The Bayou Bienvenue Wetland Triangle

Issues affecting the restoration of a former cypress-tupelo swamp
Lower Ninth Ward, New Orleans

Water Resources Management Practicum 2008
Nelson Institute for Environmental Studies
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Preface

The Water Resources Management (WRM) program is an interdisciplinary course of study leading to an M.S. degree in environmental studies. Degree requirements include a group practicum focusing on a contemporary water resources problem. In 2007, in fulfillment of this requirement, a group of University of Wisconsin-Madison students studied the Bayou Bienvenue Wetland Triangle and its connection to the Lower Ninth Ward neighborhood. These student researchers published their findings in a document titled "*Wetland Restoration and Community-Based Development, Bayou Bienvenue, Lower Ninth Ward, New Orleans*," (hereby referred to as WRM 2007).

This report represents a second-year continuation of these efforts by a new group of UW students. Although its authors include students not pursuing the WRM degree, the report is based on the WRM model and is submitted in fulfillment of those requirements. Like its predecessor, this report is intended to help Lower Ninth Ward residents and other stakeholders of the Bayou Bienvenue Wetland Triangle better understand the current issues affecting the wetland and plan for its future. Funding for this study was provided by the McKnight Foundation and the Sierra Club—Delta Chapter of Louisiana.

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Cover Photos (clockwise from top): Cypress "ghosts" in the BBWT (photo by Andrew Leaf), a remnant bald cypress in the "Backside" of the Lower Ninth Ward (photo by Dan Cornelius), and the sign (created by Common Ground, a local volunteer organization) marking the Florida Ave observation deck. The sign and the BBWT were illuminated for the First Annual Bayou Bienvenue Days event, held on November 1, 2008 (photo by Dan Cornelius).

Acknowledgements

We are honored to contribute to the ongoing work aimed at restoring the Bayou Bienvenue Wetland Triangle to a healthy cypress-tupelo swamp. This work has been sustained by the vision, devotion and action of Lower Ninth Ward residents and community organizations, academic institutions, non-profit organizations and government agencies.

We would like to enthusiastically and sincerely thank the Lower Ninth Ward community for inviting us into their neighborhood and providing the opportunity to learn from them. The residents have welcomed us into their homes and their lives and have shared stories of hardship and also stories of hope and faith. The Holy Cross Neighborhood Association and the Center for Sustainable Engagement and Development have offered their continuous guidance and assistance. They have made us feel like a welcome and essential part of the rebuilding process. We would like to specifically thank our individual partners in the Lower Ninth Ward who have shown us the human side of these issues: Pam Dashiell, Charles Allen, Warrenetta Banks, Kathy Muse, David Eber, Ward (Mac) McClendon, Smitty, John Taylor and John Koeferl (who generously provided housing for our research team).

It has been a privilege to work with the varied and knowledgeable organizations and individuals who make up the newly-formed Bienvenue Restoration Alliance. We would like to thank these members for continuing to inspire us: the Tulane/Xavier Center for Bioenvironmental Research; the Tulane Water Policy Institute; the Landscape Architecture Program at Louisiana State University; the Landscape Architecture Program at University of Colorado-Denver; the Sierra Club—Delta Chapter of Louisiana; the Lake Ponchartrain Basin Foundation; the Gulf Restoration Network; the Louisiana Bucket Brigade; NOW Bienvenue; the Lower Ninth Ward Village; the Make It Right Foundation; and the Dr. Martin Luther King Jr. Charter School for Science and Technology.

We would also like to thank the Army Corps of Engineers Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) Program and especially Travis Creel for familiarizing us with the technical and institutional aspects of government restoration projects. We would additionally like to thank Eric Glisch for volunteering his time and assistance with salinity monitoring in the BBWT. Also, Rob Moreau, of the Turtle Cove Environmental Research Center (Southeastern Louisiana University) has welcomed us to Louisiana with open arms and has contributed to our scientific understanding of coastal Louisiana.

This project would not have been possible without generous contributions from the McKnight Foundation. The multi-year McKnight grant has allowed this project to grow and expand. In addition, the Sierra Club—Delta Chapter of Louisiana has provided financial support which has allowed us to collaborate more closely with the neighborhood.

Additionally, we would like to extend heartfelt thanks to the University of Wisconsin-Madison's Nelson Institute for Environmental Studies. We would especially like to thank the UW faculty who have provided guidance, reviews and feedback on this project and report. Specifically, the authors would like to thank Lydia Zepeda, who has taken on the responsibility of chairing the advisory committee, and also Lewis Gilbert, Gregg Mitman, Quentin Carpenter, Sue Thering, David A. Hart, Stephanie Tai, Ken Potter, Jack Huddleston, and Joy Zedler.

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We are deeply indebted to the 2007 UW Water Resources Management students who initiated this project and gave it momentum. Their inspiration and continued support have been instrumental in the making of this report.

Most importantly, we would like to thank our faculty advisor, Herb Wang. Dr. Wang has been unwavering in his encouragement and belief in both the students and the project. By allowing us substantial freedom to self-organize and pursue our individual research interests, he has provided us with a unique and invaluable educational and leadership experience. A professor of his caliber is rare, and we are both fortunate and honored to benefit from his guidance.

List of Acronyms and Abbreviations

ARNI	Aquatic Resources of National Importance
BBWT	Bayou Bienvenue Wetland Triangle
BOD	Biological Oxygen Demand
CAWIC	Citizens Against Widening the Industrial Canal
CCC	Criterion Continuous Concentration
CEI	Coastal Environments, Inc.
CIAP	Coastal Impact Assistance Program
CMC	Criterion Maximum Concentration
COC	Constituent of Concern
CPRA	Coastal Protection and Restoration Authority
CRI	Comite Resources, Inc.
CSED	Lower Ninth Ward Center for Sustainable Engagement and Development
CWA	Clean Water Act
CWPPRA	Coastal Wetland Planning, Protection and Restoration Act
CWU	Central Wetlands Unit
DMMU	Dredged Material Management Unit
DO	Dissolved Oxygen
EBWTP	East Bank Wastewater Treatment Plan
EC50	Median Effective Concentration
EDC	Endocrine Disrupting Chemicals
EDMS	Electronic Document Management System
EIS	Environmental Impact Statement
ERL	Toxic Effects-Range Low
ERM	Toxic Effects-Range Medium
EST	Environmental Sampling Technologies
GIS	Geographic Information System
GIWW	Gulf Intercoastal Waterway
GNOCDC	Greater New Orleans Community Data Center
HCNA	Holy Cross Neighborhood Association
IHNC	Inner Harbor Navigation Canal
LAC	Louisiana Administrative Code
LACPR	Louisiana Coastal Protection and Restoration Project
LCA	Louisiana Coastal Area Ecosystem Restoration Study
LDEQ	Louisiana Dept. of Environmental Quality
LDNR	Louisiana Dept. of Natural Resources
LPDES	Louisiana Pollution Discharge Elimination System
LSU	Louisiana State University at Baton Rouge
LULU	Locally Unwanted Land Use
MDP	Mississippi Delta Plain
MLODS	Multiple Lines of Defense Strategy
MRGO	Mississippi River Gulf Outlet
MSGP	Multi-Sector General Permit
NENA	Neighborhood Empowerment Network Association
NEPA	National Environmental Policy Act

NOAA	National Oceanic and Atmospheric Administration
NOSWB	New Orleans Sewerage and Water Board
NWF	National Wildlife Federation
NWS	National Weather Service
PDR	Purchase of Development Right
PPCP	Pharmaceuticals and Personal Care Products
PPL	Project Priority List
PPS	Proportionate to Size Method
SEIS	Supplemental Environmental Impact Statement
SMPD	Semi-Permeable Membrane Device
TDR	Transfer of Development Right
TKN	Total Kjeldahl Nitrogen
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UW	University of Wisconsin-Madison
WRM	Water Resources Management
WSNC	Waldemar S. Nelson and Company

Executive Summary

The Bayou Bienvenue Wetland Triangle (BBWT) is a 427-acre, triangular-shaped body of open water located on the northern boundary of New Orleans' Lower Ninth Ward. Fifty years ago, this area was a wooded swamp, part of a network of swamps and marshes that spanned the 30,000 acres between New Orleans and Lake Borgne. In the past, this wetland offered the Lower Ninth Ward community protection from storms, a place to hunt and fish, and natural beauty. Since then, floodwall improvements and subsidence have placed the wetland out of sight, severing its connection to the Lower Ninth community and concealing its degradation to open water.

In recent years, residents, community leaders, public agencies and others have taken interest in restoring the BBWT to a freshwater swamp. The University of Wisconsin-Madison (UW) has provided academic expertise toward this effort since 2006. In the summer of 2007, a group of UW graduate students conducted an environmental baseline study of the BBWT, researched wastewater assimilation techniques, and examined the post-Katrina social context surrounding a wastewater assimilation proposal by the New Orleans Sewerage and Water Board.

In summary, the 2007 UW group found the current water depth in the BBWT to be too great for cypress-tupelo reintroduction and expressed concerns about the ability of the wetland to properly treat wastewater in its current state. They found the community to be supportive of wetland restoration, but focused on more immediate rebuilding tasks. These findings were published in a report, which was distributed to the Holy Cross Neighborhood Association (HCNA) and other stakeholders, and which is available online through the University of Wisconsin-Madison's Nelson Institute for Environmental Studies website (WRM, 2007[1]; see references for the URL). Since then, continuation of the project into a second and third year has been made possible by generous support from the McKnight Foundation and the Sierra Club—Delta Chapter of Louisiana.

This document summarizes the 2008 efforts of a new group of UW students. These include the continuation and expansion of the previous environmental and socio-environmental studies (WRM 2007) and research into several new areas. The selection of research topics (organized below under bold headers with respective chapter numbers) was both a function of students' interests and the diversity of issues affecting the BBWT. Although chapters are focused around individual students' areas of expertise, there is much overlap between topics. For example, as a result of human activities, natural systems on the Mississippi Delta Plain have undergone significant alteration. In turn, restoration of these systems depends on government agencies, issues of property rights and societal preferences.

[1] References for citations in the Executive Summary are listed at the end of their respective chapters.

Chapter 1: Regional Environmental Context

New Orleans lies within a geographic province known as the Mississippi Delta Plain (MDP), which marks the crossroads between North America's largest river system and the Gulf of Mexico. The existence of land in this area hinges on a delicate balance between the deposition of sediments by the Mississippi, the growth of vegetation, subsidence and the erosion of sediments by the Gulf of Mexico. Over the past 6,000 years, a net accretion of sediments from the Mississippi River has built the Mississippi Delta Plain in what was formerly open water.

Human activities have reversed this trend, producing land-loss rates of 16 to >100 km^2/yr (Barras et al., 2008). This loss has primarily resulted from the construction of levees and reservoirs along the Mississippi, which have severed the river's sustaining supply of freshwater, nutrients and sediment to MDP wetlands (Day et al., 2000, 2007). Extensive canal dredging has also drastically altered MDP wetland hydrologies and allowed for saltwater intrusion (Bass & Turner, 1987; Day et al., 2007; Turner 1997). In some areas, the withdrawal of oil and gas from the subsurface has also destroyed wetlands by greatly increasing the rates of subsidence and saltwater intrusion (Bernier, 2008).

As the wetlands surrounding New Orleans continue to erode, neighborhoods constructed on drained swamps and marshes (now generally below sea level) continue to subside at rates of up to 3cm/yr (Dixon et al., 2006). Recent modeling has suggested that New Orleans also occupies a hurricane "bulls-eye," with nearly double the Category 3+ hurricane probability of Texas or Florida (USACE, 2008a). When considered with the anticipated effects of climate change, these circumstances present significant challenges to the future of this city (Day et al., 2007).

Despite uncertainties resulting from the complexities of storms, there is a growing consensus that wetlands serve a critical role as storm buffers for coastal communities. In Louisiana, recent region-wide planning documents have converged on the Multiple Lines of Defense Strategy (MLODS; Lopez et al., 2008) concept, which seeks to synergistically organize natural and man-made systems to minimize storm damage. A core element of the MLODS is its focus on sustaining historical salinity gradients and their corresponding wetland communities through Mississippi River diversions.

Although no wetland community in the BBWT will provide comprehensive protection to the Lower Ninth, a buffer of woody vegetation extending from the BBWT eastward through St. Bernard parish would enhance the integrity of the existing back floodwall. Under the MLODS, salinities in the BBWT and neighboring Central Wetlands Unit (CWU) would be maintained at 0-3 parts per thousand (ppt); subsequently, the goal habitat for the BBWT would be a freshwater swamp (Lopez et al., 2008).

Chapter 2: Hydrology of the BBWT

The ongoing losses of MDP wetlands resulting from the above-mentioned hydrologic changes are a testament to the fundamental control exerted by the water cycle on Louisiana's wetland ecosystems. In the case of the BBWT and CWU, increased salinities and tidal influence resulting from the construction of the MRGO resulted in the near-total destruction of all cypress-tupelo swamps (CEI, 1982; USACE 1999). Continuous water-level data were collected in the BBWT from June 18-November 1, 2008 and as of the writing of this report, continue to be collected. Salinity levels and other basic water quality data were also collected during this period.

Currently, the BBWT exists as an open-water intermediate to brackish marsh, with mean tides of approximately 6 in., mean water depths of 2.0-2.5 ft, and salinities ranging from approximately 1-9 ppt. The successful restoration of a cypress-tupelo community requires both a reduction in salinity to <2 ppt, and a decrease in water depth (Hoeppner et al., 2008). Current regional-scale restoration plans include the impending closure of the MRGO and an authorized Mississippi River diversion at Violet (see figure 2-1). Modeling studies by the University of New Orleans have suggested that these measures, if implemented properly, can restore historical salinity conditions (Georgiou et al., 2007).

Chapter 3: Vegetation in the BBWT

A detailed vegetation survey was also conducted during the summer of 2008. Of the 49 species found, 40 were positively identified. In the open-water area that comprises the majority of the BBWT, widgeon grass was the only identified submerged aquatic species. In other areas of the BBWT, 23 of the 40 identified emergent aquatic and terrestrial species are weedy or introduced. Although some brackish species have colonized the northeast corner of the BBWT, weedy species have proliferated along the Florida Avenue floodwall. The prevalence of open water suggests that water depth is a significant obstacle to colonization by emergent vegetation. Both in-filling with sediment and active vegetation management (to ensure the success of desired species over weeds) are likely needed to successfully restore any plant community to the BBWT.

Chapter 4: Locally Unwanted Land Uses

The BBWT and the Lower Ninth Ward are surrounded by a scrap metal recycling facility, a municipal solid waste landfill, the sole wastewater treatment plant for the East Bank of New Orleans, and the Inner Harbor Navigational Canal (IHNC; colloquially referred to as the Industrial Canal). The histories and activities of these surrounding facilities, their relationships to the BBWT, and relevant regulations were investigated. Although federal and state statutes exist to regulate these land uses, they are not necessarily capable of protecting the environmental quality of Bayou Bienvenue and the BBWT.

Presently, activities at the Southern Scrap recycling facility and the possible introduction of dredged IHNC sediments present the biggest potential threats to environmental quality in the BBWT. Until recently, the discharge of heavy metals from scrap recycling operations was unregulated. In 2007, Southern Scrap was cited for negligence in their control of stormwater. The potential closure of this facility without an appropriate clean-up/remediation plan is perhaps a larger concern. IHNC sediments designated for "marsh creation"[2] in the BBWT contain six organic compounds at potentially harmful levels (for biological effects), (USACE, 2008c) though their ecotoxicity in relation to sediments in the BBWT is unclear.

[2] Under the U.S. Army Corps of Engineers' 2008 Supplemental Environmental Impact Study for the IHNC Lock Expansion Project

Chapter 5: Environmental Quality

The University of Wisconsin-Madison student researchers supplemented their investigation of the built environment by sampling for dissolved organic contaminants and sediment concentrations of heavy metals in the BBWT. A new, time-integrated passive sampling method (Semi-Permeable Membrane Devices), in combination with a bioassay[3] analysis (Microtox® test), was used to evaluate the presence and potential for biologic uptake of organic pollutants dissolved in the water column. Two of three sampling sites indicated possible organic contamination at biologically significant levels. However, individual compounds were not identified, and the potential source of contamination is unclear.

Sediment sampling revealed elevated levels of copper, lead, zinc and arsenic at multiple locations within the BBWT and Bayou Bienvenue. Concentration distributions suggest both point source contamination from surrounding land uses and nonpoint source contamination resulting from the surrounding metropolitan area. In general, Bayou Bienvenue appears to be more contaminated with heavy metals than the BBWT. The distributions of zinc and copper indicate possible contamination from the scrap recycling facility, while those of lead and arsenic suggest a more distributed source; possibly the deposition of sediments during hurricanes.

Although it is clear that the BBWT is polluted to some extent with heavy metals (and possibly organic contaminants), it is not possible from concentrations data alone to draw any firm conclusions about potential biological effects, including those to humans.

Chapter 6: The Lower Ninth Ward Community

The 2008 UW student team conducted survey research that evaluated past uses of the BBWT by Lower Ninth Ward Residents, as well as residents' knowledge and perceptions of different restoration options—in continuation of the WRM 2007 research study. Aside from functioning as an assessment of the community, these surveys also serve as an outreach mechanism to educate neighborhood residents about the BBWT and restoration proposals. Surveys were conducted between 10:00 am and 4:00 pm during the months of June and July of 2008. Thirty-five surveys were conducted. To obtain a greater sample size for some analyses, 2008 results were combined with those of the WRM 2007 community survey, which was conducted using similar methods.

The demographic characteristics of surveyed participants are similar to those described in the 2000 US Census, with the exceptions of age and home ownership rate—both of which were higher in the surveyed participants. However, as of August 2008, the Lower Ninth Ward population (1,468) remains well below pre-Katrina levels (19,515 in 2000). Despite significant attention from outside organizations, this vacancy is coupled with a continued lack of services.

Survey participants overwhelmingly selected hunting/fishing/shrimping/crabbing as their primary past uses of the Bayou Bienvenue and surrounding wetlands. Indicated future uses could also include other forms of recreation, such as walking or bird watching. However, the community remains significantly disconnected from the wetland. Most residents have not visited the wetland recently, despite the newly constructed observation deck at the corner of Florida and

[3] Biological assays are tests designed to comparatively evaluate the biological effects of a substance by observing its effects on a living organism (in this case by exposing luminescent bacteria to dissolved contaminants sequestered by the membrane).

Caffin avenues. In addition, there is a widespread lack of knowledge in the community about the general relevance of wetlands and the current BBWT restoration proposals. Additional outreach and education in this area are needed. Bayou Bienvenue Wetland Triangle restoration efforts could likely be enhanced by Lower Ninth residents' strong sense of place and commitment to community.

Chapter 7: Government Institutions

Efforts to restore the BBWT on any sort of significant scale will require substantial funding and coordination from numerous governmental and private stakeholders. While necessary funding and basic governmental approval are obvious prerequisites to initiating any project, the long-term importance of stakeholder coordination should not be overlooked, especially due to the extended nature of restoration projects such as a cypress-tupelo reintroduction.

Coastal restoration programs in Louisiana have been created and have evolved as increased understanding of the importance of ecosystems to storm protection has become widespread. Since the signing of the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) in 1990, efforts to address the problem of coastal erosion have not only expanded, but have also become more comprehensive in their approach, especially following the devastating 2005 hurricane season.

The BBWT's location is a major asset from an accessibility perspective, but it is also a challenge due to the proliferation of surrounding land uses and corresponding stakeholders. While some of these stakeholders' interests may be in conflict, most do have an interest in successful restoration of the wetland. Bringing the key stakeholders together into a unified partnership with decision-making ability, such as a restoration authority, is an important step in laying the foundations for restoration because it could dramatically improve communication and coordination.

Chapter 8: Land Tenure

The BBWT can be seen as an ecological resource and part of the urban environment, but it also constitutes real property. Land owners could play powerful roles in restoration of the wetland, either by hindering progress (by refusing to relinquish land rights) or by lending support to the effort. University of Wisconsin-Madison urban and regional planning students conducted a preliminary analysis of the land tenure history and associated property rights. Bayou Bienvenue Wetland Triangle property records were mapped using a Geographic Information System (GIS), and analyzed to investigate current title holders, property sale dates and prices, and incidences of tax delinquency.

The BBWT contains 496 lots owned by 178 different parties, including individuals, private companies, and public agencies. Considerable variety was found in owner types, sale dates and states of tax delinquency. While the majority of BBWT lots are owned by individuals, private companies have made the most recent purchases. Approximately one quarter of the lots were purchased after 1990. These factors may be unrelated, or they may indicate that recent purchasers have specific plans for their lots.

In the dynamic coastal landscape of Louisiana, definitions of property are complicated by anthropogenic and naturally-occurring processes of land-building (by sediment accretion or drainage) and land-loss (by erosion or permanent inundation). Despite claims to its property, the BBWT's characteristics of permanent inundation and tidal influence may place it under the public trust, meaning ownership would revert to the state. The successful legal establishment of the BBWT as a navigable waterway or as an *arm of the sea* could provide a "silver bullet" option that would nullify all private claims to its property.

Other options for acquiring BBWT parcels include fee-simple acquisition, involuntary forfeiture, eminent domain, conservation easements, purchase or transfer-of-development-rights, and land trust programs. Despite widespread tax delinquency, the most recent BBWT parcel adjudication (to the City of New Orleans) took place in 2001. This suggests that the city of New Orleans is not taking full advantage of its right to claim tax delinquent parcels. Our findings suggest that half of the tax delinquent non-adjudicated parcels could technically be placed in the hands of the city through adjudication. Aside from involuntary forfeiture, fee-simple acquisition may be the best method for acquiring land in the BBWT. However, this option requires extensive government support.

Chapter 9: The BBWT as a Community Asset: Possibilities for Education, Recreation and Alternative Tourism

Community survey results and recent discussions among BBWT stakeholders have revealed an interest in utilizing the BBWT for education, recreation, and alternative tourism. A combined education and research facility at the BBWT could potentially strengthen the connection between the BBWT and the Lower Ninth neighborhood, raise awareness about Louisiana's disappearing wetlands, and promote autonomous, community-based economic development. The BBWT is the closest wetland to downtown New Orleans, and is a prime example of recent and ongoing wetland degradation in the MDP. If restoration efforts were to be initiated (e.g. sediment introduction and tree plantings), the BBWT could also serve as a first-hand demonstration of the efforts required to restore historical habits in the Pontchartrain Basin and elsewhere in coastal Louisiana. While survey results suggest that residents are receptive to tourism and interested in utilizing the BBWT for educational and recreational purposes, more research is needed to determine the actual feasibility of such a facility.

Table of Contents

Appendices

List of Figures

List of Tables

Introduction

Over the Florida Avenue floodwall and out of sight, past the devastated backside of New Orleans' Lower Ninth Ward, sits a triangular area of open-water littered with dead cypress ghosts. Fifty years ago this area was a wooded swamp, part of a network of swamps and marshes that spanned the 30,000 acres between New Orleans and Lake Borgne. In the past, this wetland offered the Lower Ninth community protection from storms, a place to hunt and fish, and natural beauty. Today, many local residents hardly know it's there. A century of levee construction and canal-building have left the wetland an open-water, intermediate to brackish marsh, with only dead trees and some older residents' memories to attest to its past.

Figure 0-1: The BBWT and the backside of the Lower Ninth Ward, looking north towards Lake Pontchartrain. (Photo by Andrew Leaf, January 2008)

Despite the fact that the Bayou Bienvenue Wetland Triangle (the BBWT, as we will refer to the wetland in this report) was parceled out and sold in the nineteenth century, this wetland remains a blank spot on many maps. When the northern portion of the Lower Ninth (commonly referred to by residents as "the Backside") was drained, the BBWT was separated from the neighborhood by a floodwall and back levee.

As the backside became populated and subsided, the wall between the community and their swamp grew, and few witnessed its conversion to open water. As the Backside became populated, the land subsided and the flood wall between the community and their swamp grew; few residents witnessed its conversion to open water. During this time, the levee crest (which today stands more than nine feet above Florida Avenue) also concealed the construction of a large wastewater treatment plant, a landfill, and a scrap material recycling facility.

In Louisiana, the boundary between land and sea is a gradual transition through wetland ecosystems, which are defined by their saltiness and tidal influence. In earlier times, people traveling bayous into New Orleans from the Gulf would have first encountered barrier islands and sounds, and as they worked their way landward, salt, brackish, intermediate and freshwater marshes. As they reached the freshwater zone, closest to the Mississippi River and its distributaries, they would have encountered swamps dominated by bald cypress (*Taxodium distichum*), and water tupelo (*Nyssa aquatica*).

The geographic distribution of these ecosystems is dynamic, and changes with the shifting Mississippi River Delta. Recent human activities, especially those of the twentieth century, have significantly altered the natural functioning of this landscape. The effect on coastal Louisiana has been the destruction of some 2,000 square miles of wetlands, and the continued landward encroachment of the Gulf of Mexico. In the Pontchartrain Basin, which contains Bayou Bienvenue, many cypress swamps are gone, and the rest are rapidly deteriorating (Hoeppner et al., 2008)[1]. The story of the BBWT is therefore not unique, but rather a microcosm of a larger phenomenon, considered by some to be among North America's largest environmental problems.

The destruction caused by the 2005 hurricanes (Katrina and Rita) increased public awareness of the importance of coastal wetlands (Day et al., 2007; Hoeppner et al., 2008). However, sustainable solutions for coastal Louisiana require expensive, large-scale efforts. As a result, meaningful political and public support for the changes needed remains uncertain. A new generation of ambitious plans emphasizing the importance of wetlands (e.g. CPRA, 2007; Lopez, 2006; USACE, 2008) gives hope for the future. In the Lower Ninth, grass-roots efforts towards sustainable rebuilding include an interest in reconnecting the community with the BBWT, and restoring the habitat to freshwater swamp.

The idea of restoring the BBWT is not new. A 2001 Coastal Wetlands Planning Protection and Restoration Act (CWPPRA) funding proposal by the Louisiana Department of Natural Resources (LDNR) sought to restore the BBWT and the adjacent Central Wetlands Unit (CWU) by utilizing a series of earthen terraces to trap freshwater and sediments discharged from pumping stations (Hartman Engineering, 2001). The proposal was de-authorized due to anticipated cost. In 2008, a CWPPRA proposal by the United States Army Corps of Engineers (USACE) sought to decrease water depths in the BBWT by importing sediment piped from Lake Borgne. Although a finalist for that funding year, the proposal was not funded.

At present, the New Orleans Sewerage and Water Board (NOSWB) has proposed using the BBWT and CWU for wastewater assimilation. In the spring of 2009, it released a pre-design feasibility report for this project (WSNCI, 2008). According to this document, the NOSWB has

[1] All references for the introduction are listed at the end of Chapter 1.

funding to fill, plant, and discharge effluent to a small number of sites, which may include two 20-acre test plots in the BBWT. If additional funding is obtained, more extensive cypress-tupelo restoration in the CWU and the BBWT is possible.

In 2006, the Holy Cross Neighborhood Association (HCNA) expressed interest in a third-party assessment of the BBWT, along with a review of restoration plans. With the help of Darrell Malek-Wiley (Sierra Club–Delta Chapter of Louisiana), a team of University of Wisconsin-Madison (UW) graduate students in environmental studies and geology was connected with the HCNA.

In the summer of 2007, the UW group conducted an environmental baseline study of the BBWT, researched wastewater assimilation techniques, and examined the post -Katrina social context surrounding a wastewater assimilation proposal by the New Orleans Sewerage and Water Board. In short, the 2007 students found the current water depth in the BBWT to be too great for cypress reintroduction, and expressed concerns about the ability of the wetland to properly treat wastewater in its current state. The group also found the Lower Ninth Ward community to be supportive of wetland restoration. However, surveys indicated that the residents remained more focused on more immediate rebuilding tasks.

These findings were published in a report, which was distributed to the HCNA and other stakeholders, and is available online at the UW Nelson Institute website (WRM, 2007; see references for the URL). Since then, continuation of the project into a second and third year has been made possible by generous support from the McKnight Foundation and the Sierra Club—Delta Chapter of Louisiana.

This document summarizes the 2008 efforts of a new group of UW students. Since 2007, the interdisciplinary make-up of our group has grown to include expertise in urban and regional planning, law, botany, and environmental engineering. Over the past year, we continued previous baseline data collection efforts—including the collection of BBWT water level data, basic water quality parameter data, along with socio-environmental surveys of the Lower Ninth neighborhood. In addition, we investigated potential sources of environmental pollution to the wetland and their regulatory framework, as well as the land tenure, bureaucratic, and stakeholder issues facing the BBWT. We also conducted vegetation surveys, and performed additional testing of sediment quality and water toxicity. In this report, we present our findings from these efforts, as well as some recommendations for the community as they seek to move forward.

Chapter 1: Regional Environmental Context

Andrew Leaf

New Orleans lies within a geographic province known as the Mississippi Delta Plain (MDP), which marks the crossroads between North America's largest river system and the Gulf of Mexico. This unique location and its rich natural environment are the primary reasons for both New Orleans' success as one of North America's oldest cities, and its biggest obstacle to a sustainable future.

The existence of land on the MDP hinges on a delicate balance between the deposition of sediments by the Mississippi, the growth of vegetation, subsidence and the erosion of sediments by the Gulf of Mexico. Only 6,000 years ago, the place now occupied by New Orleans was open water. Since then, the Mississippi has built up land in this region by eroding sediments from the interior of North America, and depositing them in a series of delta lobes (Figure 1-1). Now, current rates of land loss are returning much of this region to the Gulf of Mexico. When considering the BBWT and its future, it is both useful and essential to place it in this larger picture. This chapter examines the interconnected human and natural systems of the MDP and the associated problem of land loss. It concludes with a discussion of the importance of wetlands to the future of the region.

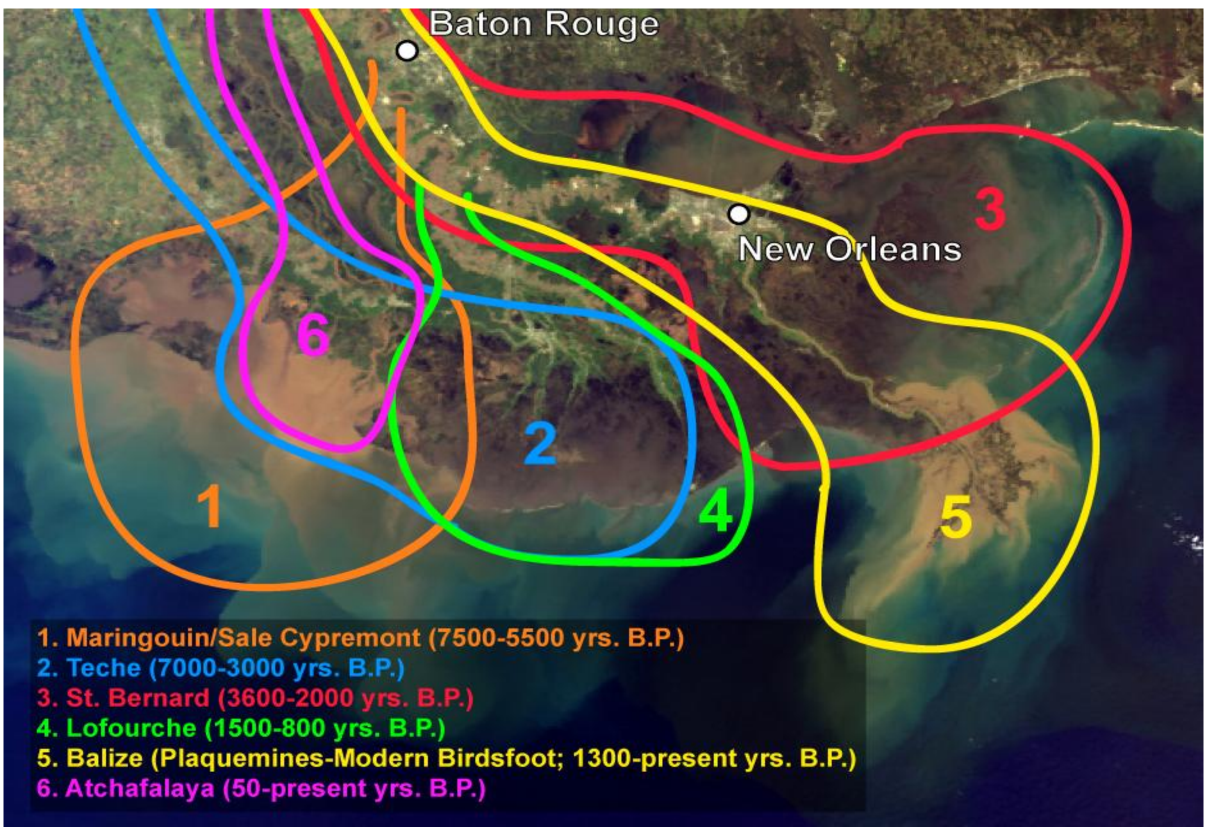

Figure 1-1: Chronology of MDP development, showing the major delta lobes and their periods of activity. (After Bloom, 1998; Day et al., 2007; Image courtesy of NASA)

MDP Geology

The Formation and Destruction of Delta Lobes in the MDP

Deltas are formed when a sediment-laden river meets a level surface of water (in this case the Gulf of Mexico), and in response to decreasing flow velocities, the river deposits its sediments. In seeking the easiest course towards the ocean, the main river channel commonly divides into multiple *distributary channels*, which together deposit sediment in a deltaic lobe around the original river mouth (Bloom, 1998). Eventually, enough of this sediment accumulates to cause a major change in the course of the main channel (called an *avulsion*). Following an avulsion, the river mouth is relocated, and the river and its distributaries begin constructing a new delta lobe.

Throughout this entire process, the newly deposited sediment is continuously compacting under its own weight. When a delta lobe is abandoned by an avulsion of the main channel, rates of subsidence and erosion exceed those of sediment deposition, the land surface sinks, and the ocean advances landward. Coastal processes collect and deposit eroded sand to form *barrier islands* such as the Chandeleur Islands east of New Orleans. Over the past several millennia, this cycle of growth, avulsion, and abandonment has repeated itself to produce an overlapping sequence of delta lobes, which together comprise the MDP (Figure 1-1).

Geomorphologic Features of Deltas

The characteristic landscape features of the MDP are the result of the sedimentary processes by which deltas are built. In the active delta lobe, the coarsest sediments (sands) are deposited in distributary channels, where water velocities are highest. Distributary channels are flanked by *natural levees*, which also contain coarser sediments ranging in grain size from sands and coarse silts to silty clays (Fisk, 1960). Sediments accumulate on natural levees during periods of overbank flooding along the margins of the channel.

The low-lying areas between distributary channels contain the finest sediments—mostly organic-rich fine silts and clays. Sediments are deposited in these areas during floods, when the natural levees are overtopped or breached by *crevasses*. Fans (*splays*) of sand and silt are deposited in proximity to crevasses as velocities in the incoming channel water decrease. At greater distances from active distributary channels, in intermediate to brackish marshes, peat[2] accumulates from the remains of cattails, sedges, and grasses (Fisk, 1960).

Upon abandonment, coarser channel and natural levee deposits form ridges as they subside at slower rates than the surrounding inter-distributary deposits (Snowden et al., 1980). The continued growth and decay of marsh vegetation in the inter-distributary areas can produce peat accumulations that offset ongoing subsidence, resulting in stable marsh surface elevations. The accumulation of peat ends when tidal channels cut into the marsh, and the formation of ponds, lakes, and bays lead to erosional feedbacks that destroy emergent marsh vegetation (Fisk, 1960).

[2] A light, watery sediment composed primarily of partially decayed vegetation.

Influence of Delta Geomorphology on Ecosystems and Humans

The MDP is home to three primary habitats: natural levees and ridges, freshwater swamps and estuaries[3] (Figure 1-2). Their distribution is mostly determined by elevation and salinity levels, which range from freshwater (<1 part(s) per thousand (ppt)) near the river, to greater than 30 ppt in the Gulf.

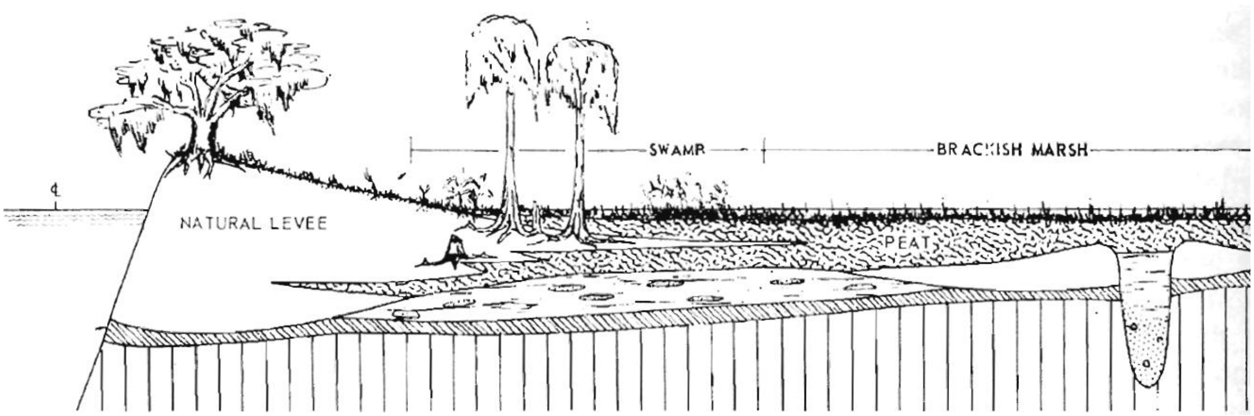

Figure 1-2: Conceptual diagram showing MDP habitats in relation to the geology. Note the former bayou channel (the U-shaped deposit on the right-hand side) which has subsided and has been buried by peat deposits (from Fisk, 1960).

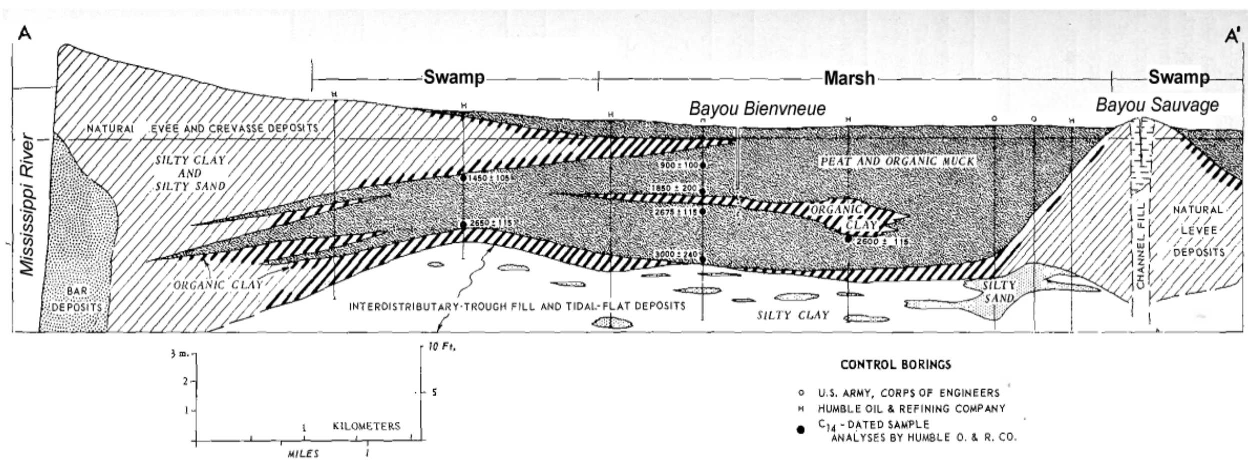

Figure 1-3: Cross section along Paris Rd. (St. Bernard Parish), showing typical geology of the New Orleans area. Note the historic locations of swamps in proximity to the Mississippi River and Bayou Sauvage. The dark gray area between Bayou Sauvage and the Mississippi River represents peat deposited in marshes, which is interfingered with organic clays (denoted by bold, diagonal lines) deposited by the Mississippi River. The wedge-shaped layer of silty clay and silty sand (light diagonal lines) extending from the natural levee of the Mississippi to Bayou Bienvenue, is a crevasse splay deposit. The coarser material in the splay likely provided a superior location for Paris Rd. A cross section through the Lower Ninth and BBWT (where no crevasse splay exists) would show a narrower natural levee, and larger areas of organic clay (from Fisk, 1960).

[3]The term "estuary" generally describes a landscape consisting of "a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage," (Pritchard, 1967). The term "swamp" describes a habitat dominated by woody vegetation (i.e. trees), while "marsh" describes a habitat dominated by grasses or low-lying shrubs. Given the MDP's proximity to the sea, most of the swamps and marshes discussed in this report are also estuaries.

As the sole topographic high points in the New Orleans area, natural levees and ridges formed by abandoned distributary channels were historically the only dry ground. In pre-settlement times, they harbored hardwood forests, with plant communities that varied with local drainage conditions (CEI, 1972). Freshwater cypress and tupelo swamps (described in greater detail by WRM, 2007) grew parallel to the natural levees along the back sides. These unique freshwater communities evolved under conditions of periodic flooding, and were sustained by runoff carrying nutrients and sediment from the natural levees. Beyond the swamps, towards Lake Borgne and the Gulf, were marsh ecosystems adapted to increasing salinities. In a second 1982 study, CEI classified these marshes as intermediate (0.6-5.9 ppt), brackish (0.9-18.6 ppt), and saltwater (1.5-26.2 ppt). A sharp gradient generally existed between freshwater swamps (<1 ppt) and brackish marshes. In some areas, intermediate marsh directly abutted the natural levee. In others, it was absent, with brackish marsh directly abutting freshwater swamp (CEI, 1972, 1982). The historical locations of these habitats near the BBWT are labeled in Figure 1-3.

Initially, New Orleans was settled on the natural levees of the modern Mississippi and on ridge remnants of abandoned channels (e.g. the Metarie and Gentilly ridges). Localized crevasse-splay deposits (such as the one illustrated in Figure 1-3) also provided firmer high ground for development. It wasn't until the twentieth century—when A. Baldwin Wood, an engineer for the Sewage and Water Board, invented the necessary pumps—that the city expanded into newly drained back-swamps and marshes, creating neighborhoods such as Lakeview, New Orleans East, and the Backside of the Lower Ninth.

The Land Loss Problem and Its Causes

In the twentieth century, the historical salinity gradient east of New Orleans shifted landward, leading to wholesale environmental transformation. Today, cypress and tupelo swamps are largely gone from this area. Many other previously emergent marshes are now open water. This problem is widespread across coastal Louisiana. As wetlands constitute the vast majority of the loss, the term "land loss" is essentially synonymous with "wetland loss." For the past century, the MDP has been losing land at average rates of approximately 16 to >100 km^2/yr. Although rates have decreased since the 1970s (Barras et al., 2008) the overall trend of loss is expected to continue (Figure 1-4, Figure 1-5), thus, it is considered by some to be among North America's largest environmental problems.

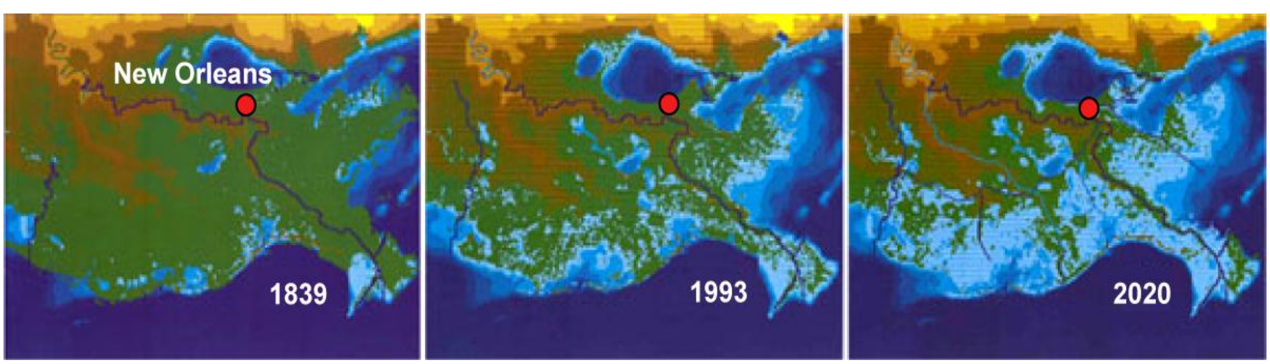

Figure 1-4: Recent and projected land loss for the MDP (USGS). Figure 1-5 shows the area of land built by the Mississippi over time, including recent losses.

There are many interrelated causes, most of which relate to the dynamic interplay between the accumulation of mineral (non-organic) and organic (vegetative material) sediments and *subsidence* (sinking of the land surface). Although it is perhaps impossible to exactly determine the extent to which recent losses are anthropogenic, the timing and severity of the modern decline in land area suggest a human influence.

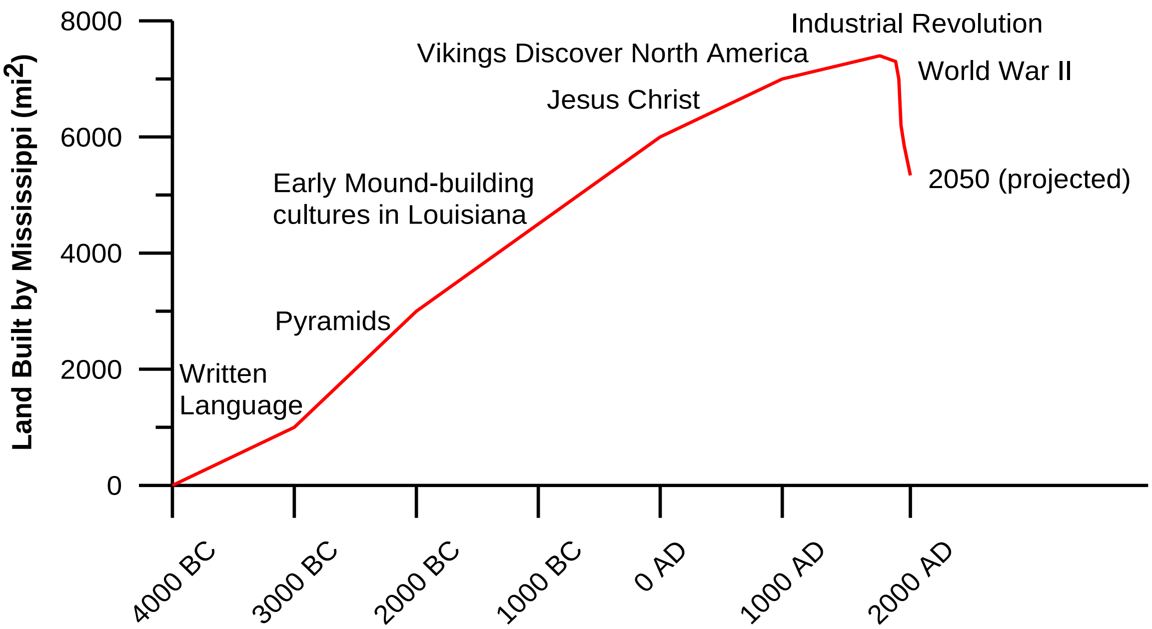

Figure 1-5: Cumulative land built by the Mississippi River, showing recent losses. It should be noted that the data for this graph comes from two different sources: aerial photography (mid-twentieth century to the present) and sedimentological records (pre-aerial photography). The latter of these methods carries significantly less precision. (After LSU, 2006. With additional data compiled from Barras et al., 2004, 2008, and Britsch & Dunbar, 1993.)

Subsidence

Subsidence is ubiquitous in the MDP, and occurs at a variety of scales. Regionally, the entire MDP is thought to be sinking at rates of approximately 0.1-1.0 mm/yr in response to the sediment load deposited over the past 7,000 years (Blum, 2008; Törnqvist, 2007). On a local scale, subsidence occurs from the natural compaction of loose sediments. Drainage and development enhance this process, leading to subsidence rates upwards of 3 cm/yr (Figure 1-7; Dixon et al., 2006). Prior to human alterations, rates of sediment deposition in the active Mississippi River delta (by riverine, tidal and biological processes) were greater than subsidence, and the MDP as a whole was gaining land (Figure 1-5).

Figure 1-6: Lower Ninth resident John Taylor, next to the old Florida Avenue Floodwall (foreground), which was chest high in the mid-twentieth century, but the land has since subsided several feet. The current floodwall can be seen in the background. (Photo by Lauren Brown, November 2008.)

Areas underlain by peat and organic-rich clays subside at faster rates than natural levees, due to their high water content, lack of grain-supported mineral structure, and the oxidative decay of organic material. This is especially true for peat, which is mostly comprised of partially decayed organic material, and has an initial water content of approximately 85 percent (Fisk, 1960; Snowden et al., 1980). This is a chronic, immutable problem for New Orleans neighborhoods constructed on drained swamps and marshes. Elevations in these neighborhoods have sunk well below sea level (as low as -14 ft in some areas; Figure 1-7, Figure 1-8 and Figure 1-9) and will continue to sink. In many unleveed areas like the BBWT, subsidence and erosion in the absence of vegetation have contributed to the creation of open water.

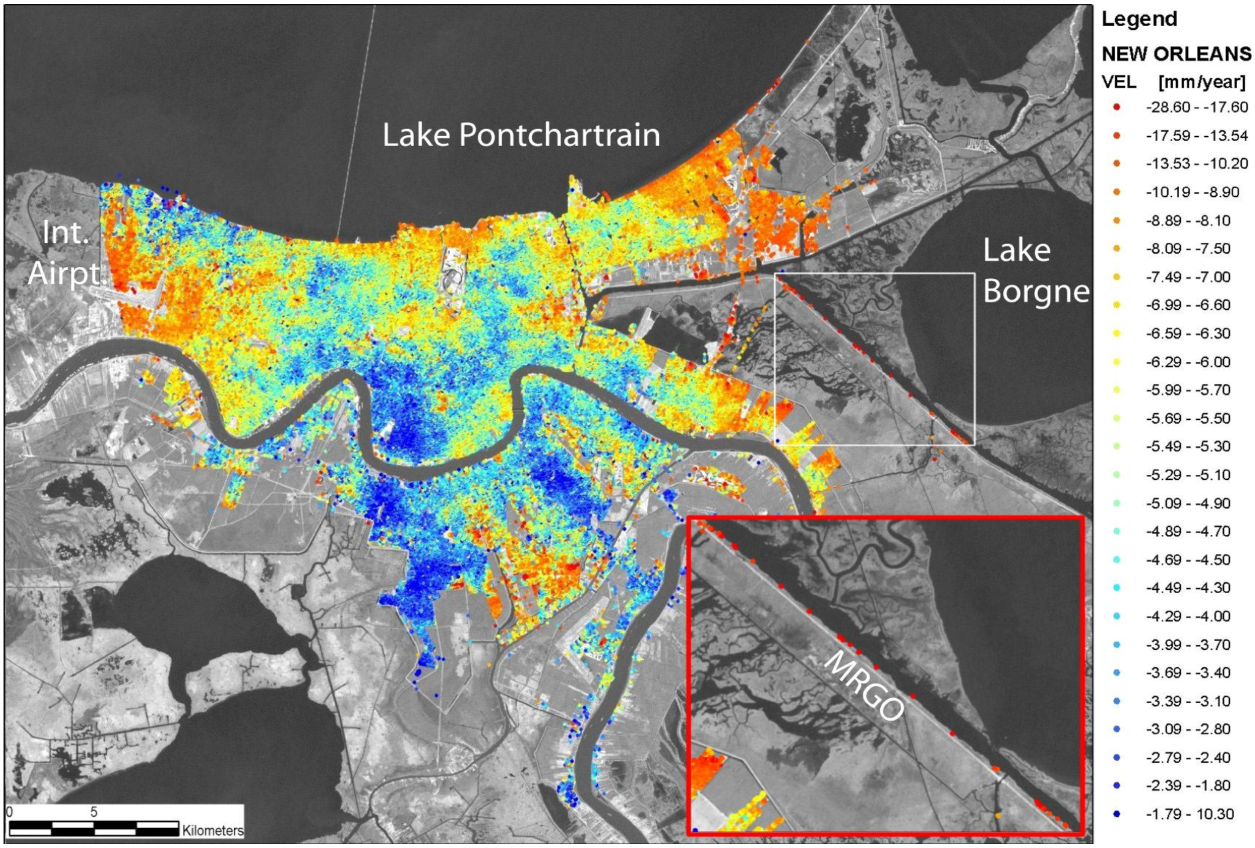

Figure 1-7: Local rates of subsidence for New Orleans, 2002-2005, as determined by synthetic-aperture radar images taken from space. (Dixon et al., 2006; Image courtesy of NASA.)

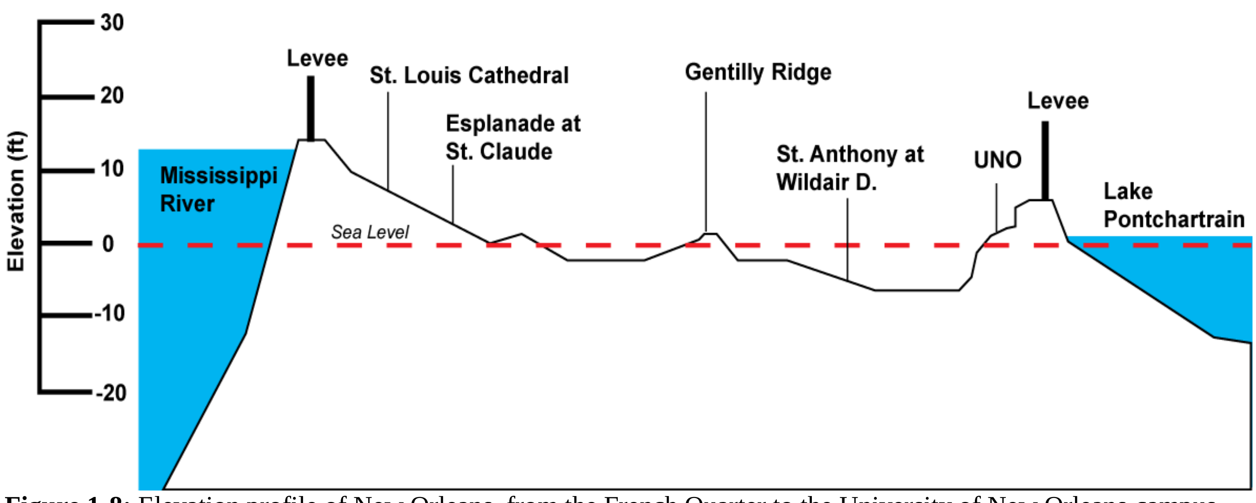

Figure 1-8: Elevation profile of New Orleans, from the French Quarter to the University of New Orleans campus. (Redrawn by the authors from Wikipedia)

Alterations to the Mississippi

Historically, periodic overbank flooding and crevassing introduced nutrients, freshwater, and mineral sediments into MDP wetlands. Extensive levee improvements in the late 1920s have since severed this connection, and are thought by many to be the primary cause of land-loss (Day et al., 2000, 2007). In the past, distributaries of the Mississippi carried sediment into the shallow waters of the continental shelf, where currents transported it landward and deposited in it saltwater estuaries. However, levees and navigational dredging of the main channel now ensure that this sediment is piped down the naturally elongate “Bird’s Foot” Delta to the edge of the continental shelf, where it is lost to deep water (Figure 1-1).

An exception to this is the Atchafalaya Delta (Figure 1-1), the only area in Louisiana where substantial new land is being built. Under natural conditions, the Mississippi would begin constructing a new delta lobe in this area. However, currently the USACE’s Old River Control Structure (located near the 90 degree bend in the Louisiana-Mississippi border) holds the existing channel in place, ensuring that two thirds of all flow continues to pass Baton Rouge and New Orleans.

In addition to river levees, back-levees, which are essential for hurricane storm surge protection, create additional problems for back-swamps and estuaries, by blocking the evenly distributed flow of run-off from high areas into adjacent freshwater swamps and marshes. The discharge of urban runoff is instead concentrated at discrete pumping station outfalls. This results in more extreme fluctuations in salinity and nutrients.

Upstream reservoirs in the Mississippi basin trap sediment that would otherwise go to Louisiana. Since recordkeeping began in the mid-nineteenth century, the average load and grain size of sediment carried by the Mississippi has decreased. Although improved agricultural practices could explain initial decreases, the sharp decreases observed since the 1950s are likely the result of extensive basin-wide dam construction during that decade (Kessel, 1989).

Canal Dredging

Canals alter the hydrologic regimes of wetlands by allowing saltwater intrusion and increased fluctuations in water level. In addition, the accompanying banks of dredge spoil can also create impoundments, changing the frequency and duration of floods, while also reducing drainage and the influx of nutrients and sediment (Bass & Turner, 1987). These hydrologic changes can stress and eventually destroy existing vegetation, leading to the cessation of biological sediment deposition and a relative rise in sea level (Day et al., 2000; Gagliano & Wicker, 1989; Turner, 1997).

Some 15,000 km of canals have been dredged across the MDP for navigation, drainage, logging, and oil and gas development. Most canals were constructed for the latter, during its mid-twentieth century boom. The Mississippi River Gulf Outlet (MRGO; perhaps the most extreme example of canal-induced wetland destruction) was also constructed during this time period. This activity was closely followed by the highest rates of land loss (Barras et al., 2008) suggesting the importance of canals in greatly accelerating the destruction initiated by engineered alterations to the Mississippi (Turner, 1997).

Oil and Gas Withdrawal

The physical removal of oil and gas from geologic formations under the MDP also contributed significantly to peak rates of land loss in the 1960s. Withdrawal of these fluids caused decreases in volume that ultimately led to faulting and localized “bowls” of subsidence in the land surface. Although this activity did not occur under New Orleans, it was likely the cause of accelerated rates (over 5 times greater than normal) of subsidence observed near Grande Isle during this period (Bernier, 2008).

Hurricanes

Hurricanes deposit large amounts of sediment onto coastal wetlands, and can produce runoff that stimulates marsh growth by introducing freshwater and nutrients (Turner, 2006). However, hurricanes also destroy large tracts of wetlands by uprooting vegetation (“marsh bales”) and inundating wetlands with relatively saline storm-surge water. During hurricanes Katrina and Rita alone, an estimated 513 km^2 of wetlands were converted to open water (Barras et al., 2008).

The creation of open water in an emergent marsh allows wave action and currents to erode additional land. Erosion increases fetch lengths.[4] Longer fetch lengths then encourage additional erosion in a vicious cycle of feedback. Thus, hurricanes can initiate land loss that continues for decades (Barras et al., 2008; Reed, 2008a). With the exception of the Atchafalaya Delta, and areas in proximity to freshwater Mississippi River diversions (e.g. Caernavon), current conditions in the MDP do not favor a rebound from hurricane destruction.

Climate Change

Currently, absolute sea level (ASL) is rising at approximately 2-3 mm/yr in response to rising ocean temperatures (thermal expansion) and meltwater from glaciers and ice sheets (IPCC, 2007). This trend is expected to continue beyond the twenty-first century, even if global greenhouse gas emissions are curbed by 2050. There is much uncertainty about total rise in sea level; values of 0.2-0.3 m represent minimum estimates. The total rise in ASL could be much greater, depending on uncertainties such as carbon cycle feedback mechanisms and rates of ice-sheet flow (IPCC, 2007). When combined with subsidence, the current rates of relative sea level (RSL) rise in the MDP are comparable to those expected for many coastal areas by the end of this century (Day et al., 2007).

New Orleans also occupies a hurricane “bulls-eye,” with nearly double the Category 3+ probability of Texas or Florida (USACE, 2008a). With climate change, the destructive power unleashed by the average tropical storm is expected to increase, as higher ocean-surface temperatures create stronger, longer-lasting storms (Emanuel, 2005; IPCC, 2007). This problem will be compounded by the eroding coastline, which is already producing greater storm surge heights. In 1985, Tropical Storm Juan created the highest storm surge on record, exceeding that of Hurricane Betsy. Twenty years later, Katrina doubled this value (Lopez, 2006).

These circumstances can be viewed both as severe challenges to the future habitability of this area, and as an opportunity for developing future adaptations to climate change (Day et al., 2007).

[4] The length of open water over which wind blows. Longer fetch lengths produce larger waves with increased erosional power.

Wetlands as Storm Protection

"The role of wetlands in hurricane surge level reduction and wave attenuation is a linking pin between the issues of flood risk reduction and the degradation of the delta ecosystem."
-Jos Dijkman (Editor) A Dutch Perspective on Coastal Louisiana, October 2007

The value of wetlands in protecting coastal communities from the damaging effects of storms is becoming increasingly apparent. This is especially true in the wake of hurricanes Katrina and Rita, when many southeast Louisiana levees exposed to open water failed, while others buffered by wetlands remained undamaged (Day et al., 2006, 2007). It is well-established that emergent wetland vegetation reduces wind-stress and open-water fetch, while submerged vegetation and shallow water depths attenuate waves and reduce wind-setup effects. However, an extensive ring of wetlands did not prevent flooding during Hurricane Betsy, nor did numerous barrier islands prevent 10 m of storm surge on the Mississippi coast during Hurricane Katrina. The buffering capabilities of wetlands are highly complex and storm-specific. Thus, they are difficult to quantify with deterministic models (Day et al., 2007; Resio & Westerlink, 2008; Wamsley, 2008).

Still, evidence from recent storms suggests wetlands are important. A statistical study of 34 recent US hurricanes (Costanza et al., 2008) found a highly significant correlation between wetlands and reduced storm damage. In addition, the study estimated that coastal wetlands provide the U.S. with $23.2 billion in storm protection annually. During the 2004 Indian Ocean tsunami, areas fronted by mangrove forests suffered less damage than those with no vegetative buffer. Subsequent modeling revealed that a 100m buffer of trees could reduce a tsunami's destructive power by 90% or more (Danielsen et al., 2005). Studies by the United States Geological Survey (USGS), the Louisiana Department of Natural Resources (LDNR), and the USACE all show wetland storm surge attenuation rates on the order of cm/km (inches/mile) for hurricanes Katrina and Rita (Day et al., 2007). A widely-cited statistic (which originated in a 1963 USACE report) states that "every 2.7 miles of wetlands reduces storm surge by 1 foot."

Although convenient, such simplifications aren't necessarily correct, and should be approached with caution. A second look at the original 1963 (USACE) plot of surge heights vs. distances reveals a poor correlation between the data and the 1 ft /2.7 mi line. A universal linear relationship for storm surge attenuation implies that surge heights are only dependent on the slope of the water surface and bottom friction produced by wetland vegetation. In reality, the characteristics of the storm (including direction, speed and size) and the shape of the coastline (including topography, bathymetry and levee/ridge configurations) are at least as important (Resio & Westerink, 2008; Wamsley, 2008).

Other research (e.g. Barbier et al., 2008; Reed, 2008b) suggests that "ecosystem services," including storm protection, are usually nonlinear. For Louisiana, this suggests the possibility of optimizing the protective benefits of MDP wetlands at a lower cost (i.e. by restoring some instead of all MDP wetlands, which is very likely unfeasible). However, as discussed above, much of the current understanding of wetlands' protective value is empirical rather than physical, and is drawn from areas other than Louisiana (e.g. Southeast Asian mangrove swamps in the cases of Barbier et al., 2008, Danielson et al., 2005). More physics-based studies on the protective attributes of MDP ecosystems are needed. Advances in numerical computing are beginning to make this possible (Resio & Westerink, 2008).

In any case, engineered systems such as levees and floodgates will remain important. This is especially apparent in an example from Hurricane Rita cited by surge modelers Resio and Westerink (2008): During Rita, winds in western Louisiana blew towards the coast for only a short duration, and marshes attenuated surge heights at rates ranging from 1 m per 11-19 km. On the eastern side of the state, however, steady winds out of the southeast pushed the surge crest from Breton Sound across 40 km of marsh, resulting in surge levels that were highest near the Mississippi River levees (Resio & Westerink, 2008). These contrasting responses from wetlands suggest the need for a storm protection approach that includes both man-made and natural elements.

Ideas for Shoring Up the Louisiana Coast: How Wetlands Fit In

The general consensus—among scientists, non-profits, and government institutions—regarding the protection of the Louisiana Coast includes wetlands as an integral component of a multiple lines of defense strategy (MLODS; Lopez et al., 2008). Originally proposed by the Lake Pontchartrain Basin Foundation in 2006, MLODS has since been adopted by the State of Louisiana (CPRA, 2007) and the Louisiana Coastal Protection and Restoration Plan (LACPR) (USACE, 2008a). In addition, a recent consulting study by Dutch engineers (Netherlands Water Partnership in cooperation with the USACE; Dijkman, 2007) emphasized many of the MLODS core principles. The results of this study are now being integrated into the LACPR.

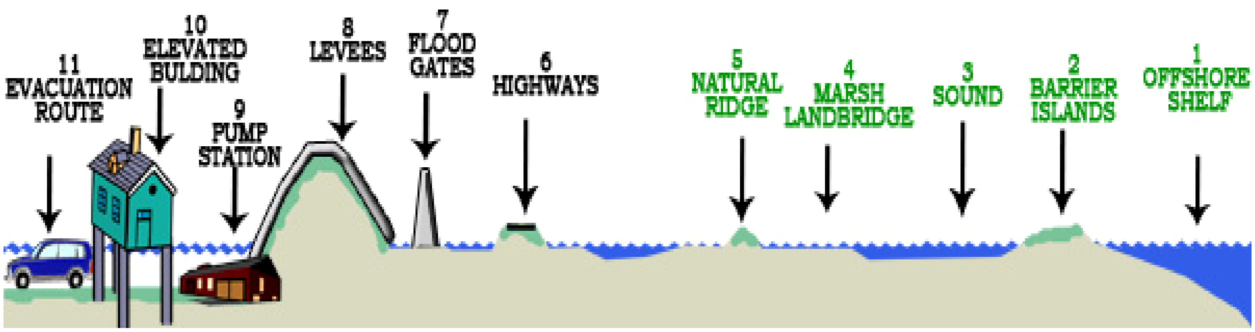

Figure 1-9: Conceptual diagram showing physical lines of defense against hurricanes. Wetlands are a key component of the multiple lines of defense strategy, due to their ability to buffer physical lines of defense, and sustain themselves against relative sea level rise. (From Lopez, 2006; Courtesy of the Lake Pontchartrain Basin Foundation and the Coalition to Restore Coastal Louisiana.)

Inherent in the MLODS is the recognition that neither wetlands nor engineered flood protection alone can protect New Orleans and surrounding areas. Instead, MLODS calls for a system-wide approach, where concentric lines of defense (extending from natural systems near the Gulf to engineered systems near populated areas) work synergistically to protect communities and maintain ecosystems in a sustainable manner (Figure 1-9). Wetlands are a critical component of this system. Under the right conditions, their self-sustaining ability to keep pace with RSL rise (by producing accumulations of organic sediments) adds considerable sustainability. By acting as buffers, wetlands also reduce the cost of engineered systems, and provide additional insurance against the failure of those systems.

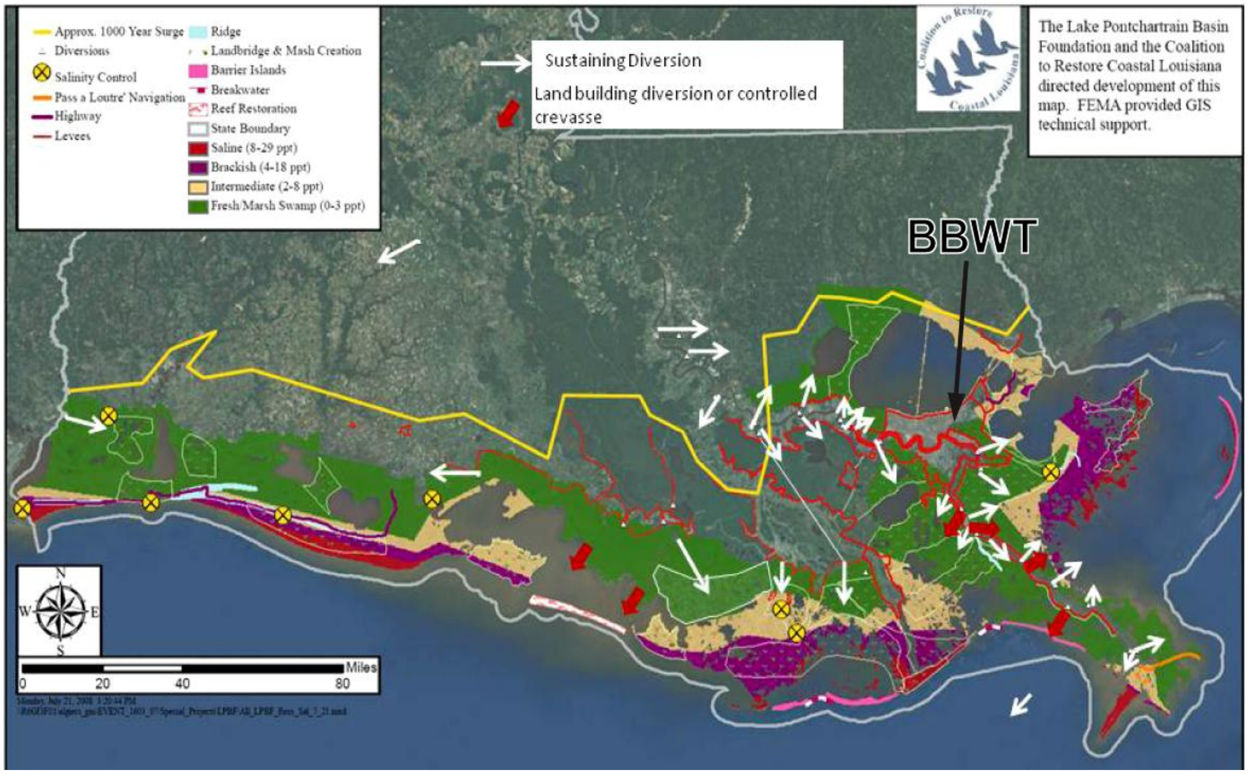

Figure 1-10: Map showing lines of defense, including goal habitats and proposed diversions of the Mississippi and Atchafalaya Rivers (indicated by the white arrows). Goal habitat salinity zones are indicated by green (freshwater swamp/marsh), beige (intermediate), purple (brackish), and red (saline). Existing and proposed levee systems are outlined in red. (From Lopez et al., 2008; Courtesy of the Lake Pontchartrain Basin Foundation and the Coalition to Restore Coastal Louisiana).

The MLODS would achieve an appropriate buffer of sustainable wetlands by using freshwater diversions of the Mississippi to restore historical salinity gradients and maintain existing wetlands. In addition, a relatively small amount (98,000 acres, or 7.3 percent of lost land) of wetlands would be re-created at strategic locations using piped sediment. Many other areas suffering extensive, chronic land loss would be abandoned. The overall distribution of ideal habitats under this plan is based on historical conditions, including freshwater swamp in the BBWT and much of the Central Wetlands Unit[5] (CWU; Figure 1-10, Lopez et al., 2008).

This integration of wetlands is in marked contrast to the much-heralded storm protection model adopted by the Netherlands following the catastrophic flooding of 1953. The original "Dutch model" relied heavily on engineered protection and the reclamation of estuaries for settlement and agriculture (which had already been occurring, and which had exacerbated flooding in 1953). Although this system was highly successful in providing improvements in flood

[5] The estuaries located to the east of the BBWT, which are bordered to the south by the St. Bernard Parish back floodwall and to the north by Bayou Bienvenue and the MRGO.

protection (up to 10,000 years in some areas), navigation, and freshwater supply (Dijkman, 2007), it also resulted in the destruction of 90 percent of wetlands, and following subsidence, 60 percent of the population living below sea level. With climate change and on-going subsidence, this defense system will require continuous maintenance (Lopez et al., 2008). Additional problems include degraded water quality, erosion, and curtailed recreational opportunities. Given the circumstances mentioned in the preceding pages, Louisiana cannot afford to make this same mistake. The 2007 Netherlands Water Partnership report urges Louisiana to be “eco-pragmatic” in the design of future flood protection systems.

The BBWT as a Line of Defense

The Lower Ninth can potentially be flooded from all four sides. Therefore, no amount of vegetation in the BBWT can provide the neighborhood with comprehensive protection. As an example, high water levels in the IHNC, which caused breaching of the west floodwall during Hurricane Katrina and overtopping during Hurricane Gustav, are independent of the condition of the BBWT. In addition, the BBWT lies inside the outer levees along the MRGO/GIWW (Figure 1-10). Therefore, it would only face the full storm surge if these levees were to fail (as they did extensively during Katrina).

However, woody vegetation (such as cypress) in the BBWT would likely enhance the integrity of the Florida Avenue floodwall, which would provide an additional line of defense should the outer levees fail. If such a buffer were extended eastward into the CWU, it could also prevent flooding in St. Bernard Parish, which borders the Lower Ninth on its eastern side. A buffer of bald cypress in this area is recommended in the MLODS report (Lopez et al., 2008), and could potentially be restored and sustained under current salinity conditions by a combination of wastewater assimilation and locally-borrowed sediment, as proposed in the New Orleans Sewerage and Water Board’s feasibility report (WSNC, 2009).

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Chapter 2: Hydrology of the BBWT

Andrew Leaf

The way that water cycles through Louisiana's coastal wetlands has a fundamental effect on the character of those wetlands. Changes in tidal fluctuations and salinity levels following the construction of the MRGO had a transformational effect on the CWU and other wetlands east of New Orleans, including the destruction of virtually all cypress-tupelo swamps. Despite its mostly enclosed appearance, the BBWT is well-connected to this larger wetlands system by Bayou Bienvenue (Figure 2-1), and thus shares its complex hydrology. Water levels and salinities in these estuaries are highly variable on timescales of minutes to months, and are controlled by astronomical tides, wind intensity and direction, and point discharges from antiquated drainage systems. The success of future restoration efforts aimed at replacing bald cypress and other freshwater species in this area will depend on the consideration of appropriate hydrological conditions.

Water Levels and Salinity

Water budgets account for the rates at which water cycles through a water body via various inputs (precipitation, surface water and groundwater inflow) and outputs (evapotranspiration[6], surface water and groundwater outflow).

The 2007 WRM group created a basic water budget for the BBWT. They found tides, precipitation, evaporation, and discharge from Pump Station 5 to be the major components. Investigation into the groundwater component was hampered by difficulties in obtaining water from mini-piezometers installed in the underlying impermeable clays (WRM, 2007). Given extremely low permeabilities and small hydraulic gradients, the influence of groundwater on the BBWT is likely negligible. Other water budget studies in southern Louisiana have come to similar conclusions (e.g. CRI, 2005; Hyfield et al., 2008). This document attempts to address unanswered questions from the 2007 WRM report, including the influences of wind-setup, tides, and pump station discharge on water levels and salinities in the BBWT.

Methods

Continuous water-level data were collected from June 18-November 1, 2008, and as of the writing of this report (June, 2009) continue to be collected at location WL (Figure 2-2). Measurements were taken using a self-contained Solinst Levelogger® pressure transducer/data logger—housed in a stilling well, to minimize the influence of waves and currents on measurements. Since water levels are measured as pressures, measurements reflect not only the weight of the overlying water column, but also that of the atmosphere (barometric pressure). To correct for this effect, measured barometric pressures were converted to equivalent water depths, and subtracted from the total water level measurements.

[6] Evapotranspiration includes evaporation and also the uptake and release of water into the atmosphere by plants (transpiration).

Figure 2-1: The BBWT and surrounding features.

From June 20 - August 4, 2008, the 2008 WRM group collected weekly synoptic measurements of salinity at 20 locations around the BBWT. Many of these locations were previously sampled by WRM 2007, while other sampled areas were new (Figure 2-2). Monthly salinity measurements were also collected in the fall of 2008 at 12 of these locations. Synoptic sampling entailed canoeing to most of these locations in a single trip, which typically took 4-5 hours. Additional salinity measurements were taken at various locations on other days. Sampling was conducted at various times throughout the day, ranging from 7:00 am to 11:00 pm. Measurements were taken with a YSI EC300 conductivity, salinity, and temperature meter.

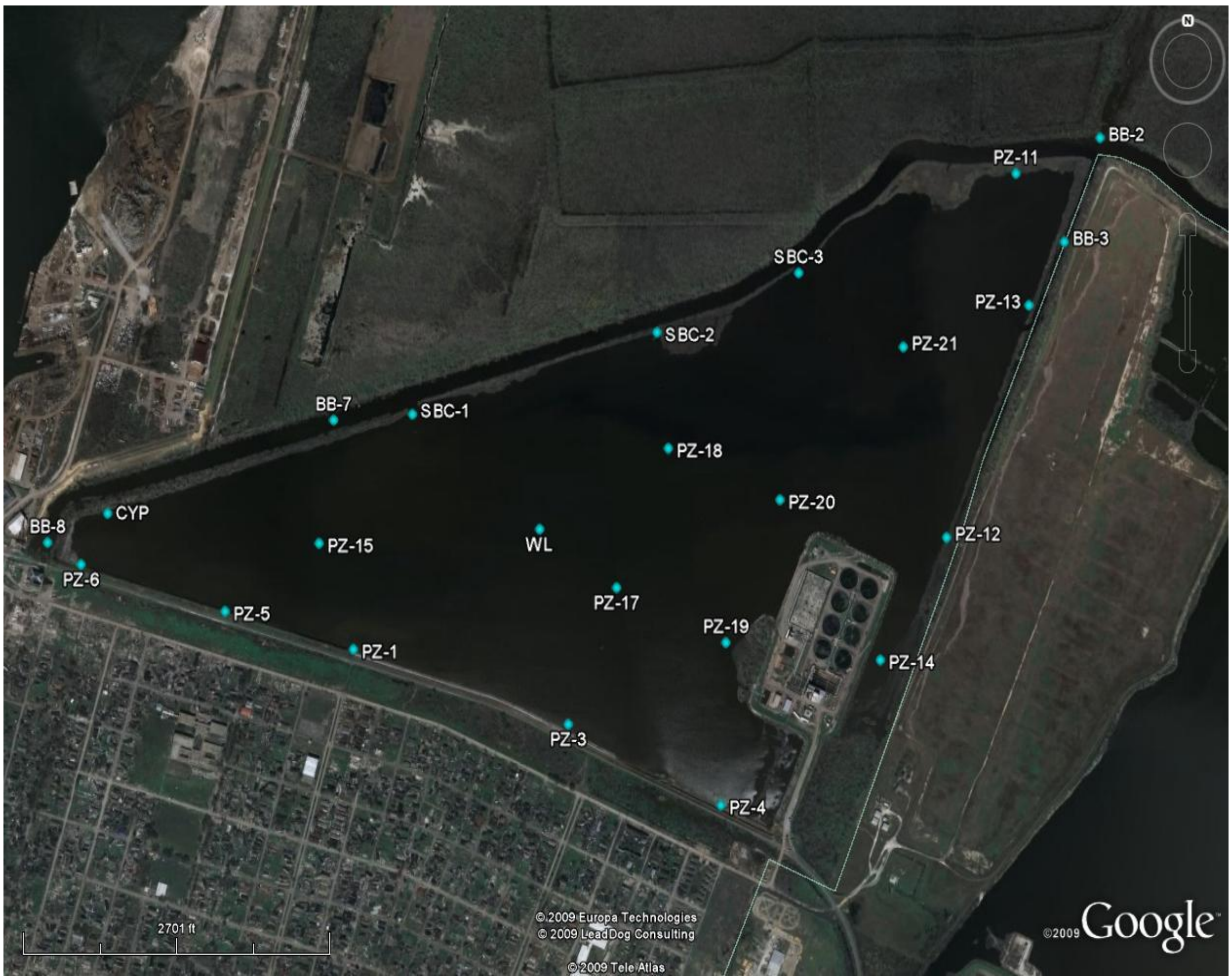

Figure 2-2: BBWT sampling locations. The points SBC-1, 2, 3 refer to "cuts" in the dredge-spoil bank (WRM, 2007) through which water is exchanged between the BBWT and Bayou Bienvenue. Points labeled "BB" are within Bayou Bienvenue itself, or connecting channels (BB-3). Points labeled "PZ" are located within the BBWT; their naming is an artifact of the groundwater investigation conducted by the WRM 2007 group (PZ is an abbreviation for piezometer). The point "CYP" indicates the location of the single remaining cypress.

Wind Setup

The 2007 WRM group showed the BBWT to be dominated by diurnal tides[7], which add and remove approximately six inches of water (spread over the BBWT) per day. Additional work in 2008 suggests that periodic "wind-setup" events can have an even greater effect, producing changes in water levels exceeding one foot over the course of a day (Figure 2-3). Wind-setup is a common occurrence on surface water bodies and is characterized by increases in water levels on the down-wind shore during periods of strong, sustained wind. These changes in water levels are the result of wind-induced surface currents, which in shallow water run parallel to wind direction. The magnitude of this effect is inversely proportional to water depth (Harris, 1963).

In estuaries such as those in the Pontchartrain Basin, wind-setup manifests itself in a fashion similar to astronomical tides (Harris, 1963). Generally, high (greater than 15 mph) winds from a sustained eastern or western direction induce currents that fill or drain (respectively) the Pontchartrain basin, creating water levels significantly above or below the normal ranges. Wind-step is a major component of hurricane storm surge, and its effect on water levels in the Central Wetlands has been documented in earlier publications (e.g. CEI, 1982).

[7] Whereas many parts of the world experience semi-diurnal (twice daily) tides, the Gulf of Mexico experiences only one high and low tide each day.

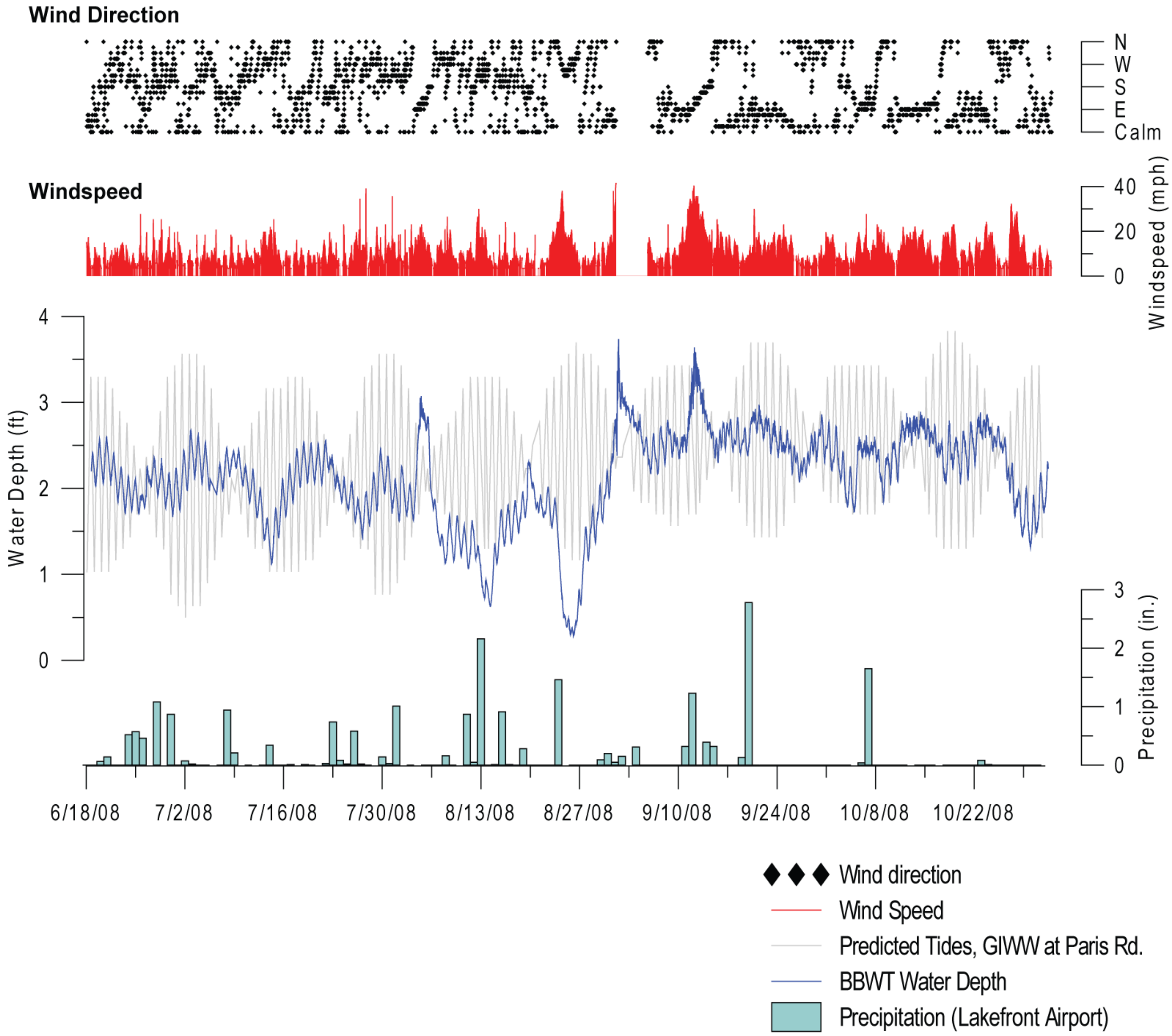

Figure 2-3: BBWT stage (blue) recorded from June 18-November 1, 2008, in comparison to predicted tides in the Gulf Intercoastal Waterway (GIWW) at the Paris Road Bridge (gray), as well as daily precipitation, and hourly wind-speed and direction observed at New Orleans Lakefront Airport. Note that the Paris Road tide predictions are not set to a particular datum; rather, they are matched with the plot of BBWT stage for conceptual comparison. The effects from hurricanes Gustav (September 1, 2008) and Ike (September 13, 2008) are significantly muted by the closure of floodgates along the MRGO levee, at Bayous Bienvenue and Dupree. The August 3, 2008 peak is from Tropical Storm Edouard.

During our period of observation this summer (2008), wind-setup events created the highest and lowest observed water levels (Figure 2-3). Wind-setup was also undoubtedly responsible for the previously unexplained July 7, 2008 drop in water levels observed by the 2007 WRM group (WRM, 2007). Typically, the effects of wind-setup on water levels in the BBWT appear short-lived, with normal levels returning within days following the event (Figure 2-3).

Drainage from the Lower Ninth Ward

Aside from precipitation, pump station outfalls, which drain leveed communities, are the primary inputs of freshwater into the wetlands east of New Orleans. Although the quantities of water discharged are small in comparison to tides, the influence on immediately adjacent wetlands can be significant. In the BBWT, discharge from the New Orleans Sewage and Water Board's (NOSWB) Pump Station 5 (near location BB-8; essentially at the "headwaters" of Bayou Bienvenue; see Figure 2-2) creates lower salinities at the BBWT's western end (Figure 2-6 and Figure 2-7. A previous restoration proposal (Hartman Engineering, 2001) sought to take advantage of this by constructing a series of vegetated earthen baffles, which would retard incoming tides and increase the retention of discharging freshwater.

Pump Station 5 drains the Lower Ninth Ward by lifting stormwater and so-called "dry weather" flow out of the Lower Ninth's drainage system. Dry weather flow consists mostly of leakage from broken water and sewer mains, and native groundwater. The station has seven pumps, with a total capacity of 2,300 cubic feet per second (cfs), a flow similar to that of the Wisconsin River in dry conditions. Two 500 cfs pumps and one 1,000 cfs pump, which were installed in the early twentieth century, are among the largest in the world, and are only used during major storms. Four smaller, 75 cfs "constant duty" pumps are used on a more regular basis, as a typical day requires only a single 75 cfs pump to operate for 90 minutes (Kenneth Smith, personal communication, 2008).

Two main subterranean canals running along Florida and Jourdan avenues feed the pump station. Two additional underground canals exist in the Lower Ninth Ward: one runs below Tupelo Street, from St. Claude Avenue to Florida Avenue, and the other runs beneath St. Claude, from Reynes Street to Jourdan Avenue.

The remaining streets are drained by surface ditches, or pipes of various diameters, the largest of which are 4 ft (under Claiborne Avenue and St. Claude Avenue—east of Reynes Street). Large rain events can overwhelm the system's ability to transport runoff to the sump beneath the pump station, causing backup and standing water along Florida Avenue. This phenomenon was observed on August 1, 2008, following morning rains and an afternoon rain event where 0.8 in. fell in less than 30 minutes. According to residents, this is not uncommon.

With the current (as of August, 2008) NOSWB record-keeping system, quantification of discharge entering Bayou Bienvenue is not feasible. However, back-of-the envelope calculations can produce conceptually useful estimates. A look at the pumping records for the third week in July, and a discussion with the station operator suggested that during typical dry-weather conditions, the station discharges approximately 3 million gallons per day (or about 0.26 in. spread over the BBWT) into Bayou Bienvenue (Kenneth Smith, personal communication, 2008).

Figure 2-4: Pump Station 5 effluent entering the BBWT through the westernmost opening in the spoil bank. (Photo by Dan Cornelius, January 2008)

The amount of stormwater generated by a given rainfall event is much more difficult to determine. If all rain falling on the Lower Ninth Ward reached Pump Station 5, approximately 3.4 in. (spread over the BBWT) would be discharged per inch of rainfall. In reality, this would not be possible, due to losses[8] which inevitably occur as the water makes its way through the neighborhood. The amount of water lost depends on prior (antecedent) conditions. If the neighborhood is already saturated from previous rain, a greater percentage of rainfall will reach the sump. Several characteristics of the neighborhood suggest a high capacity to store rainwater (in comparison to other urban areas): relative flatness, numerous potholes and other small depressions resulting from differential subsidence, and a high percentage of vegetated, open area (especially north of Claiborne Avenue). This capacity may be enhanced by a high evaporation rate (NWS, 2008a), which can remove water between events. However, given the underlying clay soils, a presumably high water table, and an average annual precipitation of over 60 inches, significant discharge of freshwater into the BBWT following prolonged periods of rain is also likely. Both of these hypotheses are supported by our salinity measurements.

[8] These include the infiltration into soil, storage in potholes, swales and other depressions, capture by plant leaves and other objects, along with uptake by plants (transpiration), and evaporation.

Salinity

The 2007 WRM group observed salinities in the range of 2-5 ppt with concentrations increasing from west to east across the BBWT (Figure 2-6 and 2-7). Additional work this year recorded a higher range in salinities (>9 ppt), and also found a high temporal variability (Figure 2-5, 2-6, 2-7, and 2-8). This variability is the result of tidal and wind-driven mixing (via Bayou Bienvenue) between the BBWT and more saline estuaries to the east (i.e. the Central Wetlands). These exchanges cause diurnal variations, with daily averages rising and falling over several days or weeks in response to fluctuations in rainfall. Generally, salinity is highest in the mid to late fall, when rainfall is lowest. Similarly, salinity levels are generally lowest in late spring/early summer, when precipitation is higher. This seasonal variation is enhanced by high evapotranspiration[9] during late summer and early fall, and reduced evapotranspiration in the winter and early spring. Variations in annual precipitation can cause longer-term trends in average concentrations (CEI, 1982).

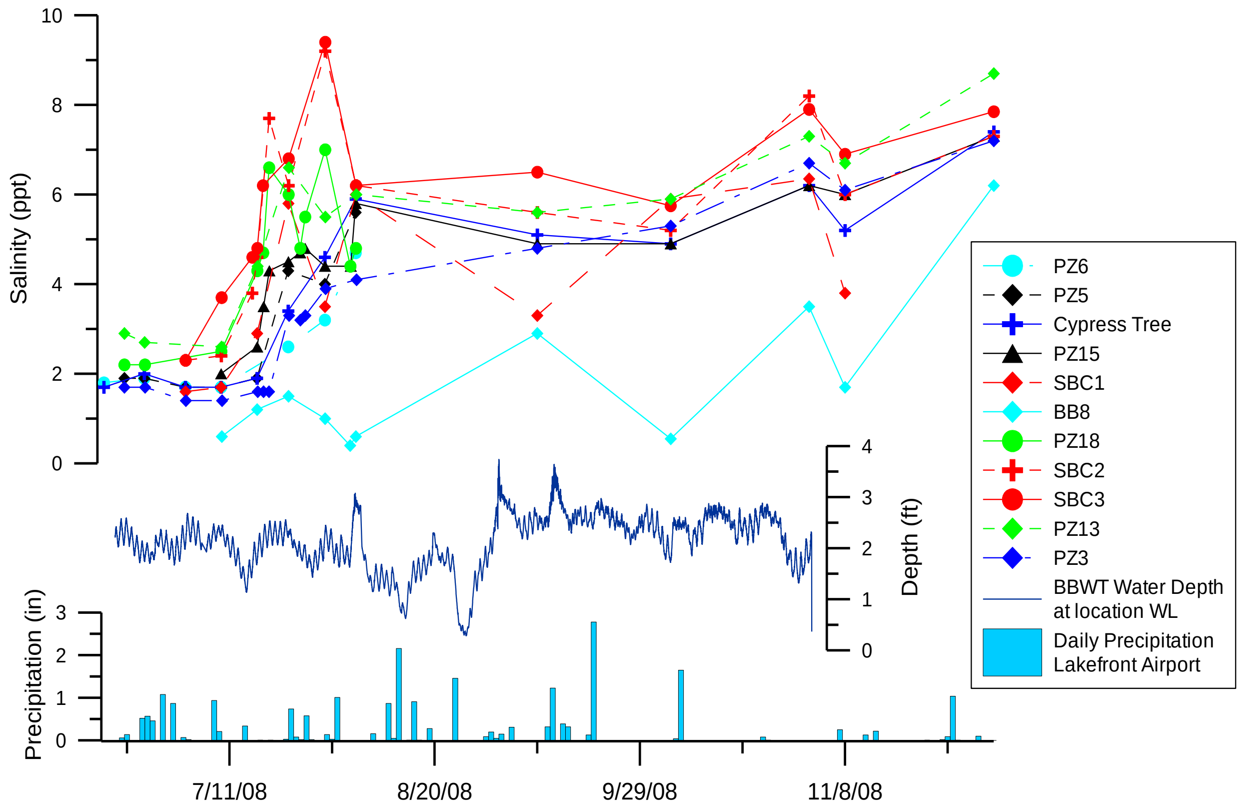

Figure 2-5: BBWT salinities with water levels and precipitation.

[9] Evapotranspiration includes evaporation and also the uptake and release of water into the atmosphere by plants (transpiration).

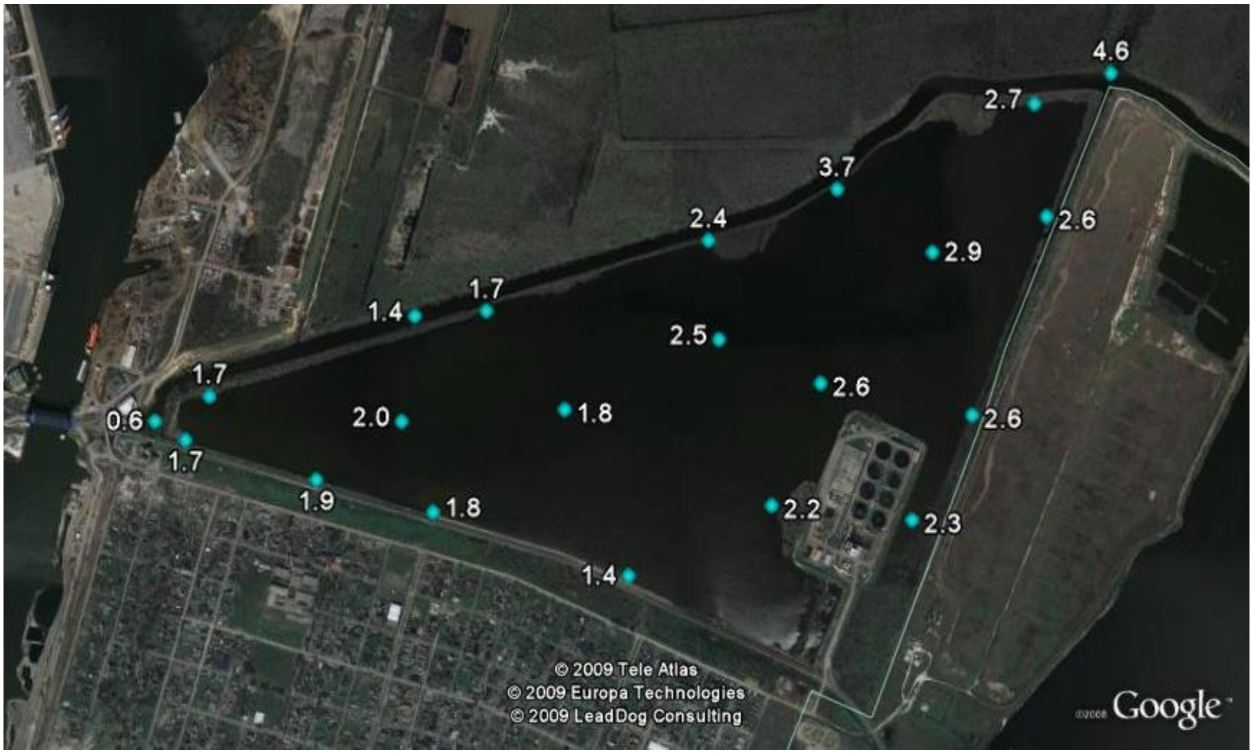

Figure 2-6: BBWT salinities measured on July 9, 2008.

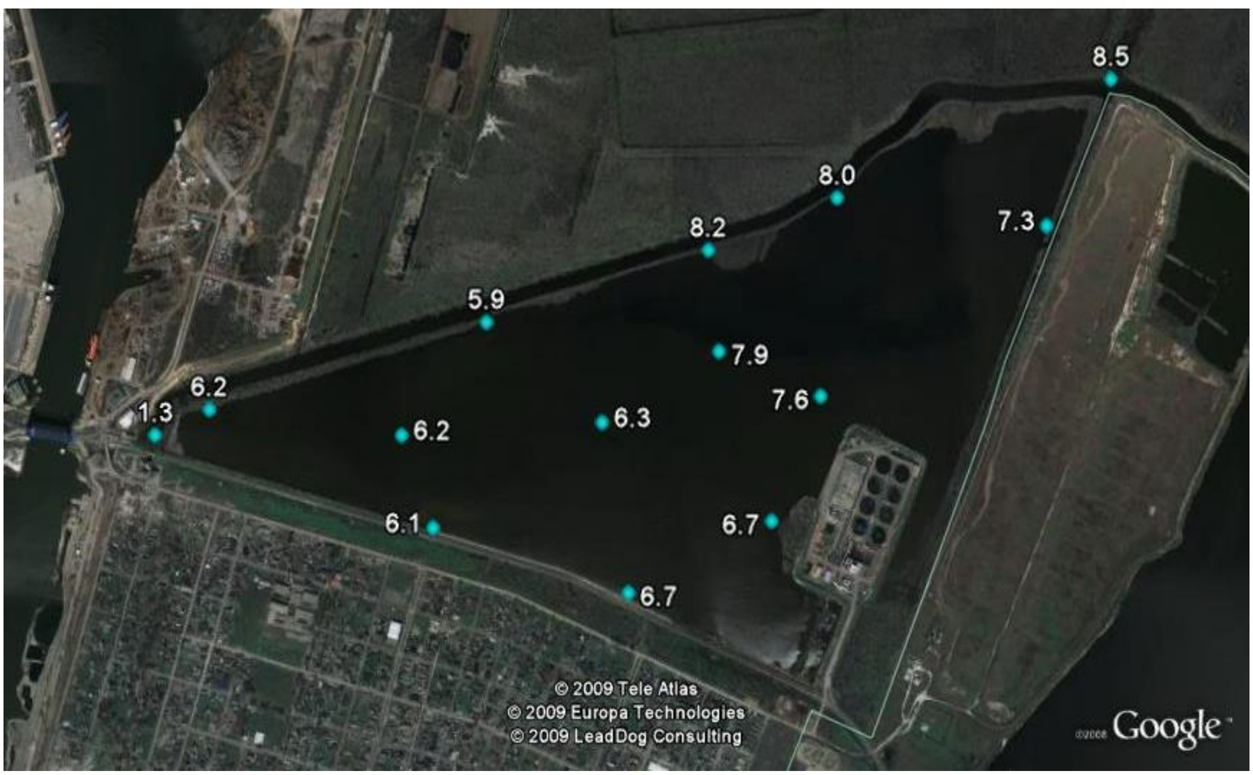

Figure 2-7: BBWT salinities measured on November 1, 2008.

A result of this complexity is that there are no single numeric values with which to characterize BBWT salinity concentrations or rates of fluctuation. Rather, salinity should be thought of as occurring in ranges that vary with location in the BBWT and with time, depending on rainfall and evapotranspiration conditions. The qualitative discussion that follows is meant to help the reader better understand this variability.

Increases in salinity during incoming tides were observed (Figure 2-9). Outgoing tides were not observed, as they typically occur in the middle of the night, although they likely have an inverse effect. The magnitude of these fluctuations depends on the salinity gradient between the BBWT and the estuaries to the east, from which the incoming water originates. When the BBWT is relatively fresh and a large salinity gradient exists along Bayou Bienvenue, salinity in the BBWT can increase rapidly (as seen in Figure 2-9) with incoming tides. Periods of low rainfall tend to reduce the salinity gradient between the BBWT and the CWU, resulting in less temporal variation (this was observed in the late fall of 2008; Figure 2-5 and Figure 2-7).

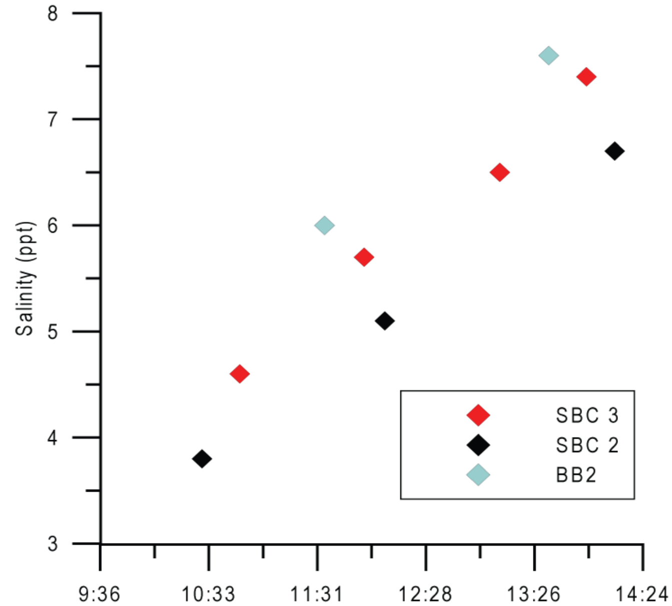

Figure 2-8: Increasing salinities observed during the incoming tide on July 15, 2008.

Wind-setup events, which cause large volumes of water to flow between the BBWT and CWU, have the potential to cause dramatic increases in salinity. Salinity increases from hurricane storm surge present a significant obstacle to cypress restoration in areas that are hydraulically well-connected to the larger Pontchartrain Basin (e.g. Pass Manchac; Moreau, 2008). Figure 2-10 shows salinity levels in western Lake Pontchartrain (near Pass Manchac) following Hurricane Gustav. Similar increases in the BBWT were likely prevented by the closure of the flood gate at the MRGO levee.

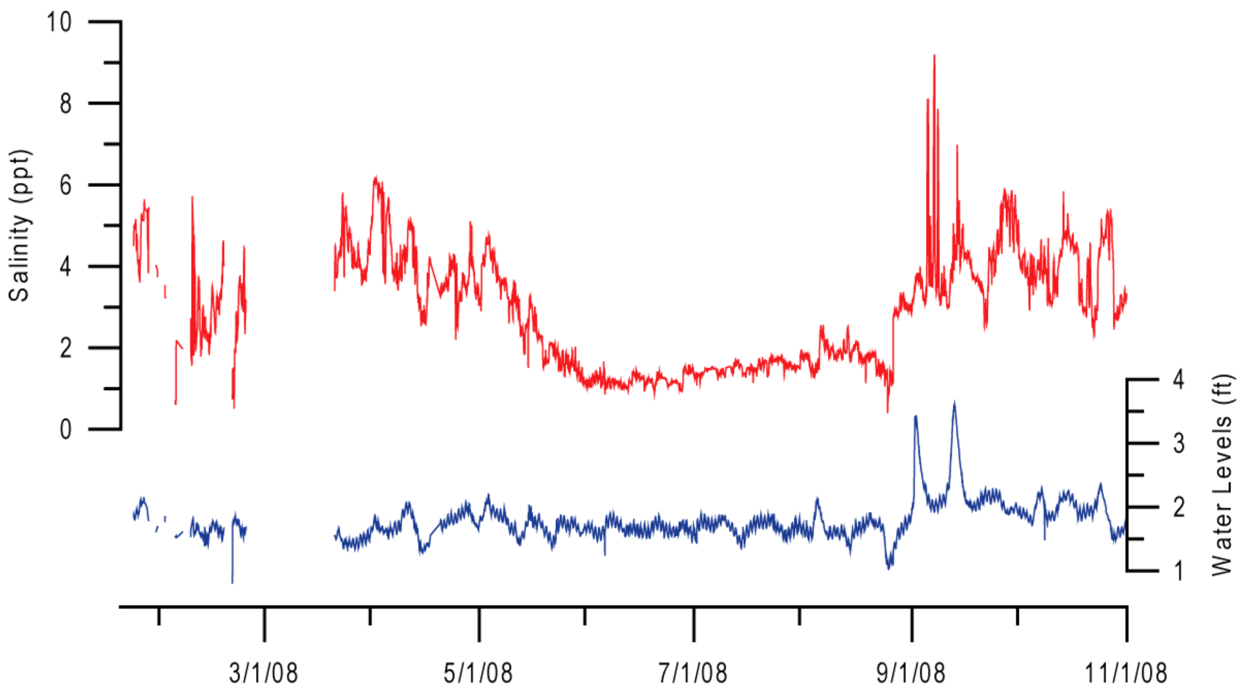

Figure 2-9: Hourly salinity (red) and water levels (blue) in western Lake Pontchartrain (LUMCON).

Salinity increased sharply in July 2008, from 1-4 ppt at the beginning of the month, to 3-10 ppt near the end (Figure 2-5). These increases were likely due to a lack of rainfall (precipitation in July 2008 was half the long-term average). The differences, however, could have been enhanced by lower than average June salinity levels (Figure 2-5 and Figure 2-6) resulting from the April 11, 2008 opening of the Bonnet-Carré spillway, which had a significant effect on salinities in Lake Pontchartrain (Figure 2-). From August through December, measured salinities were mostly above 4 ppt.

Spatial variation in salinity within the BBWT can be enhanced by aquatic vegetation, which appears to significantly retard circulation. In June and early July 2008, thick mats of algae covered the southern and western ends of the BBWT. In mid-July, when salinities in the open areas of the BBWT were increasing, salinities within the areas covered by algal mats remained close to June levels. Following the breakup of the mats during the third week in July, salinities in these areas increased, approaching those in other parts of the BBWT (Figure 2-5). Dramatically reduced turbidities within the mats provided further evidence for reduced circulation.

Basic Water Quality Parameters

Basic water quality parameters were also collected during synoptic sampling sessions between June 20, 2008-August 4, 2008. These included temperature, pH, alkalinity, and dissolved oxygen (DO). In addition, limiting nutrient concentrations (nitrogen—as nitrate and total kjeldahl nitrogen, and phosphorus (total and ortho) were sampled in mid-July and early August from five sites: PZ3, PZ15, PZ18, SBC3, and BB7 (Figure 2-2). Sampling data are available from the authors upon request.

pH[10]

pH was measured in the BBWT using an YSI pH 10 handheld meter. A three-point calibration of the instrument was performed before each sampling session. pH levels in the BBWT ranged from 7.0-9.7, with typical values falling between 8 and 9. These values are consistent with those reported by WRM 2007. Generally, pH increased slightly from west to east across the BBWT, presumably with a decreasing percentage of Pump Station 5 effluent. Location BB8 (Figure 2-2) consistently had the lowest pH values, while the highest were found along the Florida Avenue floodwall, where mats of algae were present during June and part of July (see below).

High pH levels could be the result of biological productivity. Higher rates of photosynthesis (which consumes CO_2) can increase pH by lowering concentrations of dissolved CO_2 (Day et al., 1989). In June, higher productivity was apparent in the thick algal mats that covered the BBWT. The average pH measured in June was 8.7. In July, this decreased to 8.2.

The pH of BBWT soil was not measured. For restoration purposes, soil pH is important, as it affects the geochemical environment in which plants root. However, this parameter would be likely to change considerably with restoration, as most scenarios (especially the planting of cypress and tupelo trees) require the BBWT to be filled with sediment to mean-tide height (2.0-2.5 ft above the current sediment-water interface).

Alkalinity[11]

Alkalinity was measured in the BBWT as dissolved carbonate, using field titration kits manufactured by CHEMetrics ®. Alkalinity levels were consistent throughout the sampling period, ranging from 90 to 300 mg/L $CaCO_3$[12], with most values falling between 125-200 mg/L $CaCO_3$. Alkalinity levels generally decreased from west to east across the BBWT. Additionally, the alkalinity levels were higher than those recorded downstream in the Bayou Bienvenue (at the Paris Road Bridge) by the Louisiana DEQ (between 1991–2006): 40–100 mg/L $CaCO_3$, with most values falling between 60–90 mg/L (LDEQ, 2008).

Dissolved Oxygen

Dissolved oxygen (DO) enters estuarine water via photosynthesis in plants, diffusion from the atmosphere, aeration of the water and tides. Dissolved oxygen leaves estuarine water via respiration, diffusion into the atmosphere, chemical oxidation reactions, and tides. Researchers measured DO using CHEMetrics ® test kits, and a YSI DO200 meter. Dissolved oxygen in the BBWT varied widely, ranging from 0.1 mg/L to over 14 mg/L. Most concentrations were above 6 mg/L, indicating conditions near or above saturation. However, strong diurnal fluctuations

[10] pH measures how acidic or basic a solution is. It is defined as the negative logarithm of hydrogen ion activity (pH = $-\log [H^+]$). The pH scale ranges from 0 (extremely acidic) to 14 (extremely basic). A value of 7 is considered neutral. pH is a “master variable” (Stumm & Morgan, 1996) that affects many of the chemical reactions taking place in water, with implications for ecosystem health, along with the mobility and toxicity of contaminants. It is therefore, an important measure of water quality. pH is affected by atmospheric CO_2, which dissolves in water to form carbonic acid (H_2CO_3). The dissociation of carbonic acid liberates hydrogen ions, which decreases the pH. As a result, pure water exposed to the atmosphere is naturally slightly acidic, with an approximate pH of 5.6-5.7. In estuaries, pH typically ranges from 7.8-8.8 (Day et al., 1989). These values are higher than those of pure water because of the dissolved minerals present in seawater.

[11] Alkalinity measures the acid-buffering capacity (resistance to decreases in pH) of a solution.

[12] Dissolved carbonate equivalent.

were observed, with the lowest concentrations occurring in the morning (following nighttime respiration) and the highest concentrations occurring in the afternoon (during photosynthesis). There were no apparent spatial trends in concentrations, likely a result of small-scale microgradients (Day et al., 1989) and the difficulty of comparing temporally-changing concentrations measured over a four hour sampling period.

Limiting Nutrients

A wide variety of nutrients (including chemical elements and compounds) are required for the growth and survival of organisms. Nutrient cycling is a fundamental part of the flow of energy through ecosystems, and can exert control on this process. Most nutrients (for example, carbon, sulfur, potassium, etc.) are abundant relative to biological requirements. Nitrogen and phosphorus, however, are often in scarce supply relative to these requirements, and can therefore limit biological productivity (growth).

In coastal wetlands, concentrations of nutrients are in a constant state of flux in response to input from rivers, the exchange of water with the ocean, and biological processes (Day et al., 1989). Increases in the concentrations of limiting nutrients can lead to excess biological production (often manifested in algal blooms), which can have disastrous consequences for ecosystems. These include large diurnal swings in dissolved oxygen levels (excessive daytime levels, when photosynthesis is occurring, and nighttime oxygen depletion, when respiration is consuming oxygen), and an overall crash in oxygen levels associated with decaying organic matter. In the Gulf of Mexico, this problem has resulted in an ecological "Dead Zone," where increases in nitrogen loading (due to agricultural land use practices in the Mississippi Basin) over the past two centuries have created a 16,700 km^2 area in which DO is less than 2 mg/L (Turner et al., 2007). Biodiversity in this area has collapsed. A particularly dramatic example of the ecological consequences are summertime "jubilees" in which residents of Grand Isle, LA (a barrier island south of New Orleans) observe sharp increases in fish and shrimp, which are thought to result from marine life fleeing the expanding Dead Zone (Achenbach, 2008).

Wastewater assimilation, which redirects treated sewage effluent from the Mississippi River to wetlands, has the potential to help reduce the Dead Zone problem (Mitsch et al., 2001). Many wetlands in Louisiana (especially cypress-tupelo swamps) have a proven capacity to remove excess nutrients from wastewater (Day et al., 2004). However, it must be emphasized that the BBWT and open water areas of the CWU are not analogous to the wetlands at Hammond, Thibodeaux, or Mandeville (where assimilation has been successful).

Whereas these sites are wooded, the BBWT and open water areas of the CWU lack significant amounts of either emergent or submerged vegetation. The thick mats of algae covering the BBWT in June 2008 (which anecdotal evidence suggests are an annual phenomenon) are likely a typical response of this water body to increases in levels of limiting nutrients. Any proposal seeking to use the BBWT or the CWU for wastewater assimilation must specifically demonstrate (possibly through pilot studies) the ability of these wetlands to sequester nutrients without unwanted effects such as algae blooms.

Nutrient samples were collected on June 17, 2008 and in early August 2008 at five sites in the BBWT. Both nitrate-nitrite, and total kjeldahl nitrogen (TKN) were sampled, along with orthophosphorus and total phosphorus. Total kjeldahl nitrogen (TKN) is the sum of ammonia/ammonium, and all organic nitrogen compounds. Together, TKN and nitrate-nitrite encompass the forms of nitrogen that are available for biologic uptake. Orthophosphorus is the form of phosphorus that is available to biologic uptake. Total phosphorus includes orthophosphorus. Samples collected in July were analyzed at the University of Louisiana-Monroe Plant and Soil Analysis Laboratory; those collected in August were analyzed at the Wisconsin State Laboratory of Hygiene (this is the reason orthophosphorus was sample in June, and total phosphorus was sampled in July). Concentrations of nutrients samples are shown below in Table 2-1.

Table 2-1: Nutrient Concentrations in the BBWT (in mg/L)

Site	**Date**	**Nitrogen as Nitrate-Nitrite**	**Nitrogen as TKN**	**Orthophosphorus**
SBC3	7/17/08	0.13	1.25	0.61
PZ18	7/17/08	0.15	2.33	0.61
PZ3	7/17/08	0.14	1.39	0.46
PZ15	7/17/08	0.13	NS	0.79
BB7	7/17/08	0.14	2.56	0.69
Detection Limits:		0.01	0.14	0.04
Site	**Date**	**Nitrate-Nitrite**	**TKN**	**Total Phosphorus**
BB8	8/2/08	0.844	0.89	0.280
BB8	8/3/08	1.130	0.80	0.285
PZ3	8/4/08	ND	2.59	0.377
PZ15	8/4/08	ND	2.00	0.254
PZ18	8/4/08	ND	3.06	0.411
SBC3	8/4/08	ND	2.12	0.263
BB7	8/4/08	ND	2.13	0.481
Detection Limits:		0.019	0.14	0.005
BB at Paris Rd. Mean Concentrations 1991-2006 (LDEQ 2008)				
Annual Mean:		0.100	0.68	0.115
June-August Mean:		0.090	0.76	0.159
Notes: ND=Below Detection Limit, NS=No Sample				

Uncertainties[13] in the nutrient concentrations sampled by the 2007 WRM group preclude a full comparison with that dataset. Nitrate concentrations measured in 2008 do not compare well to those measured in 2007, which ranged up to 10 mg/L. However, total phosphorus levels compare fairly well, with average values of 0.48 mg/L for June 2007, and 0.39 mg/L for July 2007. TKN was not sampled in 2007.

[13] These include charge balance errors in excess of 10%, extreme outliers, and concentration distributions that contradicted other observations (WRM 2007).

From 1991-2006, the Louisiana Department of Environmental Quality (LDEQ) conducted extensive water quality sampling in Bayou Bienvenue at Paris Road on an approximately monthly basis (LDEQ, 2008). Their measured nutrient concentrations are also shown in Table **2-1**. Overall, nutrients concentrations in the BBWT are higher than those downstream. This is consistent with Pump Station 5 effluent as a major source. Nutrients in the pumping station effluent could be sourced from lawn and garden fertilizers, animal feces, and leaking sewer lines. Lower nutrient concentrations observed at Paris Road could be the result of dilution and/or sequestration along Bayou Bienvenue.

The Effects of the Mississippi River Gulf Outlet (MRGO)

The impacts of the MRGO on wetlands east of New Orleans have been well documented (e.g. CEI, 1972, 1982; Day et al., 2006; Kerlin, 1979; USACE, 1999, 2004). By enhancing tidal influence and saltwater intrusion, the MRGO has been the primary driver of wetland destruction in this area. These wetlands provided valuable storm protection to the city, which has been severely compromised (Day et al., 2006). The strong hydraulic connection these wetlands (including the BBWT) have with each other and with the MRGO requires a system-wide approach to their restoration. Mitigation of the MRGO's effects is critical to this process.

Pre-Construction Concerns

Construction of the MRGO was authorized by the River and Harbor Act of 1956 under the rationale of creating a "short cut" that would decrease the shipping distance from the Gulf of Mexico to New Orleans by 40 miles. Consequences of its construction were foreseen by the U.S. Fish and Wildlife Service (USFWS) and documented in numerous letters to the USACE. Predictions included increased tidal influence in marshes, increased average salinities, increased variances in salinities and increased turbidities, which would likely result in wetland degradation (Kerlin, 1979). These concerns motivated the USFWS to fund numerous environmental baseline studies in the area, including Rounsefell (1964), which documented the pre-construction hydrologic regime.

Increases in Tides and Salinity

Comparison of Rounsefell's data with post-construction annual mean salinities in the areas surrounding MRGO, including Bayou Bienvenue and the Central Wetlands, shows dramatic increases (two- or three-fold) resulting from altered tidal circulation patterns. Prior to construction, the La Loutre Ridge acted as a natural barrier between more saline Breton Sound and the wetlands near Lake Borgne. The MRGO severed this ridge, creating an artificially deep (36 ft) conduit for enhanced tidal influence and saltwater intrusion (CEI, 1982).

Temporal salinity fluctuations in this area have also increased. In 1960, Rounsefell observed salinity fluctuations of approximately 5 ppt or less. Salinity now varies by up to 20 ppt or more. Coastal Environments, Inc. (1982) cite the construction of levees along the MRGO's southwest bank, which allow for the temporary impoundment of precipitation and pump station effluent, and increased tidal action, which can rapidly exchange this freshwater with more saline waters, as the primary causes of this phenomena. The post-MRGO salinity regime is illustrated in measurements collected by the Louisiana Department of Fish and Wildlife at Site 65 (located on Bayou Bienvenue near Lake Borgne; Figure 2-10).

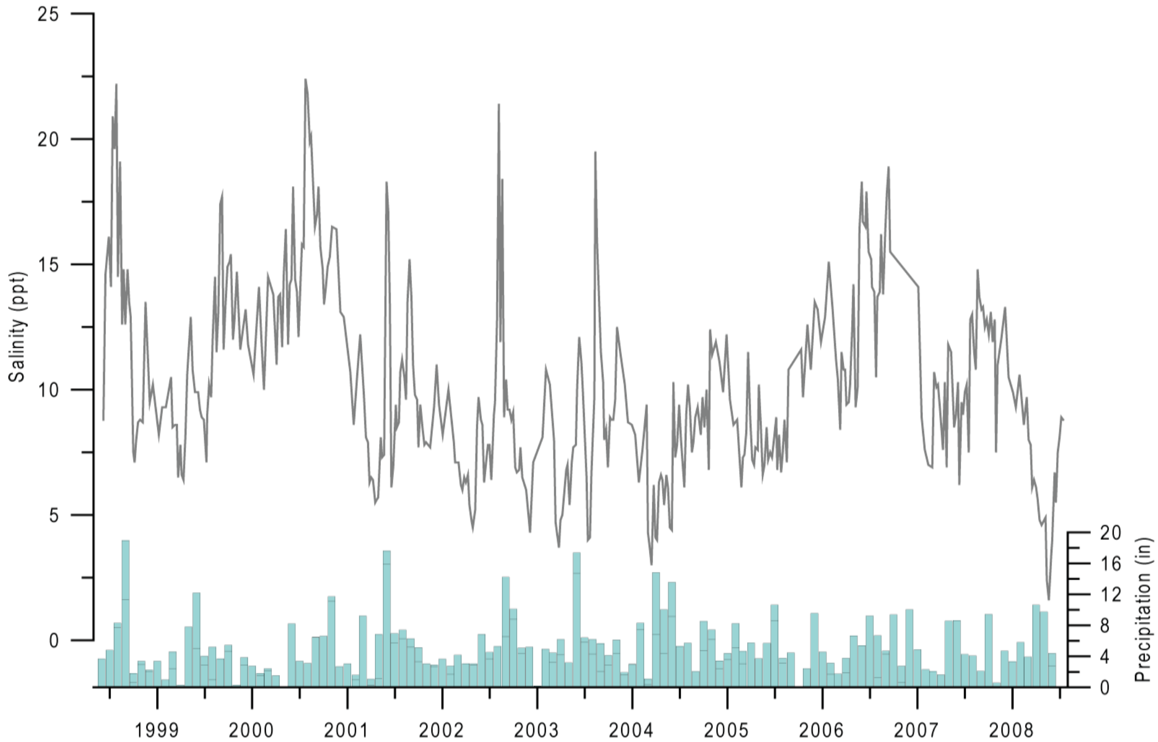

Figure 2-10: Salinity at Louisiana Department of Wildlife and Fisheries Site 65, 1998-2008, with monthly precipitation at New Orleans Lakefront Airport.

The hydrologic changes resulting from the MRGO have severely impacted wetland ecosystems east of New Orleans. Since its construction, virtually all cypress swamps (over 8,000 acres by the USACE's own 1999 estimate) and freshwater marshes (5,678 acres; CEI, 1982) in St. Bernard Parish have been destroyed. In addition, thousands of acres of intermediate and brackish marsh were converted to brackish and saltwater marsh, respectively (USACE, 1999). Total estimates of habitat loss due to the MRGO (the more liberal estimates account for salinity increases in Lakes Pontchartrain and Borgne) range up to 618,000 acres (Day et al., 2006). The BBWT is among the casualties.

Figure 2-11: Looking southeast down the MRGO near its intersection with Bayou Bienvenue. Originally dredged to a 500 foot bottom-width specification, it is now half a mile wide in some places. (Photo by Andrew Leaf)

MRGO Closure and Remediation Plans

Additional measures besides the planned closure structure at La Loutre Ridge (USACE, 2008b) are likely needed to create conditions favorable for wetland restoration (Day et al., 2006). A recent modeling study conducted at the University of New Orleans (Georgiou et al., 2007), showed that a freshwater Mississippi River diversion at Violet, when combined with the MRGO closure, could return salinities in the Pontchartrain Basin to pre-MRGO levels. Congress authorized such a diversion in November 2007, but the timeframe for its implementation is unclear.

Other recommended measures include bank restoration/stabilization along the MRGO, restoration/fortification of the narrow strip of land in between the MRGO and Lake Borgne, and additional constrictions across the channel at several locations (Day et al., 2006).

The coincidence of the BBWT's degradation (WRM, 2007) with the loss of wetlands in St. Bernard Parish suggests that it is also hydraulically well-connected to the MRGO. This idea is supported by water levels and salinities measured by the 2007 and 2008 WRM research groups.

Implications for BBWT Restoration

Current salinity levels and a permanent state of inundation in the BBWT do not support the regeneration of a cypress-tupelo swamp. This is generally true for the Pontchartrain Basin as a whole, where most historical swamps are either gone or deteriorating (Hoeppner et al., 2008). In the BBWT, the introduction of sediment, in combination with a pulsed delivery of wastewater, as proposed by the NOSWB (WSNC 2009) and the USACE (2008c) could allow for the successful re-introduction of cypress and tupelo. However, because of the strong hydraulic connection between the BBWT and the larger Pontchartrain Basin, such an effort would likely require structures to control saltwater intrusion. The restoration of historical salinity gradients to the Pontchartrain Basin through Mississippi River diversions and the closure of the MRGO is feasible (Lopez, 2008; Day et al., 2007, 2006) and represents a more sustainable, comprehensive, and long-term solution to the regional problem of wetland degradation and the future habitability of New Orleans.

If the primary storm-protection role of the BBWT is to reinforce the Lower Ninth Ward's back floodwall against waves (see Chapter 1), woody vegetation is likely required. With the closure of the MRGO and a Mississippi River diversion at Violet, favorable salinity conditions for cypress in the BBWT are likely. Aside from cultural, historical and aesthetic reasons, cypress trees are highly desirable for storm protection, due to their size and proven ability to withstand hurricanes (WSNC, 2009; Moreau, 2008). Cypress restoration will not come cheap, however. In 2008, the USACE estimated the cost of filling the BBWT with sediment to be approximately $40 million (USACE, 2008c). In the Multiple Lines of Defense report, Lopez et al. (2008) cite a cost of $2.6 billion for restoring 98,000 acres of MDP wetlands critical to storm protection.

Should salinities and water levels remain in their present state, a mangrove swamp might present a feasible future alternative to a cypress-tupelo community. Black mangroves are tolerant of a wide range of salinities (Lugo & Snedaker, 1974), and currently exist on the southern fringes of Louisiana, where periodic frosts are less common (Twilley et al., 2001). They are capable of regenerating after hurricanes, although hurricanes appear to place a limit on their growth (Lugo & Snedaker, 1974). If climate change significantly reduces the frequency of frosts in the New Orleans area, and if hydrologic conditions continue to degrade existing ecosystems, it is possible that black mangroves will gradually migrate northward and establish themselves. Many consequences of this scenario are undesirable, including the continued enlargement of open water areas, a heightened vulnerability to storms and the potential loss of freshwater fisheries (Keddy et al., 2007).

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Chapter 3: Vegetation in the BBWT

Amanda Perdzock

The 2007 WRM report included a 1723 map of the New Orleans area that showed the BBWT to be part of a contiguous cypress swamp partially cleared for settlement and agriculture (WRM, 2007). This study aims to characterize current vegetation communities in the BBWT, and compare them to historic conditions. A 1938 study of wetlands surrounding New Orleans (Penfound & Hathaway, 1938) was used as a baseline for comparison.

Wetland Community Composition in 1938

Penfound and Hathaway (1938) provide an illustration of early twentieth century cypress swamp conditions. From 1932-1933, they surveyed transects of relatively undisturbed areas within a 70 mile radius of New Orleans, and compared community compositions in relation to salinity gradients. Wetland types analyzed included fresh water marshes, salt marshes, and cypress-tupelo swamps. A list of cypress swamp species found by this study, as well as a list of brackish marsh species, can be found in Appendix A.

Although their study was conducted prior to the most intensive twentieth century alterations, Penfound and Hathaway noted that man-made canals near one transect had already altered salinity levels. According to their study, during normal patterns of succession, cypress trees slowly become established in open freshwater marsh areas. The canopy of the trees then block the light needed by the marsh plants, killing them off and making room for shade-tolerant swamp species to become established. The introduction of saltwater disrupts this natural pattern, creating salinity levels that are inhospitable for many swamp species. Once swamp species die, a new pattern of succession, outlined in Figure , results in the establishment of a more saline marsh**.**

During their transect studies, Penfound and Hathaway noted a positive relationship between stunted cypress growth and increasing salinities. Salinity increases near the most saline transects (those in the upper range of bald cypress salt tolerance) resulted in “ghost forests” of dead cypress. Primary colonizers of these newly created, brackish dead-zones were smooth cordgrass (*Spartina alterniflora*) and three-cornered rush (*Schoenoplectus robustus*). This was in contrast to existing salt marshes, which were dominated by marsh-hay cordgrass (*Spartina patens*), black rush (*Juncus Roemerianus*), salt grass (*Distichlis spicata*), and smooth cordgrass.

Intrusion of salt water kills cypress trees and other salt intolerant swamp species	→	Widgeon grass fills in open water left behind by degraded cypress swamp	→	Pioneering species, such as smooth cordgrass and three-cornered rush, creep in to further fill in open water and form substrate	→	Marsh dominants start to grow on substrate created by pioneering species

Figure 3-1: Marsh Succession (Penfound & Hathaway, 1938)

WRM 2007 Findings

The 2007 WRM research group conducted a preliminary BBWT vegetation survey. Although no species were positively identified, the following species were noted: marsh-hay cordgrass (*Spartina patens*), sago pond weed (*Stuckenia pectinata*) and widgeon grass (*Ruppia maritima*). The group also noted an emergent species found along the northern and western edges of the wetland triangle, two submerged aquatic species found throughout the wetland triangle, and a single bald cypress tree (*Taxodium distichum*) located on the western end of the northern spoil bank (WRM, 2007).

The presence of both the widgeon grass and the lone cypress tree were confirmed during the 2008 summer research period. It is still suspected that sago pond weed and marsh-hay cordgrass are present in the BBWT, however, no fertile specimens were found in July 2008 to positively identify these species.

Methods

Vegetation was sampled during July and the first week of August 2008. The BBWT was divided into five sections based on substrate type and overall community structure:

Section 1: Artificial land area of riprap substrate along the southern wall of BBWT. Contains study points PZ1 through PZ4.

Section 2: Strip of soil along BBWT's southern flood wall. Contains study points PZ 5 and PZ6.

Section 3: Vegetated embankment separating the northern edge of the BBWT from Bayou Bienvenue proper. Contains study points CYP through PZ11.

Section 4: Covering the bulk of the BBWT, this section encompasses the inundated body of the Bayou with submersed and floating vegetation. Contains study points PZ15 through PZ21.

Section 5: The eastern edge and northeastern corner of the BBWT which are predominantly edged with grass and sedges. Contains study points PZ13 through PZ-14.

Plot sizes and sample methods were determined by ease of access, physical characteristics and the availability of time for sampling. The vegetation in sections 1 and 2 was sampled using an area reaching five meters (parallel to the BBWT edges) on each side of the sample point. This area, spanning 10 meters in width, extended from each water sampling location marker to the floodwall. In section 3, the same 10m width (this time parallel to the spoil bank) was used, with the plot extending from the sampling location marker to the opposite side of the spoil bank.

Figure 3-2: Vegetation survey sections.

Figure 3-3 (left): Sedge rooted in substrate along the Florida Avenue floodwall in Section 2.

Figure 3-4 (above): Riprap along the Florida Avenue floodwall in Section 1. (Photos by Amanda Perdzock).

Books used to identify plants included *Aquatic and Wetland Plants of Southeastern United States: Dicotyledons* and *Aquatic and Wetland Plants of Southeastern United States: Monocotyledons* by Robert K Godfrey, and Jean W. Wooten, the *Field Guide to Coastal Wetland Plants of the Southeastern United States* by Ralph W. Tiner, along with *Common Vascular Plants of the Louisiana Marsh* by RH. Chabreck & R.E. Condrey.

Results

In section 4, the sole species identified was the brackish submerged aquatic, widgeon grass. In sections 1, 2, 3 and 5, 49 species were found, of which 40 were positively identified, although there are likely many more species present than were growing during the study period. Of the 40 species identified, 11 were identified to the genus level and 30 were identified to the species level (Table 3-2).

Table 3-2: Plant species identified in the BBWT.

Species (or genus*)		
*Amaranthus spp.**	*Kosteletzkya virginica*	*Sambucus canadensis*
*Ambrosia trifida**	*Lantana spp**	*Samolus parviflorus*
*Ampelopsis arborea**	*Lemna minor*	*Sapium sebiferum*
Baccharis halimifolia	*Hibiscus moscheutos*	*Schoenoplectus maritimus*
Bacopa monnieri	*Ipomoea sagittata*	*Sesbania drummondii*
Campsis radicans	*Iva frutescens*	*Setaria pumila*
Celtis laevigata	*Juniperus spp. **	*Smilax bona-nox*
Cuscuta indecora	*Lythrum lineare*	*Spartina alternaflora*
Cyperus stigosus	*Morus spp **	*Tillandsia usneoides*
Cyperus surinamensis	*Myrica spp.**	*Toxicodendron radicans*
Echinochloa crusgalli	*Rubus trivialis*	*Typha spp*.*
Eleocharis flavescens	*Ruppia maritima*	*Vigna luteola*
*Galium spp.**	*Sabal palmetto*	*Woodwardia virginica**
Gleditsia triacanthos	*Salix spp.**	

*Species could not be positively identified due to the lack of fertile specimens.

Discussion

Plant phenology cycles were the main obstacle to positively identifying a majority of the species present in BBWT. Some plants present reach their peak bloom in the spring, while others peak in the fall, resulting in a lack of the fertile structures necessary for plant identification. Many herbaceous species identified during an initial site evaluation in March were no longer visible in summer. Surveys at other times of the year will be necessary to completely catalogue BBWT species and analyze species succession.

As expected, species with higher salt tolerances were more common in more saline areas of the BBWT. For example, salt tolerant species such as cosmopolitan bulrush (*Schoenoplectus maritimus*) and smooth cordgrass (*Spartina alternafloraI*) were found in the north-eastern corner of the BBWT, while less salt tolerant species, such as marsh morning glory (*Ipomoea sagittata*) and poison ivy (*Toxicodendron radicans*), were found on the western end of the BBWT (see Chapter 2 for salinities).

Comparing the 40 identified plants to the results of the 1938 study, 5 had been found only in the cypress swamp community, 2 in both the cypress and salt grass communities, 6 in both the cypress and brackish communities, 1 in both the salt grass and brackish communities, 3 in only the brackish communities, and 23 had not been found in any of the communities studied by Penfound and Hathaway (1938) (Appendix A). Of these "new" species, many were weedy and escaped species that tend to inhabit disturbed areas, indicating the degree to which the BBWT has become ecologically degraded**.** It is also noteworthy that several species currently present in the BBWT are present in multiple community types, which can be attributed to their tolerance for a range of salinities. These salt tolerant species, as well as weedy and escaped species, could play important roles in the species succession and restoration of the BBWT.

Succession in the BBWT

Penfound and Hathaway (1938) observed a successional pattern in cypress swamps invaded by saltwater, which began with die-off of the cypress, followed by the formation of open water with dense widgeon grass thickets and eventually, in-filling of open water with marsh dominants. The BBWT, which has become more saline, could be following this pattern, as thick stands of smooth cordgrass have formed along its north and eastern edges, and its only identifiable submerged aquatic is widgeon grass (Figure 3-12). However, the BBWT's present hydrological conditions are the result of twentieth century anthropogenic alterations which were not observed by Penfound and Hathaway. In addition, there is no evidence to suggest that the open-water areas of the BBWT are being colonized. It is likely that the permanently inundated state of this area presents an obstacle to colonization by emergent vegetation.

Figure 3-12: Smooth cordgrass growing along eastern edge of BBWT near PZ14. (Photo by Amanda Perdzock)

At the western end of the BBWT, along the flood wall, many non-wetland species can be found. Most likely, several of these species have been introduced by human development, as many of them can be found in overgrown lots throughout the neighborhood. Low salinity levels along these banks help to make these areas highly suitable for weed propagation. The bare, disturbed soils along the flood wall provide an ideal substrate for weed establishment.

Potential impacts of sediment introduction on existing vegetation communities

One benefit to the lack of plant diversity in the inundated portions of the wetland is that any efforts to restore the BBWT through sediment diversion will do little damage to recently established communities. Because no thriving plant community has been established in the BBWT's open area, any restoration efforts will only bring more diversity to the wetland, as lowered water levels will provide more surface area for upland species to colonize.

One hindrance to establishing a thriving plant community in the event of sediment diversion, however, is the high presence of opportunistic and weedy species. The seed banks of the imported fill must also be considered. If the sole action of restoration is adding sediment and letting species fill in the wetland themselves, it is possible for opportunistic species to take advantage of the new habitat and lessen the native species' ability to colonize. Regardless of the goal habitat (brackish/intermediate marsh or freshwater swamp), some management of vegetation will be required, in addition to hydrological considerations.

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Chapter 4: Locally Unwanted Land Uses

Hiroko Yoshida

The BBWT and the Lower Ninth Ward are surrounded by a scrap metal recycling facility, a municipal solid waste landfill, the sole wastewater treatment plant for the East Bank of New Orleans, and the Industrial Canal (IHNC). These facilities would generally be categorized as Locally Unwanted Land Uses (LULUs) in the parlance of Robert Bullard (1990). The LULU terminology has become an integral concept within the environmental justice literature. It is similar in the lexicon of planners to the acronym NIMBY (Not In My Back Yard) when it comes to siting facilities usually considered to be nuisances. Each of these entities has a different history and relationship to the Lower Ninth Ward community. Generally, they were built decades before the era of environmental justice awareness, but it is perhaps telling that such a concentration of potential nuisances exists near this neighborhood. The past, present, and future activities of these LULUs have shaped and continue to shape the Lower Ninth Ward as it rebuilds.

This chapter reviews relevant federal and state regulations, and describes individual LULUs in relation to this regulatory framework. Although federal and state statutes exist to regulate these land uses, they are not necessarily capable of protecting the environmental quality of Bayou Bienvenue and the BBWT.

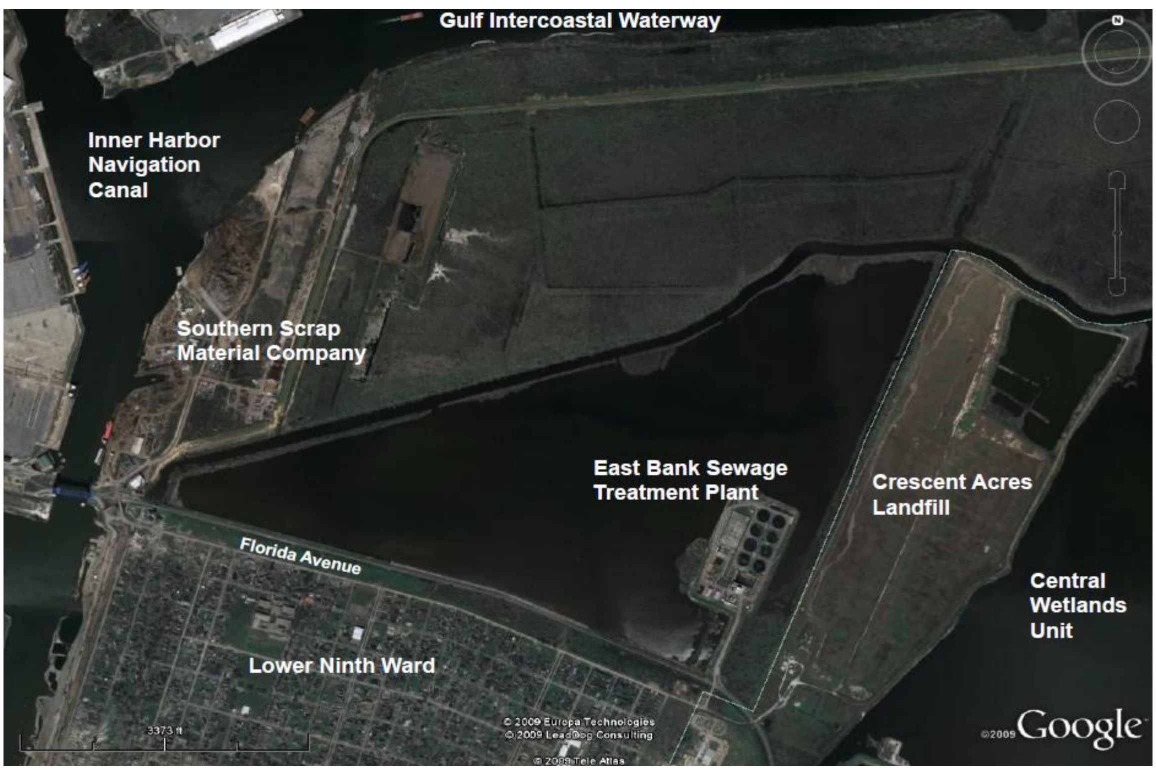

Figure 4-1: The BBWT with and its surrounding built environment.

Regulatory Framework

Environmental quality in Bayou Bienvenue and surrounding areas is legally protected by a combination of state and federal regulations. The primary legislation protecting water quality is the Federal Water Pollution Control Act of 1972, commonly known as the Clean Water Act (CWA). In Louisiana, the Department of Environmental Quality (LDEQ) assumed responsibility for the National Pollutant Discharge Elimination System[14] from the US Environmental Protection Agency (USEPA) in 1996. The LDEQ administers the Louisiana Pollution Discharge Elimination System (LPDES) under Louisiana Administrative Code Title 33 subpart IX (LAC 33:IX). Storm water discharge (from the Southern Scrap Material Company recycling facility and Pump Station 5), and treated wastewater discharge (from the East Bank Wastewater Treatment Plant (EBWTP)) are regulated under the LPDES. Sediment deposition to navigable water (the Bayou Bienvenue channel) and adjacent wetlands (the BBWT) is regulated by section 404 of the CWA. The United States Army Corp of Engineers (USACE) is the primary administrator of this permitting system.

Act 449 established the Louisiana Environmental Control Commission to regulate solid waste. The commission adapted the solid waste management program formulated by the USEPA in 1980 to upgrade Louisiana's presently existing solid waste facilities to sanitary landfills. Regulatory responsibility for this program was transferred to the LDEQ upon its establishment in 1984.

Finally, the National Environmental Policy Act of 1969 (NEPA) requires all federal agencies, including the USACE to incorporate environmental considerations into their planning and decision-making through an environmental impact statement (EIS).

The public can participate in the EIS process by attending NEPA-related hearings or public meetings, and by submitting comments directly to the federal agency. The agency is required to receive public comments during a designated comments period. Final EIS drafts are reviewed by the USEPA for compliance with current environmental regulations. When a potentially significant impact is found through this process, the agency is required to submit a supplemental environmental impact statement[15] (SEIS) with mitigation plans.

Designated uses of Bayou Bienvenue

The portion of Bayou Bienvenue which is classified as navigable water[16] (from its headwaters at Pump Station 5 to the hurricane gate at the MRGO) is also listed as "impaired[17]" under CWA Section 305(b), and thus requires regular water quality monitoring. While the BBWT is not currently considered navigable water under the CWA, the strong hydraulic connection between Bayou Bienvenue and the BBWT means that regulation of Bayou Bienvenue directly impacts

[14] The National Pollutant Discharge Elimination System is a permitting system for surface water pollution. It was created under Section 402 of the CWA. As of 2009, 48 states had assumed responsibility from the USEPA for administrating the permitting system

[15] When an adverse, unmitigatable environmental impact is found in the EIS review process, the project will be suspended until the lead agency significantly changes the project or mitigation plan. SEIS are formulated to show revisions to the original plan.

[16] Navigable waters are loosely defined as "waters of the U. S., including the terrestrial seas" under section 502 of the CWA. EPA defines them as 1) Traditionally navigable waters. 2) Tributaries of traditionally navigable waters 3) Waters "the use, degradation or destruction of which could affect interstate or foreign commerce" 4) Wetlands, which are defined as swamp, marsh and areas which support types of plant life that biologists characterize as living in the saturated soil. In court cases, navigable waters generally include wetlands that have "significant nexus [to]" or which "significantly affect the chemical, physical, or biological integrity [of]" other covered waters. Significant impacts are determined on a case by case basis (Gaba, 2005)

[17] Not "fishable or swimmable" (Federal Water Pollution Control Act of 1972).

water quality in the BBWT. For a more in-depth discussion on the legal definitions of navigability, see Chapter 8 of this report.

The LDEQ assigns designated uses[18] to waters of the United States. According to LAC 33: IX.1123, the designated uses of Bayou Bienvenue include: primary contact recreation, secondary contact recreation and fish and wildlife propagation. The definition and water quality standard for each designated use are shown below in Table 4-1 (LDEQ, 2007). In their 1998 Statewide Water Quality Assessment, the LDEQ initially listed Bayou Bienvenue as an impaired waterway, under the suspicion that levels of mercury, metals, organic enrichment/DO, and pathogens did not meet designated use standards (LDEQ, 2009). However, following the subsequent collection of water quality data, the LDEQ found Bayou Bienvenue to be within the designated use guidelines (LDEQ, 2006).

[18] Section 303(c) of the CWA requires states to specify the use of each water body, such as drinking water intake points. The goal of the CWA (as defined in Section 101) is to ensure that all waters are fit for fishing and swimming. Thus, primary and secondary contact recreation, and fish and wildlife propagation are minimum requirements (Gaba, 2005).

Table 4-1: Designated uses of waters of the United States.

Designated Use	Definition	Relevant water quality standard set by CWA
Primary contact recreation	Any recreational or other water contact activity involving prolonged or regular full-body contact with the water and in which the probability of ingesting appreciable amounts water is considerable. Examples of this type of water use include swimming, skiing, and diving.	No more than 25 percent of the total samples collected on a monthly or near-monthly basis shall exceed a fecal coliform density of 400/100 mL. This primary contact recreation criterion shall apply only during the defined recreational period of May 1 through October 31. During the non-recreational period of November 1 through April 30, the criteria for secondary contact recreation shall apply.
Secondary contact recreation	Any recreational or other water contact activity in which prolonged or regular full-body contact with the water is either incidental or accidental, and the probability of ingesting appreciable amounts of water is minimal. Examples of this type of water use include fishing, wading and boating.	No more than 25 percent of the total samples collected on a monthly or near-monthly basis shall exceed a fecal coliform density of 2,000/100 mL. This secondary contact recreation criterion shall apply year round.
Fish and wildlife propagation site	The use of water for aquatic habitat, food, resting, reproduction, cover, and/or travel corridors for any indigenous wildlife and aquatic life species associated with the aquatic environment. This use also includes the maintenance of water quality at a level that prevents damage to indigenous wildlife and aquatic life species associated with the aquatic environment and contamination of aquatic biota consumed by humans.	Numeric criteria for the specific toxicants for both acute and chronic standard for both aquatic life and human health protection.

Information collection

Much of the information presented in this section was obtained from the LDEQ Electric Document Management System (EDMS). The EDMS provides free access to public records and correspondences submitted to the LDEQ. Agency Interests (AI) numbers are needed to access information in the EDMS. Table 4-2 lists AI numbers relevant to the BBWT:

Table 4-2: Agency Interests numbers for facilities surrounding the BBWT.

Facility Name	AI Number
City of New Orleans Drainage System	6016
Crescent Acre Land Fill	11072
East Bank Wastewater Treatment Plant	4859
Southern Scrap Material, Co. LLC.	1173

The Inner Harbor Navigation Canal

The Inner Harbor Navigation Canal (IHNC; commonly referred to as the Industrial Canal) forms the western boundary of the Lower Ninth Ward, separating it from the rest of New Orleans. The IHNC Lock (which connects the Mississippi River and the Gulf Intercoastal Waterway) was installed in 1923. The current lock is 75 ft wide, 640 ft long and 31.5 ft deep, which only allows for shallow-draft navigation.

In 1956, expansion to accommodate deep-draft vessels was authorized by Public Law 84-455. In 1976, section 186 of the Water Resource Management Act assigned federal jurisdiction to expansion. Over the next decade, a location and cost sharing agreement for the new lock were determined. In 1986, the USACE and Port of New Orleans reached an agreement on the location and cost sharing for the new lock. The first EIS to comply with NEPA was submitted in 1997 (USACE, 1997).

Figure 4-2: **The existing IHNC lock (with the St. Claude Avenue Bridge raised), looking north from the Mississippi towards the BBWT (right) and Lake Pontchartrain.** (Photo by Dan Cornelius, January 2008)

The Lower Ninth community responded to the EIS with concerns regarding construction-related noise, traffic delays, and compromised flood protection, as well as the disposal of contaminated dredged material (United States District Court E.D. Louisiana, 2000). According to John Koeferl, president of Citizens Against Widening the Industrial Canal (CAWIC), these concerns were inadequately addressed in the public hearing process (CAWIC, 2008).

With assistance from the Tulane University Environmental Law Clinic, the HCNA and several other environmental groups challenged the effectiveness of the EIS in protecting their right to a clean environment. In 1999, with support from the McKnight Foundation, the HCNA commissioned an independent study of the IHNC bottom sediments, which found high levels of naphthalene, arsenic, and chromium (NWF, 2000, 2004). The Federal District Court of Eastern Louisiana District responded to an HCNA appeal by suspending construction. In October of 2008, the USACE submitted SEIS to continue the project.

In the 2008 SEIS, the Float-in-Place Lock was chosen as the most desirable construction method. The expansion requires the removal of approximately 2.2 million cubic yards of sediment from the existing IHNC. To accomplish this, the 2008 plan divided the site into 11 Dredged Material Management Units (DMMUs). Within each DMMU, sediments are further classified (based on origin) into three categories: native subsurface soils, non-native sediment, and non-native fill. In order to comply with the requirements of CWA sections 402 and 404, between 2-16 sediment samples were taken from each DMMU and analyzed for 170 potential constituents of concern (COCs), solid and suspended phase toxicity, bioaccumulation rates for benthic and pelagic organisms. The disposal strategy for each DMMU is contingent upon the results of these analyses.

Under the 2008 SEIS plan, dredge material will be disposed of in several ways. Suspended sediments will be flushed into the Mississippi River. For sediments deemed contaminated, two storage cells will be built on the strip of land between the BBWT and the GIWW. One cell will temporarily store less contaminated sediments, which will later serve as backfill for the newly constructed lock. The other cell will provide final disposal for sediments with higher concentrations of contaminants.

Discharge effluent and runoff from these disposal cells will be released untreated into the Gulf Intercoastal Waterway. According to Appendix C, page 91 of the 2008 IHNC SEIS, discharge water will contain tributyltin, total PCBs, Aroclor 1016, and dieldrin at levels exceeding the water quality standard (USACE, 2008a). Under LAC 33: IX.1115.C., this is legally acceptable, as mixing of the contaminated water with native water in the GIWW will dilute these COCs down to compliant levels.

The remaining dredged material will be used as fill for "marsh creation" in 85 acres on the west side of the BBWT, under the assumption that this sediment platform will be naturally colonized by marsh grasses. This newly created "marsh" would serve as a mitigation site for other wetlands along the GIWW that would be destroyed under the 2008 SEIS plan. In addition to the deposition of dredge material in the BBWT, $38 million is allocated for a community mitigation plan[19].

[19] The Community-Based Mitigation Committee (http://www.communitymitigation.org/cbmc.htm) was formed to represent communities affected by the lock expansion. These include the Lower Ninth Ward, Holy Cross, St Claude, Desire/Florida and Bywater neighborhoods. Between 2001- 2005, the community mitigation fund has spent $991,000 on job training, $13,000 on improving communication between bridge operation and emergency services, $547,551 on additional police protection below the Industrial Canal, $200,000 on renovation of playgrounds and a minor amount on vacant lot clean up. An additional $38 million has been granted to these communities for future mitigation of the lock expansion construction.

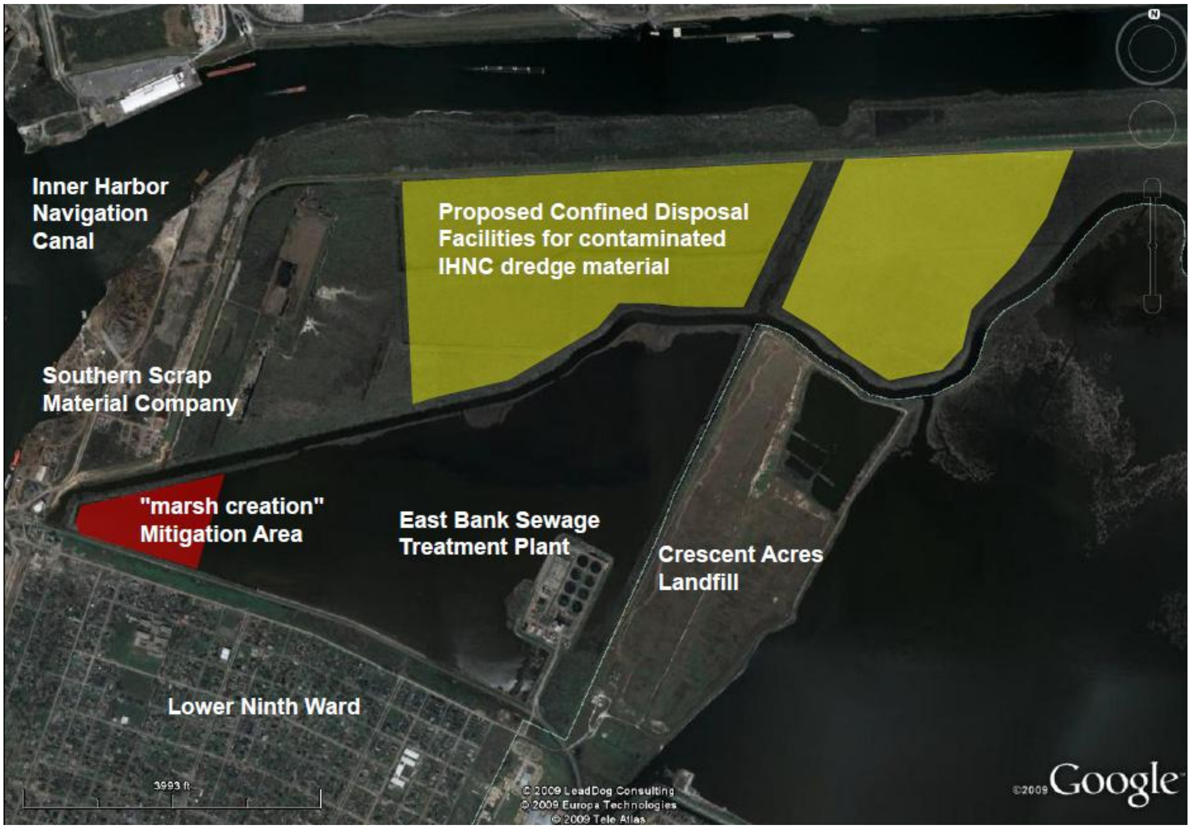

Figure 4-3: Proposed areas for wetland mitigation and the disposal of contaminated IHNC dredge material. (After USACE, 2008)

According to Appendix C of the 2008 SEIS, the canal sediments designated for "marsh creation" in the BBWT contain levels of lead, PAHs, DDT, delta-BHC, dieldrin, endosulfan II, and heptachlor epoxide that present "a high potential concern" for bioaccumulation. Despite this, the USACE justifies the use of these sediments because 1) they view the amounts by which these compounds exceed the "high potential concern" threshold to be small, 2) they view this list of compounds to be a relatively "small number" and 3) they predict "no adverse biological effects associated with measured body residue in invertebrates and predicted body residue in predator fish" (USACE, 2008a).

Section 404 of the CWA regulates the deposition of fill material into waters of the United States and adjacent wetlands. Administration of section 404 is shared by four federal agencies: the USEPA, the USACE, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. The USACE has a lead role in the permitting process under Section 404 (b) (1) of the CWA. However, if the USEPA determines that the issuance of the permit will result in unacceptable adverse impact to Aquatic Resources of National Importance (ARNIs)[20], it can require a review of the process by the assistant secretary of the army. If a permit is issued against the USEPA's suggestion, the USEPA can veto the permit under the authority defined by Section

[20] The determination of ARNIs is based on the economic importance of the aquatic resource, and/or its rarity/uniqueness/importance to the protection, maintenance, or enhancement of the quality of waters of the United States. As of 2005, only 20 applicants (out of 1,580,000 permits issued) have received ARNI status through this process. Existing ARNIs include Chesapeake Bay, sub-alpine fens, and vernal pools (USEPA, 2003).

404 (c). Given the highly degraded condition of the BBWT and its low level of economic importance, there is a very little chance that the Section 404 (q) process would take place.

In 2005, prior to Hurricane Katrina, the USACE conducted an updated economic analysis of the IHNC lock expansion project. Assuming a 50-year project lifetime, and federal discount rate[21] of 7.000 percent, the USACE determined a benefit-cost ratio[22] of 1.5. With a federal discount rate of 4.875 percent, the benefit-cost ratio increased to 2.44. However, since Hurricane Katrina and the deauthorization of the MRGO, economic conditions and use of the IHNC have changed. In October 2006, the US District Court instructed the USACE to update the cost benefit analysis to reflect post-Katrina conditions.

The economic analysis for the 2008 SEIS accounted for reduced use of the IHNC since Hurricane Katrina and the MRGO deauthorization. It also accounted for the suspension of construction on the Florida Avenue high bridge in its traffic estimates. However, a future 0.8 percent annual increase in water-borne traffic was still assumed. The 2008 SEIS found a benefit-cost ratio of 0.92 with a 7 percent discount rate, and 1.57 with a discount rate of 4.875 percent.

In 2007, the CAWIC conducted an independent economic assessment. With current levels of IHNC use, and a discount rate of 7.375 percent, the group found the cost of lock expansion to substantially exceed anticipated benefits: for every dollar spent on the lock, 40 cents of benefits could be expected (a benefit-cost ratio of 0.4; CAWIC, 2007). An additional letter by the Lower Ninth community opposing lock expansion plans was submitted to the USACE on February 23, 2009.

Southern Scrap

The Southern Scrap Material Company was founded in New Orleans in 1900. Currently, it operates a dozen recycling centers across the Gulf states, and ranks 13th (in the United States) for ferrous scrap processing and 18th for the non-ferrous scrap processing. Ninety percent of the company's business comes from iron yard and shipwrecking (Recycling Today, 2002, 2005). Southern Scrap's Florida Avenue facility began operation in 1957. Presently, the 32-acre operation employs 75 people, and hires roughly 300 contract workers.

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[21] Federal projects, especially many of those undertaken by the USACE, often involve not only high up-front costs, but also long construction times and benefits that accrue over long periods (100 years or more). In general, present day dollars are considered to be worth more than future dollars. This is due to the investment potential of current dollars, the cost of diverting current resources from other investments or consumption (opportunity cost), and inflation, if it hasn't already been accounted for (Powers, 2003). To correct for these effects, an arbitrary discount rate is used in calculations of costs and economic benefits. A discount rate of 0 assumes present costs and future benefits to be equal, while a high discount rate assumes future benefits to be low in relation to present costs. Therefore, high discount rates generally favor projects with low short-term costs and high long-term maintenance, while low discount rates favor projects with high upfront costs and substantial long-term benefits. There are many methods of calculating the discount rate. Therefore, although its concept is supported by economists, its use and method of determination are heavily debated. A commonly used rate for federal projects, (set by the Executive Branch's Office of Management and Budget) is 7 percent (Powers, 2003).

[22] Benefit-cost analysis is a formal measure of a project's economic return within a given lifetime. As such, it relies on many arbitrary assumptions, including the discount rate (see above), to which it is often particularly sensitive. As a result, it is one of the most controversial components of the federal process for evaluating projects (Powers, 2003). Currently, the minimum benefit-cost ratio used by the USACE for project recommendation is 1.0, as set by the 1983 U.S. Water Resources Council's *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. This standard is currently under revision, and may be revised (for hydroelectric and navigation projects) to 1.5 under the Water Resource Development Act of 2007 (USACE, 2008b).

Despite the positive aspects of recycling, improperly managed facilities can contaminate soil, surface and ground water, or even air (Jemsen et al., 2000; Pierce & Kenney, 1997; Satry et al., 2002).
Table 4-3 lists common COCs that can be emitted by metal recycling facilities.

Table 4-3: Common COCs at Metal Recycling Facilities[23]

Metal/Metalloids	antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, tin, zinc
Inorganic	acids (hydrochloric, phosphoric, sulfuric), alkalis (caustic, ammoniacal), chlorides, cyanides, fluorides, phosphorus compounds, sulfate, sulfides
Organic	fuels (diesel, petrol), hydraulic oils (mineral oils) lubricating oils, paints, phenols, polychlorinated biphenyls (PCBs), solvents (trichloroethylene, methyl ethyl ketone and others)
Other	asbestos, radioactive components, biodegradable items used for oil absorption such as paper, wood, and sawdust

Despite this environmental risk, metal recycling was not listed as a primary industry prior to 1990. As a result, only biannual monitoring of stormwater discharges for biological oxygen demand (BOD), total suspended solids (TSS), fecal coliform counts, and pH was required under the NPDES. In 1990, the USEPA established the multi-sector general permit program (MSGP) to address "stormwater discharges associated with industrial activity" (USEPA, 2008). The MSGP standards have undergone several revisions, the latest of which were published in September 2008. All targeted industries[24] must comply with the new MSGP by January 5, 2009.

Southern Scrap obtained LPDES and MSGP permits in 2006 (LDEQ-EDMS, 2006a, 2006b). According to the LPDES permit, the Florida Avenue facility has 11 outfalls, 4 of which discharge into Bayou Bienvenue **(**LDEQ-EDMS, 2006a). Additional details about individual outfalls are listed in

Table **4-4**. Two of these outfalls—009 and 011—are discussed in the Sediment Quality section of this report. It is unclear from the coordinates provided in the permit whether the other two outfalls discharge to the same locations, or to other locations along Bayou Bienvenue.

Southern Scrap's total discharge to Bayou Bienvenue averages less than 500 gallon per day. The LPDES General Permit requires biannual monitoring for BOD, TSS, fecal coliform counts, and pH. The MSGP permit sets limits on total organic carbon (TOC), chemical oxygen demand (COD), aluminum, copper, iron, lead, and zinc.

[23] This list is not comprehensive, nor does it imply anything about the presence of these COCs at a particular site, or their potential for release into the environment (UK DOE, 1995).
[24] Besides monitoring, current MSGP regulations include (1) requirements for the installation of stormwater controls to meet technology-based and water quality-based effluent standards, (2) inspection and effluent monitoring requirements, and (3) the development of the stormwater pollution prevention plans (SWPPPs) (USEPA, 2008a)

Figure 4-4: **The Southern Scrap Florida Avenue facility, looking southeast towards Bayou Bienvenue and the BBWT.** (Photo by Dan Cornelius, January 2008)

Southern Scrap has submitted biannual reports in compliance with the monitoring requirement. However, most monitoring reports are submitted to the LDEQ as empty, stating that "no water discharge" occurred during the period of monitoring. In September 2007, Darryl Malek-Wiley (Sierra Club–Delta Chapter of Louisiana) reported a breach in the stormwater control wall of the Florida Avenue facility’s fluff management area. Upon further investigation, the LDEQ found Southern Scrap to be negligent in their prevention of stormwater pollution (LDEQ-EDMS, 2007).

Table 4-4: Southern Scrap Stormwater Outfalls

Outfall	Operation	Size	Treatment
Outfall 08	Storm water from trucking area and wash water from truck wash	5 acres	Oil/water separator, septic tank
Outfall 09	Wash water from the maintenance area	N/A	Oil/water separator
Outfall 10	Storm water from the active northern fluff and treated fluff management areas	17 acres	none
Outfall 11	Storm water from the inactive southern fluff management area	10 acres	none

(LDEQ-EDMS, 2006a)

Severe damage from the 2005 hurricane season combined with the recent deauthorization of the MRGO has negatively impacted industry along the IHNC. In addition, the current IHNC lock is incapable of handling large ships. Bollinger Gulf Repair, LLC (a ship repair company situated adjacent to Southern Scrap), has already abandoned its IHNC facility in favor of Morgan City. In July 2008, Southern Scrap shifted some operations to a newly acquired site in St. Charles Parish (New Orleans City Business, 2007). In the event that the company vacates the Florida Avenue facility, residents are concerned about post-closure clean-up (Malek-Wiley, personal communication, November 4, 2008)

East Bank Wastewater Treatment Plant

The New Orleans Sewerage and Water Board's (NOSWB) East Bank Wastewater Treatment Plant (EBWTP) is located in the southeast corner of the BBWT. In 1970, it was upgraded to handle five times its original capacity. Currently, the facility treats all wastewater produced by the East Bank of New Orleans. Wastewater reaches the EBWTP after traveling a subterranean network of some 1,600 miles of sewer, with the help of 83 pumps spread across the city.

The primary goal of wastewater treatment is to protect human health and aquatic ecosystems by removing colloidal, suspended and floatable material, biodegradable organics[25], and pathogenic organisms (Tchobanoglous et al., 2003). As described in the WRM 2007 report, the primary treatment of the EBWTP is a sedimentation basin where 25-40 percent of suspended, biodegradable organics are removed. The aeration tanks follow as secondary treatment, where supplemental oxygen enhances bacterial growth in the wastewater. The bacteria then deplete the remaining dissolved biodegradable organic material. Subsequent removal of these "well-fed" bacteria through a secondary clarifier leads to greater than 99 percent reduction of biodegradable organics material. After secondary treatment, the water is disinfected with chlorine.

[25] Biodegradable organics are often measured as biological oxygen demand (BOD), which is the amount of oxygen microorganisms would utilize in their consumption of the organic matter. Wastewater with high BOD levels can deplete oxygen and kill aquatic organisms.

Figure 4-5: One of eight clarifiers at the EBWTP. (Photo by Dan Cornelius, July 2008)

Natural wear and tear and extensive damage from the 2005 hurricane season have greatly lowered the integrity of New Orleans' wastewater collection system (Daily Commercial News, Aug 8, 2007). In 1996, the Sewerage and Water Board of New Orleans launched the Sewer System Evaluation and Rehabilitation Project, to comply with the S*ection XV-Clean Water Act Remedial Measures: Comprehensive Collection System Remedial Program.* The project, which aims to update the city's sewer system, had an original cost estimate of $640 million and an estimated completion time of 10 years. However, the 2005 hurricane season has delayed anticipated completion until the end of 2010. Sewer upgrades in the Lower Ninth were completed in December of 2007 (NOSWB, 2009).

Despite these efforts, the collection system remains porous. As a result, intense rain events can produce inflows that exceed the EBWTP's capacity. Typical inflows range from 80 to 90 million gallons per day, but heavy rains can more than double this value. To prevent overflow during these events, influent is bypassed to the secondary clarifiers without the removal of dissolved organic matter. Typically, this happens two or three times per year. During large hurricanes, untreated wastewater is sent directly to the Mississippi River (NOSWB, 2008).

Hurricanes Katrina and Rita inundated the EBWTP, which was already suffering from subsidence-related structural damage. As of August 2008, half the air pumps in the aeration tanks were not functional. Thus, to maintain BOD removal, the EBWTP currently pumps compressed oxygen into the aeration basin (NOSWB, 2008).

The NOSWB has proposed discharging treated wastewater into the CWU, and possibly to the BBWT (WSNCI, 2009). Although there are many potential benefits to this process (WRM, 2007; Day et al., 2004), it is worth noting some key risks:

- **Emergency Response:** During emergencies, the EBWTP currently discharges partially treated or untreated wastewater. Emergency responses to extreme rain events should be addressed in the planning process to avoid negative impacts to the CWU and BBWT.
- **Eutrophication:** As discussed in the hydrology section of this report, the loading of excess nitrogen and phosphorus into the CWU and BBWT, which both lack substantial vegetation, could potentially promote algae blooms. Consequences include low levels of dissolved oxygen (harmful to fish and other aquatic life), and a reduction in the aesthetic and recreational value of these wetlands.
- **Residual Chlorine and Disinfection Byproducts (DBPs):** Currently, EBWTP does not have dechlorination facilities. The residual chlorine imposes an acute health risk to the aquatic organisms. DBPs are formed when chlorine reacts with organic matter and are potentially carcinogenic.
- **Pathogens:** Some parasitic pathogens (especially *Cryptosporidium*) are resistant to chlorine and could impose a health risk for direct contact recreation.
- **Odor:** The accumulation of sulfur could produce an odor problem.
- **Emerging Contaminants:** Pharmaceutical and personal care products (PPCPs) along with endocrine disrupting chemicals (EDCs) are present in wastewater, and accumulate in the CWU and BBWT. Although EDCs are known to interfere with animal reproduction and development (USGS, 2008), the long-term toxicological effects of most emerging contaminants on ecosystems is unknown.

Crescent Acres Landfill

Constructed in the early 1960s, the Crescent Acres Landfill served as a repository for Hurricane Betsy debris (LADEQ-EDMS, 1986). It was operated by Allied Waste, formally known as Browning-Ferris Waste System of North America, Inc. In 1983, Crescent Acres obtained permission from the LDEQ to accept the incinerated remains of infectious wastes from New Orleans hospitals. Infectious waste is defined as "waste which may cause disease or reasonably suspected of harboring pathogenic organism: includes but not limited to, diseased human and animal parts, contaminated bandages, pathological specimens, hypodermic needles, contaminated clothing, and surgical gloves," (LADEQ-EDMS, 1985). In 1989, Browning-Ferris was fined for violating sanitary operations, due to excessive odors and failure to keep animals away from the operation site.

In 1987 Crescent Acres obtained a standard permit from the LADEQ (LADEQ-EDMS, 1987). As part of the permit application process, an environmental impact assessment was conducted. Since no critical wildlife habitat, public recreational area, or archeological/ historical sites existed in immediately adjacent areas, the assessment focused on the potential spread of contaminants and the economic viability of the project. The final version of the environmental impact assessment report concluded that "with all other elements of this facility meeting or exceeding the requirement of the Louisiana Solid Waste Rules and Regulations, there are no mitigating measures (i.e. a lining) which would offer more protection to the environment without unduly curtailing non-environmental benefits," (LADEQ-EDMS, 1986). Supporting reasons included:

- No shallow aquifer exists beneath the landfill.
- Naturally occurring clays beneath the landfill, which are greater than 17 ft thick, and extend to an average depth of 30 ft, would likely prevent the vertical migration of contaminants.
- Peat surrounding the landfill, although permeable, would likely remove horizontally-migrating contaminants through biological degradation and absorption.
- Surrounding environments were already sufficiently degraded to the point where additional contaminants from the landfill would have minimal impact.

Crescent Acres ceased its acceptance of waste in 1993. In 1996, a closure plan was approved by the LDEQ. The plan requires the bi-annual monitoring of groundwater and surface water leachate for 5 years, and biannual cap inspection for 50 years. During the mandatory monitoring period, groundwater chemistry measurements from 32 monitoring wells showed no sign of contaminant release. In failed landfills, the greatest release of contaminants typically occurs immediately after the waste is deposited. Following the closure of these sites, the rates at which contaminants are “washed out” into the environment decrease over time (Fetter, 2008; Williams et al., 1987). After 15 to 20 years, the effluent is typically sufficiently diluted so that it no longer poses an environmental threat, and the faulty landfill is said to have reached “maturity” (Williams et al., 1987). Since Crescent Acres has been closed for 16 years, it is very likely mature, with a negligible impact on the BBWT.

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Chapter 5: Environmental Quality

Presence and Potential Bioavailability of Organic Contamination

Dalayna Tillman

In light of current local practices of crabbing and fishing, and potential future recreational uses, the facilities surrounding Bayou Bienvenue and the BBWT have created concerns over the release and bioaccumulation (the concentration of toxic substances in the food chain at harmful levels) of anthropogenic organic contaminants. In the summer of 2008, the WRM group used a new passive sampling method to investigate the presence and bioavailability of organic contaminants in the BBWT.

Motivation

Investigating contamination by organic compounds is difficult because of the diversity of potential COCs—thousands are manufactured every year (Huckins et al., 2005). In addition, there is wide variation in COCs tendencies to transform and/or degrade, and also much variation in the way that COCs interact with the environment (i.e. water solubility) and biological systems. The transport, fate, and bioaccumulation of organic pollutants are controlled by their physicochemical properties, environmental conditions and the characteristics of species inhabiting the affected ecosystems (Huckins et al., 2005). Lipophilic compounds (those which readily dissolve in lipids, such as fats, oils, etc.) are a particular concern because of their tendency to accumulate in the fatty tissues of organisms (Chambers, 1999). Previous studies in aquatic environments have sought to evaluate bioaccumulation by comparing concentrations of individual COCs in the water column with those in the tissues of organisms.

Grab samples (taken from a single location at a single instant in time) have traditionally been used to determine contaminant levels in water. The discrete nature of these samples, however, presents a significant challenge to determining long-term trends. This is especially true for lipophilic compounds, which only dissolve in water at small concentrations (which may be difficult to detect with standard analytical methods), but which can become toxic over longer periods of continued exposure. While grab samples can indicate temporal variation in concentrations at a given location, the requirements of their sampling protocol can limit the number of sites sampled per day. Additionally, problems with sample preservation (e.g. losses due to volatilization, sorption to container walls and chemical degradation) can also negatively impact results (Huckins et al., 2005).

Overview of SMPD Technology

Semipermeable membrane devices (SPMDs) are a relatively new method for the in-situ detection of organic contaminants over longer monitoring periods. Developed in the early 1990s by the USGS, semipermeable membrane devices have primarily been used to indicate the presence of dissolved lipophilic contaminants (see
Table 5-1) in aquatic systems. During deployment (typically 28-31 days), SPMDs sequester contaminants in a lipid membrane similar to the fatty tissues of animals. In this way, they can act as "virtual fish," (Chapman, 2008) providing a controlled, time-integrated look at the availability of contaminants for biologic uptake (Namiesnik et al., 2005). Because of this property, and also

their simplicity, reliability, and ease of deployment, SMPDs have gained widespread acceptance in environmental quality assessments (Chapman, 2008).

Table 5-1: Common Contaminants sampled by SMPDs

Common compounds which accumulate in SPMDs	Major Sources
Polycyclic Aromatic Hydrocarbons (PAHs)	Emissions from road traffic, fuel oil, coal combustion, incomplete combustion and pyrolysis of fossil fuels and other organic materials[26]
Polychlorinated Biphenyls (PCBs)	Coolants; lubricants in transformers, capacitors, and other electrical equipment; old fluorescent lighting fixtures; old microscope and hydraulic oils; heat transfer systems, hydraulic systems, mining equipment; natural gas pipelines (compressors, scrubbers, filters); electromagnets, switches, voltage regulators, circuit breakers, reclosers, cable; carbonless copy paper[27]
Polychlorinated Dioxins and Furans	Incomplete combustion; incineration of solid waste, sewerage sludge, and hospital wastes; high temperature steel production, smelting operations, and scrap metal recovery furnaces; burning of coal, wood petroleum products, and used tires, manufacture of chlorine & chlorinated organic compounds; combustion of automotive fuel; some pesticides[28]
Organochlorides	Biological decomposition, forest fires, volcanoes, pesticides, insecticides[29]
Pyrethroids	Insecticides
Alkylated Selenide	Fossil fuels
Trybutyltin (TBT) compounds	Wood preservation, marine maintenance (used as an anti-fouling agent in marine paints), and industrial maintenance (used as an anti-fungal agent)
Nonylphenols	Manufacturing (used as a surfactant), pesticides, detergents, cosmetics, and contraceptives (Nonxynol-9)
Pyrethroid insecticides	Household insecticides

Analysis Methods

Following SMPD deployment, the accumulated compounds are extracted from the lipid membrane into a solvent for analysis. There are two general methods for analysis:

[26] Harrison, R.M., Smith, D.J.T., Luhana, L. 1996. Source Apportionment of Atmospheric Polycyclic Aromatic Hydrocarbons Collected from an Urban Location in Birmingham, U.K. Environ. Sci. Technol., 30 (3), 825-832.

[27] Department of Health and Human Services http://www.atsdr.cdc.gov/tfacts17.html &
Fact Sheet: Sources of Polychlorinated Biphenyls http://www.deq.state.or.us/lq/cu/nwr/PortlandHarbor/docs/SourcePCBs.pdf

[28] Australian Department of the Environment, Water, Heritage and the Arts: National Pollutant Inventory http://www.npi.gov.au/database/substance-info/profiles/73.html#common

[29] Australian Department of the Environment, Water, Heritage and the Arts: National Pollutant Inventory http://www.environment.gov.au/settlements/publications/chemicals/scheduled-waste/ocpfactsheet4.html

1) The extracted solvent can be analyzed for specific compounds (using chromatographic techniques).

2) The solvent can be subjected to a biological assay, such as the Microtox® test. The Microtox ® test exposes luminescent (light producing) bacteria to increasing concentrations of the extracted solute. The light output of the bacteria (which decreases with increasing concentrations if the solute is toxic) is quantitatively measured. After the concentration of solute has been increased enough times to kill the bacteria, a median effective concentration (EC50, a concentration which is 50 percent of the smallest fatal dose) is computed (Wells et al., 1998). The EC50 provides a numeric value indicating the overall ecotoxicity of the water at a sampled site. EC50 values obtained from SMPDs at different sites can be compared if sampling times, water temperatures, and geochemical conditions are similar.

Table 5-2: Microtox® EC50 values of common contaminants sampled by SPMDs*.

Category	Compound	EC50 (µL/mL)
Insecticides: Organochlorine	Aldrin	0.88
	DDT	1.25
	Mirex	1.4
	Toxaphene	4.9
Insecticides: Pyrethroid	DDE	0.97
Herbicides:	Permethrin	1.56
	Decathal	1.3
PCBs:	Treflan	3.7
	PCB1242	1.2
	PCB1248	0.55
Petroleum Products	PCB1254	1.01
	Fuel Oil #2	0.06
	Jet Fuel JP4	0.12
	Gasoline	0.16
	Crude Oil	0.4
	Recycled Motor Oil	1.0
PAHs	Flourene	0.5
	2-Aminoflourene	4.1
	Naphthalene	0.9
Mixtures of Compounds	PCBs: 1242+1248+1254+1260	0.9
	DDT+DDE+DDD	1.5
	Carbofuran+DDT+ Atrazine +Permethrin	1.6
	DDT+Benxo(a)pyrene+PCB 1254+1260+Atrazine	2.2

*From Johnson, 2005.

SPMDs in the Bayou Bienvenue Wetland Triangle

From June 20–July 21, 2008, SPMDs were deployed at three sites in the BBWT (Figure 5-1). Sampling equipment was obtained from (and returned for extraction to) Environmental Sampling Technologies, Inc. (EST; the exclusive U.S. license holder for SPMD patents), located in St. Joseph, Missouri. The extracted solutes were then sent to the Wisconsin State Lab of Hygiene for the Microtox® test. All proper sampling and handling protocols, as dictated by EST, were strictly followed. A more detailed description of SMPD technology, methods/protocols, and analysis can be found in Appendix C.

Figure 5-1: SMPD sampling locations.

Results

Table 5-3:EC50 values and toxicity ratings for SMPDs in the BBWT

Site	Exposure Period (days)	EC50 Value (µl/ml)	Toxicity Rating[30]
Dialysis Blank (control)	31	9.4	Nontoxic
SPMD # 1	31	4.1	Toxic
SPMD # 2	31	9.4	Nontoxic
SPMD # 3	31	1.2	Toxic

[30] Following the method of Johnson (1998), samples with EC50 values below that of the control are designated as "toxic." Values close to zero are generally considered to be more toxic (Beg & Ali, 2008).

The two sampling sites—1 and 3—which were the sites closest to the Sewage and Water Board facility and to the neighborhood (respectively) had lower EC50 values than the lab control, which could indicate the presence of organic contaminants available for biologic uptake. The site located near Southern Scrap, (Site 2, located at the westernmost notch in the spoil bank separating the Bayou Bienvenue channel from the BBWT) had an EC50 value equal to the control (standard laboratory water), which indicates that no meaningful quantity of contaminants was sequestered in that membrane.

Discussion

This distribution of EC50 values is inconsistent with any of the potential sources for contamination discussed in the LULUs chapter of this report. Potential causes for this distribution beyond an error in the method are unclear. Although all sampling and handling protocols were followed as closely as possible, contamination during the intricate SMPD deployment, recovery and analysis process is not impossible.

In addition, recent studies have shown that elevated levels of elemental sulfur dissolved in solutes extracted for Microtox ® testing can produce falsely positive (i.e. "toxic") Microtox® results (Pardons et al., 1999). To minimize these effects, a copper cleanup method is suggested to remove the sulfur (Harkin, 1999; Huckins et al., 2002). This procedure was not performed on the BBWT membrane extracts. Sulfur is abundant in the BBWT in the form of hydrogen sulfide gas (observed bubbling up from sediments) and as sulfate in the water column (WRM, 2007).

Conclusions

Based on the spatial distribution of sample toxicities, and additional uncertainty resulting from the potential effects of elemental sulfur, no conclusions can be drawn about the presence of dissolved organic contaminants and potential sources.

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Sediment Heavy Metals

Hiroko Yoshida and Andrew Leaf

The urban location of the BBWT and surrounding land uses place it at a potential risk for contamination by heavy metals[31], with implications for ecosystem health and human consumption of crabs and fish. The bioavailability of heavy metals in water and sediment is heavily dependent on their speciation and local geochemical conditions. Therefore, bulk concentration data alone are insufficient for determining the ecotoxicology of a given site (Millward et al., 2001). However, bulk concentrations can provide a useful screening tool for a coarse assessment of anthropogenic contamination (Birch & Olmos, 2008), as well as spatial information towards determining contamination sources.

Long et al. (1998, 1995) statistically compared extensive NOAA datasets of metals concentrations and organism toxicity to develop predictive guidelines for the ecotoxicity of estuarine sediments. Manheim and Hayes (2002) later used these guidelines in the comparative screening of heavy metals concentrations in Pontchartrain Basin sediments. The USEPA (2005) has developed similar guidelines for heavy metals concentrations in surface water. These guidelines and their sources are defined in Table 5-4. It should be noted that the guidelines do not necessarily imply a level of toxicity. Rather, they represent increasing levels of statistical likelihood for adverse biological effects (Long et al., 1998).

The 2007 WRM group sampled heavy metals concentrations (cadmium, chromium, copper, nickel, lead, zinc, and mercury) approximately one foot below the sediment-water interface at 10 sites in the BBWT. Their results showed a sporadic distribution of concentrations, with no clear spatial trends. Site PZ-19 had the overall highest concentrations of heavy metals, with lead and zinc exceeding the toxic effects-range medium (ERM) level, as used by Manheim and Hayes (2002). Site PZ-11 had the second highest concentrations of lead and zinc, although neither of these exceeded the ERM levels. At most sites sampled by the WRM 2007 researchers, copper, lead, and zinc all exceeded the toxic effects-range low (ERL) levels (Manheim & Hayes 2002).

The 2008 WRM group collected additional sediment samples in August 2008, including samples in the Bayou Bienvenue channel, and near the Southern Scrap stormwater outfalls (Figure 5-2). So as not to under-sample recently deposited sediments, and/or recently sorped metals (accumulated in the top layer of sediment), these samples were taken from less than one foot below the sediment-water interface. In addition, water samples were taken at each location for comparison. Samples were preserved and shipped on ice to the University of Wisconsin-Madison Soil and Plant Analysis Laboratory, where they were analyzed for a suite of heavy metals. Table 5-5 shows sediment results and Table 5-6 shows the water column results. Mean values from Lake Pontchartrain (Manheim & Hayes, 2002) are provided for comparison.

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[31] "Heavy metals" is a poorly defined term that refers to metals and metalloids associated with environmental contamination and ecotoxicological effects (Duffus 2002). The use of this term is problematic because 1) no definitive list of "heavy metals" exists 2) many species are necessary nutrients in small concentrations (e.g. copper, which is listed on nutrition labels), but are toxic at large concentrations 3) significant differences in toxicity and mobility can exist between different species of a given element (e.g. hexavalent chromium (Cr VI) is mobile and acutely toxic, while trivalent chromium (Cr III) is much less toxic, and less mobile (Palmer and Puls 1994). Large datasets have shown the metals sampled in this study to have adverse biological effects at higher concentrations (Long et al 1998,1995). Therefore, for the purposes of this report, they will be referred to as heavy metals.

Table 5-4: Sediment Quality Guidelines

Guideline	Definition	Source
Low Alert Level	Ranges of contamination for natural, uncontaminated sediments. Based on reference publications and drill cores from the Atlantic continental shelf.	Manheim & Hayes, 2002
Toxic Effects-Range Low (ERL)	Concentrations below this level are not considered toxic. Adverse effects to organisms occurred in less than 10 percent of studies where concentrations were below ERL values.	Long et al., 1995, 1998
Toxic Effects-Range Medium (ERM)	Concentrations above this level are considered toxic. Adverse effects to organisms occurred in more than 75 percent of studies where concentrations exceeded ERM values.	Long et al., 1995, 1998
High Alert Level	From USEPA (1996). Many of these are the same as ERM values. Manheim and Hayes estimated values not given in USEPA (1996) from the upper 10 percentile of the NOAA dataset.	Manheim & Hayes, 2002
Criteria Maximum Concentration (CMC)	An estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect.	US EPA, 2005
Criterion Continuous Concentration (CCC)	An estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect	US EPA, 2005

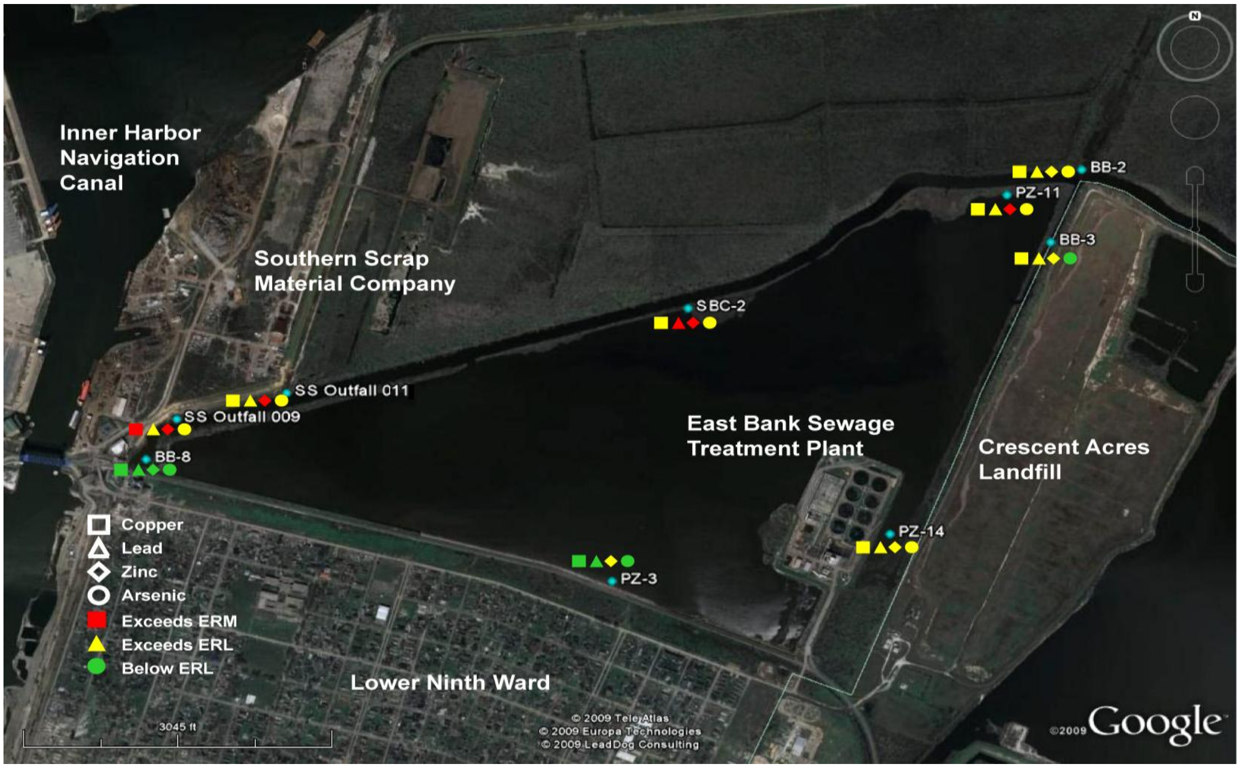

Figure 5-2: Sediment sampling locations with concentration levels (see Table 5-4) of copper, lead, zinc and arsenic.

Table 5-5: Bulk Heavy Metal Concentrations in Bayou Bienvenue and BBWT sediments (mg/Kg)

Site	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Zn	Li	As
BB-8	0.41	3.45	2.23	20.18	5,745	100.07	0.06	<0.3	21.31	115.7	3.93	5.78
SS Outfall 009	2.44	8.66	52.06	336.22	27,369	522.82	0.64	<0.3	133.45	1218	19.34	11.19
SS Outfall 008	1.0	8.66	46.03	102.78	21,546	542.86	0.06	<0.3	169.23	524.3	22.57	14.68
SBC-2	3.44	8.04	164.51	143.26	19,392	469.35	0.06	<0.3	267.95	660.9	24.31	25.34
BB-3	0.55	7.86	59.1	56.82	22,692	515.26	0.06	<0.3	49.66	244.8	26.06	5.98
BB-2	0.93	6.87	42.6	72.73	19,211	410.76	0.06	<0.3	129.26	366	19.11	42.98
PZ-14	0.57	8.45	54.3	69.92	25,464	607.35	0.06	<0.3	51.65	310.8	29.46	25.39
PZ-11	1.15	8.31	61.29	89.88	23,377	627.57	0.06	<0.3	98.47	429.5	27.17	14.74
PZ-11 (WRM 2007)	2.1	NA	61.6	62.3	NA	NA	NA	ND	210	315.2	NA	NA
PZ-3	0.22	4.96	16.47	25.86	12,886	276.47	0.06	<0.3	26.65	144.7	8.26	6.0
Lake Pontchartrain mean*	0.211	9.41	56.3	17.5	24,292	526.2	NA	18.2	17.5	73.3	NA	7.02
Low Alert Level*	0.04	0.5	4	2	2,000	NA	0.5	3	2	5	NA	0.5
ERL*	1.2	NA	81	34	NA	NA	NA	20.9	46.7	150	NA	8.2
ERM*	9.6	NA	370	270	NA	NA	NA	51.6	218	410	NA	70
High Alert Level	9.6	120	370	270	100,000	NA	18	50	218	410	NA	70

* from Manheim and Hayes (2002), NA=no data, ND=below detection limits

Exceeds ERM   Exceeds ERL   Below ERL

Table 5-5: Water Column Heavy Metal Concentrations in Bayou Bienvenue and the BBWT (mg/L)

Sample	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Zn	Li	As
BB-8	<0.004	<0.003	<0.001	0.03	0.06	0.07	0.02	0.01	<0.01	<0.001	0.01	<0.03
Discharge 1	<0.004	<0.003	<0.001	0.01	0.07	0.15	0.55	0.01	<0.01	<0.001	0.03	<0.03
Discharge 2	<0.004	<0.003	<0.001	0.01	0.01	0.16	0.05	<0.003	<0.01	<0.001	0.01	<0.03
SBC2	<0.004	<0.003	<0.001	<0.005	<0.001	0.01	0.07	<0.003	<0.01	<0.001	0.03	<0.03
BB3	<0.004	<0.003	<0.001	<0.005	<0.001	0.02	0.02	<0.003	0.02	<0.001	0.03	<0.03
BB2	<0.004	<0.003	<0.001	<0.005	<0.001	0.01	0.02	<0.003	<0.01	<0.001	0.03	<0.03
PZ11	<0.004	<0.003	<0.001	<0.005	<0.001	0.01	0.04	0.01	0.02	<0.001	0.03	<0.03
PZ3	<0.004	<0.003	<0.001	0.02	0.01	0.11	0.02	<0.003	<0.01	<0.001	0.01	<0.03
CCC*	0.009	NA	0.05	0.0031	NA	NA	NA	0.01	0.0081	0.081	NA	0.036
CMC*	0.04	NA	1.1	0.0048	NA	NA	NA	0.07	0.21	0.09	NA	0.069

* from USEPA (2005), NA=not sampled

Exceeds CMC   Exceeds CCC   Below CCC

Comparison of these data with results from WRM 2007 broadly suggests lower concentrations of metals in sediments closer to the Florida Avenue floodwall, and higher concentrations in Bayou Bienvenue. A notable exception to this trend are the concentrations at site BB-8 (close to the Pump Station 5 outfall), which were all below the ERL standard. This could indicate that the pump station is not a significant source of heavy metal contamination to Bayou Bienvenue. This idea is reasonable, considering the lack of industry in the Lower Ninth, and also a recent study of heavy metals in the Poydras-Verret wetlands (St. Bernard Parish), which found no evidence for contamination from the Gore pumping station (WSNC 2009).

Due to the limited number of samples, there is some uncertainty regarding how well this data reflect the actual distributions of these metals and metalloids. There is also potential uncertainty regarding the degree to which concentrations vary at each sampling site. For example, the 2007 and 2008 data for PZ-11 compare reasonably well, with the exception of a 100 percent difference in lead concentrations. Although the 2007 sample was potentially taken from several inches deeper below the water-sediment interface, there is no clear trend of increase or decrease in concentrations between the two data sets. These uncertainties could be evaluated with additional data from future studies in which additional sampling sites are included, and multiple samples are collected from important locations (e.g. the Southern Scrap outfalls).

Overall, copper, lead, zinc and possibly arsenic appear to present the biggest concern. In the BBWT, concentrations of these metals exceeded ERL levels at almost every site, with the exception of BB-8 and PZ-3 (Table 5-5 and Table 5-6). Manheim and Hayes (2002), found the highest concentrations of these (and many other metals) to be clustered in proximity to New Orleans. It is therefore highly likely that elevated concentrations of these contaminants are the result of human activity. High concentrations of these metals have demonstrated harmful effects to both humans and ecosystems (Eisler, 1993, 1998; Solomon & Ellman, 2006). The distributions and possible sources of these four contaminants are discussed below.

Lead

Like many old cities, New Orleans suffers from extensive lead contamination, which is reflected in high blood levels among children (Mielke, 1993; Mielke et al., 2002; Solomon & Ellman, 2006; USEPA, 2008). Therefore, it is not surprising that lead concentrations were high in BBWT sediments. Anthropogenic sources of lead include old paint, gasoline and industrial sites. A probable source of lead to the BBWT is deposition during major hurricanes (which breach city flood protection). Pardue et al. (2005) reported high levels of lead in Katrina floodwaters. Historic leaching of the Crescent Acres Landfill could also be responsible. Pump Station 5 effluent is another possible source, although this seems less likely since the lowest concentration measured by our group was in closest proximity to the outfall.

Zinc

Zinc is commonly used to prevent corrosion in galvanized steel and other alloys—it is also used in brass. The manufacture, recycling and disposal of these materials therefore represents an additional source of zinc contamination (Eisler, 1993). It is possible that much of the zinc in the BBWT and the Bayou Bienvenue is sourced from Southern Scrap. Sediments at Southern Scrap outfalls 009 and 008 both exceeded the ERM zinc standard—in fact, outfall 009 exceeded the standard by almost 300 percent. Pump Station 5 is another possible source of zinc, as vehicles, vehicle emissions, and galvanized roofs commonly add zinc to urban runoff. However, the lowest concentration of zinc was measured in close proximity to the pumping station outfall.

Copper

The distribution patterns of copper and zinc are almost identical, although levels of copper are not as severe in relation to the ERM guideline—which was only exceeded at Southern Scrap outfall 009. In the water samples, copper concentrations exceeded the CMC guideline at four sites, including BB-8 and PZ-3, which had the least contaminated sediments. The reason for this is unclear. Copper is also common in urban runoff, which would make Pump Station 5 a possible source.

Arsenic

Immediately following Hurricane Katrina, the USEPA conducted extensive testing of surficial sediments in the New Orleans area (USEPA, 2008). In 95 percent of these samples, arsenic levels were high enough to potentially pose a significant cancer risk (according to EPA guidelines), and 28 percent of these samples contained arsenic levels above the LDEQ threshold for clean-up (Solomon & Ellman, 2006). Arsenic in New Orleans could potentially be sourced from pesticides, trash incineration, industrial sites, and wood treated with chromium copper arsenate.

Arsenic levels in the BBWT were elevated (above the ERL guideline) at the same sites as copper, zinc and lead. However, the distribution pattern is different from that of all other sampled metals. High arsenic levels could also be the result of major hurricanes, which suspend contaminated sediments in surrounding basins (lakes and wetlands) and wash them into the city. This idea is supported by USEPA (2008) data showing the highest levels of soil arsenic in neighborhoods close to Lake Pontchartrain (Solomon & Ellman, 2006). Elevated arsenic in the BBWT could have come from the IHNC, St. Bernard industries or Lake Pontchartrain. Arsenic could also have come from past leaching of the Crescent Acres Landfill.

Metals in IHNC Lock Expansion Mitigation Sediments

To legally mitigate the destruction of wetlands along the GIWW during the IHNC lock expansion, the USACE has proposed using sediments dredged from the IHNC for “marsh creation” in the BBWT. This proposal has raised concerns over its potential to contaminate the BBWT. A comparison of heavy metals concentrations shows higher concentrations of metals in the BBWT than in the IHNC sediments designated for mitigation (Table 5-7).

Table 5-6: Bulk Heavy Metal Concentrations in IHNC sediments designated for BBWT mitigation (mg/Kg) (From USACE, 2008)

Sample	Cd	Cr	Cu	Ni	Pb	Zn	As
BBWT Reference Sample	1.7	42.3	84.5	28.2	254	292	12.4
DMMU 3 (Non-Native Fill)	0.19-0.29	6.9-9.2	6.0-7.9	10.7-15.0	9.7-20.2	24.3-37.7	2.6-3.6
DMMU 4/5 (Native Subsurface Soil)	0.06-0.65	8.9-22.3	4.8-33.0	6.1-32.1	7.4-35.2	20.1-102	4.2-9.5
DMMU 7 (Native Subsurface soil)	0.43-0.64	10.4-15.9	21.0-25.7	20.0-24.2	14.0-34.6	56.0-116	4.8-7.5
DMMU 9 (Non-Native Sediments)	0.43-0.72	15.8-23.5	21.8-31.7	22.9-25.5	25.1-54.0	78.2-142	5.2-7.5
Lake Pontchartrain Mean*	0.211	56.3	17.5	18.2	17.5	73.3	7.02
Low Alert Level*	0.04	4	2	3	2	5	0.5
ERL*	1.2	81	34	20.9	46.7	150	8.2
ERM*	9.6	370	270	51.6	218	410	70
High Alert Level	9.6	370	270	50	218	410	70

* From Manheim and Hayes (2002)

Exceeds ERM   Exceeds ERL

While this suggests heavy metal contamination of the BBWT from IHNC sediments to be less likely, it should not be taken as an endorsement of the USACE's mitigation proposal. Significant concerns remain concerning other pollutants[33], the sporadic distribution of contamination "hot spots" in IHNC sediments, and the potential suspension and commingling of "clean" and contaminated sediments during IHNC dredging.

In conclusion, these data suggest contamination of the BBWT from surrounding facilities superimposed on regional contamination of the New Orleans area. Sediments in Bayou Bienvenue appear to be more contaminated that those in the BBWT. Copper, lead, zinc and arsenic are all present at elevated levels, with levels at some sites statistically likely to produce adverse biological effects in both the aquatic ecosystem and humans. However, bulk sediment concentrations are insufficient to evaluate bioaccumulation in larger animals such as fish and crabs. Bayou Bienvenue sediment quality is an interesting topic with implications for public and environmental health that extends beyond the confines of the BBWT. Future study in this area could also prove important to the fate of Southern Scrap's Florida Avenue facility and the future environmental quality of the Bayou Bienvenue and surrounding wetlands.

[33] According to the lock expansion SEIS, IHNC sediments designated for BBWT mitigation contain several organic contaminants at levels with a "high potential concern" for bioaccumulation (USACE, 2008; see the section of this report which discusses the built environment and LULUs).

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Chapter 6: The Lower Ninth Ward Community

J. Ashleigh Ross

The students involved in this project have operated under the premise that the future of the BBWT should be determined, at least in large part, by the residents of the Lower Ninth Ward. Historically, this community has enjoyed a long relationship with the BBWT. Yet, in recent years, residents have lost access to this resource due to the construction of physical barriers—such as the Florida Avenue floodwall—and the ecological degradation of the wetland itself.

Thanks to an increased awareness of the importance of coastal wetlands post-Hurricane Katrina, along with increased access to the BBWT—due to the construction of a new viewing platform over the floodwall (by the University of Colorado-Denver)—the residents of the Lower Ninth Ward are poised to re-establish this relationship. In 2008, a team of UW students continued research on the community's experience with the BBWT. Specifically, the researchers evaluated existing knowledge about the BBWT, current connections to the wetland, residents' opinions of the wetland and restoration plans, as well as residents' hopes regarding the BBWT's future.

History of the Lower Ninth Ward

The Lower Ninth has a strong sense of community. Before Hurricane Katrina the neighborhood had a reputation as a close-knit community with multiple family members living within blocks of each other. The Lower Ninth became a desirable neighborhood for African American homeowners—a neighborhood where families often moved so that they could be closer to each other, and one which gained a reputation for its rural atmosphere and activist traditions (GNOCDC). This long-established activist spirit has been maintained following the 2005 hurricanes (Landphair, 2007).

The Lower Ninth was originally settled in the 1800s in the Holy Cross area (GNOCDC, Holy Cross Snapshot). In 1923, the Lower Ninth neighborhood was cut off from New Orleans city proper by the construction of the Inner Harbor Navigational Canal (IHNC), commonly known as the Industrial Canal (GNOCDC, Lower Ninth Ward Snapshot; Germany, 2007). The Gulf Intercoastal Waterway separated the Lower Ninth from the city to the north. Development continued into the "back-a-town" sections of the neighborhood (north of St. Claude Avenue) until the 1950s when the wetlands were drained for residential development (GNOCDC, Lower Ninth Ward Snapshot). The area retained a rural atmosphere; many of the residents hunted, fished and gardened on the borders of the neighborhood. The BBWT played an important role in providing both food sustenance and economic opportunities for residents in the neighborhood. The area was also used as a place for recreation and relaxation.

The 1960s proved to be a tumultuous time for the Lower Ninth neighborhood. Hurricane Betsy, the construction of the Mississippi River Gulf Outlet (MRGO) and integration dealt the neighborhood a blow both socially, economically and environmentally. The Mississippi River Gulf Outlet, an Army Corps of Engineers canal, provided a direct link from the Gulf of Mexico to Lake Pontchartrain, which allowed salt water to intrude into the Central Wetland Unit, which eventually killed off the cypress trees in the Bayou Bienvenue Wetland Triangle (Day, et al, 2006). Hurricane Betsy ravaged the neighborhood and submerged 80 percent of the area under water (GNOCDC, Lower Ninth Ward Snapshot). Integration and suburbanization policies encouraged white flight and de-investment of the neighborhood (Landphair, 2007). This marked a decline of the Lower Ninth that continued until Hurricane Katrina hit in 2005.

At the time of Hurricane Katrina, the neighborhood was in an increasingly vulnerable position environmentally and socially. The slow destruction of the Bayou Bienvenue Central Wetland Unit and the BBWT made the neighborhood susceptible to flooding and storm surges. Economically, the neighborhood had no financial institutions or grocery stores. Socially, white flight left the neighborhood with a larger African American population, the area was rumored to be red-lined, and marginalization of the Lower Ninth had continued. When the levee breeched, the water flooded an already weakened neighborhood.

The Lower Ninth has gained a reputation for being politically organized. That strong organization is due, at least in part, to a sense of shared neglect from the city (Colten, 2005; Germany, 2005; GNOCDC). From demanding education and services in the 1950s, to opposing the Industrial Canal Lock Expansion project from the 1980s to the present, the Lower Ninth has been actively working to address and solve the challenges the community has faced. This "sense of activism" (GNOCDC, Lower Ninth Ward Snapshot) remains with the community and is demonstrated in their post-Katrina planning charettes and the subsequent reports for the sustainable restoration of the neighborhood (Sustainable Restoration, 2006).

The Lower Ninth was one of the most severely hit neighborhoods in New Orleans from Hurricane Katrina. The neighborhood suffered near total destruction and the entire area endured a forced evacuation for six months. The community continues to struggle to regain its pre-Katrina population and has steadfastly worked to rebuild homes, return residents and build infrastructure.

The physical damage sustained by the neighborhood affected the community's economic and social structure. The Lower Ninth had the highest number of home demolitions in the New Orleans area. Since Hurricane Katrina 2,072 homes were demolished with the bulk of these being in the northern section of the neighborhood (The Katrina Index, 2009).

In addition to fewer residents, businesses and basic services in the Lower Ninth remain sparse. Only one school, the Martin Luther King Charter School for Science and Technology, has reopened in the neighborhood. Approximately five corner stores/gas stations—which offer limited food selections—are open for business. Electricity and water can be unreliable, and perceived police presence remains nominal. In addition to the Holy Cross Neighborhood Association, a variety of neighborhood and non-profit organizations provide services to the neighborhood.

Background of the Lower Ninth Resident Survey

The UW research team conducted social science surveys in 2007 and 2008 designed to gather information on residents' relationships to the BBWT including their past usage histories and preferred future uses of the wetland, along with residents' knowledge of wetland restoration. In addition, the contact during the surveys also served as an outreach method to educate the residents about the proposed restoration.

A key objective of the survey is to identify (and track over time) residential use patterns in the BBWT—specifically, how residents have used the BBWT in the past and how they hope to use it in the future. Another important objective is to gauge current knowledge and understanding of restoration options to identify needs for further outreach and to include residents in restoration plans. A third objective is to identify demographic characteristics and strengths in the community that can be built on during restoration and outreach. The fourth objective is to address residents' concerns and identify areas of common needs and interests between rebuilding the Lower Ninth neighborhood and restoring the BBWT.

This survey, to be conducted every year of the UW-Madison New Orleans project, will serve to document and measure changing perceptions, uses and trends. Some questions of the survey may change from year to year depending on current proposals and plans, but many questions will remain the same. This method provides an opportunity to track changes over time in neighborhood responses and demographic characteristics. In the future, the multiple years of data can be used to conduct time series analysis. Understanding residents' perceptions gives researchers and restorationists a starting point against which to measure changing perceptions and knowledge. The two years of findings (2007 & 2008) provide baseline knowledge of resident perceptions and attitudes regarding wetland restoration.

The two hypotheses of the survey are 1) residents would be moderately aware of the importance of wetland restoration and the role that coastal wetlands play in the future of the neighborhood, and 2) knowledge and use of the BBWT in the past would be minimal. After the first year (2007), it was discovered that although many residents thought restoration was important for the long term survival of the neighborhood, they were largely unaware of the local wetlands and plans for restoration. However, the 2007 survey team found that half of the neighborhood was aware of the BBWT and that the wetland had been used for hunting and fishing purposes in the past. The 2008 survey was restructured accordingly and questions were substituted that dealt more with the basics of wetlands and restoration plans.

Methodology

The U.S. census recognizes two distinct neighborhoods in the Lower Ninth: Holy Cross and what is referred to as the Lower Ninth Ward. For our analysis, and to accommodate the neighborhoods' desire to merge the two areas, we refer the entire neighborhood as the Lower Ninth Ward and our survey is intended to represent the general trends of the entire neighborhood. To account for the two separate census tracts, a weighted average was calculated for the entire Lower Ninth based on the combined population from both neighborhoods. The Lower Ninth Ward combined census data was compared to the results from the two years of UW surveys.

The majority of the results discussed are based on 72 surveys that were conducted over a two year period, 37 in the summer of 2007 and 35 in the summer of 2008. Results from the 2007 survey were reported in that year's report and were also used in 2008. The years are combined for much of this analysis to create a larger sample size which more accurately reflects trends in the neighborhood.

Our sampling method, a form of quota sampling which ensures proportionate samples to the population, was not random due to difficulty in developing a strictly random sampling method (Schutt, 2006), No phone numbers or exact population information were available, and the neighborhood repopulation trends were too inconsistent to go to every *nth* house; therefore participants were chosen by stratified geographical samplings of recent population estimates. Using the population proportionate to size (PPS) (Czaja, 2005; Raj, 1965; Sirken, 2001; WRM, 2007) the neighborhood was divided into eight sections and the number of surveys conducted in each section was based on estimated populations of that section.

Any resident encountered over 18 years of age could participate in the survey. One resident participated in both the 2007 & 2008 samples. Our sample is not likely to be a generalizable representation of the neighborhood due to the sample model *i.e.* all participants encountered were eligible to participate versus a random sampling method which ensures each household the same probability of selection (Schutt, 2006). The small sample size was due to the amount of time necessary to administer the surveys. For both 2007 and 2008 we had higher survey goals but were unable to meet those due to time constraints. Only one survey was not fully completed because the participant had to leave in the middle of the survey.

Survey teams generally consisted of two UW student researchers and occasionally a neighborhood advisor from New Orleans. Hired at the outset to assist in conducting the surveys and clarifying questions to the participants, the neighborhood advisor was phased out as student researchers became more confident and familiar with the community. Survey questions consisted of both open-ended questions and Lichert scale-style questions. One student administered the survey while the other student recorded the responses. Additionally, the UW 2008 team lived in the Lower Ninth, which contributed to a broader understanding of the neighborhood. This understanding proved beneficial in discussions with residents during the survey.

Although in some cases the survey teams knocked on doors, residents who were outside of their homes typically had a higher response rate than those who were inside. Despite the intended geographic distribution of surveys based on PPS, it often proved difficult to engage residents in the northern sections that are closest to the BBWT. This could be because of the overall sparseness of that area, and the residents' distrust of strangers due to isolated nature of that part of the neighborhood. Of the 35 surveys completed in 2008, only 7 (20 percent) were from the northern half of the neighborhood.

For safety purposes the survey was administered during working hours between 9:00 am and 5:00 pm. This methodology likely introduced bias in our sample in favor of older residents and those who were out of the work force and residents who were engaged in working on their houses. The neighborhood's returned population is believed to be largely composed of an elderly population, based on conversations held with community leaders. For the full breakdown of demographic and other information for survey participants, see the charts in Appendix D.

In addition to the descriptive survey data, ethnographic methods such as participant observations and interviews were used to gain a more detailed understanding of the relationship between the community and BBWT. Participant observation was conducted through casual interactions with residents and during neighborhood and stakeholder meetings. Community interview participants were found based on restoration involvement and/or knowledge about the environmental history of the neighborhood. Interviewees were found from existing relationship and through the convenience sampling method (Glesne, 1999).

Questions and Analysis

The 2007 survey format was altered slightly in 2008. Questions asked in 2007 regarding wastewater assimilation were beyond the average residents' knowledge of restoration, the 2008 survey substituted questions that assessed more general knowledge about restoration. For example, we included the questions, "Have you heard of any restoration plans?" and "Have you visited the platform at the corner of Caffin and Florida Avenues?" to evaluate basic knowledge of recent events regarding the BBWT. In order to conduct future time series analysis about resident knowledge and neighborhood demographics the 2008 survey sought to keep as many of the same questions as possible (35 out of 50; 70 percent). Expanded questioning dealt with the role of student researchers, alternative tourism, as well as neighborhood sustainable redevelopment because there was a growing movement among the neighborhood leaders to pursue these topics as a source of economic development.

In order to obtain a larger sample number 2007 and 2008 data were combined when deemed appropriate. The sample size was relatively small, so many relationships were difficult to discern. However, the population of the Lower Ninth was 1,468 in January, 2009, meaning our sample of 72 residents represents 2.5 percent of the current population (The Katrina Index, 2009). In the results below, it is noted when only 2007 data were analyzed (UW 07, n=37), only 2008 data (UW 08, n=35) and both years combined (UW 07, 08, n=72).

Three methods of analysis were used for the survey data: use of basic percentages to demonstrate likely neighborhood trends, determining 95 percent confidence intervals to provide statistical techniques for extrapolating and chi-squared analysis to determine relationships between two characteristics (Schutt, 2006). The results from the confidence interval and the chi-squared analysis, detailing water and fish safety, BBWT use, perceived importance of wetland restoration against demographic characteristics can be found in Appendix D.

Demographic/Socio-economic Findings

The Lower Ninth has not regained its pre-Katrina populations. Only 34.6 percent of the Holy Cross area and 11.2 percent of the Lower Ninth pre-Katrina households have returned for an overall average of 19 percent (The New Orleans Index, 2009). Redevelopment is heaviest in the Holy Cross area, which is as stark contrast to the rest of the Lower Ninth where many of the houses in the sections north of Claiborne Avenue have been torn down—and where in some cases entire blocks of the neighborhood are devoid of human habitation.

The survey sample respondents were older than the average age listed in the 2000 census for the area. However, these survey results reflect the current make up of the Lower Ninth. Demographic information collected for both years included: gender, age, race, marital status and homeownership status. Of the surveyed residents, 46 percent were over 61 years of age. Unfortunately, this research group was unable to accurately compare our age findings with those from the 2000 US Census because the categories were incompatible. For more detailed demographic data see Appendix D.

Neighborhood Trends and Community Cohesiveness

Table 6-1: Demographic comparison between the 2000 U.S. census and WRM surveys (2007, 2008).

	2000 US Census data: Holy Cross & Lower Ninth Ward census tracts combined	2007 UW WRM survey data	2008 UW WRM survey data
Homeownership			
Owner	54.1%	89%	86%
Renter	45.9%	8%	14%
Marital Status		3%	
Married	33.3%	46%	26%
Never Married	36.7%	27%	0%
Separated	6.3%	0%	0%
Widowed	10.7%	0%	0%
Divorced	12.7%	0%	34%
NA	0%	14%	23%
Gender			
Female	54.3%	46%	63%
Male	45.7%	54%	37%
Ethnicity			
African American	95.3%	86%	91%
White	3.0%	0%	0%
Asian	0.1%	0%	0%
American Indian	0.1%	0%	3%
Other	0.1%	0%	6%
2 or more race categories	0.7%	5%	0%
Hispanic	0.8%	0%	0%
NA	0%	0%	0%

A section of the survey investigated the current sense of place and dedication to community. Sixty percent of the survey participants have lived in the Lower Ninth for more than 25 years. Furthermore, 69 percent of residents plan to live in the area for as long as possible (n=72). The 2000 US Census found the Lower Ninth to have a 59 percent homeownership rate (GNOCDC, Lower Ninth Ward Neighborhood). Our survey population had a higher rate of homeownership: 79 percent of surveyed residents own their own homes and 71 percent had family in the area.

The strong sense of community in the Lower Ninth is reflected in the close relationships that often exist within the neighborhood: 54 percent of residents surveyed in 2007 and 2008 reported that they were "close like family with their neighbors", and an additional 36 percent said they were "close like good friends/friendly", while only 8 percent reported that they were "not close" with their neighbors. These responses speak to the close relationships that have been created in the neighborhood and the social networks that support residents. One question included in the 2008 survey asked residents what they were proud of about the Lower Ninth. Homeownership, family and general neighborliness (“everybody knows everybody”, “feels like home”) were frequently mentioned as sources of neighborhood pride, and respondents also mentioned that people are continuing to move back.

Sense of place and neighborhood dedication has the potential to influence the restoration of BBWT and the larger rebuilding of the Lower Ninth. Many residents expressed commitment to rebuilding based on the strong ties within the neighborhood. If their history is any indication of the future, the returned residents will continue to be active in the enhancement of the neighborhood.

Community Knowledge and Perceptions of the BBWT and Restoration Proposals

Knowledge of the BBWT

Assessing residents’ knowledge and familiarity of the BBWT is important to developing strategies to engage the community in prospective restoration efforts and to identify areas of overlap between neighborhood rebuilding and wetland restoration. Community-building efforts, such as crab boils and education events encouraged community collaboration with the restoration efforts and provided an opportunity for residents and researchers to discuss the merits and challenges of restoring the wetland. Additional quantitative data, gathered in the surveys, is useful to discern past uses of the BBWT, similarly residents’ memories of the wetland provide insight into how community members will view the restoration and use the BBWT in the future. Thus, the UW research group set out to collect baseline information on community familiarity with, and knowledge about, the BBWT, as well as data regarding residents’ understanding of the current restoration plans.

The UW research team defines the BBWT as the 427-acre triangle section located at the western end of the 28,000-acre Central Wetlands Unit (WRM, 2007). Residents report that the wetland was also referred to as the “Loggers Bayou” and the “Swamp in the back-a-town”. Today the area is known by many names including the “BBWT”, the “Bayou Bienvenue”, “the wetland”, and “the Cypress Triangle”. During the surveys we generically referred to this area as Bayou Bienvenue, which is the name of the bayou channel adjacent to the BBWT and Central Wetlands Unit. Due to this overlap in names, we are unclear as to the precise location of many past uses and experiences.

Prior to Hurricane Betsy, the steel floodwall reinforcements which separated the neighborhood from the Bayou Bienvenue wetland area had not yet been installed. Back then, residents and wildlife could easily cross from Florida Avenue to the BBWT. The floodwall—which was built in the 1960s—along with railroad tracks north of Florida Avenue, create a visual and physical barrier to the BBWT. This research group hypothesized that due to this barrier, and the historic lack of popularity of wetlands, residents would have scant knowledge of the BBWT.

Resident familiarity with the Bayou Bienvenue was gauged by asking respondents if they had looked over the floodwall that separates the BBWT from the neighborhood. Of the surveyed residents, 56 percent had looked over the Florida Avenue floodwall (n=72) into the BBWT. This is encouraging considering the aforementioned hypothesis of low resident familiarity and knowledge of the BBWT. Residents often evoked fond memories of the area. One respondent recalled, “Oh yeah, we used to go and shoot hokey there!” another remembered, “People used to bring their fishing poles… it was a beautiful place.” The findings showed that half of the respondents are aware of the BBWT, which indicates that it is a recognized landmark in the neighborhood.

Seeking to assess the ecosystem change over time, two questions were asked about the current appearance of the BBWT and observations of the transformation of the wetland over time. Although 56 percent of the residents have looked over the Florida Avenue floodwall, 57 percent didn’t know what it looks like now, and 54 percent couldn’t recall what it looked like in the past (n=72). Roughly 57 percent did not report observing any changes in the wetland. One survey question, “In terms of plant, animals, and water quality, what characteristics would indicate a healthy Bayou Bienvenue Wetland?” was helpful in gauging community expectations for restoration efforts. While 34 percent reported the presence of wildlife, 17 percent said clear water and 11 percent responded with food-related answers (n=72).

Current plans for the restoration of the BBWT are proposed by the New Orleans’ Sewerage and Water Board, the Army Corps of Engineers, and various academic, governmental, non-profit and private companies. Given the popularity of restoration plans, this research group assessed resident knowledge of these plans. We found that respondents’ knowledge of restoration plans was minimal: 20 percent of respondents reported having knowledge of BBWT restoration efforts, but none cited any specific restoration proposals (n=35). Instead, various other state and federal projects were mentioned: 9 percent of respondents mentioned the Florida Avenue Bridge project, 6 percent had heard plans to build a stronger levee, 3 percent had learned about some plans from last year’s survey and the remaining 9 percent were miscellaneous responses.

A focal point for the BBWT restoration is the recently constructed BBWT viewing platform, located near the corner of Caffin and Florida avenues near the northern border of the Lower Ninth. Yet, of the surveyed residents, 94 percent had not yet visited the platform, largely because they had no knowledge of it (n=35). The platform has become a visited spot for people driving though the Lower Ninth; the UW team has observed tour buses, volunteers and celebrities routinely stopping there, but residents remain largely unaware of its existence. Providing opportunities for resident use of the platform, and promoting it as a public space could encourage ownership in the restoration and encourage more neighborhood use of the space.

Community Perceptions of Importance of Restoration

Wetlands have historically been viewed in a negative light, and proximity to wetlands had social and economical relevance as a result of the geography of development. Swamps were popularly viewed as disease-ridden wastelands whose value lay in drainage and development; the wealthiest residents in New Orleans owned the higher land along the river, whereas the low-lying swampy areas were home to the city’s low-income residents (Colton, 2005). Because of this historical view of swamps as nuisances, we assumed that residents would have a negative perception of the BBWT. When asked, 63 percent of the survey respondents said the BBWT was, in fact, a benefit for the neighborhood while only 14 percent reported that it was a nuisance (n=35). These findings suggest that the neighborhood does find value in the wetland which could influence public will in its restoration.

With the myriad rebuilding tasks facing the neighborhood, questions were asked gauging rebuilding priorities. Residents were asked to prioritize a list of options that they felt student researchers/volunteers, and city government should be working on. Analysis revealed that many residents are focused on immediate concerns such as housing (the most important) and general infrastructure improvements (e.g. transportation, jobs and education). While 23 percent of respondents said "all [options listed] are important", 60 percent said that volunteers should be rebuilding homes, while none mentioned wetland restoration specifically (n=35). A similar response was obtained when we asked about the most important task for the city of New Orleans; 26 percent said that everything was important, 43 percent mentioned housing specifically (the most common response), and only 3 percent specifically said wetland restoration was important (n=72). This result implies that the neighborhood is focused much more on basic needs than on long-term ecological restoration efforts.

Conversely, survey results show that nearly two-thirds, (64 percent) of the sample considers wetland restoration important for the long-term survival of New Orleans (n=72). Results from chi-squared analysis found that the belief that wetland restoration is important for the long-term survival seems to be widely held regardless of demographic differences. This discrepancy between the priority of immediate rebuilding needs such as housing and the perceived importance of wetland restoration deserves further research which could reveal effective methods of community education and outreach.

In order to gain an understanding of residents' expectations regarding restoration, questions assessing the possibility of restoration and the timeline were included in the survey. When asked if the BBWT could be restored to a cypress swamp the neighborhood was optimistic: 46 percent said that it could be, 30 percent said "I don't know/maybe" and only 6 percent said it could not be restored (n=72). When asked how long the process would take, 29 percent said 6-10 years and 34 percent said more than 10 years (n=72). These responses indicate an understanding of the long-term commitment that is needed for successful restoration.

While rebuilding homes remains the top priority of returned residents in the Lower Ninth, there is a recognized need for wetland restoration. Prior to Hurricane Katrina, wetland restoration was not a popular topic in mainstream media, but today people across coastal Louisiana are gaining a new understanding of the role of healthy wetlands. During the course of the surveys a TV station aired a special on coastal wetlands. After that, residents referred to the program during the surveys. Other residents would recall reading newspaper articles about the role of wetlands. With this surge in coverage of wetlands, and with additional outreach and education to detail the relationship, resident priority may begin to change with more support be given to wetland restoration.

Further outreach and education on the role of wetlands in storm protection and in preventing land loss could increase the perceived relationship between the wetland restoration and the neighborhood. Also, developing areas of overlap between residents' top priority i.e. rebuilding houses, and wetland restoration would be beneficial.

Community Use of the BBWT

The test the hypothesis that community use of BBWT was low, explicit questions regarding past use and frequency of use were asked. Most respondents (53 percent, n=72) have used the BBWT in the past. Fishing was the most commonly reported use (46 percent), and relaxation, walking, and hunting were also frequently cited as past uses (11 percent). Of the proportion of respondents who reportedly used the BBWT in the past, 82 percent of all use was for fishing/crabbing/shrimping. Although no survey respondents presently use the wetland respondents indicated that fishing, walking, relaxation and bird watching would all likely increase if the area becomes more accessible.

In a chi-square analysis, it was determined that men tended to use the BBWT more than women, and that they tended to fish there more than women. Qualitative data from interviews suggest a possible explanation for the split: some men reported playing in the bayou as boys, while some women said that they were often told to stay away from for safety reasons. If the restoration includes design and facilities to enhance the safety of the BBWT, women might use it more.

Community Perceptions of Fish and Water Quality Safety

Due to the popularity of fishing/crabbing/hunting in the bayou, it is important to gauge any perceived health risks related to consumption of the catch. The question of water and fish safety is a central focus of our wetland science and neighborhood-based social science research. Overall, residents do not consider the water and fish in BBWT to be safe (for consumption). Among respondents to the 2007 and 2008 surveys, 57 percent considered the water unsafe, 29 percent were neutral or uncertain about the safety of the water, and 14 percent considered it safe (n=72). Similarly, 47 percent of respondents considered the fish unsafe for consumption, 22 percent were neutral or unsure about the safety, and 31 percent feel that the fish are safe (n=72). See Appendix D for tables illustrating 95 percent confidence intervals for perceived safety.

Chi-square analysis indicates that perceptions of fish and water safety did not seem to be associated with use of the BBWT for food. It is possible that residents used the wetland at an earlier time when they considered the fish and water safer. We did not know the exact time frame during which respondents previously used the BBWT. In the future, questions regarding exact times of usage will be helpful in determining if perceived water and fish safety affects use of the wetland.

An additional question related to use of neighboring water bodies as a food source was added to the 2008 survey. This question was meant to gauge both safety concerns and overall popularity of fishing in neighboring waters. Of the surveyed residents, 49 percent reported that they do eat from neighboring water bodies (such as the IHNC) and 66 percent reported that they have consumed fish or seafood from these areas in the past (n=35). This information, coupled with the high level of use of the bayou for food indicates that the water bodies are still used as a food source regardless of perceptions of safety, which could have implications for potential health hazards. For information regarding toxicity testing please see Chapter 5 of this report and Chapter 4 of the previous report.

Conclusions

The BBWT has been an integral part of the Lower Ninth. In the past, residents used the BBWT primarily for hunting and fishing, but data indicate that future uses could include recreation. Surveyed residents generally view the wetland as a positive attribute of the neighborhood. However, despite the familiarity with the area, most respondents do not know what the wetland looks like now, nor how it has changed in the over time. More research should be conducted into the time frame of wetland use and the reasons for declining wetland usage. Continuing to build on the strengths in the community (i.e., dedication and close-knit relationships) can positively contribute to the rebuilding effort through increased resident participation. Future questions regarding *why* residents think restoration would be beneficial could provide additional insight into the services and opportunities they offer to the neighborhood. Educating the residents so that they more fully understand the role that the BBWT plays in their life and especially in the protection of their homes could encourage them to become more active and involved in restoration that can serve their interests.

Extensive outreach is necessary to: identify resident concerns, educate residents about restoration efforts, and to include them in future planning designs and discussions. While many of the residents view housing as the most important issue facing their community, many also recognize the importance of wetlands for the long-term survival of New Orleans. Working with residents to determine how restoration overlaps with their current housing needs may strengthen public support. If the BBWT were to become a well-known natural area, it could encourage residents to place more priority on the restoration. Full support of the neighborhood would greatly contribute to the overall political will of the restoration of BBWT, a strength recognized by the Army Corps of Engineers' Coastal Planning, Protection and Restoration Authority (CWPPRA) funding. The increase in public discussions about wetland loss in coastal Louisiana and increased education and outreach could encourage residents to place a higher priority on wetland restoration which would enhance and fortify the public will to restore the BBWT.

Trust in governmental and organizational partners is crucial to achieving restoration success. Environmental injustices and residents' experiences with eminent domain (Jackson, 2006) remain a sensitive topic for many residents. Feelings of distrust and marginalization were intensified after Hurricane Katrina when proposals to turn various neighborhoods park space were advanced (Finch, 2009). Coupled with the documented neglect from the city and residents' history of activism, a successful restoration effort must have broad support from the local community (WRM, 2007). If residents are not educated and kept informed about the restoration efforts, existing rumors regarding land development and forced removal will likely be exacerbated. With the history of neglect felt by the neighborhood and the damage caused by commercial and government projects, resident knowledge and buy-in is crucial for successful restoration. Based on this history, a lack of neighborhood buy-in could negatively impact rebuilding efforts if wetland restoration is perceived to be against neighborhood interests.

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Chapter 7: Government Institutions

Dan Cornelius and Ben Tansey

The health of the BBWT depends not only on the physical environment, but also upon the decisions of institutional actors who help shape that environment. Understanding those institutional actors and their guiding framework is essential to developing an effective restoration plan for the wetland.

While the erosion of Louisiana's coasts did not receive much national attention until the devastation wrought by hurricanes Katrina and Rita, numerous scientific experts and a range of governmental agencies recognized the problem decades earlier and began to develop strategies to counter the adverse impacts. Basic scientific understanding of the Mississippi Delta Plain (MDP) formation is long-standing, but it wasn't until the first of several mapping efforts were completed by Gagliano and van Beek in the 1970s that the true magnitude of the coastal erosion was understood.

Since the 1970s, enhanced scientific knowledge and improved technology to understand coastal processes have produced increasingly dire warnings and more pressing calls for action. The federal government and the state of Louisiana have responded to these concerns with programs that have attempted to address the problem of coastal land loss beginning with the Coastal Wetland Planning Protection and Restoration Act of 1990, et seq. (CWPPRA, also known as the Breaux Act). Clear recognition that CWPRRA is unable to solve the problem has led to the creation of additional programs over the past decade to broaden the availability of coastal management tools.

CWPPRA and other Coastal Programs

Overview

Since its passage, the CWPPRA program has been the primary tool for responding to coastal wetland loss in southern Louisiana by providing interagency coordination and tens of millions of dollars in coastal ecosystem restoration funding per year. CWPPRA's strength is its ability to adapt and respond to the specific needs of geographic regions as well as human and animal populations. The program "is well known for employing a wide array of restoration techniques, including vegetation plantings, river diversions, hydrologic restoration, marsh creation, shoreline protection, sediment trapping, and stabilization of barrier islands," (CWPPRA Task Force, 2006).

Administered through the U.S. Army Corps of Engineers (USACE), the CWPPRA program unsurprisingly follows strict protocol and has a strong hierarchical structure (See Figure 7-1). Yet, its broad interagency composition also gives it a degree of flexibility, and even unpredictability, in ultimate project selection. Though relatively effective in its operation, the CWPPRA is far too limited in its overall scope to address the larger-scale coastal erosion problems facing Louisiana and thus must be complimented by additional expanded efforts.

Development and Guiding Documents

Federal approval of the state of Louisiana's Coastal Wetlands Conservation Plan was a major development in the early years of CWPPRA. This document is required under section 304 of the Breaux Act and "details the State's ongoing efforts to achieve a 'no-net-loss' of wetlands from all future development. The plan is based largely on public education, mitigation of unavoidable losses, and implementation of State-funded restoration projects and programs," (Louisiana Coastal Wetlands Conservation, 1998). This planning document was Louisiana's first effort to develop a framework to specifically guide restoration efforts and the mitigation of coastal land loss.

The next major event in CWPPRA's history came in 1998 with the completion and publication of "Coast 2050: Toward a Sustainable Coastal Louisiana." The report, while "recognizing CWPPRA's important role…began examining options for creating a companion program that could address the systemic problems fueling land loss in Louisiana. The resulting [document] outlined a comprehensive set of restoration strategies for restoring south Louisiana's wetlands to a sustainable level. These strategies, endorsed by state and federal partners and local governments, were integrated into CWPPRA's project selection and planning process," (CWPPRA Task Force, 2006).

Additionally, a central goal of the Coast 2050 process and report was "to address institutional issues, which are issues arising from actions such as government funding and regulation. There are literally dozens if not hundreds of Federal, State, and local programs that can have an impact on wetlands. In the past, the efforts made to align these programs toward common goals have not been comprehensive, nor have they been uniformly effective. Directing government decisions to a common end is an essential step in effective restoration," (Louisiana Coastal Wetlands Conservation, 1998). As wetland and land loss issues in coastal Louisiana gained more political traction, new and expanded efforts and programs complicated coordination. Coast 2050 was intended to help provide large-scale guidance so individual projects could work synergistically, rather than competing against each other.

Coast 2050 provided an overarching framework and a more unified process under which small- and large-scale projects could operate. The adaptability and responsiveness of the institutional structure was well received, as evidenced by extremely high levels "of citizen support for this new approach to restoration planning in coastal Louisiana … demonstrated by one astonishing fact: councils and police juries of all 20 coastal parishes have passed resolutions in support of the Coast 2050 ecosystem strategies," (Louisiana Coastal Wetlands Conservation, 1998). The importance of the document cannot be denied as Coast 2050 serves "as the joint coastal restoration plan of the Breaux Act Task Force and the State Wetlands Authority" (Louisiana Coastal Wetlands Conservation, 1998).

Following on the overall strategic goals laid out by Coast 2050, a more tactical effort in terms of specific projects, the Louisiana Coastal Area Ecosystem Restoration Study (LCA), was completed in 2004. This intensive study was undertaken to provide a comprehensive cost-benefit analysis of various restoration strategies. The initial proposals from the study recommended courses of action estimated to range from $5-17 billion, leading the U.S. Office of Management and Budget to direct the US Army Corps of Engineers (USACE) to revise the LCA Plan with a lower total cost. The subsequent revised plan—with an estimated cost of approximately $2 billion—was submitted to Congress in January 2005 (Day et al., 2007).

CWPPRA Post Katrina and Rita

The 2005 hurricane season demonstrated, on an enormous scale, the importance of restoring Louisiana's coastal landscape to provide not only habitat, but storm protection as well. There was no longer any doubt that the institutional framework in place under Coast 2050, the LCA Ecosystem Study, and CWPPRA left dramatic room for improvement. Virtually overnight, the previously exorbitant estimate of $5-17 billion in coastal improvements seemed like a tremendous bargain when compared to the shocking devastation wrought by hurricanes Katrina and Rita. The paradigm quickly shifted as policy makers finally realized that delta restoration was inseparable from storm protection and navigation (Day et al., 2007).

Congressional initiation of the Louisiana Coastal Protection and Restoration Project (LACPR), led by the USACE, and the formation of the Louisiana Coastal Protection and Restoration Authority (CPRA) are probably the two most notable developments following the 2005 hurricanes. Both affect CWPPRA through impacts on the overall approach to coastal restoration. The LACPR is an initiative aimed at first analyzing the present condition of the coastal environment across all of Louisiana and then presenting strategies for ecosystem restoration and storm protection. As of summer 2009, the LACPR was in the final stages of review. CPRA is a state effort that consolidated all state coastal efforts into a "single State entity with the authority to focus development and restoration and to interface with the USACE on LACPR coordination, (LACPR, 2009). As will be discussed later in this chapter, CPRA seeks to address the issue of unified state action.

While the ultimate impact of changes to CWPPRA and to coastal restoration efforts following the 2005 hurricanes is still uncertain, documents such as the present LACPR draft indicate a clear paradigm shift toward a more holistic approach to coastal management that integrates coastal restoration with storm protection and navigation. New programs such as the Coastal Impact Assistance Program (CIAP) may eventually have a more significant impact in reversing coastal land loss, but definite funding commitments have yet to align emerging and approved plans.

CWPPRA Voting Process

The Coastal Wetlands Planning, Protection & Restoration Act aims to utilize a "process of identifying and selecting the projects to be built [through] a 'bottom-up' model that encourages local constituencies to contribute," (CWPPRA, Task Force, 2005). This model of project selection has encouraged buy-in from a wide array of stakeholders all across southern Louisiana. Although CWPPRA is a federally funded program, local involvement has the potential to play a contributing role in the selection process through public meetings and comment periods.

Five federal agencies are involved— (the US Army Corps of Engineers, the National Oceanic and Atmospheric Administration (NOAA) (Department of Commerce), the Office of Coastal Restoration Management (Environmental Protection Agency—EPA), the Natural Resources Conservation Service (NRCS) (US Department of Agriculture), the US Fish and Wildlife Service

(Department of the Interior)—as well as representatives of the state of Louisiana, all of whom sit on the CWPPRA task force and technical committee.

This structure requires consensus building and cooperation across interests in order to achieve the shared goal of mitigating wetland loss. Each member votes for their favorite projects and rank them in order of preference; however, obtaining buy-in (even with a weaker preference) from all voting bodies is weighted heavier than receiving high preference votes from only two or three agencies. This process means that, despite CWPPRA's strong hierarchical structure, each of the five federal agencies and the state representative must cooperate and work together.

CWPPRA Techniques and Goals

These projects cover a range of techniques and goals including:
"(a) confined cell wetland creation, (b) unconfined deposition for wetland creation, (c) barrier island restoration, and (d) diversion channel construction. The Breaux Act has constructed 15 projects utilizing dredged sediment for habitat restoration. Twenty-three million cubic yards have been hydraulic dredged, and 3,100 acres have been created or benefited at a cost of $100 million," (Hales et al., 2003).

The value of the CWPPRA program may be measured by the projects actually built, but much of the value of such a program may actually be the ability to attempt novel engineering projects or previously unconsidered approaches, innovation applicable to loss of wetlands. One of the unique challenges in undertaking such projects is that "the distances the sediments need to be transported (10-30 miles or more) are greater than those typically constructed by using conventional dredging technology. Most beneficial uses of dredged material projects involve pumping distances of 3 miles or less because booster pumps are not typically used to keep costs reasonably low," (Hales et al., 2003).

The revaluation of sediment from a waste product to a resource has shifted thinking regarding what types of dredging and piping is feasible. The CWPPRA supports demonstration projects specifically to introduce new approaches to coastal issues.

CWPPRA Funding and Projects

The original CWPPRA legislation, providing authorization through fiscal year (FY) 1999, has since undergone several reauthorizations. In October 1999 Public Law 106-74 extended its authority through 2000. The Pittman-Robertson Wildlife Restoration Act Amendment (Public Law 106-408) authorized funding through 2009. The Consolidated Appropriations Act of 2005 extended CWPPRA though 2019 and removed the $70 million per year funding cap.

CWPPRA has achieved many successes. In the first 15 years of CWPPRA, the program "has constructed, is constructing, or has approved for construction 78 projects at a total cost of nearly $624.5 million," (CWPPRA Task Force, 2005).

One criticism of CWPPRA is that its focus is too local or does not respond on the appropriate scale to the massive challenge of coastal wetland loss. Various plans such as those outlined in Coast 2050, the LCA study, the LACPR, and the CPRA have attempted to address these concerns by planning and coordinating coast-wide efforts. CWPPRA has also oriented project selection to favor a series of projects (each being rather small in focus) to achieve larger restoration goals. The case studies of Barataria Land Bridge and the Louisiana Barrier Islands are two such examples with 12 and 19 CWPPRA projects in some phase of engineering and construction, respectively.

CWPPRA and the BBWT

Bayou Bienvenue Wetland Triangle (BBWT) has been proposed for a CWPPRA project twice. The first instance, in 1999 on project priority list (PPL) 8, was a proposed terracing project for a large portion of the Central Wetlands Unit. This project aimed to enhance retention of stormwater discharged into the water body by the drainage pump stations in an effort to decrease salinity—while also increasing sediment deposition in hopes of promoting growth of emergent vegetation. The PPL 8 proposal was deemed infeasible due to high estimated costs and consequently deauthorized in 2002.

However, the BBWT was targeted by another CWPPRA proposal in 2008 on PPL 18. Despite advancing to the final round of selection, the 2008 proposal was outranked by other projects. Yet, the fact that it progressed so far against so many other projects is a testament to the value of this site. The strategic importance of the BBWT is further highlighted by the New Orleans Sewer and Water Board proposal to use the area to provide tertiary treatment for wastewater effluent.

The CWPPRA portion of the project was designed to raise the sediment level in the BBWT with dredged material, which—in conjunction with introduction of freshwater and nutrients from municipal wastewater effluent—would eventually help establish conditions for wetland restoration including cypress reintroduction. The proposal was not ultimately selected, but it does provide many important insights to the challenges that subsequent efforts face in restoring the BBWT, most notably in uniting the diverse interests of multiple stakeholders.

Unifying Institutions and other Stakeholders

The 2008 CWPPRA proposal was complicated by significant expenses that were disproportionate in cost per acre restored in comparison to other proposals. Yet, numerous stakeholders comparably weakened the proposal with their divergent and often competing interests. Whereas most CWPPRA proposals and other significant restoration efforts in coastal Louisiana are in comparatively remote locations, the BBWT lies within the New Orleans Parish boundaries, meaning the overall number of stakeholders will almost inevitably be higher. A similar, yet more remote, project may still have competing federal and state agencies, private landowners and companies, and various non-profits, but the list of potential stakeholders in the BBWT is incomparable.

Identifying these stakeholders— together with their interests—and then formulating a partnership strategy or other solution is essential to any effective restoration effort because the likelihood of detrimental conflict is otherwise substantial. Perhaps the simplest solution is merely acquiring the most essential interests needed to initiate restoration (covered in Chapter 8) and then proceeding under the controlling institutional jurisdiction. This strategy may work on its own, but it does not address countless potential problems of coordination and decision-making. Therefore, a more formalized partnership or governing body may be desirable.

Stakeholder Analysis

Classes of stakeholders with clearly identifiable—or potential—interests within or surrounding the BBWT include governmental agencies, private businesses, individual landowners, non-profit organizations and educational entities. Many of these stakeholders productively work together in various forms on regular basis. Conversely, some groups have an extensive history of conflict, and some groups remain unknown to one another. Table 7-1 provides a simplified matrix listing the key stakeholders.

Table 7-1: Stakeholders and potential interests in the BBWT

STAKEHOLDERS	POTENTIAL INTERESTS
Army Corps of Engineers	Enhanced storm protection; depository for sediment dredged from IHNC; additional project resulting in management fees and possibly beneficial public relations
Holy Cross Neighborhood Association	Promoting the best interests of the neighborhood and its residents by advocating for improved recreational opportunities and long-term storm protection
New Orleans Sewerage & Water Board	Site for wastewater assimilation that would reduce overall operational costs; control over territory adjacent to its primary treatment plant
Southeast Louisiana Flood Protection Authority–East	Levee inspection and maintenance, particularly along Florida Ave.
Port of New Orleans, New Orleans Public Belt Railroad; power and other utilities	Ensuring shipping and transportation priorities; maintaining easements clear of hazards and incompatible uses
City of New Orleans elected officials	Representation of constituents' and the city's best interests in both the short and long-term
St. Bernard Parish	Important component of basin-wide efforts to rebuild natural storm protection; related collaboration on wastewater assimilation project
State of Louisiana	Could affect implementation of coastal planning efforts
Other federal agencies	Possibilities for recreational/natural area immediately within New Orleans boundaries; wildlife management; monitoring/cleanup of environmental hazards
Local Residents and Landowners	Recreational opportunities; economic growth engine; impacts (positive or negative) on property values
Southern Scrap	Ensure continued or future use of its metal processing facility; minimize future liability stemming from existing and past operations (i.e. contamination)
Martin Luther King School	Out-of-classroom, hands-on learning opportunity
Non-profit organizations including: Lake Pontchartrain Basin Foundation, Sierra Club, Common Ground, The Environmental Defense Fund, etc.	Interest depends largely on specific mission of respective non-profit, but promoting environmental justice and greater public awareness of wetland and ecosystem restoration efforts
Academic researchers	Advancing academic research in the pursuit of knowledge; opportunity to secure additional funding

As illustrated by this matrix, which is dramatically simplified in an effort to group similarly situated parties, the list of potential stakeholders is extensive. For instance, the "non-profit organizations" stakeholder group includes such major organizations as the Pontchartrain Basin Foundation, Common Ground, and The Environmental Defense Fund. Even though these groups have different overall institutional missions, this analysis assumes their overall interest is largely congruent. The same may not necessarily be said for local residents and landowners because many landowners may be interested in purely monetary gain rather than the well-being of the community. This topic will receive further attention in Chapter 8. Overall, the key take-away point is that, though numerous, the interests of various stakeholders may be broken down into a number of categories, many of which are compatible. Those conflicting may then be isolated in an attempt to find solutions.

Restoration Authority

As already mentioned, the diversity of interests and stakeholders surrounding the BBWT is significantly more expansive and complicated than most coastal Louisiana restoration projects. Unresolved property rights (to be discussed in Chapter 8) is one issue that has already emerged as a major complication, but little public debate has yet focused on control, decision-making, and ownership. Given the long-term nature of a wetland restoration project, especially one seeking to possibly reintroduce cypress trees, a stable governing

San Francisco Bay Restoration Authority/California Bay-Delta Authority

California's San Francisco Bay and its upland watershed is an excellent example of an area with numerous, and often competing jurisdictions, as well as long histories of industrial impacts and environmental action. Recognizing that informal partnerships were insufficient, the state of California formalized official authorities first in 2003 with the establishment of the California Bay-Delta Authority and then again in 2008 with the creation of the San Francisco Bay Restoration Authority.

The California Bay-Delta Authority—comprised of a wide-ranging group of upper level federal and state officials in addition to public members—works to coordinate efforts to maintain effective river levees, to ensure water quality and the reliability of drinking water supplies and to restore the area's ecosystem. With over 25 federal and state agencies involved in a myriad of related but often-conflicting efforts, the initial impetus to create such cooperation stemmed from a necessity to reduce gridlock. The authority is complimented by the 30-member Bay-Delta Advisory Committee, whose primary role is linking stakeholders and the general public to the otherwise government-dominated decision-making process.

In contrast to the wide-ranging objectives of the California Bay-Delta Authority, the state's San Francisco Bay Restoration Authority is much more narrowly focused on the goal of restoring up to 100,000 acres of wetland throughout the San Francisco Bay. The authority's 5-member governing board consists of elected officials from around the bay, plus the chair who is the executive director of the state of California's State Coastal Conservancy. Its primary purposes are raising funds for restoration, awarding grants, and soliciting input from the advisory committee that is broadly representative of parties interested in restoration. To help fulfill its fundraising mission, the authority has the power to levy assessments and taxes, as well as to issue bonds and promissory notes. However, it is prohibited from owning or controlling real property—and a sunset clause will automatically terminate the entity after 20 years. Interestingly, a legislative analysis questioned whether such an additional group was necessary given already existing cooperation and collaboration.

structure is a consideration to at least consider. A “restoration authority”—an official, legally sanctioned entity consisting of both representatives from various stakeholders and experts in the field of restoration—is one prospective approach.

By bringing various stakeholders together, a restoration authority could facilitate greater communication and cooperation among involved parties, thereby promoting more effective decision-making. Formal voting and dispute resolution procedures would provide a forum to allow these parties to make collective decisions.

The existence of the Coastal Protection and Restoration Authority (CPRA) (noted above) suggests that the concept of a restoration authority is actually familiar to Louisiana. The CPRA was created following hurricanes Katrina and Rita “to articulate a clear statement of priorities and to focus development and implementation of efforts to achieve comprehensive coastal protection,” (LA RS Title 49). The rationale for creating such an entity—that past efforts that were “inadequate, fragmented, uncoordinated, and lacking in focus”—largely parallels many of the same disjointed decision-making problems currently facing the BBWT. The CRPA seeks to overcome the united action problem by bringing together a team of members including the secretary or designee from all major state agencies with a stake in coastal protection and restoration issues, as well as representatives from respective state levee districts. Although CPRA addresses issues on a much larger scale, the rationale for both groups is nearly the same: improving coordination and cooperation among diverse groups.

Overall, the two biggest issues to resolve in terms of determining the structure of any restoration authority are the expected scope of authority and representation of stakeholders. In some cases, a restoration authority may have the powers to tax, enforce land use restrictions, or make any number of restoration-related decisions (see text box for San Francisco Bay Restoration Authority/CA Bay-Delta Authority). In the case of the BBWT, making restoration-related decisions may be the most important power. Stakeholder representation is a more difficult and likely more divisive issue. The total number of members will dictate the breadth of representation, but such an entity would surely need to include multiple governmental representatives and ideally some local (resident) representation.

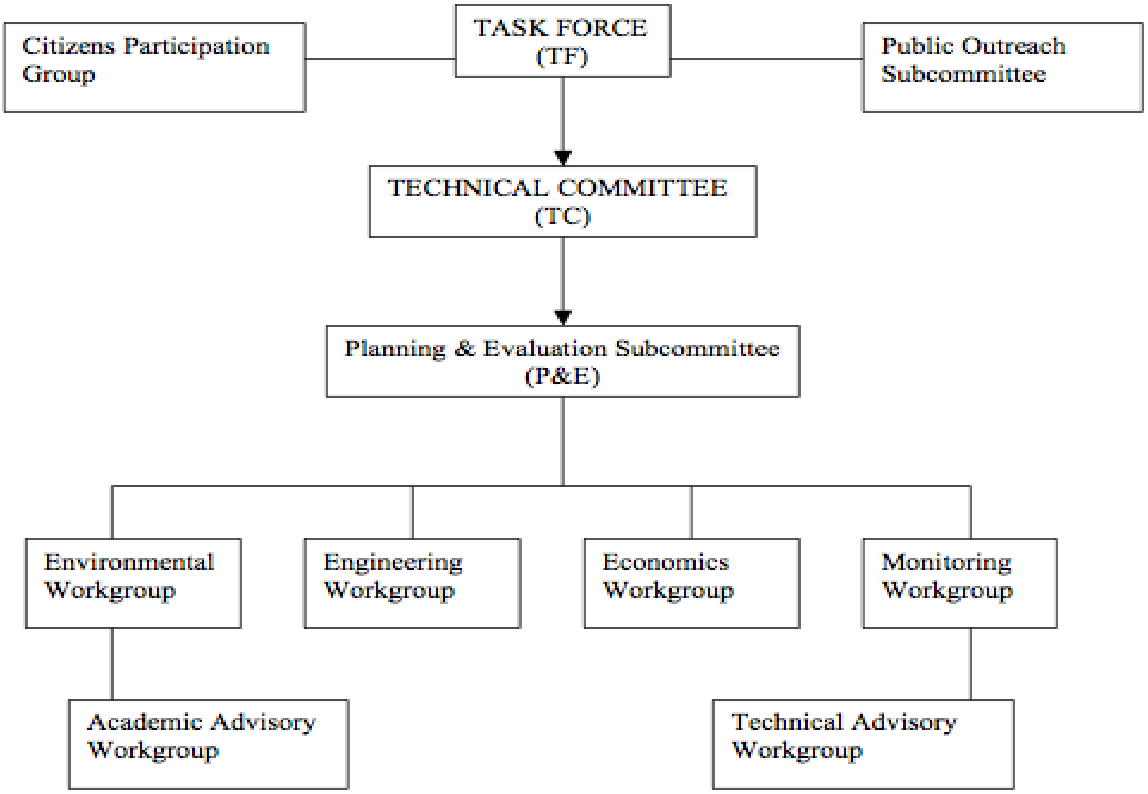
Beyond the overall scope of authority and stakeholder representation, the operational structure is another issue which would have significant ramifications related to how a restoration authority would function. Similar to the organization of a business, the restoration authority could be organized as a simple partnership where stakeholders have an equal or representational voice in decisions and operations. Alternatively, the organization could be much more complex, similar to a corporation with a board of directors. In this case, the stakeholders would make the larger-picture, governing decisions while the “corporate officers” would carry out operational responsibilities. Creating the most effective operational structure will depend in large part on the determining the overall scope of authority and stakeholder representation.

The actual act of creation will require political and public desire, which would likely be the most significant obstacle since it would require support from federal, state, and local authorities, not to mention other stakeholders. If the contentious history between two the most pertinent stakeholders, the U.S. Army Corps of Engineers (USACE) and the Holy Cross Neighborhood

Association (HCNA), is any indication, developing this political and public desire will be no easy task. However, the USACE's objection to ceding control is really a decision for the larger political process and HCNA might be convinced that participation in such a group could give local residents an official voice in making decisions. Other parties would also need to be convinced that cooperation is in their best interest. Ultimately, the prospect of a mutually beneficial wetland restoration will probably be the driving force.

Scenarios with the potential to serve as a catalyst spurring the creation of a restoration authority include the sheer need for cooperation stemming from an approved project like the recent CWPPRA sediment diversion proposal or an even more massive commitment to restore the entire Central Wetlands Unit. The biggest problem with the former is that the current lack of coordination complicates evaluation against other projects. Expansion of an existing or developing project like the CIAP wastewater assimilation might help, but stakeholders connected to existing projects are likely to be hesitant to cede control unless absolutely required.

CWPPRA ORGANIZATIONAL STRUCTURE



TASK FORCE (TF)

1. USACE – New Orleans District Office
    a. New Orleans District Commander is Chairperson of TASK FORCE (TF)
    b. Responsible for all project related accounting and tracking of project status
2. Environmental Protection Agency (EPA) – Office of Coastal Restoration Management (OCRM)
3. Department of the Interior – US Fish and Wildlife Service (USFWS)
4. US Department of Agriculture (USDA) – National Resource Conservation Service (NRCS)
5. Department of Commerce – NOAA National Marine Fisheries Service
6. State of Louisiana, Governor's Office of Coastal Activities
    a. Non-voting cost sharing partner

Figure 7-1: CWPPRA Organizational Chart
From: http://www.lacoast.gov/cwppra/org/index.htm

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Chapter 8: Land Tenure and Property Rights in the BBWT

Michelle Scott and Ashley Wallace

The property rights landscape of the Bayou Bienvenue Wetland Triangle (BBWT) is shaped by the legal framework governing land ownership and natural resources use in New Orleans and Louisiana—as well as by the activities of individuals and institutions that are able to transfer, protect, or develop the wetland. While the property rights landscape lacks the same physical presence as the ecological features of the BBWT and its adjacent facilities and neighborhoods, property rights and land tenure issues can shape or potentially halt restoration or wetland-related community development plans. This section provides an overview of property rights and land tenure concepts relevant to BBWT restoration. In addition, the chapter discusses how these issues create opportunities and constraints for restoration activities. The chapter also describes the results of initial research into ownership patterns of the BBWT bed and evaluates different strategies for acquiring and managing land.

Introduction

The ecological, social, and institutional elements of the restoration will play out in a physical space: the bed of the BBWT. However, as legal scholar Mark Davis notes, "Louisiana's coastal lands and waters are not a blank canvas just waiting to be painted with a new generation of programs and projects. They are largely under the control or jurisdiction of a number of public and private players who are charged with operating or managing these resources," (Davis, 2008).

The success of restoration efforts is dependent on the legal, political, and ownership landscapes that have shaped—and which will continue to shape—the BBWT bed. In particular, advocates must gain the consent of those who currently own land in the bed to move forward with restoration activities. Even if the rights needed to restore the wetland can be acquired, acquisition costs may overwhelm the project budget, reducing the resources available for purchasing materials and equipment or providing for long term maintenance.

These issues will need to be dealt with regardless of whether a public agency, a non-profit organization, community groups, or others manage restoration efforts. Therefore, restoration advocates will need to understand the interaction of property rights and land tenure. *Property rights* refer to an individual or government's authority to determine how a resource is used. Meanwhile, *land tenure* refers to the relationship, whether defined by laws or customary behavior, among people, individuals, or groups with respect to land. The rules of land tenure determine how property rights are allocated within society (United Nations Food and Agriculture Organization, 2002).

Is the BBWT Bed in the Public Trust?

Just as limited research had been done on the BBWT's environmental characteristics prior to 2006, the wetland's history as a tract of developed land is similarly unclear.

Figure 8-1 illustrates the geographic location of the BBWT, and displays the underlying street layout based on a plat map produced in 1961, which reflects data from the U.S. Township Plat Map of 1836. Both this map and Taylor's Map of New Orleans (1924-1925) indicate that at one point in history, the land beneath the BBWT was subdivided for urban development, even though it is currently submerged (Orleans Parish – 3rd District, 1961; Taylor, 1924; U.S. Township Map of 1836).

Although the 1836 and 1924 maps clearly demarcate boundaries, the dynamic nature of the Louisiana coastline creates changes in both the physical and legal status of property. Again quoting legal scholar Mark Davis, "In geologic terms, the area is less a place than a process, a process of land building and retreat that defies our normal notions of land as a solid, permanent thing," (Davis, 2008). For example, wetland draining can transform watery beds into private land for building, while coastal erosion and wetland degradation can submerge land.

Figure 8-1: United States Plat Map of the BBWT (1836) with Photographic Aerial Overlay. Source: Benjamin Webb, 2008.

The BBWT and the Public Trust Doctrine

Coastal Louisiana lands fall into four categories: public lands (which include navigable water bottoms), private lands, public lands burdened by a private right (such as a lease), and private lands subject to some public use (Davis 2008). Because the land comprising the BBWT bed is currently submerged and may constitute a navigable water bottom, the UW students investigated whether it might be considered public land according to Louisiana's public trust doctrine, which "provides that public trust lands, waters and living resources in a State are held by the state in trust for the benefit of all of the people," (Deleo, 1989). Should the BBWT bed be protected under the public trust doctrine, it is likely that many of the obstacles to acquiring this land for restoration purposes—including the negotiation and expense needed to acquire land rights from private individuals—would be removed. Moreover, the ecological improvements made to the BBWT would likely enjoy long-standing public protection.

Under the public trust doctrine, state governments own public trust lands and waters in *fee simple*[34]**,** though the public is given rights to fully enjoy these resources for a variety of recognized public uses, which can include navigation, commerce, and fishing (Deleo, 1989; Slade, 1997). The doctrine also provides a "non-intrusive vehicle" that enables states to restrict development for access, preservation, and environmental control purposes (Deleo, 1989). For example, it has been increasingly invoked in cases affecting wetlands around the United States to uphold the constitutionality of shoreland zoning ordinances (*Just v. Marinette County*, 1972), and to protect the hydrologic features of trust lands (*Lake Michigan Federation v. United States Army Corp of Engineers*, 1992). The public trust doctrine can be particularly effective in protecting natural resources, because while states can convey proprietary interests in public trust lands to private individuals (Deleo, 1989), they are prohibited from alienating public trust resources or from allowing the resources' value to the public to be degraded (Illinois, 1892; Slade, 1997).[35] This aspect of the doctrine may provide a legal basis for long-standing protection for any ecological improvements made to the BBWT.

In general, waters within the public trust comprise the "navigable" waters in a state, and public trust lands are the lands beneath these waters, "up to the ordinary high water mark" (Slade, 1997). However, each state codifies its own public trust doctrine. Louisiana's version is detailed in Title 41 of the state's Revised Statutes and includes "beds and bottoms of all navigable waters and the banks or shores of bays, arms of the sea, the Gulf of Mexico, and navigable lakes," (La R.S. 41:1701).[36] Louisiana currently defines navigable waterways by the standard of "navigable-in-fact," which means that such waters are capable of being used as highways for commerce, "over which trade and travel are or may be conducted in the customary modes of trade and travel on water" (Sanders, 1989). An *arm of the sea* is generally defined as bodies of water "located in the immediate vicinity of the open coast and overflowed by the tides directly," (Buras, 1923; Morgan, 1887; Yiannopoulos, 1961). Lake Pontchartrain is one of the Louisiana water bodies considered to be "arms of the sea" (Hribernick & Wascom, 1981).

According to the State of Louisiana Land Office, which manages state public lands, the BBWT is likely classified as non-navigable marshland (Carter, personal communication, April 4, 2008). However, the BBWT appears to possess many of the characteristics of water bodies protected by the public trust doctrine, particularly arms of the sea. UW-Madison students evaluating the BBWT's water levels and salinities have determined that the BBWT experiences diurnal tides of diurnal tides of half a foot, which make-up over 90 percent of the inflows of water (including precipitation).This suggests that the wetland is tidally influenced. Finally, students have found that it is possible to paddle a canoe unobstructed from the observation deck (in the BBWT) to the Gulf of Mexico, which speaks to the wetland's navigability.

Even if the BBWT is not determined to be navigable, it may still be protected under broader interpretations of the public trust doctrine established in federal courts. For example, in 1988, the United States Supreme Court established a broad interpretation of the public trust doctrine in its

[34] The term "fee simple" refers to ownership of all rights to a given piece of real estate in perpetuity: these include the owner's right to possess, use and dispose of the land as he or she pleases, as well as the right to sell it, donate it, trade it, lease it to others, or pass it on to others upon death
[35] According to *Illinois Central Railroad v. Illinois*, states are prohibited from abdicating "trust over property in which the people as a whole are interested so as to leave it entirely under the use and control of private parties (Illinois, 1892; Wilkins & Wascom, 1992).
[36] Elements of the Louisiana public trust also exist in the Louisiana Civil Code (Article 451), the Louisiana Constitution of 1974 (Article IX, Section 1), and several Louisiana judicial decisions.

adjudication of *Phillips Petroleum v. Mississippi,* in which it held that "lands under non-navigable waters subject to ebb and flow of the tide were held within public trust given to states upon their entry into Union," (Phillips, 1988). This inclusion of non-navigable tidelands into the conception of the public trust doctrine provides a potentially valuable extension of environmental protection for Louisiana wetlands and millions of acres of tidelands across the country (Deleo, 1989).

In spite of the above-mentioned evidence and benefits of the *Phillips case*, restoration advocates may encounter challenges when invoking the public trust doctrine to protect the BBWT from development or use. Perhaps the two greatest challenges are posed by other elements of Louisiana law and the geologic and hydrologic complexity of coastal Louisiana. Both issues center on the BBWT's navigability and the extent to which it is affected by the tides.

Legal Challenges. In 1992, the Louisiana Legislature enacted three new statutes regarding the ownership of non-navigable waters in order to quiet title on private properties whose titles may have been clouded by the *Phillips* decision.[37] These statutes include a definition of inland non-navigable water bodies as those which "are not navigable in fact and are not sea, arms of the sea, or seashore," and a clause establishing these water bodies as "private things that may be owned by private individuals or the state…in their capacities as private persons," (La. R.S. 9:1115.2).[38]

The State of Louisiana defines "seashore" as the "the space of land over which the waters of the sea spread in the highest tide during the winter season," (La. C.C. 451.). Based on these statutes, only non-navigable wetlands indirectly affected by tides can be privately owned, given the fact that "tides may cause other water bodies to rise and spread over the area," is insufficient to characterize the land as seashore (Dardar, 1988; La. R.S 9:1115.2). If there is not enough evidence to explicitly define the BBWT as "arm of the sea" or to demonstrate that it is directly affected by the tides, the wetland could be excluded from protection by the public trust doctrine.

Geologic and Hydrologic Complexity. It may appear that legal definitions of land and water can be applied in a formulaic way to settle property ownership disputes regarding non-navigable water bodies. In actuality, resolving these issues can be considerably difficult in coastal Louisiana. Determinations of navigability may require substantial evidence, and the "peculiar geophysical conditions that prevail at the Gulf Coast prevent the drawing of a bright line of demarcation" between navigable and non-navigable bodies of water. Rather, "thousands of acres of marshlands are traversed by innumerable bayous that empty into lakes, bays, and inlets," water bodies in the area often lack perceptible currents, and fresh water frequently mixes with salt water on the way to the Gulf and can render inland waters brackish (Perhay, 2000).

Because of this complexity, Davis notes that ultimately, "definitions of and boundaries between what is private and what is public are not precise and can be altered. Despite years of effort by Louisiana courts and lawmakers to provide greater clarity, the simple fact of the matter is that in

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[37]"Quiet Title" actions are lawsuits that establish a party's title to real property against anyone and everyone, and thus "quiet" any challenges or claims to the title (Hill, n.d.). They serve to clarify aspects of land ownership and land rights

[38] The third statute mentioned states that "Any act by which the state has transferred or hereafter transfers ownership of immovable property which, at the time of the transfer, encompasses inland non-navigable water beds or bottoms within the boundaries of the property transferred, is presumed to convey to the transferee the ownership of the inland non-navigable water bottoms, unless title thereto has been expressly reserved by the state of Louisiana in the act," (La R.S. 9:1115.3).

practice, a degree of uncertainty is the order of the day," (Davis, 2008). The information and records held by the state of Louisiana reflect this uncertainty. Davis writes that for years, the state did not attempt to identify or assert its ownership claims in a coherent manner, choosing instead to handle real estate issues on a project-by-project basis, usually only after a project is near to or being authorized for construction (Davis, 2008). Though in 2004, the Louisiana Legislature directed the State of Louisiana Land Office to complete an inventory of water-bottoms in four years, the agency is struggling to keep pace, particularly after hurricanes Katrina and Rita (Davis, 2008). It is possible that upon further review, the State of Louisiana Land Office may change the classification of the BBWT bed.

In sum, further research into whether the BBWT is protected by the public trust doctrine may prove worthwhile. Though there are challenges, as described above, it may be possible to create an adequate legal defense against ownership claims. Restoration advocates should coordinate with public agencies, lawyers, and others to determine what scientific evidence may be required for the BBWT to be classified as "seashore" or an "arm of the sea," and how these terms have been applied in court cases. Also, although UW students and others have and continue to make progress in assessing the hydrological characteristics of the BBWT, more information may be needed to come to a sufficient conclusion in order to tie these scientific data to legal principles.

Private Land Ownership Patterns in the BBWT

While further investigation may reveal that the BBWT could be protected by the public trust doctrine, UW students conducted additional research into land tenure and property rights issues under the assumption that the bed of the wetland is—and will remain—under private ownership. To better understand the land ownership patterns affecting the BBWT bed, UW students joined an existing land tenure research collaboration that includes the Holy Cross Neighborhood Association (HCNA), the Tulane University Institute on Water Resources Law and Policy, New Orleans Sewerage and Water Board (NOSWB), the U.S. Army Corp of Engineers (USACE), and the Environmental Defense Fund.

The NOSWB supplied the UW students with a database that listed the tax bill numbers and addresses of the individual parcels, as well as the names of the current owners. The tax bill numbers were used to collect additional data from the City of New Orleans Treasury and the Orleans Parish Assessor's websites, which included lot sale dates and prices, appraised and assessed values, the amount of taxes owed on each lot, and whether or not the lots had been adjudicated by the city of New Orleans. The sections below detail the results.

Land Subdivision. Based on the guidelines established by the U.S. Plat Map of 1836, the area beneath the BBWT includes 140 blocks, or "squares", which have been subdivided to produce a total of 469 lots. As shown in Figure 8- below, the number of lots on each square varies considerably across squares. The boundaries of the squares on this map, and on the maps to follow, are based on the U.S. Township Plat Map of 1836.

Data Limitations. Corruption in the land surveying and assessment practices has historically been a problem in Louisiana, and anecdotal evidence suggests that it may continue today. In addition, flooding from hurricanes has resulted in lost public and parcel records. The resulting information gaps present an additional concern (Yoachim, personal communication, 2008).

Fortunately, of the 469 lots in the BBWT, there is only 1 lot in which the landowner is unknown. However, for 167 lots, sale dates and values are missing. Moreover, some limitations were introduced in digitizing plat maps of the BBWT into a geographic information system (GIS[39]). The resulting shapefiles[40] only contain city blocks, or "squares." It is a future goal of the Tulane Institute on Water Resources Law and Policy and/or the UW student research team to map individual lots by geo-referencing[41] available lot legal descriptions to allow for more detailed spatial analysis of landownership in the BBWT bed.

These problems have likely had a negative impact on the quality and accuracy of many of Louisiana's land records. During this study, the UW team used the only available land records, regardless of their past history.

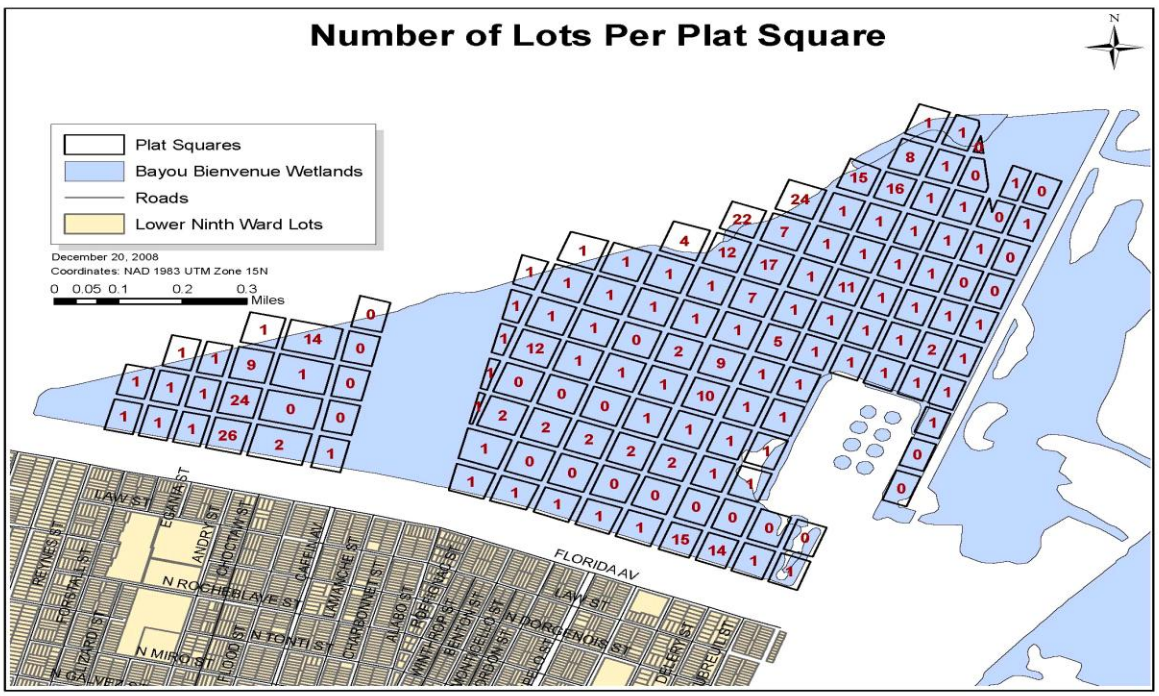

Figure 8-2: Subdivided lots per plat square.

Property Ownership. There are a total of 178 different landowners who own lots beneath the Bayou Bienvenue Wetland Triangle. Titleholders for these properties include individuals, private companies, public agencies, foundations and trusts, religious groups, banks, realty companies, and developers.[42] These landowners have been categorized into five groups, as shown in Table 8-1. The vast majority of parcels beneath the BBWT are owned by individuals, with the remainder

[39] A geographic information system, or "GIS," is a computerized mapping system that can store, present and analyze multiple layers of spatially-located data.
[40] Shapefiles are a popular geospatial vector data format for geographic information systems (GIS).
[41] Georeferencing is the process of aligning spatial data (layers that are shape files: polygons, points, etc.) to an image file such as an existing map, satellite image, or aerial photograph using GIS (see footnote 6).
[42] In this analysis, we did not group individual landowners by last name. If two individuals had the same last name but different first names, they were kept separate.

owned mostly by private institutions and companies and public entities, such as the city of New Orleans.

Table 8-1: Lot ownership by landowner type

Landowner Type	Number of Lots	Percent of Lots
Individuals	333	71.0%
Private Institutions	88	18.8%
Public Institutions	38	8.1%
Foundations/Trusts	7	1.5%
Non-Profits	3	0.6%
Total	469	100%

Figure 8-3 illustrates the number of parties owning lots on each square. In most squares—103 (73.6 percent)—one individual or institution owns property on them, in 12 squares (8.3 percent) two different individuals or institutions own property on them, and in 6 squares (4.3 percent) four or more different parties own property on the square. In one case, as many as 14 different individuals or institutions own property on a particular square.

Figure 8-3 also indicates the category of owners holding title to the majority of the lots on each square. As expected, much of the land owned by public agencies is concentrated near the East Bank Wastewater Treatment Facility located near the southeast corner of the BBWT. Property owned by private institutions is somewhat scattered throughout the wetland bed, though it is important to note that many of the squares in the center of the bed only have one or two owners. It is possible that while individuals make up the majority of many of the multi-owner squares on the BBWT's borders, private institutions may still own a considerable number of the lots in those locations.

Sale Dates. According to city of New Orleans and Orleans Parish records, the BBWT lot titles were transferred throughout the twentieth century and even into the twenty-first century. The earliest sale date listed was 1908, while the most recent was 2006. However, 172 parcels (37 percent) had no sale dates listed.

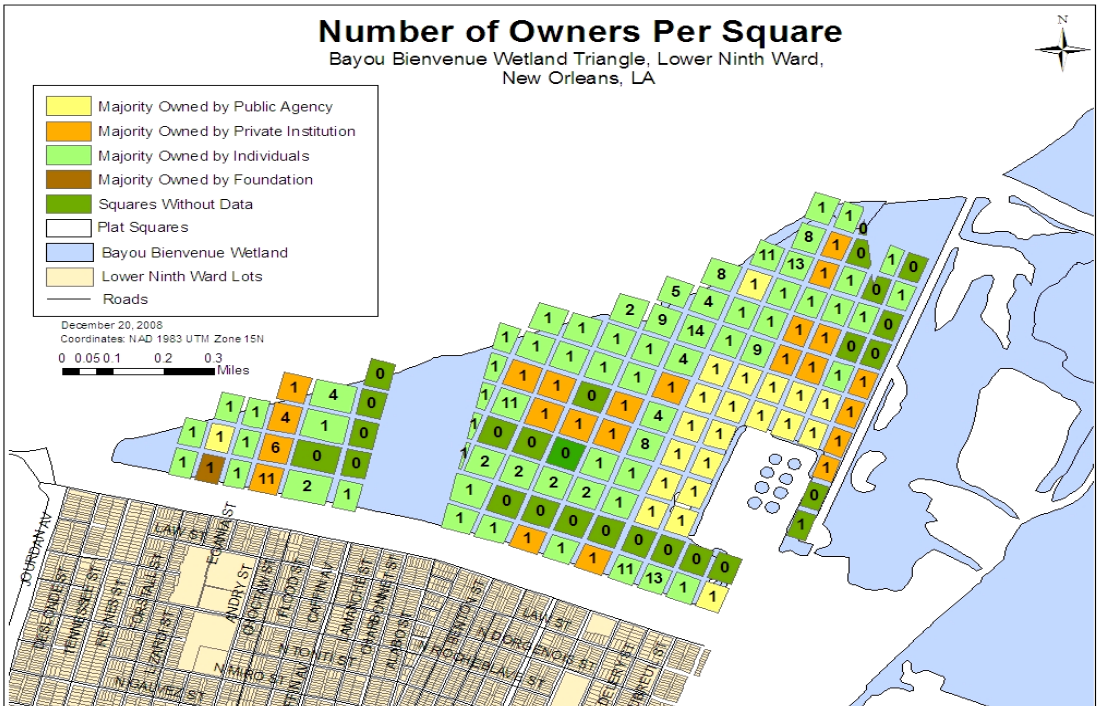

Figure 8-3: Number of owners per square.

Land ownership issues that may create obstacles are of primary interest to restoration efforts. Recent transactions may indicate strong owner interests in the use, or value, of the land. Lots were examined to determine those recently transferred (1990 to present) to new owners. Approximately 26 percent of lots have been sold since 1990, 7 percent since 2000, and 5 percent since 2006. Table 8-2 describes the number of parcels transferred since 1990, 2000, and 2006 (post Hurricane Katrina), as well as the percentage of lots purchased by each category of landowners.

Table 8-2: Parcel purchasers (by group) and sale dates

Current Landowner Type	Lots with Sale Dates Since 1/1/1990	Percent of Lots Sold Since 1/1/1990	Lots with Sale Dates Since 1/1/2000	Percent of Lots Sold Since 1/1/2000	Lots with Sale Dates Since 1/1/2006	Percent of Lots Sold Since 1/1/2006
Individuals	96	78.0%	11	33.3%	4	16.0%
Private Institutions	23	18.7%	22	66.7%	21	84.0%
Public Institutions	1	0.8%	0	0.0%	0	0.0%
Foundation/Trusts	3	2.4%	0	0.0%	0	0.0%
Non-Profits	0	0.0%	0	0.0%	0	0.0%
Total	123	100.0%	33	100.0%	25	100.0%

As the table shows, the bulk of parcel purchases since 1990 have been made by individuals. Since 2000, however, private institutions have purchased two-thirds of the land. Similarly, since

2006, private institutions have purchased 84 percent of the land. Figure 8-4 displays the location of squares containing lots sold since 1990.

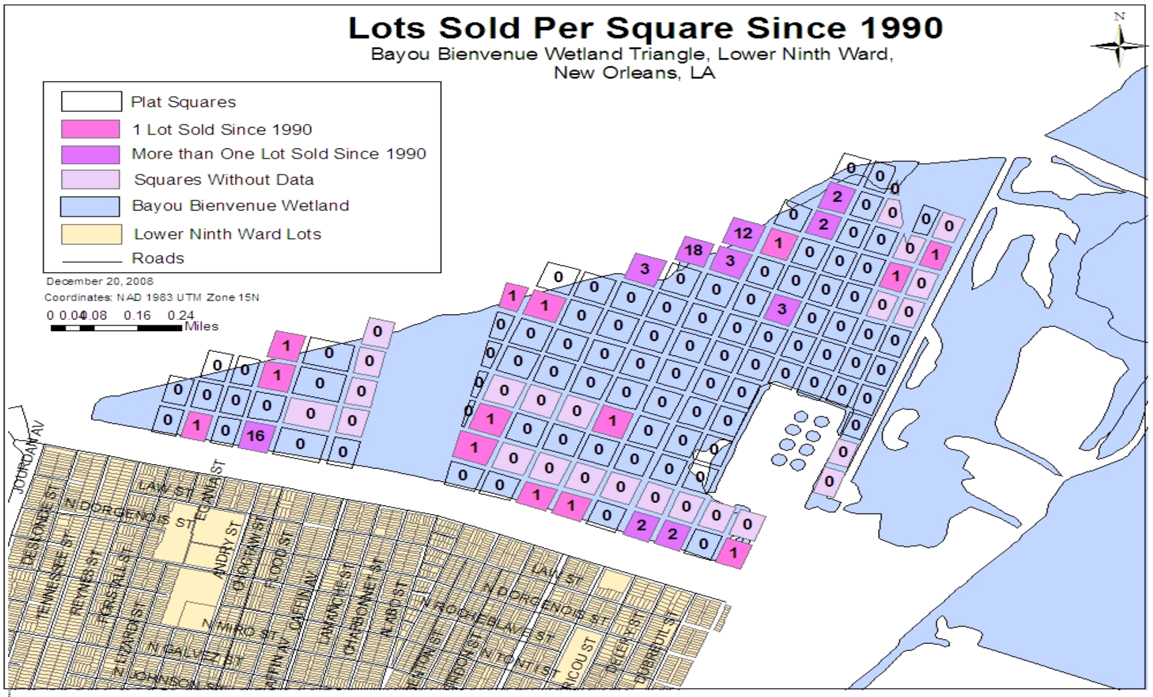

Figure 8-4: Lots sold per square since 1990.

Of the 140 squares beneath the BBWT, 49 (35 percent) have had at least one lot sold since January 1, 1990. Meanwhile, 17 squares (12.1 percent) have had at least one lot sold since the beginning of 2000, and 14 squares (10 percent) have had at least one lot sold since January 1, 2006. As the map shows, most of the lots sold since 1990 are concentrated near the borders of the wetland.

Sale Prices. Only 297 of the lots (59.4 percent of all lots in the wetland) had a sale price recorded. Of these, approximately 63.6 percent were exchanged for no money ($0). This particular trend may indicate: 1) a lack of interest in land use or value among those who previously held title for these lots, 2) that these titles were exchanged between family members, or 3) that these low cost changes occurred to expedite certain activities. About 87 percent of all lots (with recorded sale prices) were sold for $10,000 or less. In this analysis, these dollar figures have not been matched with the dates when the titles were transferred. As a result, these figures may need to be adjusted for inflation in order to make more effective comparisons.

Appraisal Values. According to the Orleans Parish Assessor's Office, the range of appraised values for the 469 lots ran from $0 to $62,800. Table 8-3 shows the most frequently occurring appraisal values for lots in the wetland, along with the percentage of lots with appraisals at those values.

Table 8-3: Top 5 Most Frequently Occurring Appraisal Values

Appraisal Value	Number of Lots	Percent of Lots
$0	26	5.5%
$400	142	30.3%
$500	20	4.3%
$700	45	9.6%
$1500	13	2.8%

More than half of the lots were appraised at values between $400 and $1500, as shown in Table 8-3. Approximately 78.5 percent of the lots had appraisal values of less than $5000, and approximately 92.5 percent have been appraised at less than $10,000. Based on these results, we can see that while the range for appraisal values is wide, most parcels in the wetland have been appraised at values toward lower end of this range.

Tax Delinquency. Information on parcels that are tax delinquent is relevant to the land acquisition issues, as county, municipal or state governments may require involuntarily forfeiture of property subject to unpaid taxes through "tax foreclosure". If the land in the BBWT bed falls under government control, it may be easier for restoration advocates to acquire it or to engage in activities that will restore the wetland. Figure 8-5 shows the locations of squares that include tax delinquent lots, along with the proportion of lots that have been adjudicated.

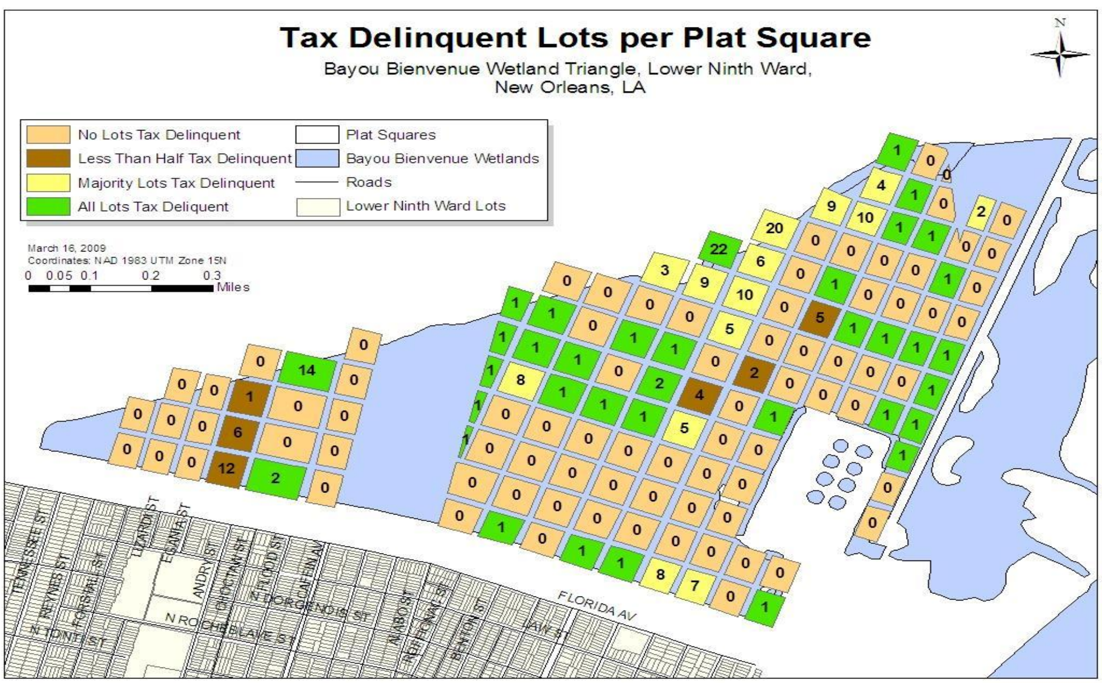

Figure 8-5: Tax delinquent lots per plat square.

Of the 469 BBWT lots, approximately 54.8 percent (257 lots) owed back taxes to the city of New Orleans at the time of this research (2008). The earliest date of tax delinquency notification was also recorded for relevant lots. The majority of tax delinquent lots were originally declared delinquent between 1981-1990. The second greatest proportion became delinquent in the past seven years (2001-2008). Roughly 64 percent of the lots have undergone legal status changes becoming tax delinquent since 1981. Table 8-5 displays the date ranges during which parcels became delinquent.

Table 8-4: Tax delinquent parcels by delinquency date.

Tax Delinquency Date Range	Number of Parcels	Percent of Parcels
1917-1930	41	15.9%
1931-1940	1	0.4%
1941-1950	7	2.7%
1951-1960	10	3.9%
1961-1970	7	2.7%
1971-1980	26	10.1%
1981-1990	61	23.6%
1991-2000	50	19.4%
2001-2008	55	21.3%
TOTAL	**258**	**100%**

According to the city of New Orleans property tax records, 33.5 percent of the BBWT lots (157 lots), have been adjudicated. Property is adjudicated to the parish or municipality five years after the obligation to pay or distribute the property arises (LA. R.S. 33:4720.16 (C)). The 11 lots adjudicated before January 1, 1975 (7 percent of adjudicated lots) are transferred to the state of Louisiana. The 146 lots adjudicated after January 1, 1975 (93 percent of adjudicated lots) are transferred to the city of New Orleans due to the state statutory changes (Davis, M., personal communication, 2008). Figure 8-6 shows the location of squares that include adjudicated lots, along with the proportion adjudicated lots make up of all lots on the square.

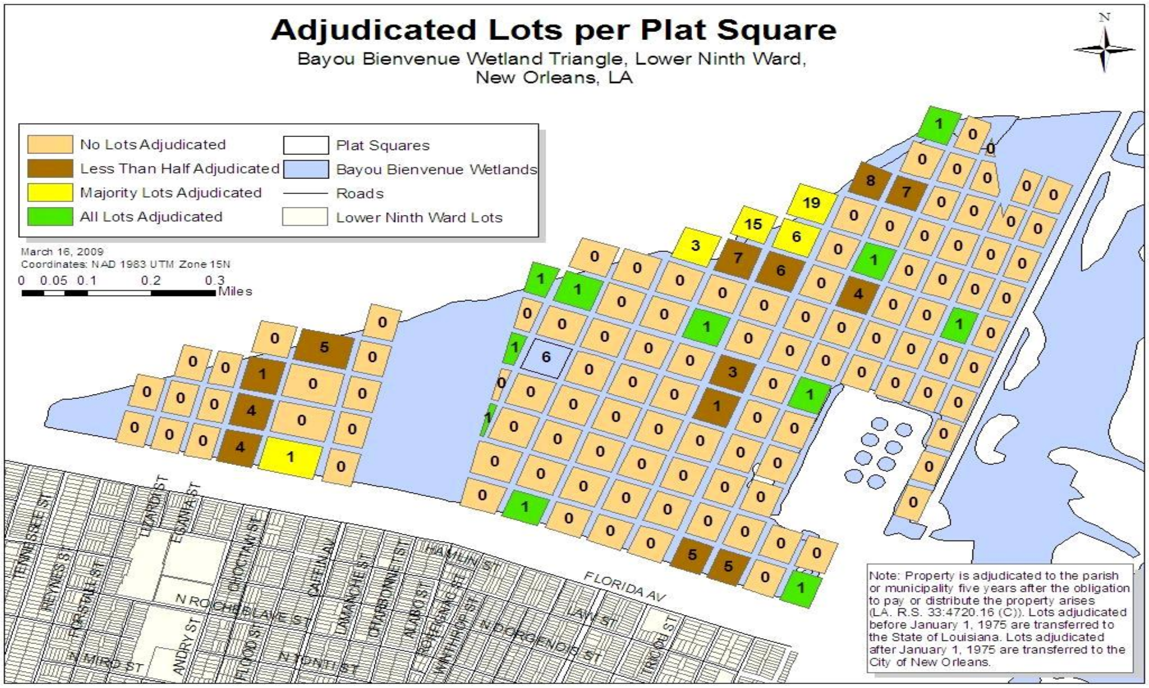

Figure 8-6: Adjudicated lots per plat square.

Of the tax delinquent properties, 101 lots (40 percent) have not been legally adjudicated to either the state or the city of New Orleans. These titles, including appropriate due taxes, remain under parcel owners' names. According to New Orleans property tax records, roughly 53 percent (53 out of 101) of delinquent lots have passed the five-year delinquency threshold. At this time, it is unclear why they remain un-adjudicated. A possible explanation is that the city and state have been lax in the upkeep of their records. On the other hand, the tax delinquent lots not adjudicated, almost half, 47 percent (48 out of the 101 lots) are still within the five-year adjudication timeline. So, these owners could technically pay off their tax debt or transfer the property. Even so, this still leaves the other half prime for the city to begin the adjudication process on those lots.

Of the 469 lots comprising the BBWT, 36 (approximately 8 percent) have been designated as "tax exempt" by the Orleans Parish Assessor's office. Of the 36 tax exempt lots, 1 lot is in a private individual's name, 3 lots are religiously affiliated, and the remaining 30 lots are under the ownership of the city of New Orleans and the city of New Orleans Sewerage and Water Board. (These lots are no longer charged with property taxes, nor are taxes owed on any of these lots. Consequently, these lots were not listed in city property tax records Parish's Assessor's office records of sale dates and prices.

Conclusions. Based on the above results, it is possible that restoration advocates could acquire land rights for most of the lots in the BBWT bed relatively easily and inexpensively, as many lots are owned by individuals and most have not been transferred since 1990. It is unlikely that these owners have purchased the land for development or investment purposes, as it is submerged. It is more probable that many have held the land in their families since the land was originally subdivided and sold. As such, these owners would likely be indifferent to efforts to restore the land for restoration purposes.

However, the fact that approximately one quarter of the lots have recently been sold—the bulk of which were purchased by private institutions—suggests that there are parties that have specific plans for their property. These landowners could ultimately compromise restoration efforts if they refuse to sell. As mentioned above, discussions with current landowners would provide the most accurate information as to how they value this submerged property.

Methods of Acquiring Land or Land Rights

The results of the property ownership analysis highlight the complexity involved in incorporating the entire BBWT into a single restoration effort. The large number of lots and the variety of landowners may increase the likelihood that some lots are expensive or that some land owners will refuse to sell the rights to their property. Moreover, the above analysis does not account for reasons why individuals and institutions have bought or sold lots. If current landowners have a strong interest in profiting (e.g. developing or extracting minerals) from their parcels, they may be unwilling to cooperate with BBWT restoration and conservation activities.

BBWT restoration will require a land rights acquisition and management strategy that 1) is appropriate to ecological restoration activities occurring in the wetland; 2) serves the community revitalization and enhancement interests of the Lower Ninth Ward, 3) responsibly uses the resources of stakeholders engaged in restoration, and 4) is able to gain cooperation from those who currently own property in the wetland.

Some initial constraints to consider include:

Ecological Constraints: Cypress swamp restoration will take several decades. As a result, the project may require a real estate strategy that places the property under control of restoration groups for a long period of time, or in perpetuity. Those involved in the project will need authority over the entire BBWT, in order to maintain optimal conditions for freshwater swamp restoration. These stakeholders will also need the power to limit both surface and subsurface activity and development in the area to ensure long-term restoration success. (See Chapter 7 for more information on restoration authorities)

Community Constraints. The leaders of the HCNA have expressed support for restoring the BBWT to a cypress swamp, and several residents and stakeholders have identified a restored cypress swamp as an important component of local tourism and community development plans. However, Lower Ninth stakeholder consensus may require additional discussions. Also, the resources of HCNA, stakeholders in the Lower Ninth, and the city of New Orleans may be necessary for acquiring land in the absence of state and federal support. Yet, these resources

Restoration and land tenure issues to think about:

- How to get control?
- How much is it going to cost?
- Who has to review the process?
- Who is needed to cooperate?
- Will the restoration actually work?

may be limited given that relatively limited municipal government resources have been made available to the Lower Ninth Ward and that many residents are still re-establishing themselves after hurricanes Katrina and Rita.

Institutional Constraints. The strategies selected for managing the wetland property will also have to account for the requirements and practices of the Coastal Wetlands Planning Protection and Restoration Act (CWPPRA) program, along with any other public programs or agencies that may become involved in the restoration effort. This includes accommodating public sector review procedures and budgets. (See Chapter 7 for more information on CWPPRA.)

The sections below detail possible land acquisition and management techniques that the HCNA and other restoration advocates and stakeholders can use to sufficiently control and protect the bed of the BBWT. These strategies involve acquisition of either some or all of the rights associated with *real property*—and each has positive and negative implications in terms of wetland restoration. It is important to note that the techniques described do not specifically address issues related to usufruct rights, which are the rights of a party to use and benefit from property owned by another entity. The nature of usufruct rights in Louisiana, along with their potential role in the protection and restoration of the BBWT, should be part of future research efforts.

Fee Simple Acquisition

The term "fee simple" refers to ownership of all rights to a given piece of real estate in perpetuity. Fee simple ownership can be particularly advantageous for wetland restoration purposes, as it can provide stakeholders with the ability to protect the property from nearly all outside influences (short of zoning regulations and deed restrictions) while the restoration is being carried out. In the case of the BBWT, fee simple ownership can be held either by a public agency or by a body comprised of residents and community leaders of the Lower Ninth Ward, along with other BBWT stakeholders and advocates. For both governments and community organizations, land acquisition is the most effective method available to local governments for conserving coastal wetlands (Dewhurst, 2002).

The main challenge of purchasing land in fee simple is that doing so can potentially require a substantial amount of capital, as this involves purchasing all of the land, improvements and rights associated with the piece of property. The willingness of current landowners to relinquish ownership can also be a factor in determining cost.[43] Overcoming these challenges frequently proves to be worthwhile, as the economic return from restoration is greater than the long-term regulation enforcement and monitoring costs which a site can incur (Dewhurst, 2002). However the cost remains a significant obstacle to organizations with limited budgets. There are several land acquisition techniques in addition to fee simple purchase that may mitigate the time and expense involved in land acquisition and assembly from the perspective of restoration stakeholders.

Gifts, Donations, and Bargain Sales. Real property may be given to anyone whom the owner selects. Frequently, portions of property belonging to an individual may be conveyed as a gift to

[43] More information is still needed to determine the likely costs of particular parcels of land beneath the BBWT, the specific factors affecting price, and how land costs compare to the financial resources of different BBWT stakeholders.

children or other relatives. Real property may be donated to non-profit organizations for charitable or conservation purposes or to government agencies. Land donations can include outright donations and death-time transfers, while “bargain sales” are part sale and part donation. The rights acquired under these strategies are the same as those acquired under fee simple ownership; the difference lies in the price negotiated with the landowner.

Regarding bargain sales, the Texas Land Office writes “If the buyer is a government agency, land trust, or public charity, the value of the donation (the difference between selling price and fair market value) may be deductible from the owner’s taxable income,” (Dewhurst, 2002). Tax deduction options may also be available for land that is donated outright. While private institutions and individuals would likely prefer to receive the market value of the land, these owners may also be amenable to the tax deduction option. However, this strategy is dependent on the opportunities afforded by the city of New Orleans and the state of Louisiana’s real estate and tax laws.

Inheritance. Real property, like personal property, may be divested by the owner through a will that is properly signed and witnessed. Where no valid will can be found, property of a descendent is inherited by “next of kin” under state law. If no relatives can be found, property transfers to the state. The value of inherited property is reduced by death taxes levied by federal, state, and sometimes local governments.

Acquisition via Involuntary Forfeiture and Eminent Domain

Fee simple purchases, donations and divestments involve choices and exercises of legal power by private actors. However, restoration stakeholders may be able to rely on power vested in government to protect the BBWT and other lands from development and further damage. These include both involuntary forfeiture and eminent domain.

One form of involuntary forfeiture is “foreclosure” by a lender when a borrower fails to make mortgage payments on time. Similarly, the parish/county or municipal government may engage in “tax foreclosure,” or foreclose on property when the property owner has not paid sufficient taxes. Louisiana offers tax deeds with a three year right of redemption, which means that the original owner may redeem the property by paying the purchase price plus 12 percent per annum along with a 5 percent penalty up to three years after the foreclosure date (La. R.S. 47:2228).

Tax Foreclosures and Adjudication. Once governments have acquired land through tax foreclosure, they have the freedom to assign it to new uses. In 1994, the Louisiana Legislature enacted legislation authorizing political subdivisions to sell abandoned and adjudicated property (La. R.S. 33:4720.11, et seq). The Legislature defined "abandoned property" to include immovable property that had been adjudicated to a political subdivision for non-payment of taxes (La. R.S. 33:4720.12(1)). Property is adjudicated to the parish or municipality five years after the obligation to pay or distribute the property arises, as long as the apparent owner has not provided any form of communication or records concerning the property (La. R.S. 9:151). The claim for ownership of land through abandonment requires the parish or municipality to provide a public notice of abandonment. Any person of interest or right/title in the property has six months after the date of notice publication to file suit for the claimed property rights (La. R.S.

48:703). The Louisiana State Land Office manages property that was adjudicated before January 1, 1975 and the city of New Orleans manages property adjudicated after January, 1, 1975.

Adverse Possession. Other forms of involuntary forfeiture include adverse possession, which refers to the occupancy of land by a squatter for a lengthy period of time. If the occupancy is "open and notorious," and without consent of the owner, the occupant may claim legal ownership after a period of years specified by state law. The purpose of adverse possession is to protect "squatter's rights," where the owner takes no interest in the land and someone else works hard to make productive use of the land (Platt, 1996). A variation on this concept is the prescriptive easement, which is a form of adverse possession asserted by the general public rather than a private occupant. It arises where the public uses a footpath, vehicular right of way, beach, or other private land without permission of the owner. If continued for the statutory period, the owner may be precluded by statute or common law from preventing the continuation of the public trespass. But the public right is limited to the particular right-of-way or tract itself and does not extend to the rest of the owner's property (Platt, 1996).

Eminent Domain. Eminent domain allows municipal, state and federal agencies to acquire property through abandonment, condemnation, and outright purchase in order to better serve the public by means of their granted police power (Kelo, 2005). This power is vested in government via the Fifth Amendment of the U.S. Constitution, which states, "nor shall private property be taken for public use, without just compensation." This concept is further applied to Louisiana state government through the Constitution of the State of Louisiana, which declares that "property shall not be taken or damaged by the state or its political subdivisions except for public purposes and with just compensation paid to the owner or into court for his/her benefit," (La Constitution. Article 1, 4(b)(1)).

With respect to the BBWT, elements of public use include—but are not limited to—the use of the wetland for: access to public waters and lands, drainage of stormwater, flood control for the city, levees, coastal and navigational protection, parks, as well as for recreational facilities generally open to the public. However, to establish these uses, the government must pay landowners fair market value for their property. It is important to note, as in *Nollan v. California Coastal Commission* (Nollan, 1987) and *Dolan v. City of Tigard* (Dolan, 1994), that an attempt to impose public access through regulation (such as zoning) is likely to be struck down as a "taking" without compensation (Platt, 1996).

These strategies provide indirect ways for BBWT stakeholders to assemble all necessary parcels or lots into a single area that can be acquired or controlled for restoration purposes. Tax foreclosure and other forms of involuntary forfeiture provide an added advantage, as public agencies may be willing to sell the wetland parcels to BBWT restoration advocates for less than market value (e.g. bargain sales). However, public agencies acquiring this land, especially in the case of forfeiture and adjudication, may wish to use this property for other purposes, including those not in-line with restoration goals.

Protection through "less than fee simple" ownership techniques

Depending on the particular restoration strategy selected, BBWT stakeholders may not need to acquire all property rights on each parcel to have sufficient control over the BBWT bed. Under alternative arrangements allowing for "less than fee simple" ownership, restoration advocates may "unbundle" the rights associated with real property and only purchase one or a few of the rights associated with each lot, such as the right to develop or the right to extract minerals. Land management options making use of this general strategy include conservation easements and the purchase of development rights.

Conservation Easements. Conservation easements are "contractual agreements between a landowner and a local government (or other legal entity) that limit or prohibit certain land use activities without the landowner's relinquishing title to the land," (Dewhurst, 2002). These easements, which are secured through deeds registered with individual parishes, constitute a relatively flexible conservation tool and can be easily adapted to meet the needs of the landowner and the parties promoting conservation. Easements can protect land in perpetuity and in other instances they have been used to restrict agricultural activities or to prohibit development in ecologically sensitive areas.

In the case of the BBWT bed, most owners would likely experience minimal impacts from having easements placed on their land (as it is submerged). The current landowners may even receive tax deductions or other benefits in exchange for managing or keeping the land in a manner that supports restoration activities. However, those with specific plans for their properties may be unwilling to agree to an easement if it will affect their operations or their right to extract minerals. Even if they agree, the wetland may need to be actively monitored to ensure these institutions are upholding the terms of the easement. Also, the managers of public sector restoration programs, such as the CWPPRA program, may be less amenable to using conservation easements as an acquisition tool. Public investments in wetland restoration may not be considered fiscally responsible or be politically feasible unless public agencies can guarantee that restored wetlands will not be compromised.

Purchase of Development Rights. Purchase of development rights (PDR) programs provide an effective and politically acceptable way to preserve wetlands. Conservation entities extinguish the development rights on a parcel of land by paying for an easement that restricts residential, commercial and other types of building development. This payment is what differentiates PDR transactions from other types of conservation easements, which can also be donated. These easements often restrict development in perpetuity, although they can also be set to expire after a certain period (Ohm, 2000).

After a PDR transaction removes development rights, the parcel remains in private ownership, and the owner can continue to use the land in ways that are consistent with the contractual conservation objectives of the easement, maintaining the right to restrict access and to sell or transfer the land. The landowner also remains liable for property taxes; though these property taxes may be reduced due to the impact the easement has on assessed value. The easement holder, on the other hand, is responsible for monitoring the parcel to ensure that the landowner is complying with the terms of the easement, and has legal authority to require the landowner to address any violations (Daniels, 1997). This approach can be low cost in the long run but initial one-capital expenditures can be costly for restoration stakeholders to cover the purchase of development rights.

The voluntary nature of PDR transactions may prevent conservation entities from assembling enough property to effectively protect the BBWT. Given the complex nature of wetland ecosystems, large areas may need to be protected in order for full restoration to occur. If there are relevant parcel owners who are not interested in selling development rights, this may not be possible. Landowners aware of the potentially high land values may not want to relinquish development rights in certain areas. It is also possible that public sector restoration authorities (e.g. Coastal Wetland Planning, Protection and Restoration Act (CWPPRA)) would reject this alternative because of the limited control it offers over the BBWT property.

The success of this strategy rests in large part on efforts by conservation entities at expending a great deal of resources and energy on monitoring property; communicating with and educating landowners, potential successors, and communities about the importance of maintaining the conservation easement; and convincing landowners to comply with the easement terms (Ohm, 2000).

Other Land Rights Acquisition Techniques

In addition to fee simple and less-than-fee simple land rights acquisition techniques, there are other methods that BBWT stakeholders can use to acquire rights to BBWT parcels for restoration and protection activities. These include transfer of development rights (TDR) programs and coordinating with conservation land trusts.

Transfer of Development Rights. Conceptually, transfers of development rights (TDR) involves severing the "right to develop" from a site that the public wishes to have preserved, such as a wetland, and transferring that right to another site where higher-than-normal densities would be tolerable (Platt, 1996). This is the functional difference between a TDR and a PDR; under a TDR program, the right to develop still remains active because the purchaser can transfer it to a different piece of land. Meanwhile, under PDR programs, entities such as municipal governments pay for an easement that prohibits development until the end of a specified period or in perpetuity. Municipalities (or regional units of government) or non-governmental organizations can either buy the rights and hold them until there is a sufficient market to sell them, or municipalities can facilitate the transactions as they arise through third party purchasers—these programs can be either voluntary or mandatory.

In order for this program to work, developers purchase a certain number of TDR's from the landowners in the preservation areas in order to build in the developable areas. In the case of the Lower Ninth Ward, these developable areas could be commercial centers or strips that are struggling to attract businesses and the preservation area could be the wetland looking to be restored. (To achieve this, the city of New Orleans may need to down-zone the developable areas to allow for higher densities.)

The city of New Orleans' new comprehensive planning process could constitute an opportunity for the community to work with the city to establish a TDR program since comprehensive plans (land use planning and zoning) are often considered a prerequisite to any TDR program (Jacobs, 1997). Also, the BBWT landowners would retain existing use rights while receiving compensation for (or by donating) their development rights that are secured through a perpetual conservation easement deed restriction. Possible appeal for landowners may be the potential decreases in property values that may be offset by decreases in property taxes. In addition, this process could provide an opportunity for the landowners (around 200 landowners in the BBWT) to be made aware of any liens owed.

Limitations associated with TDR programs:

- Programs are created but not used
- There is a lack of qualified planning staff
- TDRs are not always needed because other existing land protections techniques may already be in place (and may be successful)
- Record keeping is difficult to manage
- Recessions are threats to programs
- There can be supply and demand imbalances between the sending and receiving areas
- Some debate exists about whether these programs should be voluntary or mandatory
- Some debate exists about whether they should be decided by elected officials on a case-by-case basis or administered by the local planning agency (Daniels, 1997).

However, TDR programs are best implemented during periods of strong development demand. Though TDR sellers may lower their prices when development demand is low, potential purchasers have little incentive to buy TDRs: the purchasers are often struggling to sell their existing housing stock and are not interested in further increasing the number of units or square feet they can build per acre. Given current economic conditions, a TDR program is not necessarily recommended at this time. Also, if the city operated the TDR program, more responsibility would be placed on it to ensure the terms of the conservation easement—given post-Hurricane Katrina circumstances, this is unlikely. Alternatively, a non-profit could be developed to oversee a program. This organization could draw on the resources of existing non-profits, and might provide more support for the overall restoration goals of the community.

Conservation Land Trusts

A community-based conservation land trust may be helpful in restoring the BBWT. Land trusts are non-profit organizations that, as all or part of their mission, actively work to conserve land "by undertaking or assisting in land or conservation easement acquisition, or by its stewardship of such land or easements," (Land Trust Alliance, 2008). Land trusts have their own boards of directors, bylaws and volunteer staff—and most have received charitable organization status from the Internal Revenue Service. As of 2005, 1,667 land trusts existed in the United States, operating on local, regional, state and national levels. These land trusts presently preserve approximately 37 million acres (Land Trust Alliance, 2007a). Four land trusts currently operate in Louisiana and have preserved nearly 11,200 acres since 2000 (Land Trust Alliance, 2007b).

Conservation land trusts acquire land and land rights with the aim of protecting open space and ecological resources. The voluntary nature of conservation land trust protection strategies distinguishes them from other protection strategies, such as environmental regulations and eminent domain. They protect critical areas by 1) purchasing land in fee simple, 2) purchasing conservation, or 3) purchasing properties, placing deed restrictions on them, and then selling them to public or private institutions. The charitable organization status of land trusts enables them to offer tax benefits to those donating or selling land. If land is being donated in perpetuity for a public benefit, federal income tax deductions are available, and landowners may also be able to receive property or estate tax reductions.

To protect wetlands in particular, larger conservation land trusts may purchase parcels or easements according to a set of criteria, which may focus on preserving particularly fragile wetlands, wetlands under development pressure, or wetlands that form a large, contiguous area. Land trust activities can also extend beyond acquiring land or land rights. Land trusts may be involved in mapping and assessing the features of wetlands; monitoring their biodiversity, functions, and values (economic, community, or otherwise); and managing restoration efforts. Land trusts may also be engaged in managing or operating recreational, tourist, or educational facilities;, working with individual landowners to help them maintain wetlands; or educating others about the values of wetland preservation and restoration (Kusler, 2007). The HCNA and neighborhood residents are already involved in many of these activities with respect to the BBWT, and they are poised to become involved in several more. This indicates that Lower Ninth Ward community groups may be effective partners for existing land trusts or one formed specifically to meet the needs of the BBWT.

Land trust-based wetland protection can be beneficial in several ways. First, land trusts enable restoration stakeholders to take direct action to provide long term protection for environmental resources (as opposed to trying to push environmental regulations through the electoral process). Land trusts can also act relatively quickly, while public agencies may require more time to pass appropriate legislation or acquire land, leaving critical areas vulnerable to damage or development. Moreover, the tools used by land trusts, such as fee simple purchases and conservation easements, can provide legally binding, long term protection. In contrast, zoning or regulations may be changed, in some cases in response to development pressure. This issue may be particularly relevant to the BBWT, given the dynamic legal and regulatory landscape of New Orleans after hurricanes Katrina and Rita.

Land trusts are also flexible, and their land protection approaches can be tailored to meet both the needs of the protected area and the landowners that might otherwise experience undue hardship from regulations. Similarly, the mission of land trusts can be broad enough to encompass the land monitoring, management, education and advocacy activities described above. Land trusts can also provide the leadership and education needed to help citizens voice their concerns about local wetlands in the public planning process. This can send important signals to public agencies about how communities perceive and value their natural resources.

However, the voluntary methods used by land trusts can create problems if landowners choose not to cooperate. Such non-compliance by the BBWT parcel owners could complicate restoration efforts. Fundraising poses an additional challenge. Aside from donations of land or easements, land trusts depend on funding from foundations, government grants, individual contributions and other sources. Limited resources may restrict the amount of wetlands the trusts can protect, or may affect their protected ability to meet the terms of easements or maintain the conservation value of protected land. Land trusts are often advised to identify an alternate land trust or public agency in the event that they cannot meet their obligations. Should the HCNA or other groups choose to work with an existing land trust, financial problems may be less of an issue. If a land trust is created for the BBWT, this challenge will need to be confronted.

Leases. While leasing wetland property may not protect it in perpetuity at the level of fee simple ownership or conservation easements, it would give wetland restoration groups exclusive long-term control over the BBWT. This option may or may not be economical, given the long-term lease (several decades) necessary for cypress swamp (re)creation. The temporary nature of leases could be a disadvantage if parcel owners engage in undesirable activities (such as dumping or mineral extraction) upon lease termination. Circumstances affecting owner interest could also changes drastically during a multi-decade lease. Given the number of recent parcel sales, it is possible that many owners may have plans for their land and would thus be unwilling to lease it for conservation and ecological restoration purposes.

Conclusions and Future Work

There are a variety of approaches that the BBWT restoration advocates could use to respond to the complex land ownership patterns that currently characterize the wetland bed. However, as work on land or land rights acquisition continues, several factors merit consideration, including the reasons why landowners have recently purchased or transferred properties, the impacts that valued natural resources can have on land rights acquisition, the issues involved in coordinating with other stakeholders, and the role of land tenure within the overall restoration effort.

Landowner Motives. While data from the NOSWB property records provides a baseline of information about land ownership patterns in the BBWT, the data do not address why landowners purchase land, which may be the key factor in whether or not they cooperate with land acquisition strategies. Because the BBWT bed is submerged and its development potential is seemingly limited, it is unclear as to why individuals may be transferring lot titles aside from bequeathing them via inheritance. Future research into BBWT land tenure issues should focus on how restoration advocates can engage current landowners about their plans for their parcels. Case studies from wetland restoration efforts in other parts of the Gulf Coast or the United States may be appropriate.

Natural Resources Use. Though the BBWT is adjacent to developed areas in the city of New Orleans, it is possible that mineral excavation may pose a threat to the wetland. For example, further research is needed regarding how mineral rights can be acquired, perhaps by public agencies, to protect critical environmental areas. The Tulane Institute on Water Resources Law and Policy is in the process of examining Louisiana mineral right laws.
Additionally, potential carbon sequestration benefits stemming from successful cypress swamp restoration could have impacts on purchases and sales of BBWT land and land rights. Louisiana State University is working a carbon budget to address carbon tax trading.

Coordination with Supporting Actors and Agencies. If the BBWT is eligible for support from large-scale Louisiana coastal restoration programs, restoration advocates will need to learn more about land-rights acquisition strategies that sponsoring agencies will find acceptable. For example, as explained above, public agencies may find fee simple purchases to be more politically and administratively acceptable than strategies that only acquire a few rights out of the bundle. Certainly, stakeholders from the Holy Cross Neighborhood Association, the Lower Ninth Ward at large, the city of New Orleans, as well as those from other groups, will also be important players in the decision. Similarly, more information is needed about any real estate and tax laws that may limit or provide opportunities for particular management alternatives.

Coordination with Overall Restoration Effort. Land and land rights acquisition issues will need to be appropriately prioritized among other parts of the BBWT restoration effort.
For the BBWT to be restored as a cypress swamp, considerable environmental changes are essential. In addition to simply protecting the land, fresh water and sediment will need to be introduced; the latter can be enormously expensive.

Realistically, sustainable restoration requires basin scale changes, such as the closure of the Mississippi River Gulf Outlet and freshwater diversions such as the Violet proposal. These components may not only take precedence over land tenure issues (either at certain points or throughout the whole process), but they may also have considerable impacts on the land rights acquisition strategies that are used.

This review provides a first look at the role land tenure issues have in BBWT restoration plans and establishes directions for further analysis.

Multiple avenues are open for continued investigation of these issues. First, as mentioned above, the UW team and other stakeholders should continue to investigate the relevance of the public trust doctrine to BBWT restoration advocates. The scientific standards used for determining tidal influence and navigability—as well as for establishing what is “seashore” or an “arm of the sea”—in Louisiana should be identified. In addition, the aforementioned stakeholders should pursue collecting the specific data required and thresholds needed to meet these standards. It may be also useful to conduct a more detailed investigation into whether (and how) the public trust doctrine has been applied to wetlands protection cases in Louisiana. Future UW research teams, the Lower Ninth Ward community, and others may benefit by establishing a closer relationship with the State of Louisiana Land Office.

Research into methods for acquiring BBWT parcels or rights to these parcels should also continue. Future UW student teams and others should also explore ways to engage current landowners about plans for their property. Additionally, future teams should work to involve the landowners in restoration efforts (case studies of how this was addressed in other wetland restoration efforts in the Gulf Coast and other parts of the U.S. may be appropriate). To complement this work, students and others should continue investigating different land management strategies, and learn more about any real estate and tax laws that may limit options or provide opportunities for particular management alternatives. It would also be useful to gather more specific information on the actual costs that different land management strategies would impose on the BBWT stakeholders. Thus, the creation of a cost-benefit methodology for examining these issues and making comparisons could prove useful as well.

Finally, future student teams should explore the potential relevance of usufruct rights, and how these may supplant the need for land acquisition in wetland restoration efforts. It is up to restoration advocates, as well as to the UW student researchers to maintain this discussion and to work toward the ultimate goal of restoring the BBWT as a community-based project for storm protection, economic development and community redevelopment in the Lower Ninth Ward.

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Chapter 9: The BBWT as a Community Asset: Possibilities for Education, Recreation and Alternative Tourism

J. Ashleigh Ross, Ashley Wallace, and Dan Cornelius

> *"What would it take to bring the Ninth Ward Back? The bayou came into play because tourists have come from miles around the world down to [Louisiana] so they could see an actual bayou or see an alligator in the bayou."*
> -Steve Ringo, Lower Ninth Ward resident, 2007

Community organization and the concept of "power of place" are critical for the Lower Ninth Ward, a community that has faced high levels of ongoing upheaval and trauma. The conservation of urban wetland habitat is complicated by the need to balance multiple uses: synergies among the 3Rs of recreation, restoration and research activities (Heiman, 1986). Incorporating recreational opportunities is often essential to garner public support for habitat protection, restoration and research. In turn, restoration activities have the potential to improve the appearance and function of degraded sites. Moreover, integrating an environmental education and research station into restoration efforts, particularly those in proximity to urban areas, has the ability to serve not only the scientific interests, but the local community as well. Although the UW team did not analyze ecotourism feasibility in the form of economic or business development, this section is included as a possible area for future research.

The restoration of the BBWT fits into the Lower Ninth community's vision of sustainable rebuilding, which was initially articulated in a 2006 community restoration plan (HCNA 2006) that sought to lay the foundation for sustainable self-sufficiency, to help prevent future reoccurrences of the devastation following hurricanes Katrina and Rita. Rebuilding houses and other physical infrastructure is generally the local residents' most pressing priority, and high-visibility housing projects such as Global Green and Make It Right have received substantial amounts of attention. However, wetland restoration has become an increasingly salient topic among community residents, who have a growing understanding of the value of wetlands, including their ability to buffer storms. In this setting, the BBWT has an added significance of being a tangible and powerful example of the neighborhood's relationship to the water, the land and the area's natural history.

While storm protection is a driving force for support of restoration of the BBWT among community members, many Lower Ninth residents also hope that restoration could provide economic and educational resources through ecotourism and an environmental education center. Community surveys conducted in 2008 indicated that 77 percent of surveyed residents viewed tourists visiting the Lower Ninth Ward as a positive community asset. Surprisingly, many residents appreciated the tourists, seeing them as messengers and witnesses to the continued devastation of the neighborhood. Of the survey respondents, 46 percent said that the tourists were actually helping the neighborhood, 69 percent said that tourism could benefit the neighborhood, and 20 percent said that they would feel more positively about tourism if it were to bring money to the community.

"What every community needs … is a systematic assessment of its own landscape character, an inventory of the connectedness it has—and of any broken connections that need mending," (Hiss, 1990). This objective is one of the primary benefits that wetland restoration could add to the community. As the most well-organized community group, the Holy Cross Neighborhood Association (HCNA) has already played a pivotal role in this effort by inventorying the community environment, including changes following hurricanes Katrina and Rita (2005). Over the past two years, the UW-Madison research team has maintained a dialogue with the HCNA and other stakeholders (local residents, Sierra Club—Delta Chapter of Louisiana, the U.S. Army Corps of Engineers and several other universities) regarding the larger vision for the BBWT restoration, and the potential for a community-based research and education facility located in or near the restoration area.

Although degraded and difficult to restore, the BBWT (the closest wetland to downtown New Orleans) is at least ideally located for such an educational facility. In addition, a pristine cypress-tupelo swamp might not be needed for an education/recreation facility to be successful. Currently the BBWT provides visitors (to the newly constructed viewing platform—located on the floodwall near the corner of Florida and Caffin avenues) with a first-hand, on-the-ground look at the recent and ongoing devastation of MDP wetlands. In terms of recreation, the BBWT is currently a pleasant place to canoe and observe abundant coastal wildlife ranging from ibis to alligators (see WRM 2007 for a list of wildlife). Although restoration will likely take decades, the process could provide the public with an easily viewable demonstration of the efforts required to restore historical habits in the Pontchartrain Basin, and elsewhere in coastal Louisiana.

To evaluate local support for such an initiative, the 2008 UW research team posed an additional survey question regarding the type of facilities (if any) respondents would like to see included in wetland restoration efforts. Of those surveyed, 49 percent said they would like to see an education/research facility in the area, 60 percent expressed interest in restaurants and shops and 51 percent said that they would like hiking trails. These results demonstrate strong support for economic development and alternative tourism possibilities.

In the context of the BBWT restoration, the most likely location for an environmental education and research facility would be in an area providing some commercial activity, based on the recommendations of both the Lower Ninth Ward’s Sustainable Restoration Plan (HCNA 2006) and residential input. Such a facility could attract visitors, increasing the economic support of the local businesses and other services for the community as a whole. A steady flow of visitors to the recently constructed viewing platform has already demonstrated the BBWT's potential role as an attraction that draws tourists to the Lower Ninth.

Early Planning Efforts

At the BBWT stakeholders meeting in November 2008, many of the institutions and individuals with interests in the BBWT restoration and future plans met to discuss their work and visions for the area. Attendees included representatives from: the U.S. Army Corp of Engineers; the University of Colorado-Denver Landscape Architecture program; the Louisiana State University Landscape Architecture program; the HCNA; the CSED; the New Orleans Sewerage and Water Board; the University of Wisconsin-Madison; the Tulane University Institute on Water Resources Law and Policy; the Sierra Club—Delta Chapter of Louisiana; and local residents.

> *"I know you guys call me the bayou man but that is just something that… one of the projects that has built a little momentum. But we still have the tour thing that we want to do. So we want to bring the tours in, have them make a stop within the ninth ward.*
>
> *Now they are just passing through without stopping. So if we get them to stop, they look around and in the process of looking around they spend money.*
>
> *An entrepreneur may notice them looking around and might open a café or a chuckwagon, things like that… it's more of a spiritual thing to try [and] get the community back up and running."*
> -Steve Ringo, 2007

Following a series of individual presentations, a community-brainstorming meeting was held. This was the beginning of the local planning process for the facility—similar to the start of the visioning workshops that the Walnut Creek case study held (see the case study text box below). Goals and process timelines, along with facility uses and recommendations, were established during this meeting.

Goals for the proposed BBWT facility area are centered on local workforce and entrepreneurial opportunities, ranging from restoration work and educational leaders to small-scale artisans and other small business owners.

Visions for the facility itself include such possible features as a small botanical garden and butterfly emporium; a gift shop; space for classes focused on bayou ecology, natural history or local environmental justice; a shopping area designated to feature environmentally-friendly companies based in Louisiana; a "sustainable kids" program; and a video booth where residents can give a short history of their Lower Ninth Ward community experience.

Some neighborhood residents and others involved in the visioning process have also proposed incorporating larger-scale tourism into the project site. Prospective ideas include a small open-air auditorium and a city- or neighborhood-wide bike/bus/walking tour run by local residents that would capitalize on the exiting demand for bus tours (that currently frequent the Lower Ninth without contributing to its economy).

Figure 9-1: “Fire on the Bayou” by Barnaby Evans. Concurrent with the stakeholders meeting (November, 2008), one of the largest exhibitions of international contemporary art ever organized in the United States—the highly popular *Prospect 1 New Orleans*—was hosted throughout the city. This momentous event drew thousands of people from around the world. Local neighborhood activist Jeanell Holmes (in conjunction with the UW-Madison team and the HCNA) invited artist Barnaby Evans, to create an exhibit on the BBWT for this event. “Fire on the Bayou” highlighted the wetland’s potential: lit torches near the platform represented possible future cypress trees. (Photo by Dan Cornelius)

The HCNA and the CSED have initiated a planning process for a community-based education and research facility near the BBWT. Some of the immediate “next steps” toward facility development area already underway: a number of individual events have been held at the BBWT to raise awareness about the projects, a committee for reconciling plans has been organized, and tangible materials such as interpretive signs on the bayou viewing platform are currently being developed.

Education/Research Facility Case Studies

We provide the following case studies as “brainstorming” examples of innovative facility approaches that have worked in other communities. It should be noted that the social, economic and political circumstances related to the development and success of these example facilities are not necessarily similar to those of the Lower Ninth, and that no formal analysis of these factors has been conducted. Therefore, it is not possible for us to draw any firm conclusions regarding the feasibility of such a facility in the Lower Ninth community. Any determination regarding a potential BBWT facility will require additional research into local economic conditions, an appropriate business model and extensive discussion among stakeholders.

Turtle Cove Environmental Research Station

The Turtle Cove Environmental Research Station—a field research and education facility of Southeastern Louisiana University—is situated between Lake Pontchartrain and Lake Maurepas. The station location is significant because it is located within an hour, by boat, of various wetland environments and their aquatic counterparts including hardwood forests, freshwater marshes and cypress swamps.

In many respects, Turtle Cove is a model facility because "each of these habitat types exists in relatively undisturbed, degraded, and restored states," (Turtle Cove, 2006). Turtle Cove's mission is "to promote environmental awareness in southeastern Louisiana; encourage educators and their students to take an active role in environmental restoration and education; and serve as a liaison between research scientists, educators and students, and the general public," (Turtle Cove, 2006).

Figure 9-2: Turtle Cove Environmental research Station, a 20-minute boat ride from the parking and office location.

Turtle Cove conducts the following activities (as outlined on the facility's website)

- –University classes (undergraduate and graduate levels)
- –Professional research and collaborative opportunities
- –Graduate student research opportunities
- –Community education and outreach programs
- –K-12 field trips and inquiry-based learning experiences
- –In-service workshops
- –Programming and workshops in collaboration with LA Department of Wildlife and Fisheries and the Lake Pontchartrain Basin Foundation
- –Alternative Breaks for college age students focusing on environmental issues
- –Environmental education

The Turtle Cove facility offers an area for extensive research to be conducted and emphasizes education at all levels. It is not necessarily embedded in one community but rather serves the larger New Orleans surrounding area.

Although regarded as a model facility in many respects, one drawback of the Turtle Cove research center is the antiquated (given current and future environmental conditions) design of its building, which was heavily damaged during the 2005 hurricane season. A BBWT facility would benefit from the incorporation of sustainable design elements (i.e. stilts).

Walnut Creek Urban Wetland Education Park

The Walnut Creek Urban Wetland Education Park is located in Raleigh, North Carolina. A detailed master plan guiding the project's development was completed in 2008. The Walnut Creek 2000 Urban Wetland Education Park Master Plan is a highly detailed guide which describes the creek's context, the park's mission, the project development process, the park's educational programming, the park's design elements (indoor and outdoor settings), and the partners/stakeholders involved throughout the process. The plan also includes information about the board of directors (created as the decision-making agency). The elements this plan addresses are at the core of a wetland education facility's design and implementation process.

The goal of the Walnut Creek Park is to restore the creek to its former state as a healthy urban wetland, from one "that has suffered for years of abuse and environmental neglect." The vision for Walnut Creek Park is that it will become a natural educational area which will: improve the water quality of the Neuse Rive while serving as a demonstration of benefits of wetland conservation, create a healthy wildlife habitat, beautify an area of the city and provide a neglected neighborhood with a valuable education/recreational resource that can be incorporated into the city's greenway system.

An additional goal of this project is to improve the quality of life and to enhance the property values in the "economically depressed neighborhoods surrounding the park site," (Walnut Creek Plan, Summary) by attracting outside visitors. The philosophy behind this plan is to not only restore a creek but also to restore a community through education and awareness, community economic development and the provision of healthy recreational options for the surrounding community residents—it is an environmental justice project. The plan's mission paints the picture of a sanctuary, "The mission…is to promote an understanding and protection of an urban wetland, enhance community pride. …The park provides an accessible quiet zone for communing with nature. It preserves the natural beauty of the wetland…and lifts the spirits of those who visit through educational and recreational experiences," (Walnut Creek Plan, pg. 5).

Figure 9-3: The Walnut Creek Urban Wetland Education Park. ***Top:*** The main boardwalk trail leading through wetland vegetation. ***Bottom:*** The sustainable stormwater system incorporated into the education center. *Source: Walnut Creek Urban Wetland Education Park Master*

Based on the fact that the surrounding community was identified as an “economically depressed neighborhood,” a large portion of Walnut’s Creek’s mission is clearly providing a distressed community with solace in nature. The plan has set the stage for a very strong personal and emotional relationship between the residents and the wetland as well as to the ecosystem and the facility.

Hudson River Science Barge

The final illustrative example of potential ideas for a BBWT education and research station is the Hudson River Science Barge in New York City. Designed as an educational tool to teach children and adults about the possibilities of urban agriculture in underutilized spaces like rooftops, the small facility sits on top of an old river barge, giving it mobility to be easily towed anywhere along the New York area’s extensive waterfront. The largely self-sustaining operation employs hydroponic growing techniques to produce an array of not only vegetables, but also tilapia fish. With the exception of heat from waste cooking oil in cooler months, the entire operation’s energy and water needs are met by wind turbines, solar panels, and water filtration systems located on the vessel.

Although the primary foci are sustainable agriculture and renewable energy rather than wetland restoration, the Hudson River Science Barge highlights how integrated educational programs with topics as diverse as plant life cycles, integrated pest management, and Hudson River Ecology can be designed to flexibly accommodate audiences ranging from third grade to adulthood. Moreover, it is instructive how a unique approach can capture attention and effectively educate urban residents and tourists, as over 6000 children and 12,000 adults have visited the science and education center (Charkes, 2008).

Figure 9-4: Hudson River Science Barge.
The floating urban farm with wind turbines, solar panels, and greenhouses is docked to a pier in the Hudson River in August, 2008.

Conclusions

As the Lower Ninth Ward community rebuilds, a large percentage of local residents, especially community leaders, feel that a wetland education and research facility could be a catalyst for continued positive growth. The Turtle Cove, Walnut Creek and Hudson River Bridge case studies offer tangible ideas of how such a facility might look, and of its potential benefits. These facilities all have unique locations, purposes, and attractions. All three examples emphasize education for a wide range of ages. In the case of Walnut Creek, strong connections with local schools enabled the facility to effectively draw large numbers of area students. Conversely, while Turtle Cove also hosts grade school and high school groups, its direct university management gives the center a stronger focus on higher education. Current interest in such a facility by the local Martin Luther King Jr. Charter School and several academic institutions could position the BBWT to capture both of these audiences.

Despite ongoing efforts by multiple parties to create a permanent, operating partnership, no formal agreement has yet been reached on either initial development or ongoing management details. While the operational structure could take many forms, an organized partnership of involved universities could serve as a tremendous asset in helping to draw top research talent and in continuing to seek grant funding for various research endeavors. Care, however, ought to be taken to ensure that higher education interests do not overwhelm or overshadow other local partners whose interests would be just as, if not more, vested in the local facility.

In conclusion, the potential benefits of an educational and research facility at the BBWT are extensive not only for the Lower Ninth Ward, but also for the larger surrounding community including visitors to New Orleans and academic researchers. The proximity of the BBWT to downtown New Orleans provides a unique opportunity for the city. Refining visions for such a facility and then assessing the economic feasibility and educational potential of those visions is an area for future analysis and action.

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Chapter 10: Conclusions and Recommendations

I. Reconstructing the appropriate hydrological conditions is critical to any restoration effort.

Hydrological conditions (such as the flow, depth, and salinity of water) exert a controlling influence on the character of Louisiana's wetlands (Day et al., 1989[44]), and the Bayou Bienvenue Wetland Triangle (BBWT) is no exception. The BBWT's original cypress-tupelo swamp community was a result of freshwater, nutrients and sediment supplied by the Mississippi River and runoff from adjacent high ground. Levee construction and the opening of the MRGO have since severed these processes and have strengthened the BBWT's hydraulic connection to Breton Sound and the Gulf of Mexico (CEI, 1972; CEI, 1982; Day et al., 2006; Kerlin, 1979; USACE 1999; USACE 2004). Current levels of salinity and tidal influence resulting from this situation present a formidable challenge to restoration efforts in this area. The impending closure of the MRGO and other remediation efforts planned for the Pontchartrain Basin, such as a freshwater diversion at Violet, will likely improve hydrologic conditions for cypress-tupelo restoration in the BBWT (Day et al., 2006; Georgiou et al., 2007; Lopez et al., 2008). Specific schemes aimed at restoring any emergent vegetation to the BBWT must consider the appropriate hydrological requirements.

II. Regional-scale wetland restoration is critical to the future of New Orleans. Restoration of the BBWT should be considered in this context.

Smaller-scale projects relying on treated wastewater effluent and containment levees are a good start toward reversing the wetland-loss trends of the twentieth century. Examples of projects of this scale include the 2008 CWPPRA Bayou Bienvenue Restoration Proposal (USACE, 2008), and the smaller 20-acre test plots envisioned in the NOSWB's Wetland Assimilation Pre-Design Report (WSNC, 2009). Such projects have previously proved useful as pilot studies for field-testing new ideas. When combined, they can have large-scale positive effects (e.g. CWPPRA projects in the Barataria Basin; see Chapter 7).

However, large-scale, system-wide approaches considering the entire Mississippi Delta are the only long-term answer for a sustainable future. Only when pre-settlement salinity and tidal conditions are restored will freshwater swamps again thrive in the Pontchartrain Basin (Lopez et al., 2008; Hoeppner et al., 2008). A return to these historical conditions is critical not only for storm protection, but also for the maintenance of land (Day et al., 2007; Lopez et al., 2008) and for a reduction in the size of the Dead Zone (Mitsch et al., 2001). A patchwork of restored "project wetlands" is insufficient to accomplish these goals. Restoration of the 427-acre BBWT represents only a small portion of what is needed. Therefore, Lower Ninth residents and other stakeholders should also actively advocate for regional proposals (such as the remediation of the MRGO and a freshwater river diversion at Violet) that will create conditions favorable to the large-scale restoration of wetlands in the Pontchartrain Basin.

[44] References for citations in the Conclusions and Recommendations are listed at the end of their respective chapters.

III. Restoration efforts will require active management of vegetation.

Although a self-sustaining cypress-tupelo swamp should be the end-goal of BBWT restoration, active vegetation planting and maintenance will likely be needed in the near-term. Physical conditions in the BBWT have changed to reflect those of a brackish to intermediate marsh, but there has not been a corresponding shift in vegetation. In the open-water area that comprises the majority of the BBWT, widgeon grass was the only identified submerged aquatic species. In other areas of the BBWT, 23 of the 40 emergent aquatic and terrestrial species that were identified are weedy or introduced. Although some brackish species have colonized the northeast corner of the BBWT, weedy species proliferate along the Florida Avenue floodwall. The prevalence of open water suggests that water depth is a significant obstacle to colonization of the BBWT by emergent vegetation.

Both in-filling with sediment and active vegetation management (to ensure the success of desired species over weeds) are likely needed to successfully restore any substantial vegetative community to the BBWT.

IV. Although wastewater assimilation in the Central Wetlands Unit (CWU) and the BBWT will positively impact salinity and will provide nutrients for growth, this approach could further degrade these waters if improperly implemented.

Discharges of untreated or partially-treated wastewater during extreme events (those that exceed the inflow capacity of the East Bank Wastewater Treatment Plant) should continue to go to the Mississippi River. To prevent potential eutrophication of the CWU and the BBWT, pilot studies should be conducted to demonstrate the capacity of these ecosystems to assimilate limiting nutrients in a sustainable way. Wastewater should be dechlorinated prior to release into the wetlands. In addition, the potential for pathogen release and the fate of emerging contaminants are a potential concern.

V. The current environmental quality of Bayou Bienvenue and the BBWT show an impact from surrounding land use practices and also from its proximity to New Orleans. Further degradation is possible, depending on the fate of Southern Scrap's Florida Avenue facility and whether IHNC mitigation sediments will be deposited in the BBWT.

The environmental quality of the BBWT is likely affected by both point source contamination from surrounding land uses and nonpoint source contamination resulting from the wetland's location within the New Orleans metropolitan area. In general, Bayou Bienvenue appears to be more contaminated with heavy metals than the BBWT. Although federal and state regulations protecting water and sediment are in place, this contamination demonstrates that these are not effective in their scope and level of enforcement.

Currently, activities at the Southern Scrap recycling facility and the possible introduction of dredged IHNC sediments present the biggest potential threats to environmental quality in the BBWT. The spatial distribution of zinc and copper sediment concentrations in the BBWT suggests Southern Scrap's stormwater outfalls may be a potential source of contamination. In 2007, this operation was cited for negligence regarding stormwater control. However, until recently, the release of dissolved heavy metals from such facilities has been unregulated. Further investigation into Southern Scrap's stormwater management practices (including the timing and quality of any discharges) is necessary to accurately assess the magnitude of this threat. Larger concerns include the potential closure of this facility and the implementation of an appropriate clean-up/remediation plan. Existing regulations may or may not ensure that these things are done properly. The active involvement of Lower Ninth residents and other concerned stakeholders in this process will be important to ensuring the future quality of Bayou Bienvenue and the BBWT.

Meanwhile, IHNC sediments designated for "marsh creation" in the BBWT contain six organic compounds at potentially harmful levels (for biological effects), though their ecotoxicity in relation to sediments in the BBWT is unclear. While the USACE extensively investigated the potential biological effects of IHNC sediments, it conducted no similar experiments on BBWT sediments. Given the degraded condition and the current low recreational use of the BBWT, it is unlikely that institutional action will be taken to address these ecotoxicity issues.

A comparison of sediment heavy metals concentrations shows higher levels in BBWT sediments than in the IHNC sediments designated for "marsh creation." While this suggests heavy metal contamination of the BBWT from IHNC sediments to be less likely, it *should not* be taken as an endorsement of the USACE's mitigation proposal. Significant concerns remain over other above-mentioned pollutants, the sporadic distribution of contamination "hot spots" in IHNC sediments, and the potential suspension and commingling of "clean" and contaminated sediments during IHNC dredging.

Due to its age, and the results of a year 2000 groundwater monitoring survey, the Crescent Acres Landfill is likely not a current threat to water and sediment quality in the BBWT. However, given its poor design (by modern standards) and acceptance of a wide range of waste materials, historically discharged "legacy" pollution could remain in the BBWT sediments.

Other environmental quality data suggest contamination, but are inconclusive regarding the possible source. Lead and arsenic concentrations were elevated at the majority of sampling sites, but don't appear to follow a particular trend. Semi-Permeable Membrane Devices (SMPDs, which can broadly indicate the bioavailability of organic contaminants dissolved in the water column), showed toxic levels at two locations in the BBWT, but non-toxic levels at a location closer to Bayou Bienvenue. There are some uncertainties in these results, which are discussed in Appendix C of this report. This year (2008) the SMPD study only assessed overall ecotoxicity; future studies could test for specific compounds, such as PCBs.

Although it is clear that the BBWT is polluted to some extent with heavy metals (and possibly organic contaminants), it is not possible from concentration data alone to draw any firm conclusions about potential biological effects, including those to humans.

VI. The 2005 hurricane season shifted the paradigm of coastal restoration in Louisiana, resulting in planning documents that holistically combine coastal restoration with the previously separate storm protection and navigational objectives. The plans on paper must now be quickly and successfully implemented if coastal land loss is to be significantly

slowed or reversed. The hundreds of millions of dollars spent on restoration represent a substantial, but far from adequate, effort.

Human understanding of the complex coastal Louisiana ecosystem has improved immensely over the past several decades. Institutions aimed at restoring and protecting coastal habitats, most notably the CWPPRA program, were created in an effort to begin addressing environmental problems in these areas. However, most policy makers along with the general public did not grasp the full gravity of the situation until the massive devastation wrought by hurricanes Katrina and Rita.

Recent improvements in coordination among various federal, state, and local governments, as well as coastal activities show signs of promise for more effective future restoration. However, ongoing commitments, continued cooperation and significantly increased financial resources must accelerate over the near term—and must continue indefinitely—if coastal Louisiana is to exist in its present—much less its former—condition.

VII. Successful ecological restoration of the BBWT will almost inevitably require a formal partnership of involved stakeholders. This partnership must have decision-making authority in order to overcome the collective action problem that presently exists with so many disparate parties.

The numerous stakeholders of the BBWT have many competing interests that will almost inevitably complicate or halt any restoration effort unless an effective working relationship is formed. A restoration authority with the power to make both routine and larger-picture decisions relating to the area is one possible strategy with the potential to give a voice to these parties.

Such a restoration authority could take many forms, but it must be inclusive enough to incorporate most key stakeholders. The impetus to create such an organization could emerge from the recognition that no stakeholder group, with the possible exception of the New Orleans Sewerage and Water Board, is ideally situated to address its own specific interests in the area. The actual creation of a formal group with real powers will require political action and cooperation on multiple levels of public and private interests.

VIII. Properties in the BBWT basin vary considerably across owner types, sale dates and states of tax delinquency. Further landownership research efforts should engage current landowners in efforts to shape the future of the BBWT.

Analysis of the New Orleans Sewerage and Water Board property records shows that while the majority of the BBWT basin lots are owned by individuals, private companies have made the most recent lot purchases. Moreover, approximately one-quarter of these lots have been purchased since 1990. These factors may be unrelated, or they may indicate that recent purchasers have specific plans for their lots. These landowners could compromise restoration efforts if they refuse to sell.

Moreover, the most recent parcel adjudication (for tax delinquency) took place in 2001. This suggests that the city of New Orleans is not taking full advantage of its right to claim tax delinquent parcels. Research findings indicate that that over half of the tax delinquent non-adjudicated parcels could technically be placed in the hands of the city of New Orleans through adjudication.

Restoration advocates should more actively engage current landowners to determine landowners' plans for their properties. To ensure that this process does not encourage land speculation or the spread of misinformation, this research team recommends that advocates conduct case studies of the land acquisition approaches used in other wetland restorations. It may also be most effective to inform landowners about restoration plans through an educational campaign—which would demonstrate the community's interest in restoring the BBWT and enhancing public use—and explanations regarding how landowners may participate in achieving these goals.

IX. Fee simple acquisition of BBWT lots would address ecological and community needs but would pose challenges in terms of costs.

From an ecological and community-interest perspective, fee simple acquisition is likely the best approach for acquiring properties in the BBWT basin, as it would enable advocates to provide the wetland with comprehensive, lasting protection during and after restoration. This approach would also increase opportunities to introduce public access, educational activities and alternative tourism development. However, fee simple acquisition of wetland lots is highly unlikely without support from state or federal agencies, both in terms of purchasing the land and in coercing holdout landowners. While several plans, such the Coast 2050 plan, have called for funding for programs to fight coastal erosion and wetland degradation in Louisiana, it is unclear how much funding will actually be allotted to these activities.

X. Further research should be conducted on the public trust doctrine, as it may provide an effective way to both legally and inexpensively gain control of the BBWT for restoration purposes.

The land tenure analysis in this report could not conclude that the BBWT basin is considered public land according to Louisiana's public trust doctrine (which protects navigable water bottoms and arms of the sea, among other water bodies). It may be possible, however, for restoration advocates to make a legal defense against ownership claims by establishing that the BBWT is a navigable waterway or an arm of the sea.

Restoration advocates should coordinate with public agencies, lawyers and other professionals to determine what scientific evidence may be required for the BBWT to be classified as a "navigable waterway" or as an "arm of the sea" and how these terms have been applied in court cases. Also, subsequent teams of UW students and other researchers should continue to make progress in assessing the hydrological characteristics of the BBWT, focusing in part on collecting data relevant to these definitions.

XI. Current resident use of the BBWT is low. In general, residents have limited knowledge about wetlands and restoration proposals. However, residents have extensively used the BBWT in the past and are likely to do so in the future.

The demographic characteristics of surveyed participants are similar to those described in the 2000 US Census, with the exceptions of age and home ownership rate, which were both higher in the surveyed participants. However, as of August 2008, the Lower Ninth Ward population (1,468) remains well below pre-Hurricane Katrina levels (19,515 in 2000). Despite significant attention from outside organizations, this vacancy is coupled with a continued lack of services.

Survey participants overwhelmingly selected hunting/fishing/shrimping/crabbing as the most popular prior uses of the BBWT and surrounding wetlands. Indicated future uses included other forms of recreation, such as walking or bird watching. However, the community remains significantly disconnected from the wetland. Few surveyed residents had visited the wetland recently, despite the newly constructed wetland observation deck near the corner of Florida and Caffin avenues. In addition, there is a widespread lack of knowledge in the community about the general importance of wetlands and current BBWT restoration proposals.

Additional outreach and education in this area is needed. Such outreach could draw on residents' strong sense of place and commitment to their community to garner support for BBWT restoration efforts. Identifying and building upon shared rebuilding and restoration goals could further increase community support.

XII. An education and research facility could potentially provide an effective link between wetland restoration and local community revitalization. However, additional research is needed to determine the social, political and economic feasibility of such a facility.

Community survey results and recent discussions among BBWT stakeholders have shown interest in utilizing the BBWT for education, recreation, and alternative tourism. A combined education and research facility at the BBWT could potentially strengthen the connection between the BBWT and the Lower Ninth Ward neighborhood, raise awareness about Louisiana's disappearing wetlands, and promote autonomous, community-based, economic development. The BBWT is the closest wetland to downtown New Orleans, and serves as a prime example of recent and ongoing wetland degradation in the MDP.

If restoration efforts are initiated (e.g. sediment introduction and tree plantings), the BBWT could also serve as a first-hand demonstration site for the process of restoring historical habits in the Pontchartrain Basin, and elsewhere in coastal Louisiana. While survey results suggest that residents are receptive toward tourism and interested in utilizing the BBWT for educational and recreational purposes, more research is needed to determine the actual feasibility of such a facility.

A BBWT Master Plan should be created to provide a blueprint for the community and other Lower Ninth stakeholders as they seek to incorporate the BBWT into neighborhood development plans. Given neighborhood interest and the potential benefits mentioned above, additional research should investigate the feasibility of an education and research facility.

Appendix A – Vegetation Comparison

Species Name	Common Name	Cypress-Tupelo Swamp[1]	Salt Marsh[1]	Brackish Marsh[1]	The BB WT
Acer rubrum L. var. drummondii	Swamp maple	x			
Achyranthes philoxeroides	Marsh button	x		x	
Ageratum conyzoides	Ageratum	x			
Amaranthus australis	Southern water-hemp	x		x	?
Ambrosia trifida	Giant ragweed				x
Ammannia coccinea	Scarlet toothcup			x	
Ammannia latifolia	Toothcup			x	
Amorpha fruticosa	False indigo	x			
Ampelopsis arborea	Peppervine	x			?
Asplenium ebenoides	Scott's spleenwort	x			
Avicennia germinans	Honey mangrove		*x*		
Azolla caroliniana	Floating fern	x			
Baccharis halimifolia	Buckbrush	x	x		x
Bacopa monnieri	Hedge-hyssop	x		x	x
Berchemia scandens	Supplejack	x			
Blechnum serrulatum	Swamp fern	x			
Boehmeria cylindrica	False nettle	x			
Borrichia frutescens	Sea-oxeye		x		
Brunnichia ovata	Florida-vine	x			
Calystegia sepium	Marsh bindweed	x		x	
Campsis radicans	Trumpet creeper				x
Carex comosa	Bristly sedge	x			
Carex crus-corvi	Crowfoot sedge	x			
Carex lupulina	Hop sedge	x			
Celtis laevigata	Sugar berry				x
Cephalanthus occidentalis	Buttonbush	x			
Ceratophyllum submersum	Coontail, Hornwort	x			
Crinum americanum	String-lily	x			
Cuscuta indecora	Dodder				x
Cyperus fillicinus	Nuttall's cyperus			x	
Cyperus surinamensis	Tropical flatsedge				x
Cyperus virens	Swamp sedge	x			
Distichlis spicata	Salt grass		x	x	
Echinochloa crus-galli	Barnyard grass				x
Echinochloa walteri	Duck millet	x		x	
Echinodorus cordifolius	Creeping burhead	x			
Eclipta prostrata	Verbesina, false daisy			x	
Eichhornia crassipes	Water hyacinth	x			
Eleocharis albida	White spikerush	x		x	
Eleocharis flavescens	Yellow spikerush				x
Eleocharis microcarpa	Marsh spikerush			*x*	
Eleocharis montana	Marsh spikerush			*x*	
Eleocharis olivacea	Bright green spikerush	x			
Eleocharis parvula	Dwarf spikerush			*x*	
Eleocharis retroflexa	Dwarf spikerush			*x*	
Fimbristylis castanea	Sand rush		*x*	*x*	
Fraxinus profunda	Water ash	x			

Species Name	Common Name	Cypress-Tupelo Swamp[1]	Salt Marsh[1]	Brackish Marsh[1]	The BB WT
Galium spp.	Bedstraw				x
Gleditsia triacanthos	Honeylocust				x
Gratiola virginiana	Clammy hedge-hyssop	x			
Hibiscus moscheutos	Rose -mallow	x		x	x
Hydrocotyle verticillata	Marsh pennywort	x		x	
Hygrophila rotatum	Spider-lily	x			
Ipomoea sagittata	Marsh morning-glory	x			x
Iris virginica	Coastal plain iris	x			
Iva frutescens	Marsh elder	x	x		x
Juncus effusus	Common rush	x	x		
Juncus Roemerianus	Black rush		*x*	x	
Juniperus spp.	Juniper				x
Justicia ovata	Water-willow	x			
Kosteletzkya virginica	Saltmarsh mallow	x		x	x
Lantana spp.	Lantana				x
Lemna minor	Lesser duckweed	x			x
Leptochloa fusca	Slender grass			*x*	
Liquidambar styraciflua	Red gum	x			
Ludwigia decurrens	Primrose-willow			*x*	
Ludwigia glandulosa	Ludwigia	x			
Ludwigia palustris	Marsh purslane	x			
Lycopus rubellus	Water horehound	x			
Lythrum lineare	Marsh loosestrife			*x*	x
Micranthemum umbrosum	Shade mudflower, Dwarf moneywort	x			
Mikania scandens	Hempvine	x			
Morella cerifera	Wax myrtle	x			
Morus spp.	Mulberry				x
Myrica spp.	Myrtle				x
Myriophyllum pinnatum	Watermilfoil	x			
Nyssa aquatica	Tupelo gum	x			
Nyssa biflora	Sour gum, swamp tupelo	x			
Onoclea sensibilis	Sensitive fern	x			
Osmunda regalis	Royal fern	x			
Panicum anceps	Beaked panicgrass	x			
Panicum rigidulum	Redtop panicgrass	x			
Panicum virgatum	Feather grass	x	x		
Paspalum vaginatum	Joint grass			*x*	
Persea palustris	Red bay	*x*			
Persicaria punctata	Dotted smartweed	*x*			
Phanopyrum gymnocarpon	Swamp panicgrass	x			
Phragmites australis	Roseau			*x*	
Pluchea camphorata	Spicy fleabane, camphorweed	x	*x*	*x*	
Pluchea foetida	Viscid marsh fleabane, stinking camphorweed	x			
Polygonum glabrum	Giant knotweed	x			
Polygonum hydropiperoides	Smartweed	x			
Pontederia cordata	Pickerel weed	x			
Proserpinaca pectinata	Mermaid-weed	x			
Phyla nodiflora	Fog-fruit			*x*	

Species Name	Common Name	Cypress-Tupelo Swamp[1]	Salt Marsh[1]	Brackish Marsh[1]	The BB WT
Riccia fluitans	Dissected liverwort, crystalwort	x			
Ricciocarpus natans	Heart-shaped liverwort	x			
Rubus louisianicus	Swamp blackberry	x			
Rubus trivialis	Southern dewberry				?
Rumex verticillatus	Swamp dock	x		x	
Ruppia maritima	Widgeon grass			*x*	x
Rhynchospora corniculata	Shortbristle horned rush, shortbristle horned beaksedge	x			
Sabal minor	Dwarf palmetto	x			
Sabal palmetto	Cabbage palmetto				x
Sabbatia campanulata	Marsh pink	x		*x*	
Saccharum giganteum	Plume grass	x			
Sacciolepis striata	Gibbous panic-grass	x			
Sagittaria lancifolia	Delta potato	x		x	
Salix nigra	Black willow	x			?
Sambucus nigra L. ssp. Canadensis	Elderberry	x			x
Samolus valerandi L. ssp. Parviflorus	Brookweed	x		x	x
Sapium sebiferum	Chinese tallow				x
Saururus cernuus	Lizard's tail	x			
Schoenoplectus americanus	Bayonet rush			*x*	
Schoenoplectus californicus	Giant bulrush	*x*		*x*	
Schoenoplectus maritimus	Cosmopolitan bulrush				x
Schoenoplectus robustus	Three-cornered rush		*x*	*x*	
Schoenoplectus tabernaemontani	Blue bulrush			*x*	
Sesbania emerus	Coffee bean, danglepod	x		*x*	
Sesbania drummondii	Poison bean, rattlebush, rattlebox				x
Setaria magna	Giant foxtail	x			
Setaria parviflora	Marsh foxtail	x	x	x	
Setaria pumila	Yellow foxtail				x
Smilax bona-nox	Saw greenbrier				x
Solidago sempervirens L. var. mexicana	Seaside goldenrod	*x*	*x*		
Spartina alterniflora	Smooth cordgrass		*x*	*x*	x
Spartina cynosuroides	Quill cane, big cordgrass		*x*		
Spartina patens	Couch grass	x	*x*	*x*	
Spiranthes cernua	Lady's tresses	x			
Spirodela polyrrhiza	Greater duckweed	*x*			
Styrax grandifolia	Storax, snowbell	x			
Symphyotrichum divaricatum, Symphyotrichum squamatum	Slim aster	x		x	
Symphyotrichum subulatum	Saltmarsh aster			x	
Symphyotrichum tenuifolium	Saltmarsh aster		*x*	*x*	
Taxodium distichum	Bald cypress	x			
Thelypteris palustris	Marsh shield fern	x			

Species Name	Common Name	Cypress-Tupelo Swamp	Salt Marsh[1]	Brackish Marsh[1]	The BB WT
Thelypteris patens	Shield fern, grid-scale maiden fern	x			
Tillandsia usneoides	Spanish moss				x
Toxicodendron radicans	Poison ivy				x
Tradescantia ohiensis	Spiderwort, bluejacket	*x*			
Triadenum walteri	St. Johnswort	x			
Trisetum pennsylvanicum	False oat	*x*			
Typha angustifolia	Narrowleaf cattail	x		x	?
Typha latifolia	Broadleaf cattail	*x*		*x*	
Utricularia gibba	Humped bladderwort	x			
Utricularia macrorhiza	Common bladderwort	*x*			
Utricularia purpurea	Purple bladderwort	*x*			
Vigna luteola	Wild cowpea			*x*	x
Woodwardia virginica	Virginia chain fern				?
Zizaniopsis miliacea	Giant cutgrass	*x*			

1 From Penfound, W. T. & E. S. Hathaway. 1938. Plant communities in the marshlands of Southeastern Louisiana. Ecological Monographs 8:3–56.

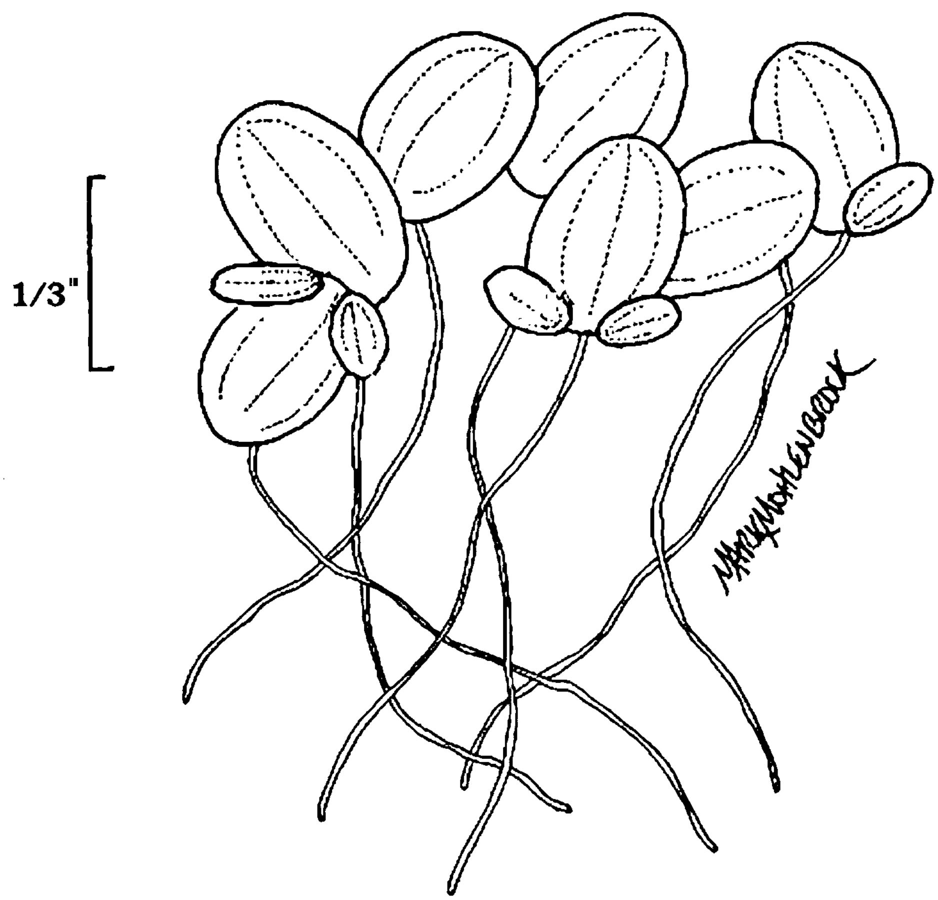
? Species marked with a question mark are suspected to occur in BBWT, but due to a lack of reproductive structures, were not able to be positively identified as of this study.

Appendix B - A Guide to Plant Identification: Pictures and descriptions of species found in the Bayou Bienvenue Wetland Triangle.

This guide describes common plant species identified in the BBWT during July 2008, including their common and scientific names, habitat, and discerning features. Species are divided into four categories:- aquatic, emergent, woody, and vines.

I. Aquatic Plants

***Lemna minor*- Little duckweed**
A small, stemless, floating, aquatic plant that occurs in fresh marshes. Big duckweed (*Spirodela polyrhiza*) is similar in form to little duckweed but can be distinguished by the presence of 6 to 18 rootlets (Tiner, 1993).



USDA-NRCS PLANTS Database / USDA NRCS. *Wetland flora: Field office illustrated guide to plant species*. USDA Natural Resources Conservation Service.

***Ruppia maritima*- Widgeon-grass**
Threadlike, alternately-arranged leaves. Usually present in saline and brackish waters. Distinguished from sago pondweed (*Stuckenia pectinata*; which has clusters of flowers born on a singular axis) by fruiting structures on separate stalks which radiate from a central point.

USDA-NRCS PLANTS Database /Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions*. Vol. 1: 88.

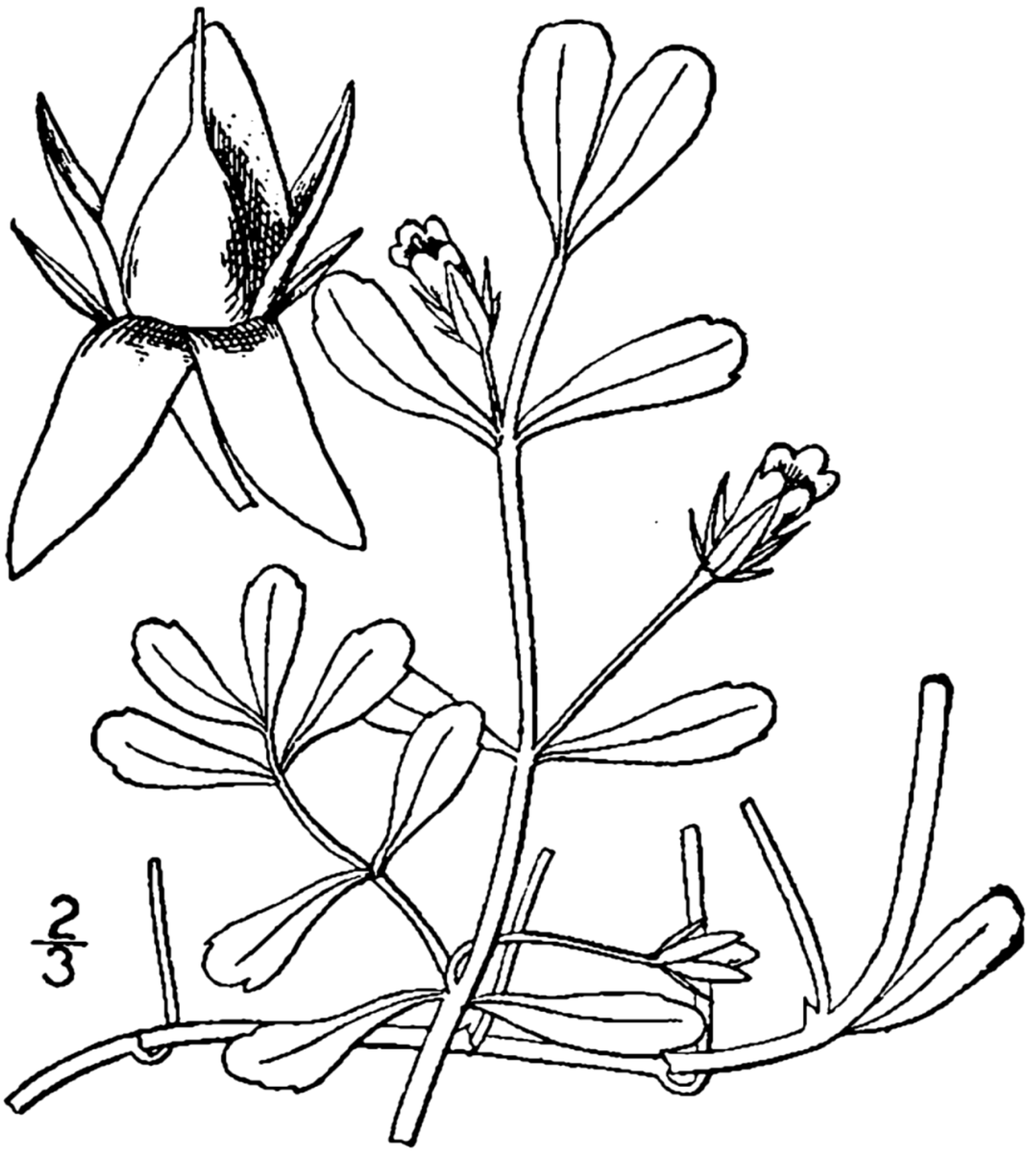
II. Emergent Plants

***Ambrosia trifida*- Great ragweed**
An opportunistic species. Often found in moist soils areas such as river banks and tidal fresh marshes, also in disturbed areas. Recognizable by its height, which can occasionally reach 17 ft, it has oppositely-arranged, distinctly three- to five-lobed leaves, and dense spikes of small green flowers.

USDA-NRCS PLANTS Database / USDA NRCS. *Wetland flora: Field office illustrated guide to plant species*. USDA Natural Resources Conservation Service.

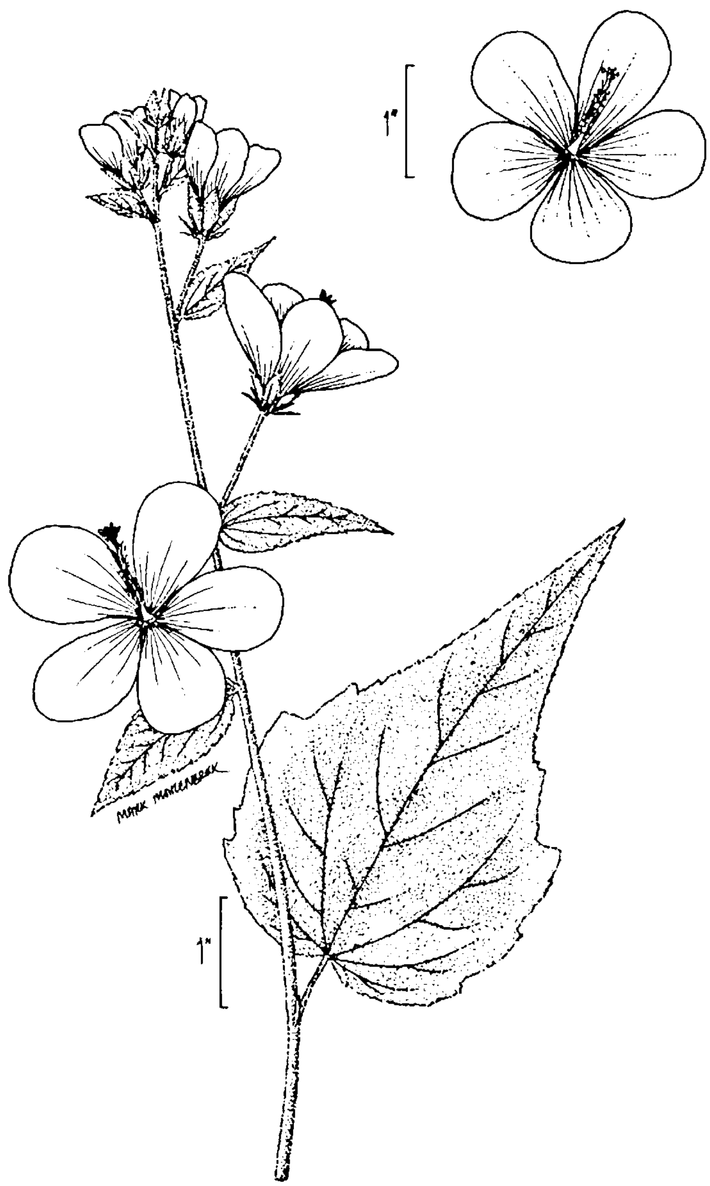
***Bacopa monnieri*- Coastal water-hyssop, herb of grace**

Often found forming dense mats in sandy, brackish and tidal fresh marshes, and on the margins of streams and ponds. This is an obligate plant which can almost always occur in wetlands. Identified by its smooth, fleshy stems, along with its fleshy, oppositely-arranged leaves. Five-petaled, white tubular flowers occur on single stalks between leaf pairs. Several species are similar in appearance to coastal water-hyssop, however the stems of coastal water-hyssop lack the hair that occurs on these other species.



USDA-NRCS PLANTS Database/Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions*. Vol. 3: 192.

***Kosteletzkya virginica*- Seashore mallow**
A wetland indicator species that occurs in salt, brackish and fresh marshes. It can reach up to 5 ft tall and has coarsely-toothed, hairy, alternating leaves, and five-petaled, pink flowers that can be found on the ends of the stems which bear them. A similar species, marsh mallow (*Hibiscus moscheutos*) can be distinguished from sea-shore mallow by white flowers with intense purple or red centers.



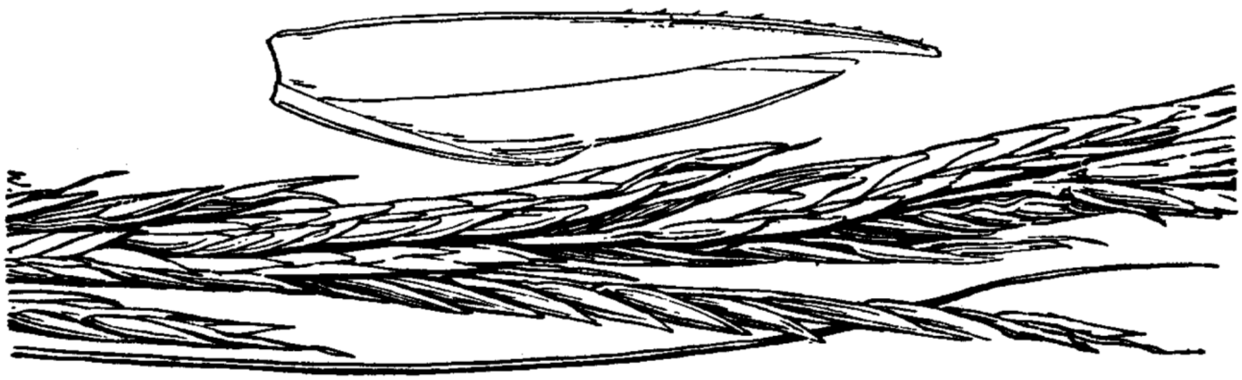
USDA-NRCS PLANTS Database / USDA NRCS. *Wetland flora: Field office illustrated guide to plant species*. USDA Natural Resources Conservation Service.

***Schoenoplectus maritimus*- Cosmopolitan bulrush**

Occurs in brackish to saline costal marshes. Grass-like in appearance, but with large triangular stems. Reddish-brown, scaly fruiting structures occur in terminal clumps. Often difficult to distinguish from salt-marsh bulrush (*Schoenoplectus robustus*). However, cosmopolitan bulrush lacks the notches on either side of the tail-like structure which are present on the scales of the fruiting structure.

USDA-NRCS PLANTS Database /Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions*. Vol. 1: 334.

***Spartina alterniflora*- Smooth cordgrass, Saltwater cordgrass**
An indicator species of salt and brackish marshes, grows in dense stands and can reach heights of 8 feet. Long, smooth leaves with hairy sheath margins. Difficult to distinguish from other closely related species.



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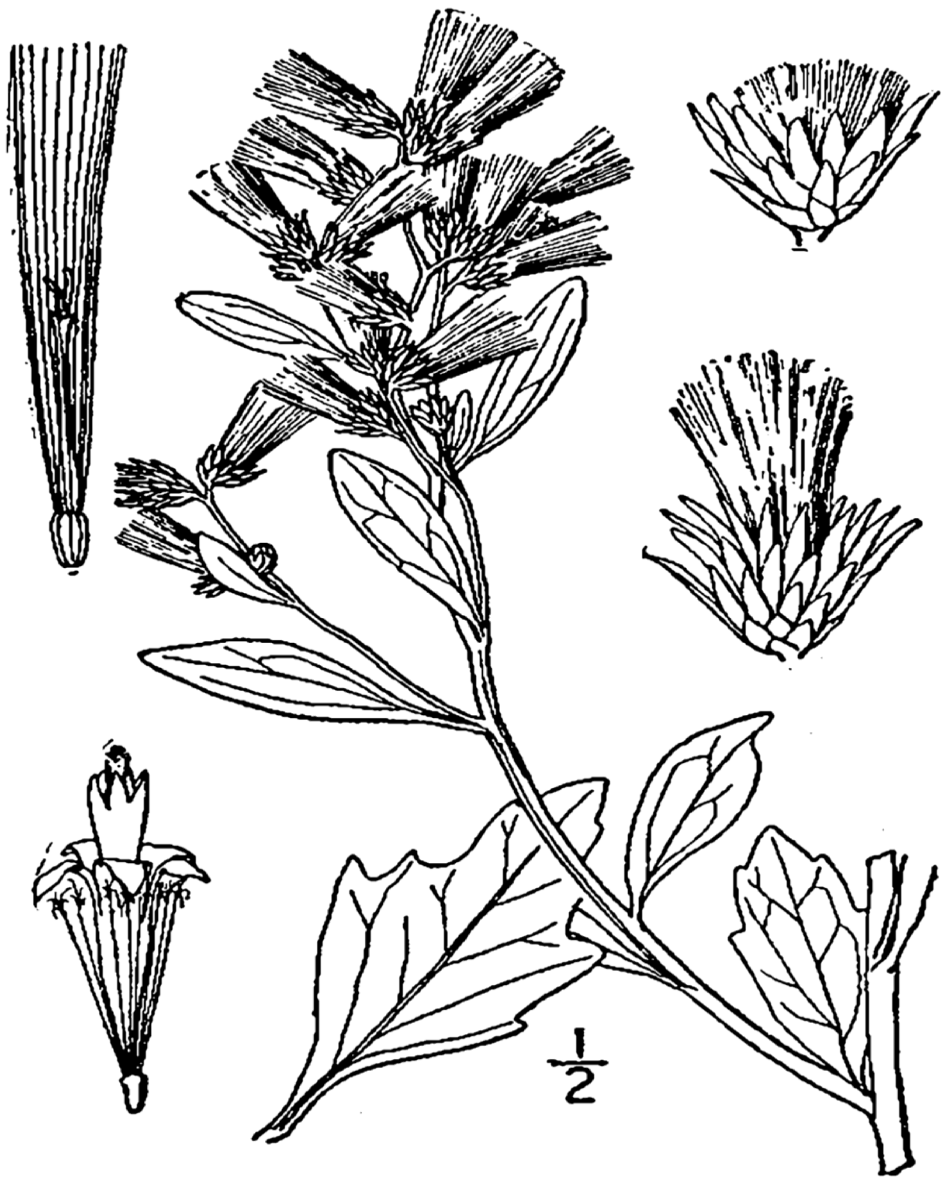
USDA-NRC PLANTS Database

III. Woody Plants

***Baccharis halimifolia*- Groundsel Bush**

An evergreen bush found in salt, brackish and tidal fresh marshes. Easily identified by its bushy habit and coarsely toothed leaves. Alternately arranged leaves, which makes it distinguishable from marsh elder (*Iva frutescens*).



USDA-NRCS PLANTS Database/Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions*. Vol. 3: 445.

***Celtis laevigata*- Sugarberry**

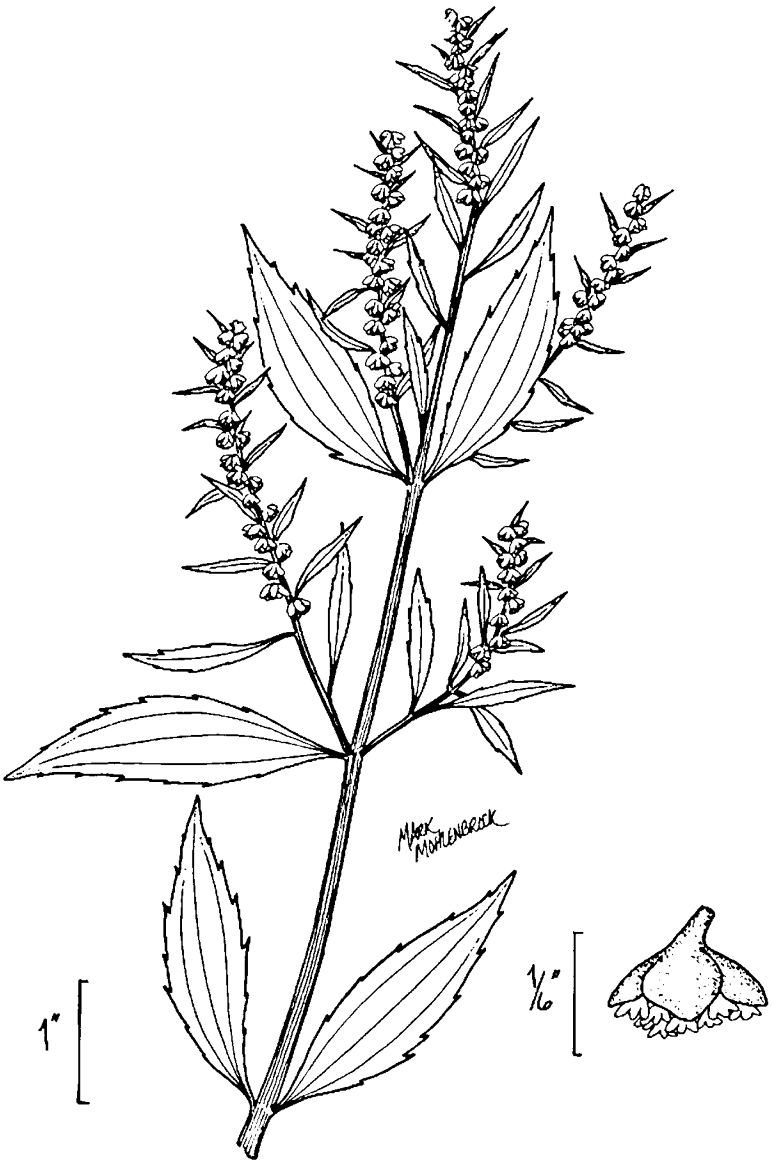
Sugar berry is a medium to large tree with distinctly bumpy, grey bark. This species can be found in wet woodlands, river banks and floodplains.

Robert H. Mohlenbrock @ USDA-NRCS PLANTS Database. USDA SCS. 1989. *Midwest wetland flora: Field office illustrated guide to plant species*. Midwest National Technical Center, Lincoln.

USDA-NRCS PLANTS Database/ USDA Natural Resources Conservation Service. *Wetland flora: Field office illustrated guide to plant species*.

***Iva frutescens*- Marsh elder**

An evergreen bush that can be found in salt and brackish marshes. Very similar to groundsel bush. However, marsh elder leaves are more finely toothed and arranged oppositely.



USDA-NRCS PLANTS Database / USDA NRCS. *Wetland flora: Field office illustrated guide to plant species*. USDA Natural Resources Conservation Service.

***Lantana spp*.- Lantana**
An escaped ornamental which has been established in BBWT. Easily distinguished by its oppositely arranged, serrated leaves and clusters of brightly colored flowers. Outer flowers in terminal clusters tend to be shades of pink, red and purple, while the center flowers tend to be various shades of yellow or orange.


Clarence A. Rechenthin @ USDA-NRCS PLANTS Database

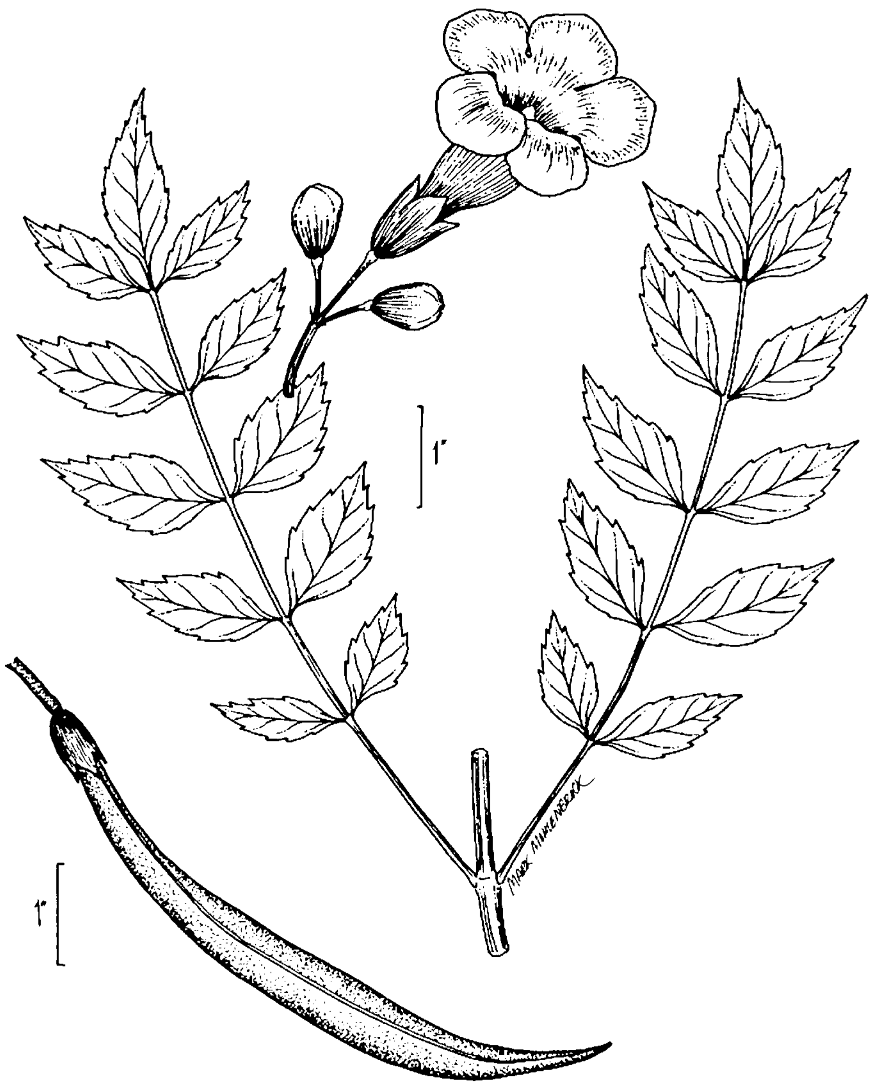
***Sabal palmetto*- Cabbage palm**

Widely planted for landscaping; also occurs naturally in brackish marshes and on the edges of salt marshes. Evergreen with a maximum height of 75 ft. However, cabbage palms in BBWT are young and only 20 ft at most. Easily distinguished by its dissected, fanlike leaves. Dwarf palmetto (*Sabal minor*) is very similar but lacks the stem of cabbage palm, as well as a prominent mid-rib in each leaf segment.

Photos by: Amanda Perdzock

IV. Vines

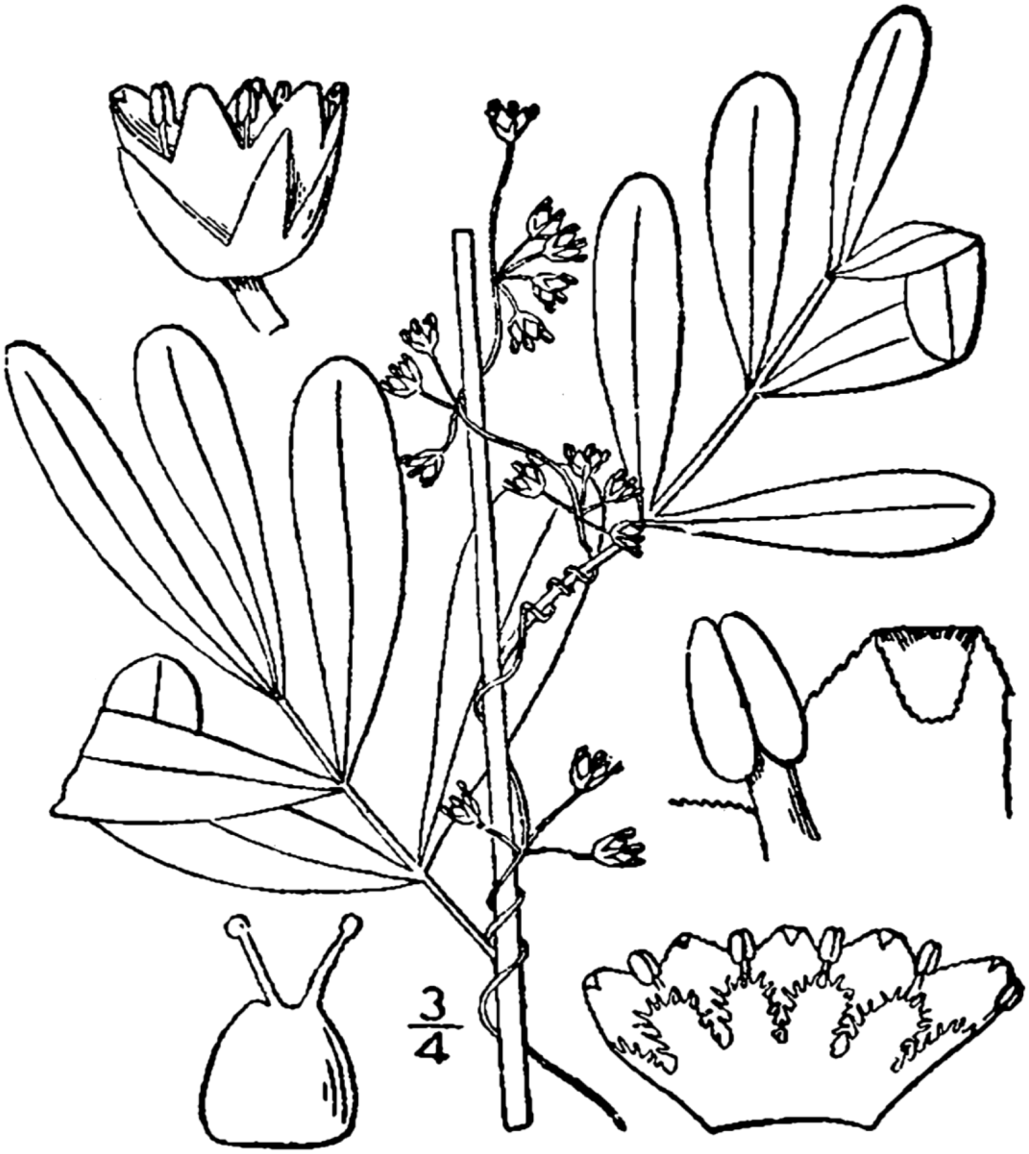
***Campsis radicans*- Trumpet creeper**
A climbing, woody vine with oppositely arranged compound leaves. Found in tidal swamps, forested wetlands, and roadsides. Large flowers are orange-red and tubular with five petals. Distinguished from cross vine (*Bignonia capeolata*; which also has bright tubular flowers) by flower location. Flowers of the cross vine are located in the leaf axils, whereas the flowers of the trumpet creeper are terminal.



USDA-NRCS PLANTS Database. / USDA NRCS. *Wetland flora: Field office illustrated guide to plant species*. USDA Natural Resources Conservation Service.

***Cuscuta indecora*- Pretty dodder**

A yellow parasitic plant which twines around other plants in salt and brackish marshes. Commonly occurs in the BBWT on the branches of groundsel and marsh elder. Minute white petals have pointed lobes, whereas those of the common dodder (*Cuscuta gronovii*) have rounded lobes.



USDA-NRCS PLANTS Database. Britton, N.L., & A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions*. Vol. 3: 50.

***Ipomoea sagittata*- Marsh morning glory**
A wetland indicator species. Found on the edges of brackish and fresh marshes, as well as along moist roadsides. Recognizable by its twinning vines with arrowhead-shaped leaves and large pink to purple funnel-shaped flowers.


Photo by: Amanda Perdzock

***Vigna luteola*- Wild cowpea**

A trailing vine that occurs on the borders of salt, brackish and tidal fresh marshes. Bright yellow, pea-like flowers and leaflets of three make it easy to identify in BBWT.

Clarence A. Rechenthin @ USDA-NRCS PLANTS Database

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Appendix C – Additional Information on Semi-Permeable Membrane Devices

SMPD Design

SMPD sampling equipment was obtained from Environmental Sampling Technologies, Inc., the exclusive license holder for SPMDs, located in St. Joseph, Missouri. The membrane devices are constructed of 99 percent triolein, a natural lipid found in the fatty tissues of organisms. They are surrounded by low-density polyethylene (LDPE) tubing that has a wall thickness of 75 mm (Huckins et al., 2005). This "thin wall" acts as a selective barrier across which only small analytes can access the SPMD lipid (Huckins, 1993).

The lipid becomes a surrogate for organic fat pools, whereas the membrane separates the lipid and aqueous phases, thus mimicking the selective capabilities of biological membranes (Chambers, 1999). Once deployed, the membrane passively accumulates organic compounds due to hydrophobic portioning into the membrane (Gustavson & Harkin, 2000). Since absorption is limited only to the transient membrane pores, it only allows dissolved compounds to transfer. Additionally, because of their high sorptive capacity for non-polar organics, they can detect compounds at small concentrations. The ultra-trace SPMDs can detect trace levels of <1 part per trillion (Petty et al., 2000). For the field investigation, ultra-trace SPMDs were used.

Compounds that Accumulate in SPMDs

The tendency of a compound to accumulate in an SMPD is dependent on its octanol-water partitioning coefficient. Octanol is an organic solvent that is used as a surrogate for natural organic matter and is frequently used in environmental studies to determine the fate of chemicals in the environment (USGS 2008). An octanol-water partition coefficient (Kow) is the ratio of the concentration of a chemical in octanol and in water at equilibrium and at a specified temperature. This value generally indicates the hydrophobicity of compound.

Generally, there is a close correlation between Kow value and the triolein-water partitioning coefficients (Huckins, 1993). Therefore, Kow can be a reliable estimator of a given compound's tendency to concentrate in SPMDs. Charge-neutral compounds with log Kow values of greater than 3 (Huckins et al., 2005) or less than 1 (WRM, 2007) tend to concentrate in SPMDs above ambient levels (Petty et al., 2000). Typical compounds available for uptake are polycyclic aromatic hydrocarbons, polychlorinated biphenyls (PCBs), pyrethroid insecticides, polychlorinated dioxins and furans, organochlorine pesticides, several new generation pesticides, some herbicides, several industrial chemicals, tributyltin, nonylphenols, alkylated selenides, and others (EST, 2009). As a result of their toxicity, these compounds have EC50 values in close proximity to zero and are summarized in Table 2, below.

Summer 2008 Membrane Deployment Protocol

Six membranes (two at each sampling site) were pre-loaded into three 9.5 cm (length) x 4.5 cm (width) (see Figure 5-1) perforated steel canisters and then shipped overnight in hexane-rinsed, gallon-sized tin cans under argon gas (EST, 2009). Samples remained sealed until they were ready for deployment.

After arriving at the field site, the shipping canisters were pried open using the special opener provided. To minimize possible membrane contamination due to exposure to air and residues on hands, the devices were handled with latex gloves and only exposed to the air briefly. The disposable deployment steel canisters were subsequently tethered to a 4 ft steel post using plastic zip ties. The post was then driven upright into the sediments. Throughout the experiment, the devices remained submerged in the BBWT, approximately 5-10 in. above the sediment-water interface. The disposable steel canisters combined with the steel posts allowed for fixed sampling and eliminated migrations problems. The membranes were removed by doing the reverse of the above procedures and shipped on ice to Environmental Sampling Technologies, Inc. in St. Joseph Missouri.

Microtox bioassays tests were conducted according to the standard test protocol described in the Microtox manual (Geis, 2008). The standard dose–response curves method was used to determine the concentration that caused a 50 percent reduction in light response from the luminescent bacteria (Geis, 2008). Positive samples for toxicity were designated ‘toxic’ when their associated EC50 values are below the average lab control, which was 9.4 (μl/ml) in this study (Johnson & Long, 1998).

Uncertainties resulting from Human Error

Error can be avoided in several different ways during sample collection and lab testing. Due to the high permeability of the polyethylene membranes, they must not be overly-exposed to air and must not be touched with bare hands. Doing either of these things could contaminant the membrane which would thus affect the lab-analysis results.

The highest confidence and precision occur with Microtox testing when samples are run in triplicates. The results of these tests should be in general agreement and if they are not in agreement, it can typically be attributed to human/operator error and not general deviation. Operator is the most common source of error, particularly in duplicate testing. These errors occur during sample preparation, salinity adjustment, sample dilution, reagent dilution, sample transfer and mixing steps, data interpretation, and resulting calculations. Use of the proper equipment and development of the appropriate skills required for using the test equipment are necessities in producing quality data.

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Appendix D - Additional Information on the Lower Ninth Ward Community Survey

I. Survey Questions

Bring Back the Bayou 2008 New Orleans Survey
[DEMOGRAPHICS]

Code Number (for confidentiality purposes) ___________
Area of Lower 9th Ward____

1. Name ____

2. Gender
   ____ Male
   ____ Female

3. Age
   ___18-29
   ___30-45
   ___46-60
   ___61-75
   ___76 or older

4. Marital Status:
   ____ Married
   ____ Single
   ____ Single – Widow/Widower
   ____ Single – Divorced

5. Ethnicity
   __African American
   __Caucasian
   __American Indian
   __Asian
   __Hispanic/Latino
   __Pacific Islander
   __Other

[COMMUNITY]

6. How long have you lived in the Lower 9th Ward?
   ___less than one year
   ___1-3 years
   ___3-8 years
   ___8-15 years
   ___15-25 years
   ___more than 25 years

7. Has your family (parents, grandparents) lived in this community for a long time?
   Yes No Don't know

8. If so for how long?

9. Do you have children? If so what ages?

10. How many people are in your household?

11. Do you own or rent your housing?
    a. Own

b. Rent
c. Other_______________________________

12. How long do you plan to live in this area?
___As long as possible
___6-10 years
___3-5 years
___1-2 years
___ Unknown
___ I don't plan to live in this area

13. How would you define your neighborhood geographically?

14. How close do you feel to your neighbors and the community?
Very close Like a family *Close like good friends* *Pretty close (friendly)* *Not too close* *Not close at all*

15. What are you proud of about the Lower 9th Ward?

16. What could be done to make the Lower 9th Ward stronger?

17. What is a good gathering spot in the neighborhood?

18. How do you get information about neighborhood activities?
___Community newsletters
___Bulletin boards/flyers/posters
___Word of mouth
___Community organizers
___Media (radio, TV, Internet, newspapers)
___Other _________________________

19. Do you feel you have enough opportunity to be involved in decisions that impact your neighborhood? If no why?

[STUDENT RESEARCHERS]

20. How do you feel about having outside student researchers working in your neighborhood?

21. What can these teams learn from you and the people that live in the neighborhood?

22. How can these teams work better with the community?

23. Which of the following activities is most important for **volunteers and student researchers** to help rebuild the neighborhood? Of these which do you think is most important? (Read list, check all that apply, then mark most important)
__Neighborhood and/or park clean up
__Tree planting
__Wetland restoration work
__Help neighbors rebuild homes
__Fundraising
__Community Organizing/Planning
__Other

24. What do you think are the most important things **for the city of New Orleans** to improve upon to stay strong for the long-term (read list, check all that apply, then mark most important)
__Housing
__Healthcare
__Improving Transportation
__Stronger Neighborhood Associations
__Restoring Wetland Areas
__Better Education/Stronger Schools
__More Jobs
__Access to food stores

[BAYOU KNOWLEDGE]

25. Have you ever looked over the Florida Avenue Levee/flood wall? Yes No

26. Have you heard of any plans to restore the swamp back-a-town? Yes No

27. If so, what plans?

28. What is the swamp back-a-town like now? (Let them know that it is called the Bayou Bienvenue Wetland Triangle)

29. What was the wetland like in the past?

30. Have you observed any changes? (If they have a lot of experience with the wetland set up a time for an in-depth interview or get contact info so we can interview them later.)

31. What characteristics would indicate a healthy Bayou Bienvenue Wetland (plants/animals/water quality)?

32. How important do you think wetland restoration is for the long-term survival of New Orleans?
    Very important *somewhat important* *neutral* *not very important* *not important at all*

[PREVIOUS AND FUTURE USE]

33. Did you use Bayou Bienvenue Wetland for any of these things)?

Please answer each of the following according to a scale of 1-5:				
Not at all	*About once a year*	*Several times/year*	*1-2 a Month*	*Once a Week*
1	**2**	**3**	**4**	**5**

___Boating	**1**	**2**	**3**	**4**	**5**
___Fishing/Crabbing/Shrimping	**1**	**2**	**3**	**4**	**5**
___Hunting	**1**	**2**	**3**	**4**	**5**
___Walking/hiking	**1**	**2**	**3**	**4**	**5**
___Swimming	**1**	**2**	**3**	**4**	**5**
___Bird Watching	**1**	**2**	**3**	**4**	**5**
___Recreation/relaxation	**1**	**2**	**3**	**4**	**5**
___Other	**1**	**2**	**3**	**4**	**5**
___No Use	**1**	**2**	**3**	**4**	**5**

34. Has there been a time when you used the Bayou Bienvenue Wetland more frequently?
    Yes No
    a. If so, when?

35. Do you use it now? Yes No
    b. How?

36. In the future, how ***would you like*** to use Bayou Bienvenue Wetland?

Please answer each of the following according to a scale of 1-5:				
Not at all	*About once a year*	*Several times/year*	*1-2 a Month*	*Once a Week*
1	**2**	**3**	**4**	**5**

___Boating	**1**	**2**	**3**	**4**	**5**
___Fishing/Crabbing/Shrimping	**1**	**2**	**3**	**4**	**5**
___Hunting	**1**	**2**	**3**	**4**	**5**
___Walking/hiking	**1**	**2**	**3**	**4**	**5**
___Swimming	**1**	**2**	**3**	**4**	**5**
___Bird Watching	**1**	**2**	**3**	**4**	**5**
___Recreation/relaxation	**1**	**2**	**3**	**4**	**5**
___Other	**1**	**2**	**3**	**4**	**5**
___No Use	**1**	**2**	**3**	**4**	**5**

37. Have you visited the platform? Yes No

    a. Why or Why not?

[SAFETY AND RESPONSIBILITY]

38. In your opinion, how safe is the quality of water in the Bayou Bienvenue Wetland?
    Very safe somewhat safe neutral unsafe very unsafe

39. Do you feel that it is safe to eat fish/crawfish/shrimp/crabs from the wetland?
    Very safe somewhat safe neutral unsafe very unsafe

40. What would convince you that the seafood from the Bayou Bienvenue Wetland is safe to eat?
41. Do you eat fish from other bodies of water nearby (industrial canal, Mississippi River)?
    Yes No
    a. Have you in the past?

42. Do you think it is a benefit or a nuisance to have a wetland in your community?
    a. Why?

43. Some people have said that the wetland should be restored to a cypress swamp. (Mention that it used to be a cypress swamp and show pictures.)
    a. Do you think Bayou Bienvenue can be restored to a cypress swamp?
    b. If so, what needs to be done?

44. If so, how long do you think this process will take?
    ___less than 3 years
    ___3-5 years
    ___6-10 years
    ___more than 10 years

45. If residents are concerned about the water in the Bayou Bienvenue Wetland whose responsibility is it to take care of the issue?
    a. Individuals
    b. Community
    c. City Government (mayor, police dept., etc)
    d. Parish Government
    e. State government (LDEQ, LDNR)
    f. Federal Government
    g. Other: ___________________________________

46. Would you contact them if you noticed a problem? Yes No Maybe

Tourism

47. If the Bayou Bienvenue Wetland is restored, how do you think it will benefit the residents of the Lower 9th Ward?
48. How do you feel about the tourists visiting the Lower 9th Ward now?

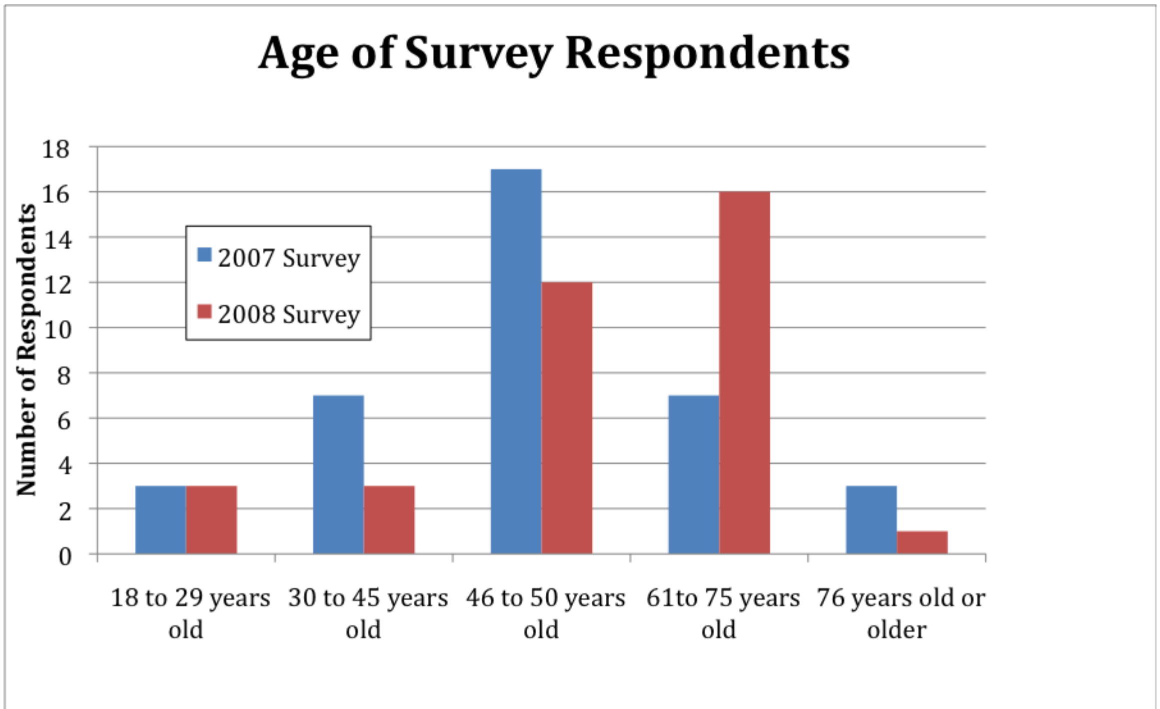
49. In your opinion, could future tourism benefit the residents of the Lower 9th Ward?

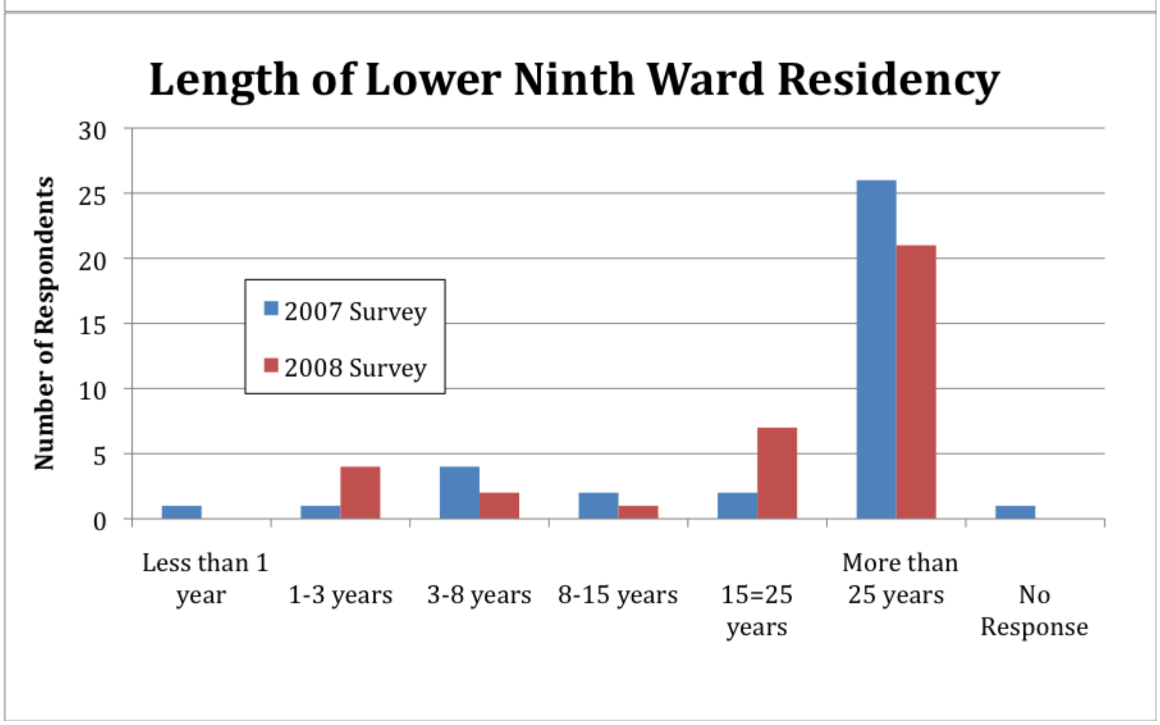
50. Would you like to see any of the following facilities located at or near the bayou?
    Yes or No
    ______Education/research
    ______boat rentals
    ______fish cleaning station
    ______Restaurants/Shops
    ______Walking trails/interpretive signs
    ______Other (please provide example)_____________________________
    ______No facilities

51. Would you be interested in any of the following events (read to participants):
    ___educational workshops on wetlands
    ___educational workshops on cypress swamps
    ___educational workshops on wetland plants and animals
    ___educational workshops on fishing/crabbing/shrimping and hunting in the wetland
    ___Other: ____
    ___I'm not interested in any workshops
    ___ Children's' activities

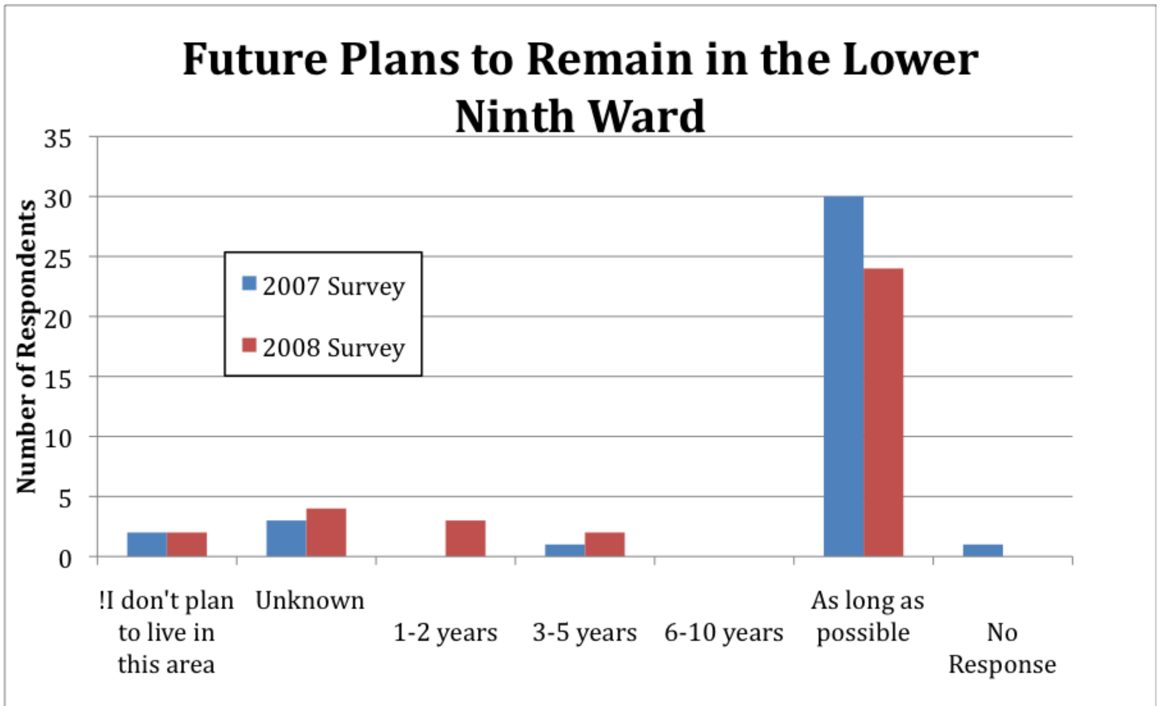
II. Demographic Charts

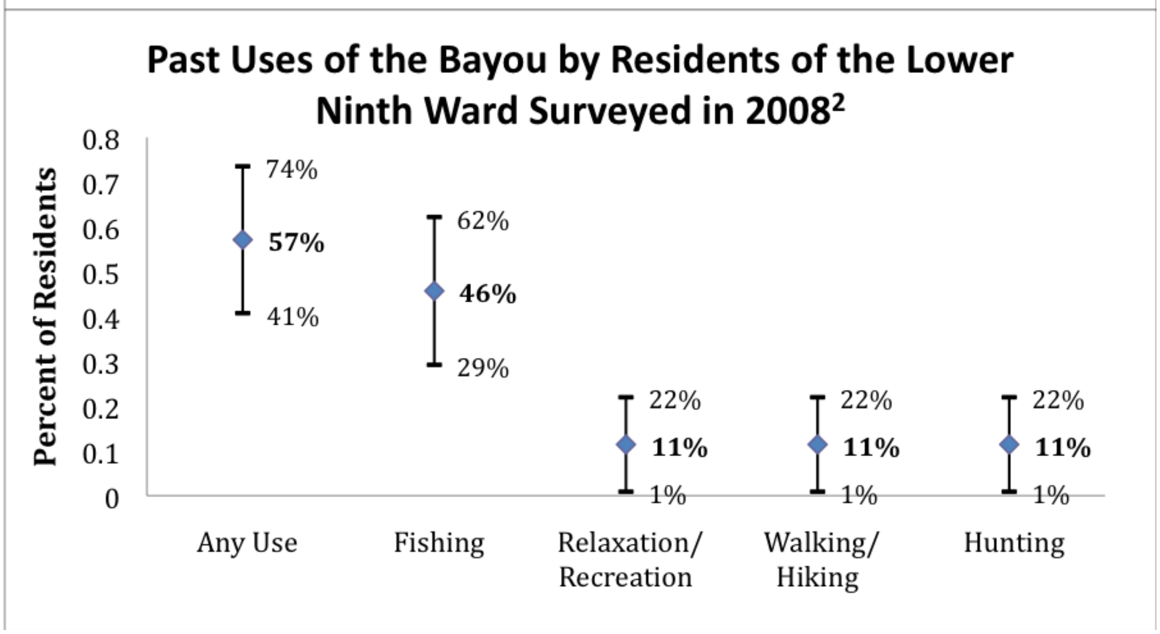
Keeley-Yonda, Jennifer[45], Mukerjuri, Nina[42], Ross, J. Ashleigh



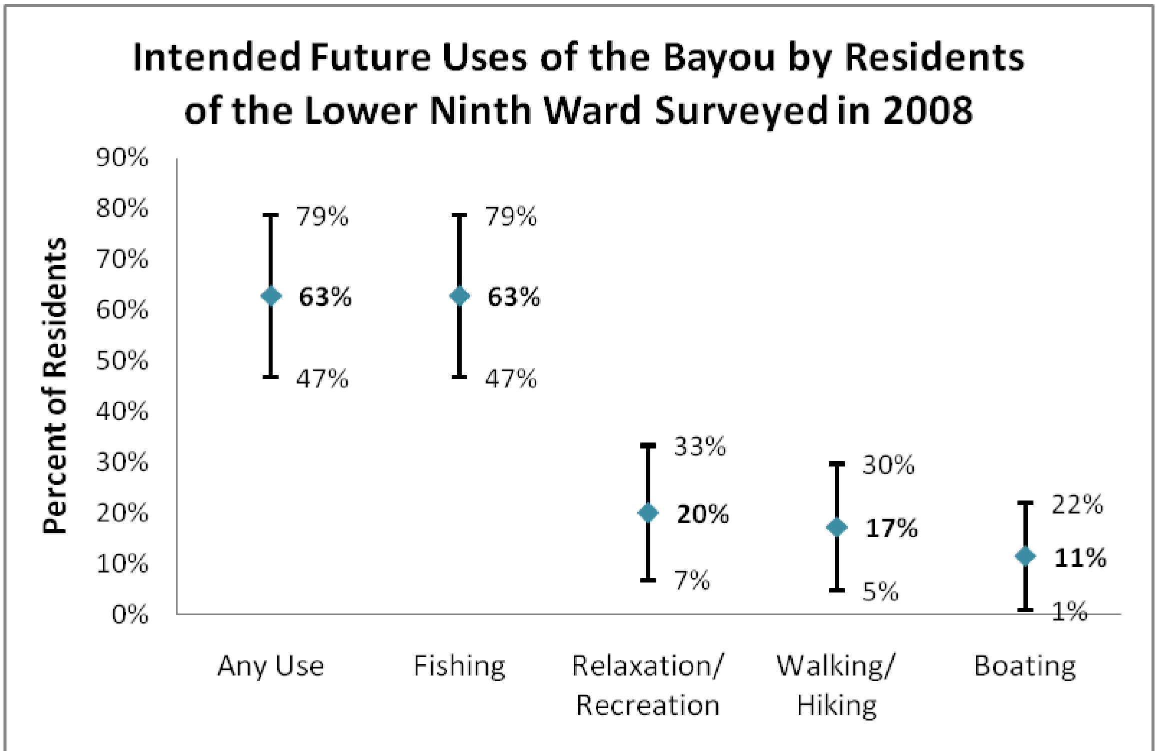


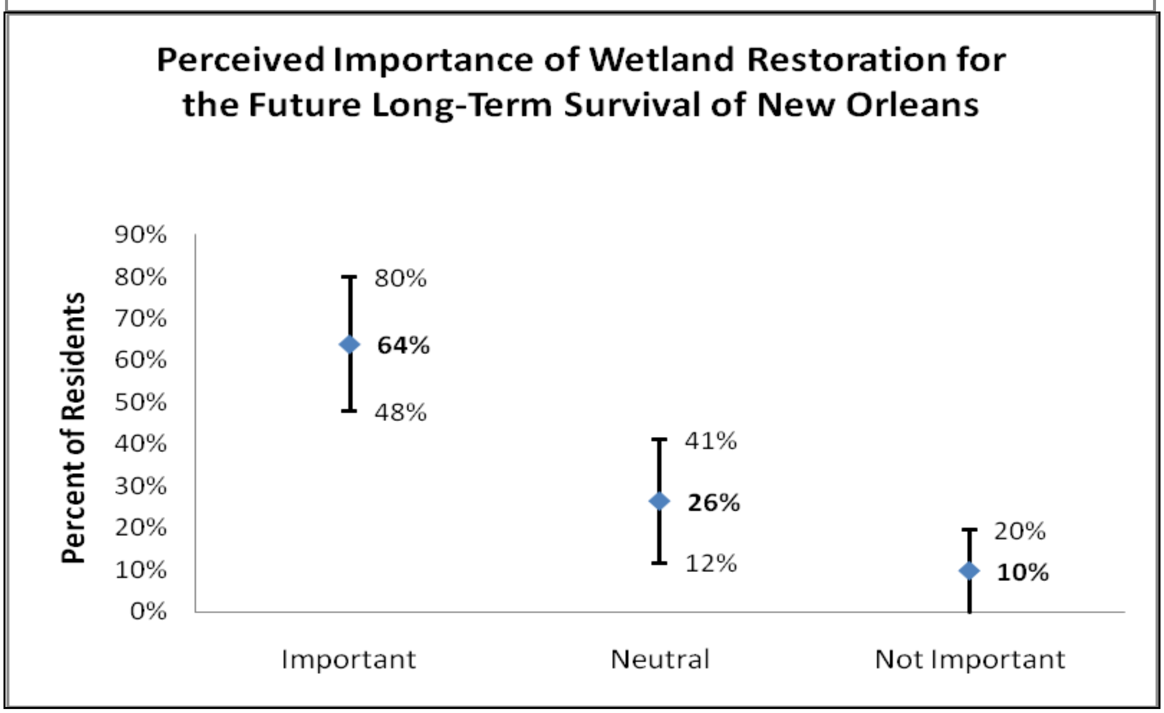
[45] UW-NOLA 2009 Group

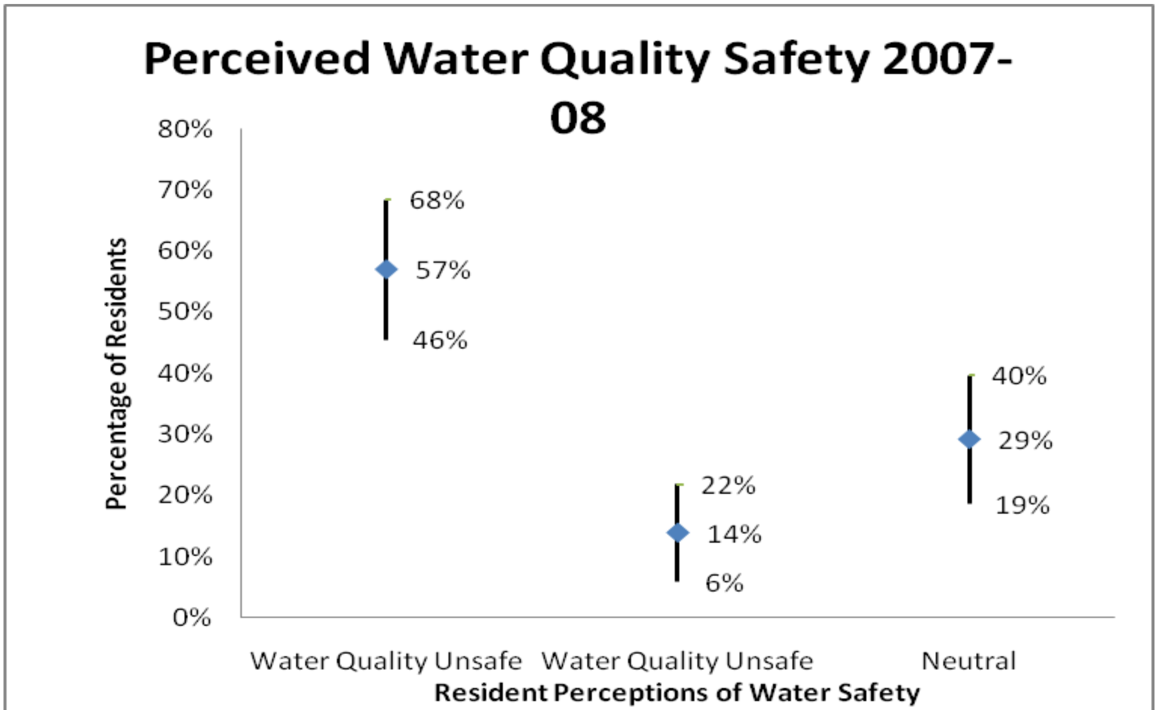


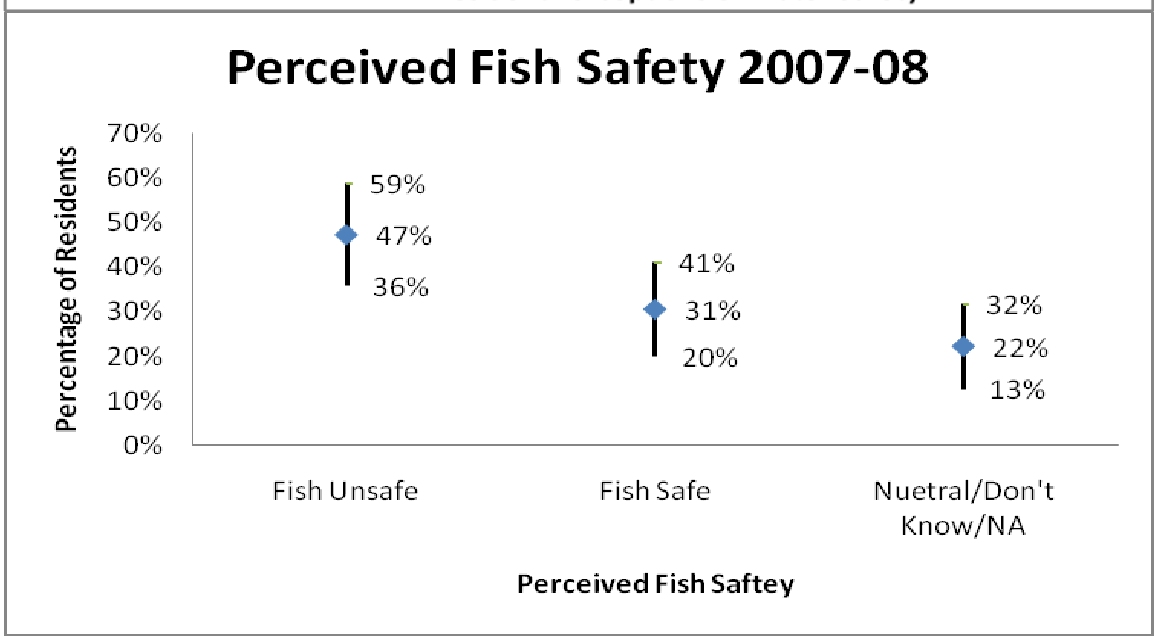


[46] All error bars correspond to a 95% Confidence Interval


Intended Future Uses of the Bayou by Residents of the Lower Ninth Ward Surveyed in 2008
Percent of Residents
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
79%
63%
47%
79%
63%
47%
33%
20%
7%
30%
17%
5%
22%
11%
1%
Any Use
Fishing
Relaxation/ Recreation
Walking/ Hiking
Boating


Perceived Importance of Wetland Restoration for the Future Long-Term Survival of New Orleans
Percent of Residents
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
80%
64%
48%
41%
26%
12%
20%
10%
Important
Neutral
Not Important


Perceived Water Quality Safety 2007-08
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Residents
68%
57%
46%
22%
14%
6%
40%
29%
19%
Water Quality Unsafe
Water Quality Unsafe
Neutral
Resident Perceptions of Water Safety


Perceived Fish Safety 2007-08
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Residents
59%
47%
36%
41%
31%
20%
32%
22%
13%
Fish Unsafe
Fish Safe
Nuetral/Don't Know/NA
Perceived Fish Saftey

Appendix E – Interviews with Lower Ninth Residents

As part of the research for this study, a series of interviews were conducted with neighborhood residents, focusing on the environmental history of the Lower Ninth Ward and residents' relationships with the surrounding natural resources.

The format of these interviews was informal. Some of were audio taped, some videotaped and others were not recorded. The participants were selected through neighborhood referrals and other networks.

Many of the interviewees are affiliated with the Holy Cross Neighborhood Association or other neighborhood organizations. These residents are all leaders in the efforts to restore the Lower Ninth Ward. An interesting component of these efforts is a focus on the environment, including not just the BBWT, but also broader issues such as energy efficiency and carbon neutrality. These interviews discuss different aspects of this environmental focus, drawing connections between the neighborhood's past, its present situation, and future aspirations.

It should be noted that the viewpoints and experiences expressed in these interviews do not necessarily represent the neighborhood as a whole. However, they do provide an interesting window into the neighborhood's past and the visions some have for its future.

> *"Building a neighborhood that can survive, that is climate neutral, carbon neutral, prosperous and beautiful. That is one aspect [of an environmental justice approach]. Another aspect is the restoration of Bayou Bienvenue. And that is something that is very, very close and dear to so many people, because that goes straight to the heart of environmental justice. It's about protecting the community, but it's also about really connecting to a beautiful area that is a huge resource for us, aside from the protection aspects.*
>
> *It's about educating children and adults about the natural world. And it's about economic development too. The birds are important too, and the fish we eat. You know that people fish. It's all interrelated. And we really started [to be concerned about these issues] pre-Katrina with the Industrial Canal thing because [of] the contamination of the surrounding water. And there were presentations and pictures of fish that were diseased, etc. People fish in these bodies of water, there are probably people fishing on the bayou right now ... But we began making that connection in people's minds and that is something we've got to continue."*
>
> —Pam Dashiell, Lower Ninth Ward resident, community activist, and former president of the Holy Cross Neighborhood Association

Perhaps the local resident with the most knowledge about the BBWT is John Taylor. Taylor has lived in the Lower Ninth Ward for most of his life, and has visited the BBWT almost every day. He has witnessed its change from a cypress-tupelo swamp to open water marsh first-hand. Taylor remembers not only the changing fish species, but the incision of the openings in the spoil-bank (sample locations SBC 1, 2, and 3) which separates Bayou Bienvenue from the BBWT. Interestingly, Taylor attributes the degradation of the freshwater swamp to these spoil bank openings. He described these events in a series of interviews:

> *"It was beautiful. All the cypress trees that you see, the stumps [of] what you now call the Florida Avenue triangle used to be called Logger Bayou… People craw-fished along here… In the '50s and '60s people came along and caught perches and green trouts[49]. They [would] sit around the levee. They didn't have the concrete and the steel pilings and levee protection [that are there now]. Never even had on the other side, they had trees, I mean real trees. You look down where you all put the boat down, they had trees. You pick yourself a tree, take a stick and move the lilies around and you had a nice place to fish under a shady tree. I mean actually, it was a beautiful place... At that time people were scared to go back there 'cause there were a lot of snakes back there. The swamp was young, in its prime. I even made money, school money, clothes money, going back there pulling Spanish moss from the trees. It phased out in the 60's, but they used to put it in the mattresses… things was done down here longer then they was done in other places. This place was more primitive then other places.*
>
> *"… Those little openings[50] that they put in after Betsy[51] … it started making the water change from fresh water to brackish water. It started killing the cypress trees. Cypress trees cannot tolerate salt water… It's a gap between time because about in the 70's, I left to get a job and when I come back, all the color in the trees were gone. The cypress had stopped growing but they were still standing. They still had moss growing so it gave them a mythic look, between the moss was grey and the trees were gray… The moss lasts longer because the moss feeds off the tree… Moss is a fresh water species too…it was breaking down slowly.*
>
> *"You still had perches in some parts of it which was fresh water. See in the front of the plant[52], right in the front of the plant, see where those trees are? That came all the way across. So there was one little part[53] that was blocked off from this part in front of the plant, and it was still freshwater. But it was one spot and the perch stayed so long they got huge. And some kind of way, some idiot did the same way. They cut a little bitty hole, and then the water started going in there and now the perch is gone… That is what happened, I watched it die out. They had fresh water fish in it. Now it only has mullet, crab and gar fish.*

---

[49] These likely refer to the white crappie (*Poxomis annularis*; also referred to as "white perch" or "sac-a-lait" in French), and the largemouth bass (*Micropterus salmoides*), both of which are freshwater species.
[50] (Referring to the incisions in the spoil bank separating the BBWT from Bayou Bienvenue)
[51] At this time, the MRGO had also just been completed.
[52] The East Bank Wastewater Treatment Plant
[53] Referring to the western end of the BBWT, where the last cypress tree remains, and where the cypress "ghosts" (stumps) are most intact.

"… It was a gradual change. So the change was taking place, but as a kid you just adapted to the changes and you continued to have fun. If I would have been educated to environmental ecosystems and things like that, then I could have rang the bell or blown the trumpet on it. But it was going on… I really couldn't tell you when it first started. I can tell you that I looked back there and there were a bunch of dead cypress trees standing tall. And… when I look back there, all the trees have gone away and they've become stumps. Something took place, for instance then the lilies showed up which was a beautiful sight because they blossomed into a nice different color flower… But at the same time it was a warning sign because lilies shouldn't have been in the water…

"And you started noticing that [the distance to] the shore line was shorter [due to erosion]. Then the word went out through the grapevine… that kids was actually swimming back there… So all these things were happening, but we didn't know what change was going on. Really the world is on that level, where they are just starting to learn to read the wetlands. And they are just starting to find out that the wetland and the nature of the wetlands is truly your nature too… When you ignore a symptom that is going on in you until it rebels and hits you hard, then you're ready to go to the doctor to see what's wrong. In our case we got hit with water and it got our attention."

"No one had time to think about restoring a swamp. The only time they wanted a swamp was to go hunt a raccoon out of the tree. Because we ate wild things and we still do. And me, I'm not ashamed of it. But when we went hunting, we didn't go hunting for a sport… We didn't hunt in camouflage pants and a hunting suit. We went hunting with a shot gun and three shells, and hoping every time we shoot would be lucky enough to get three rabbits. But if you were unlucky enough to miss three times, you had no shotgun shells and no rabbits. Even in stores in our neighborhood you could buy shotgun shells, single shotgun shells; we didn't have to buy a box… Things were different. Twenty-twos were two cents a piece.

"You had six cents, you'd buy three bullets and go stalk a rabbit, sneak up on him and pop him, and go home and eat him. Or sell it to someone for $1.50 on the way back and get yourself a little bottle of wine or beer, or whatever you wanted to do with it. It was a living. It wasn't a sport."
—John Taylor, Lower Ninth Ward resident and local bayou expert

"I was raised down here [and] that was part of the community that was a necessity because we was able to go crabbing, we caught crabs out of there, we went fishing down there, we went canoeing down there. …. It made us independent. It's like the little saying they say: you can keep giving me a fish or you can teach me to fish. And this bayou, we learned how to fish, we learned how to survive. And to not have it back, you taking, I would say, the most valuable part of a community away. In order to bring the community back you need to bring the bayou back…"

"It wasn't like no overnight thing, it was a gradual thing. And what we did was disconnect the way we was brought up and the way we was raised. And I'm gonna to tell you, it goes deeper then you think. And that is why I named this building the "village". Because it takes a village to raise a child but more than that, takes a village to raise a family. So, we had that kind of mentality here and we believed in the bartering system. We grew gardens and we had chickens and we had goats. And what we would do when we didn't have money, is we would trade the things we had ... I'm 54 now and I can't never remember going hungry."
—Mack McClendon, founder of the Lower Ninth Ward Village (community center) and life-long Lower Ninth Ward resident

"They made use of the natural resources that were available for food and they enjoyed it… Some people dealt with squirrels, but most dealt with rabbit. Some people even dealt with alligator and the cowan[54]. The turtles… the wild duck and the fish, those was most of the stuff that we would eat."

"What happened with the generation 50 and under, they started making money and they weren't connected with what was going on back there. They just lost the connections and it's a shame, because a lot of the time the parents did teach them about that. Like my husband took my son hunting and he still goes hunting today. He deer hunts and he goes out and hunts and uses the food and he brings his younger brother and they go fishing. But the others, they just disconnected. So they weren't even involved in what was going on…"
—Arletta Pittman, Lower Ninth Ward resident

"We now want to redevelop the old high school campus in the neighborhood and rehab buildings, build new ones… that are energy efficient and sustainable. We feel like that is our marketable niche. That is why everyone is coming to us—tourists and others… coming to the neighborhood wanting to see the Global Green house, wanting to see this, wanting to see that. We feel like we have a good niche here…. It just kind of evolved that way. We were really focused on getting the neighborhood back on its feet … in a sustainable manner. We didn't think it would become this attraction…. It's really viable for us economically speaking."
—Charles Allen III, President of Holy Cross Neighborhood Association

[54] Creole vernacular for turtles.