old Basin (app. 4000-5000 feet (1350 m) distance and a hydraulic head gradient of app. 11 feet). The surface level elevation near the Old Basin was 24-25 C.D. (?) above sea level. The distance between surface water level and ground level in the past is not clear. One imagines that this distance became higher in southern direction of the canal, and presumes that near The Old Basin the canal had a draining effect on groundwater and possibly caused ground settlement. In the northern part of the canal the canal buffered groundwater levels which was favorable in relation to settlement risks.
Experiences with the restoration of the harbor of the city of Breda (North-Brabant)

The European Union supported the project “Water: the blue carrier for spatial development in historic city centers”. The title reflects the central role that water is increasingly playing in the structural intensification of old city centers which have a historical relationship with water. Many European cities are not only facing increasing problems, but are also offering challenges with regard to sound water management. The six Participating cities in this project were: Breda (lead partner) and ‘s-Hertogenbosch (both from The Netherlands), Chester (England), Gent and Mechelen (Belgium) and Limerick (Ireland). These six cities joined together because their history is irrevocably linked to water, because they have been engaged in planning and executing water-related projects and because they are very similar as regards size, historical development and socio-economic aspects. The objectives, in order to contribute to the quality and sustainability of the historic city centers, are:
to use ‘historic’ water as a basic quality for spatial redevelopment of the city centers,

- to use the quality of water to support the multifunctional use of the limited space in inner city centers for economic, cultural and residential functions and simultaneously,
- to realize integral water management.

The following are brief descriptions of these six local demonstration projects:

- Breda the restoration of the historic watercourse and harbor in the city centre;
- Chester the creation of new public spaces along the River Dee to intensify the historic relationship with the city centre;
- Gent the re-excavation of the filled-in Nederschelde in the centre of the city;
- 's-Hertogenbosch the revitalization of the watercourse The Dommel through the city;
- Limerick the restoration of the Park Canal between the University City and the medieval City;
- Mechelen the reopening of the old stream The Melaan and redevelopment of the entire public areas.

The € 30 million harbor restoration project of Breda was finished in 2007. The canal was filled in during 1965 and transformed into a parking place. Re-introduction of water improved the quality of the area enormously, although the restaurant and catering trade believes that it could be improved, by buffering wind at the terraces. Also they are missing a lively water front, partly caused by bridges too low pass to under, so that at present only small, low ships can visit the harbor.
The harbor area of Breda

Some possible restoration scenarios for the Carondelet Canal

According to the historical and geological information the following rebuilding scenarios can be imagined.

1) Restoration of the Bayou-Carondelet Canal water system, the preferred but most ambitious scenario; This lay-out is close to the historical situation and has many benefits;
   a. a water and water bank connection between the city and Lake Pontchartrain;
   b. therefore the possibility to create a lively water system and waterfront;
   c. also ecological and educational opportunities like the creation of local wetlands along the salt-fresh interface in surface water and/or strengthening historical sites;
   d. increase surface water storage; and
   e. use of canal and Bayou water for groundwater level management to fight settlement with the help of irrigation/infiltration drains.
Major problems to be solved are:

a. How to connect the canal with the Bayou. An open connection like in the past or a lock-gate. An open connection is of course preferred but can intensify ground settlement. Perhaps higher water levels in the Carondelet Canal are necessary to combat settlement;

b. How to connect the Bayou with Lake Pontchartrain;

c. How to recharge the canal. One presumes that drain water quality conflicts with recreational objectives. Will there be enough groundwater recharge, especially from the river into the Old Basin.

d. How to manage water circulation; and

e. The height of bridges needs to be increased.

2) **Restoration of the Carondelet canal only;** this option still benefits the urban quality but is less vivid because boat transport will be low. The canal can be used for recreation and groundwater supply by drains. A study of the expected water balance (also in relation to the expected water quality) is needed. Perhaps water supply from the Mississippi is necessary to manage water level and water circulation. It is noteworthy that all polders in The Netherlands are recharged by surface water during dry periods. Also research is necessary to determine how to discharge water at the lower end of the canal.

**Conclusions and Recommendations**

According to experiences in Europe and the Netherlands, restoration of the Carondelet Canal will improve the urban quality and environment. The canals and canal sides are used for recreation, building and to increase surface water storage. Research topics include:

**Soil and geology:**

- Determination of sediments that silted up the canal;
- Determination of the soil quality in the project area and the quality of the sediments and/or materials used to fill the canal;
- Determination shallow geology (app. 10 m –sl.): production of several transects perpendicular to the canal. Also the depth of hydropedological characteristics need to be determined (can be used to estimate groundwater level fluctuation).
- The boreholes are used for groundwater monitoring observation wells;
- Determination of the deeper geology and hydrogeology (100-150 m –sl.): production of a deep transect from the Mississippi-Old Basin-center of old Carondelet Canal-Bayou St. John. The boreholes can be used for groundwater monitoring; an inventory of existing geological information is
needed

**Archeology;**
- An inventory of possible archeological sites. The results can also be used for the planning and design for rebuilding;

**Groundwater;**
- Depth of groundwater levels; the actual groundwater levels around the canal need to be determined. To avoid discussions about (possible) damage, observation wells should be implanted in adjacent urban areas (Until approx. 500 m from the canal). The observation wells should be installed at the beginning of design process. Time series including wet and dry periods are valuable;
- Depth of hydraulic heads; To determine the rate of seepage or infiltration (surface water loss) observation wells are needed with deep filters. The geological boreholes can be used. These activity should start at the beginning of the project;
- Dynamic interaction between surface water level and groundwater levels; To determine the effect of reintroducing surface water in this area the relation between surface level and groundwater level need to be studied. This can be done with a groundwater model. The groundwater observation measurement can be used to calibrate this model;
- The numerical model can also be used to estimate the effects of pumping on the surrounding area during the building process;
- Groundwater quality; The observation wells can be used to map groundwater quality.

**Underground infrastructure;**
- Location of cables, conduits, sewerage pipes, drains etc;

**Surface water;**
- Study of the water quality objectives; depending on the water targets for the new canal water quality objectives are needed. In the Netherlands there is a growing use of urban water for swimming;

**Geo-engineering;**
- Study the effect on soil movement;
- Design settlement monitoring network;
- Assess the existing building near the canal to avoid future damage discussions;
- Study to the need and method of canal bank stabilization; The chosen approach can be important for the groundwater-surface water interaction. Ecologically designed canal banks are preferred.
A ship dock can become very lively (left). There small docks which can be served by the boatman himself (right).

The harbor of Breda