Appendix 1
Economic Consequences: Direct Property Damages

Objective

The objective of the direct economic consequence effort is to estimate the economic cost of the physical damages to property in the greater New Orleans floodplain resulting from the extensive flooding following Hurricane Katrina. Flood waters inundated large sections of the city, damaging and destroying homes, businesses, public buildings (schools, hospitals, churches), and essential public facilities like roads and utilities. The study team assessed physical flood damages via a deliberate, multi-step evaluation of the property at risk in the New Orleans region. Property was identified and categorized according to primary usage, location in the floodplain and structural characteristics, i.e. – construction materials, foundation type, number of floors, etc. This combination of factors establishes the degree to which the property is susceptible to flood damages.

To facilitate this investigation, a GIS-based model was developed to assess the damages to structures, their contents, and vehicles in portions of Orleans, Jefferson, St. Bernard, Plaquemines and St. Charles parishes. In a separate, but related analysis, damages were also estimated for roads, utilities and other important infrastructure in the floodplain. Direct impacts were evaluated under three scenarios:

1. The Actual scenario – Katrina overtops portions of the flood-protection system, and the levees and floodwalls are breached.

2. Hypothetical Katrina scenario #1 (Resilient Levees) – Levees and floodwalls crest elevations are at their pre-Katrina levels. Katrina overtops portions of the flood-protection system, the levees and floodwalls maintain their integrity and do not breach, and interior pumping is as occurred during Katrina.

3. Hypothetical Katrina scenario #2 (Resilient Levees and Pumps) – Levees and floodwalls crest elevations are at their pre-Katrina levels. Katrina overtops portions of the flood-protection system, the levees and floodwalls maintain their integrity and do not breach, and interior pumping is at 100% availability.

4. Hypothetical Katrina scenario #3 (Resilient Floodwalls) – Levees and floodwalls crest elevations are at their pre-Katrina levels. Katrina overtops portions of the flood-protection system. Overtopped levees incur scour as in Katrina but the floodwalls maintain their integrity and do not breach, and interior pumping is as occurred during Katrina.

5. The Post-Katrina scenario – For this scenario, the conditions expected to prevail in June 2006 are expressed in terms of property at risk in the floodplain and potential for damages in the coming hurricane season. These post-Katrina stage-damage functions are used by the Risk and Reliability Team to assess the residual risks in the greater New Orleans area.

In scenarios 1, 2, 3, and 4, the property in the floodplain is the same. The only difference is the performance of the protection system. This highlights an important point for scenario 5, or for any other future scenario that would be evaluated for risk exposure. The reliability of the protection system and the development plans for the floodplain should both be considered mechanisms for managing flood risk.

The economic consequences considered include 1) direct property damages, and 2) indirect economic impacts on local and regional economies. Direct property damages represent monetary damages to the following types of property at risk: residential, commercial, industrial, public buildings, vehicles and infrastructure. Direct property damages were calculated for both the actual and hypothetical (without system failure) Katrina event scenarios, except for damages to infrastructure, which were calculated for the actual Katrina event only. For the probabilistic risk scenarios, both pre- and post-Katrina stage-damage functions for properties, which are based on base property conditions expected to prevail in June 2006, provide the means to estimate residual property damages associated with the hurricane protection system once Katrina-related damages to the system have been repaired.

Conceptual Model of Flood Damage Assessment

In the face of a given storm event, the combination of system performance and property in the floodplain determine the level of physical flood damages. The typical flood damage assessment process is diagramed in Figure 1-1, a schematic representation from FEMA's HAZUS-MH model. The figure shows a combination of five layers that determine the consequences of flooding in a given area. Layer (a) displays the topographic (ground elevation) data for the study area. When storm surge and rainfall runoff are combined with the ground elevation data, the peak water surface elevation can be calculated and used to determine flood depths across the study area, as shown in layer (b). The location of property and population in the floodplain (c) are overlaid on the areas of flooding to determine (d) flood damages and (e) social and economic consequences. The process of gathering the data for the present analysis is described in the following paragraphs and related to the layers of this schematic for clarity.

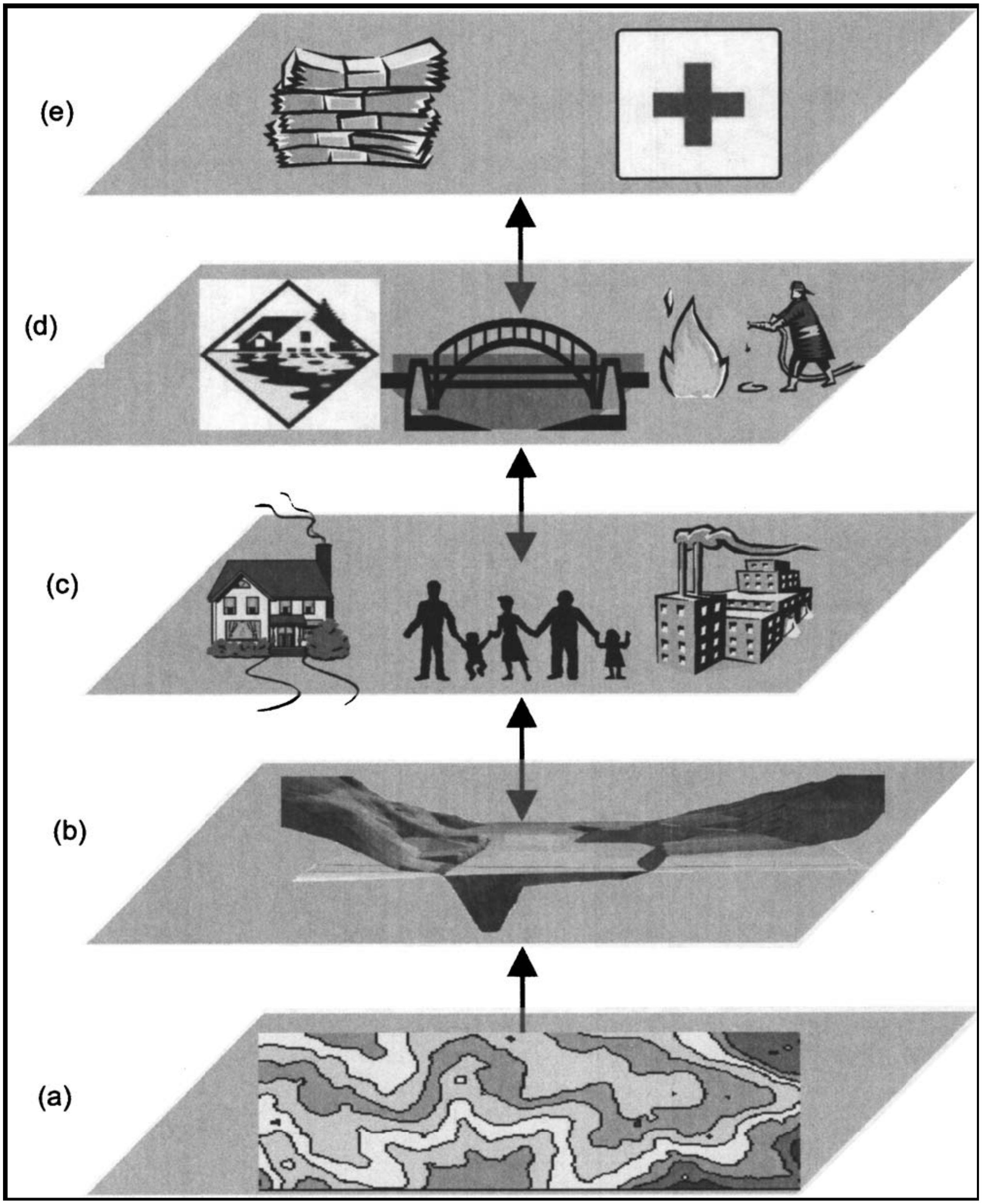

Figure 1-1. Schematic Representation of Flood Loss Estimation Source: Scawthorn, (2006)

Topographic data (a) was provided by the Engineering Research and Development Center (ERDC) in the form of digital elevation models (DEMs) created with a LIDAR (Light Detection And Ranging) process, an aerial mapping technique used to create topographic maps. The DEMs have been adjusted to the NAVD88 2004.65 epoch to be consistent with other elevation data used in the IPET investigation.

Water surface elevations, layer (b), were determined via a combination of simulations with interior flooding models and surveyed high watermarks left behind by the Katrina flooding. Water surface elevations will be further discussed in the Results section of the report.

FEMA's HAZUS-MH model was used to develop the structure inventory, layer (c), and members of the IPET team developed a GIS-based model to manage and map the property data to facilitate the calculation of flood damages, layers (d) and (e). These three pieces, (c) through (e), structure inventory through damage calculations, comprise the bulk of the work undertaken in the direct damages assessment and are explained in detail in this section of the report.

Structure Inventory. The first pieces of the structure inventory were developed using the HAZUS-MH (MR1, Release 39 copyright 2004) software package. HAZUS-MH is a collection of models developed by FEMA and the National Institute of Building Sciences (NIBS) to estimate potential losses from floods, hurricane winds and earthquakes. The general building stock component of HAZUS was used to quantify development within the study area. The building stock database identifies, by census block, the square footage, building count, and depreciated exposure value for the residential and non-residential structures in the five-parish area.

The beginnings of the structure inventory were established by aggregating, within HAZUS, the number of square feet in each census block that is identified as residential and non-residential property. The model combines data from the 2000 Census and the Department of Energy Building Characteristic Reports to allocate the total square footage among six residential occupancy categories:

- Single-family dwellings,
- Manufactured housing/mobile homes,
- Multi-family dwellings,
- Temporary lodgings,
- Institutional dormitories, and
- Nursing homes.

A similar procedure used a Dun and Bradstreet database to identify the square footage in each of 27 non-residential occupancies, broadly categorized as commercial, industrial, public, and agricultural. Table 1-1 displays the HAZUS-MH occupancy categories and the eight stage-damage categories into which they were organized.

TABLE 1-1 HAZUS-MH OCCUPANCY CATEGORIES AND STAGE-DAMAGE CATEGORIES				
HAZUS-MH Occupancy		**HAZUS Definition**	**Occupancy Example**	**Stage-Damage Category**
1	RES1	Single Family Dwelling	1-Sty/2-Sty/Slab/Pier	SINGLE FAMILY
2	RES2	Manufactured Housing/Mobile	Manufactured Housing	MOBILE/MFG
3	RES3A	Multi Family Dwelling - small	Duplex	MULTI-FAMILY
4	RES3B	Multi Family Dwelling - small	Triplex/Quads	MULTI-FAMILY
5	RES3C	Multi Family Dwelling - medium	5-9 units	MULTI-FAMILY
6	RES3D	Multi Family Dwelling - medium	10-19 units	MULTI-FAMILY
7	RES3E	Multi Family Dwelling - large	20-49 units	MULTI-FAMILY
8	RES3F	Multi Family Dwelling - large	50+ units	MULTI-FAMILY
9	RES4	Temp. Lodging	Hotel, medium	MULTI-FAMILY
10	RES5	Institutional Dormitory	Dorm, medium	MULTI-FAMILY
11	RES6	Nursing Home	Nursing home	MULTI-FAMILY
12	COM1	Retail Trade	Dept Store, 1st	COMMERCIAL
13	COM2	Wholesale Trade	Warehouse, medium	COMMERCIAL
14	COM3	Personal and Repair Services	Garage, Repair	COMMERCIAL
15	COM4	Professional/Technical/Business	Office, Medium	COMMERCIAL
16	COM5	Banks	Bank	COMMERCIAL
17	COM6	Hospital	Hospital, Medium	COMMERCIAL
18	COM7	Medical Office/Clinic	Med. Office, medium	COMMERCIAL
19	COM8	Entertainment & Recreation	Restaurant	COMMERCIAL
20	COM9	Theaters	Movie Theatre	COMMERCIAL
21	COM10	Parking	Parking garage	COMMERCIAL
22	IND1	Heavy	Factory, small	INDUSTRIAL
23	IND2	Light	Warehouse, medium	INDUSTRIAL
24	IND3	Food/Drugs/Chemicals	College Laboratory	INDUSTRIAL
25	IND4	Metals/Minerals Processing	College Laboratory	INDUSTRIAL
26	IND5	High Technology	College Laboratory	INDUSTRIAL
27	IND6	Construction	Warehouse, medium	INDUSTRIAL
28	REL1	Church	Church	PUBLIC
29	AGR1	Agriculture	Warehouse, medium	AGRICULTURAL
30	GOV1	General Services	Town Hall, small	PUBLIC
31	GOV2	Emergency Response	Police Station, Fire	PUBLIC
32	EDU1	Schools/Libraries	High School	PUBLIC
33	EDU2	Colleges/Universities	College Classroom	PUBLIC
34	n/a	n/a	Automobiles	VEHICLE

Notes:
1. Residential Single Family Dwellings (RES1) include one- and two-story structures, and slab and pier structures.
2. Private autos were estimated external to HAZUS-MH Program and valued using 2005 prices.

Once the number of square feet is determined for each occupancy category, the HAZUS model is used to calculate the depreciated exposure value of the property in each census block. The model contains unit replacement costs, at 2002 price levels, for each occupancy category. The unit cost for each category is multiplied by the square footage in the same category to calculate replacement values for the structures in that category. The appropriate measure of economic loss is the depreciated values, so the model uses the average age of the structures in a census block to determine the appropriate depreciation factor from a built-in depreciation schedule. The corresponding depreciation factor is applied to the replacement value to produce the depreciated replacement value for structures in each occupancy category. This process is repeated for all census blocks in the study area to produce a database of depreciated structure values that are exposed to the flood hazard. These values are referred to as depreciated exposure values.

The HAZUS model provided a third piece of information for the structure inventory; a count of structures in each census block, derived from the square footage data and the known mix of occupancies. Therefore, the three contributions of HAZUS-MH to the analysis include the square footage, depreciated exposure value, and estimated building count, sorted by occupancy category and aggregated by census block. Other information is required to complete the structure inventory so that flood damages can be calculated. This other information includes first-floor elevations, foundation type, content values, and construction type (wood, masonry, stucco, steel) for structures in the inventory. These data were developed outside of the HAZUS flood model and were integrated with the HAZUS data in a GIS-based model developed by the U.S. Army Corps of Engineers, New Orleans District.

The flow chart in Figure 1-2 shows the details of the flood damage calculations.

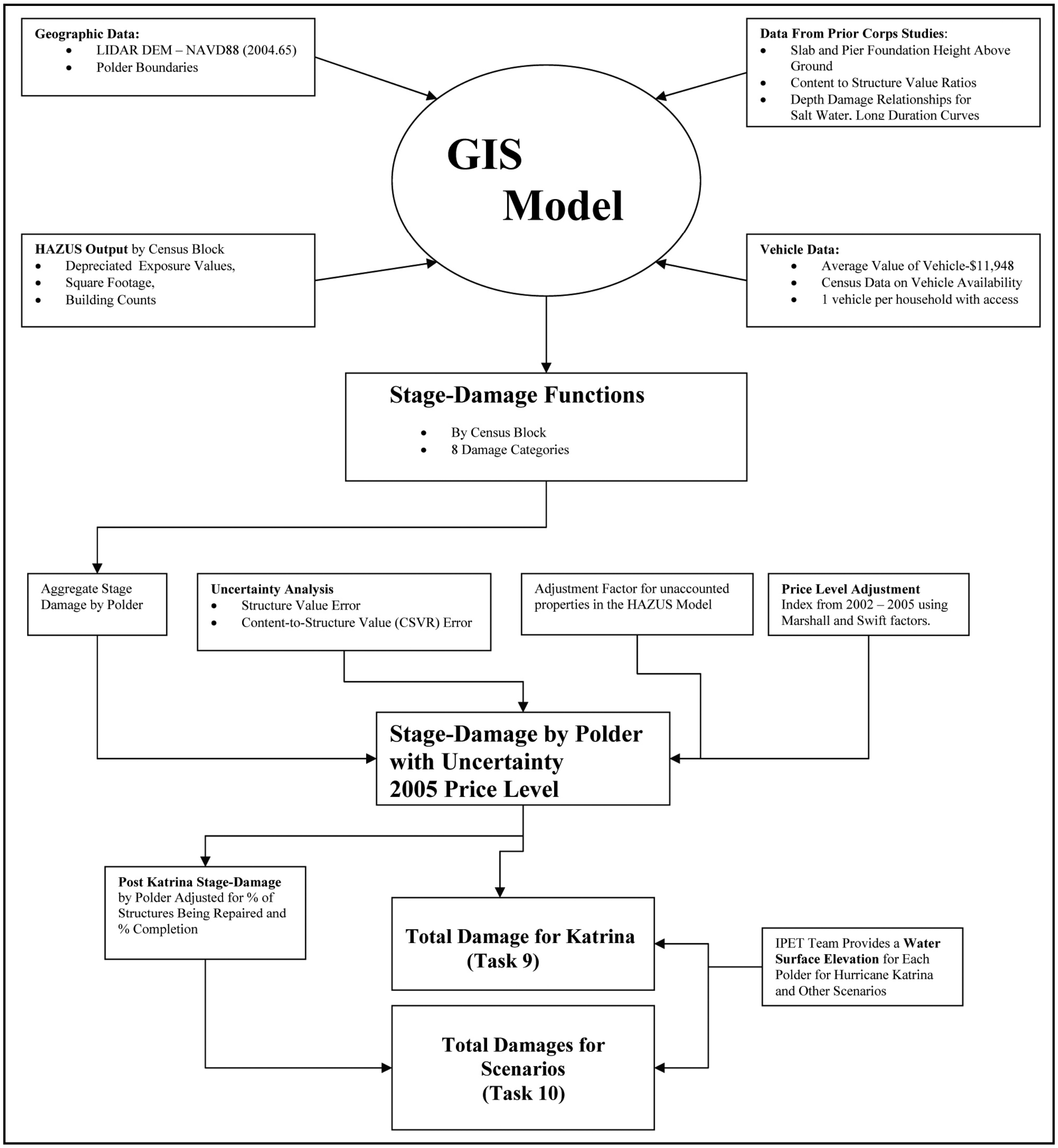

Figure 1-2: Flow Chart of Flood Damage Calculations in GIS-based Model

Stratification of Residential Structures by Number of Stories and Foundation Type. The HAZUS output aggregated all single family dwellings into one occupancy category; however, previous Corps studies have determined the relative percentages of homes by number of stories and foundation types. These home characteristics have a bearing on damage results, so the findings of previous studies were used to further stratify the single family home category. Accordingly, the depreciated exposure values were allocated to one-story and two-story structures, with pier and slab foundations.

Residential and Non-Residential Contents Valuation. Another consideration in the calculation of flood damages was the contents of the structures. For residential structures, contents include furniture and other belongings, as well as property that may be stored outside of the home. Different floor plans can allow homeowners to distribute their contents differently, thereby altering the potential damage to contents. For example, a two-story home would have furniture and other belongings on the second floor where it would presumably have a lower risk of damage than if all furnishings were on the first floor. A home with a basement may have even more property at risk, depending on the value of items kept in the basement level.

Commercial structures would exhibit similar variances in damage susceptibility depending on the use of the property. For commercial or public structures, the contents include inventory, equipment, and office furniture. The occupancy category of commercial and public structures will greatly affect the value of the contents. For example, grocery stores, professional offices, manufacturing firms and churches will have contents that serve their primary operations and the value of those contents in relation to the value of the structure will differ greatly from one entity to the next.

The value of contents for residential (one-story, two-story, mobile homes, and multi-family) and non-residential (seven categories) structures were based on limited field surveys and the experience of a building and insurance expert panel for the Southeast Louisiana (SELA) Flood Control Feasibility Studies in 1996. A representative sample was developed of structures in the floodplain, and an expert panel was assembled to develop estimates of the content values of those structures. Prior to convening the expert panel, interviews were conducted with a sample of homeowners and business owners/managers in each of the categories of residential and non-residential structures. During the interviews, contents of each structure were inventoried and for the residential structures, videotapes were made of the inventoried contents. Expert panels were then convened to review the structure categories under consideration and determine the estimated value of the contents of those structures. A multi-step process was employed to develop estimated value of contents for the structures. First, each panel member developed their own estimate of content value based on a description of the structure's characteristics, i.e. number of rooms, bathrooms, square footage, and age of construction. The panelists then viewed a videotape of the sampled home inventories. Following the video, the panel discussed a "typical" contents list for each category of structure based on the inventories and estimated the value of the items on the list. The value of the contents of each structure category were totaled and then compared to the total value of the structure in order to develop contents-to-structure ratios (CSVRs).

The structure values were developed using the Marshall & Swift (M&S) Residential Estimator software package. Marshall & Swift estimating tools enable users to develop cost-based appraisals of individual properties. Characteristics of individual structures were entered into the estimator from data gathered during field surveys. The software then provided depreciated replacement values for the structures.

More specific detail regarding the development of the content values can be found in the final report dated June 1996 entitled *Depth-Damage Relationships for Structures, Contents, and*

Vehicles and Contents-to Structure-Value Ratios (CSVRs) in support of the Jefferson and Orleans Flood Control Feasibility Studies. (USACE, 1996).

The CSVRs developed for each of the four residential structure categories and seven commercial structure classifications are shown below:

Residential:

- One-story - 69%
- Two-story - 59%
- Mobile home - 79%
- Multi-family residence - 37%

Commercial:

- Eating and Recreation - 114%
- Grocery and Gas Station - 127%
- Professional building - 43%
- Public and Semi-public Building - 114%
- Repairs and Home Use - 206%
- Retail and Personal Services - 142%
- Warehouse and Contractor Services - 168%

The GIS model multiplied the total exposed value by the appropriate CSVR to determine the total value of the content for each residential and non-residential occupancy. The commercial CSVR's were assigned to the appropriate HAZUS-MH non-residential occupancy categories.

Structure Elevation Data. The first floor elevation is the common reference point for depth-damage functions, so the spatial distribution of the structures in the inventory had to be analyzed to determine estimated first floor elevations. The first floor elevation of any given structure is controlled by a combination of ground elevation and height of the structure's foundation. Accordingly, the Lidar DEM data were combined with census block boundaries to determine the mean ground elevation for each census block in the five-parish area. An additional increment was then added to the ground elevation to account for the foundation height. The result was a representative first floor elevation for the structures in each census block.

The estimated foundation height was not applied uniformly to all structures across the individual census blocks. Information developed in prior USACE studies was used to determine the appropriate foundation height. The foundation height applied to residential structures is based on the results of a first-floor elevation survey conducted by Corps personnel in 1991 for the geographic areas known as traffic-zones in Jefferson and Orleans Parishes. A sampling of residential structures by traffic zone was used to estimate the percentage of residential structures with pier foundations and the percentage with slab foundations and to determine the average height of the pier and slab foundations above ground level. The surveys were also used to estimate the percentages of one-story and two-story residential structures in each traffic zone. A similar process was followed in St. Bernard, Plaquemines, and St. Charles parishes, except that the structures were identified by community rather than traffic zone. Once the foundation heights were segmented by foundation type and structure type, a proportionate share of the single-family homes within each census block were adjusted to match the foundation heights found in the field surveys. Mobile homes in each of the five parishes were assigned an average foundation height of 2.0 feet above ground level based on previous studies. Non-residential properties were assigned an average foundation height of 1.5 feet above ground level based on previous field surveys.

Depth-Damage Relationships. Damages from flooding were calculated for residential and non-residential buildings, their contents, and vehicles based on the depth-damage relationships developed by a panel of building and construction experts in 1996 for the Southeast Louisiana (SELA) Flood Control Feasibility Studies. Salt-water, long-duration (greater than two days) depth damage curves were used to indicate the percentage of the structural value that was damaged at each depth of flooding. Damage percentages were determined for each one-half foot increment from one foot below first-floor elevation to two feet above first floor, and for each 1-foot increment from 2 feet to 15 feet above first-floor elevation. The depth-damage relationships for residential structures, residential contents, non-residential structures, non-residential contents, and vehicles are displayed in Tables 1-2 through 1-6.

Table 1-2
Saltwater Depth-Damage Relationships for Residential Structures, Percent Damaged, Expert Panel (1-Week Damages)

	Percent Damaged				
Flood Depth (ft)	**One-Story on Pier**	**One-Story on Slab**	**Two-Story on Pier**	**Two-Story on Slab**	**Mobile Home**
-1.0	4.0	0.0	4	0.0	12.1
-0.5	5.4	0.0	4.7	0.0	12.1
0.0	20.5	7.2	17.5	5.1	32.1
0.5	62.4	56.4	53.6	44.2	62.1
1.0	62.4	56.4	53.6	44.2	63.8
1.5	64.0	58.7	54.4	45.1	64.2
2.0	65.6	58.7	55.2	46.0	66.3
3.0	65.6	58.7	55.2	49.7	66.3
4.0	68.7	63.4	56.8	51.6	66.3
5.0	71.9	66.4	59.9	51.6	66.3
6.0	71.9	66.4	59.9	51.6	66.3
7.0	71.9	66.4	59.9	51.6	66.3
8.0	71.9	66.4	59.9	51.6	66.3
9.0	84.4	82.1	63.1	55.7	66.3
10.0	84.4	82.1	71.2	66.2	66.3
11.0	84.4	82.1	72.8	68.0	66.3
12.0	84.4	82.1	74.4	68.0	66.3
13.0	84.4	82.1	74.4	69.9	66.3
14.0	84.4	82.1	74.4	69.9	66.3
15.0	84.4	82.1	74.4	69.9	66.3

Source: Expert Panel Meeting, New Orleans District USACE, March 13, 1996.

Table 1-3
Saltwater Depth-Damage Relationships for Residential Contents, Percent Damaged, Expert Panel (1-Week Damages)

Flood Depth (ft)	1-Story	2-Story	Mobile Home
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.0
1.0	95.0	95.0	95.0
1.5	95.0	95.0	95.0
2.0	95.0	95.0	95.0
3.0	95.0	95.0	95.0
4.0	95.0	95.0	95.0
5.0	95.0	95.0	95.0
6.0	95.0	95.0	95.0
7.0	95.0	95.0	95.0
8.0	95.0	95.0	95.0
9.0	95.0	95.0	95.0
10.0	95.0	95.0	95.0
11.0	95.0	95.0	95.0
12.0	95.0	95.0	95.0
13.0	95.0	95.0	95.0
14.0	95.0	95.0	95.0
15.0	95.0	95.0	95.0
CSVR	0.69	0.59	0.79

Source: Expert Panel Meeting, New Orleans District USACE, March 14, 1996.

Table 1-4
Saltwater Depth-Damage Relationships for Non-Residential Structures, Percent Damaged, Expert Panel (1-Week Damages)

	Percent Damaged		
Flood Depth (ft)	**Metal Frame**	**Masonry Bearing**	**Wood or Steel Frame**
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.7	0.0	3.5
0.5	13.2	13.1	36.5
1.0	13.7	13.5	36.8
1.5	15.2	14.3	36.8
2.0	17.2	15.0	41.1
3.0	19.7	21.9	41.1
4.0	19.7	22.3	48.5
5.0	20.1	24.0	48.5
6.0	20.1	24.0	48.5
7.0	20.1	30.7	49.5
8.0	27.6	30.7	49.5
9.0	33.9	30.7	65.0
10.0	41.6	30.7	65.0
11.0	41.6	30.7	72.5
12.0	41.6	30.7	75.0
13.0	41.6	45.0	77.8
14.0	44.5	45.7	77.8
15.0	44.5	46.7	78.8

Source: Expert Panel Meeting, New Orleans District USACE, March 27, 1996.

Table 1-5
Saltwater Depth-Damage Relationships for Non-Residential Contents, Percent Damaged, Expert Panel (1-Week Damages)

Flood Depth (ft)	Eating & Recreation	Groceries & Gas Stations	Multi-Family Residences	Professional Businesses	Public & Semi-Public	Repairs & Home Use	Retail & Personal Svcs.	Warehouse & Contractor Svcs.
-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	61.6	82.5	100.0	98.5	60.2	87.5	99.4	36.1
1.0	82.6	97.5	100.0	98.5	60.2	87.5	99.5	53.0
1.5	87.3	97.8	100.0	98.5	60.2	87.5	99.7	61.5
2.0	88.4	99.1	100.0	98.5	60.2	87.5	99.8	69.9
3.0	93.3	99.4	100.0	100.0	60.2	98.9	99.9	79.9
4.0	93.5	99.7	100.0	100.0	60.2	100.0	100.0	96.3
5.0	93.5	99.7	100.0	100.0	60.2	100.0	100.0	97.0
6.0	93.5	99.7	100.0	100.0	60.2	100.0	100.0	97.0
7.0	93.5	99.7	100.0	100.0	60.2	100.0	100.0	97.0
8.0	99.3	100.0	100.0	100.0	60.2	100.0	100.0	97.0
9.0	99.3	100.0	100.0	100.0	60.2	100.0	100.0	97.0
10.0	99.3	100.0	100.0	100.0	100.0	100.0	100.0	97.0
11.0	99.3	100.0	100.0	100.0	100.0	100.0	100.0	97.0
12.0	99.3	100.0	100.0	100.0	100.0	100.0	100.0	97.0
13.0	99.3	100.0	100.0	100.0	100.0	100.0	100.0	97.0
14.0	99.3	100.0	100.0	100.0	100.0	100.0	100.0	97.0
15.0	99.3	100.0	100.0	100.0	100.0	100.0	100.0	97.0
CSVR	1.14	1.27	0.37	0.43	1.14	2.06	1.42	1.68
(Panel)								
Source: Expert Panel Meeting, New Orleans District USACE, April 1, 1996.								

Vehicles. Damages to private automobiles were also evaluated and was based on the number of automobiles estimated to have been directly impacted per household. The elevation of each automobile was assumed as the ground elevation near the structure. Automobile damages were then calculated by using the depth of flooding applied to the depth-damage relationships for vehicles.

According to statistics compiled by the Louisiana Department of Motor Vehicles, there are approximately twice as many privately owned vehicles registered in the New Orleans Metropolitan Area as there are occupied housing units. Census data show that approximately 82 percent of the households in the five-parish area have access to at least one vehicle. However, this percentage was found to be variable across census blocks. For at least some census blocks, Census data showed access to a vehicle as low as 10 percent in Orleans Parish.

In order to estimate flood damages to privately owned vehicles, it was assumed that on average, for each of the households with access to one or more vehicles, one vehicle was left parked at the residence, and the remainder of the vehicles were used for evacuation. The average value of these automobiles was determined to be $11,918, based on the average Manheim auction value of a vehicle adjusted to reflect replacement value at the retail rather than the wholesale level of sales. The depth-damage relationships for vehicles that were developed by a panel of experts for the SELA studies were used to calculate damages at the various levels of flooding.

No vehicles were assigned to commercial properties due to insufficient data.

Table 1-6
Depth-Damage Relationships for Vehicles, Percent Damaged, Operator Interview

Flood Depth (ft) Over Ground	Percent Damaged - Automobiles (Avg. Value $11,918)
0.5	2.3
1.0	22.8
1.5	54.2
2.0	95.8
3.0	100.0

Source: G.E.C., Inc., Commercial Operator Interviews, January 1996.

Table 1-7 shows the HAZUS-MH residential and non-residential occupancy categories and the structure and content depth-damage relationships that were assigned to these categories.

Table 1-7
HAZUS-MH Occupancy Categories and Depth-Damage Relationships

Occupancy			HAZUS Definition	Occupancy Example	Structures Depth-Damage	Contents Depth-Damage
1		RES1	Single Family Dwelling	1-Sty/2-Sty/Slab/Pier	RES	RES
2		RES2	Manufactured Housing/Mobile	Manufactured Housing	MOB	MOB
3		RES3A	Multi Family Dwelling - small	Duplex	RES	RES
4		RES3B	Multi Family Dwelling - small	Triplex/Quads	RES	RES
5		RES3C	Multi Family Dwelling - medium	5-9 units	WOOD	MULTI
6		RES3D	Multi Family Dwelling - medium	10-19 units	WOOD	MULTI
7		RES3E	Multi Family Dwelling - large	20-49 units	MAS	MULTI
8		RES3F	Multi Family Dwelling - large	50+ units	MAS	MULTI
9		RES4	Temp. Lodging	Hotel, medium	MAS	MULTI
10		RES5	Institutional Dormitory	Dorm, medium	MAS	PUB
11		RES6	Nursing Home	Nursing home	MAS	PUB
12		COM1	Retail Trade	Dept Store, 1st	MAS	RET
13		COM2	Wholesale Trade	Warehouse, medium	MAS	RET
14		COM3	Personal and Repair Services	Garage, Repair	WOOD	REP
15		COM4	Professional/Technical/ Business	Office, Medium	MAS	PROF
16		COM5	Banks	Bank	MAS	PROF
17		COM6	Hospital	Hospital, Medium	MAS	PROF
18		COM7	Medical Office/Clinic	Med. Office, medium	MAS	PROF
19		COM8	Entertainment & Recreation	Restaurant	WOOD	EAT
20		COM9	Theaters	Movie Theatre	WOOD	EAT
21		COM10	Parking	Parking garage	MET	PUB
22		IND1	Heavy	Factory, small	MET	WAR
23		IND2	Light	Warehouse, medium	WOOD	WAR
24		IND3	Food/Drugs/Chemicals	College Laboratory	WOOD	WAR
25		IND4	Metals/Minerals Processing	College Laboratory	WOOD	WAR
26		IND5	High Technology	College Laboratory	MET	WAR
27		IND6	Construction	Warehouse, medium	WOOD	WAR
28		REL1	Church	Church	MAS	PUB
29		AGR1	Agriculture	Warehouse, medium	MAS	WAR
30		GOV1	General Services	Town Hall, small	MAS	PUB
31		GOV2	Emergency Response	Police Station, Fire	MET	PUB
32		EDU1	Schools/Libraries	High School	MAS	PUB
33		EDU2	Colleges/Universities	College Classroom	MAS	PUB
34		n/a	n/a	Automobiles	AUTO	n/a

Notes:
1. Abbreviations for Structures: RES - residential; WOOD - wood or steel frame; MAS - masonry bearing; and MET - metal frame.
2. Residential structures can be classified as: 1-story pier; 2-story pier; 1-story slab; 2-story slab; and mobile home.
3. Abbreviations for Contents: EAT - eating and recreation; GRO - grocery and gas station; MULTI - multifamily residences; PROF - professional buildings; PUB - public and semi-public; REP - repairs and home use; RET - retail and personal services; and WAR - warehouse and contractor services.
4. Private autos were estimated external to HAZUS-MH Program.

Adjustments to Estimates. During the analysis, two issues were considered in regards to structure valuations. First, the HAZUS-MH building stock is valued at 2002 price levels. The forthcoming release of a revised version of the model will include 2005 price levels; however, factors were not readily available from HAZUS to index the 2002 to 2005 prices. To compensate for the price level changes, index values from the Marshall and Swift building cost database were used to escalate structure values to 2005 levels.

The second valuation issue is in the accuracy of the general building stock database, which is a national dataset. The national dataset is intended for use in gross assessments of potential hazard damages. These gross analyses are identified as Level 1 studies in the HAZUS documentation. Model developers recommend using region-specific datasets to improve the accuracy of the value estimates. In order to validate the values assigned to the HAZUS-MH residential building stock, the total depreciated exposure value for each census block was compared to the depreciated replacement cost that was calculated by Army Corps of Engineers personnel. Corps personnel utilized aerial photography and conducted field surveys to collect site-specific structure characteristics to calculate the depreciated replacement value using the Marshall and Swift Valuation Service. A sampling of city blocks from the actual structure inventories compiled as part of previous feasibility studies in the five-parish area was used in the comparison. For the HAZUS-MH non-residential building stock, a comparison was made for larger areas such as census tracts or portions of a previous study area. The total depreciated exposure value for each census block for residential occupancies and each census tract for non-residential occupancies was compared to the aggregated Marshall and Swift value for the sampled city blocks or tracts, and the difference in the two values was used to calculate confidence intervals for the HAZUS-MH residential and non-residential occupancy data. Tables 1-8 and 1-9 compare the residential and non-residential HAZUS-MH depreciated exposure values to the Marshall and Swift depreciated replacement values.

Table 1-8
Comparison of Residential HAZUS-MH Depreciated Exposure Value to Corps Field Surveys Using Marshall and Swift Valuation Service 2002 Price Level

Number	Census Block	Parish	Depreciated Exposure Value HAZUS-MH	Depreciated Replacement Value Field Inventory	Difference
1	220870306021032	St. Bernard	$ 728,000	$ 1,294,221	$ (566,221)
2	220870306021014	St. Bernard	$ 1,176,000	$ 942,950	$ 233,050
3	220870306021016	St. Bernard	$ 1,681,000	$ 2,303,684	$ (622,684)
4	220870306021036	St. Bernard	$ 4,251,000	$ 1,432,831	$ 2,818,169
5	220870306021030	St. Bernard	$ 1,401,000	$ 1,546,355	$ (145,355)
6	220870306021029	St. Bernard	$ 1,513,000	$ 2,223,083	$ (710,083)
7	220870306021012	St. Bernard	$ 2,923,000	$ 2,104,181	$ 818,819
8	220870306021031	St. Bernard	$ 1,661,000	$ 2,440,194	$ (779,194)
9	220750502003004	Plaquemines	$ 2,503,000	$ 2,339,628	$ 163,372
10	220750502002015	Plaquemines	$ 2,101,000	$ 3,798,160	$ (1,697,160)
11	220750502002022	Plaquemines	$ 2,243,000	$ 2,302,430	$ (59,430)
12	220750502002021	Plaquemines	$ 1,614,237	$ 2,302,430	$ (688,193)
13	220750502002019	Plaquemines	$ 1,828,000	$ 2,008,494	$ (180,494)
14	220750502002018	Plaquemines	$ 1,864,000	$ 1,646,512	$ 217,488
15	220750502005031	Plaquemines	$ 2,104,000	$ 1,512,835	$ 591,165
16	220510249002002	Jefferson	$ 1,968,000	$ 967,482	$ 1,000,518
17	220510249002003	Jefferson	$ 1,010,000	$ 1,938,629	$ (928,629)
18	220510244001018	Jefferson	$ 519,000	$ 390,854	$ 128,146
19	220510244001008	Jefferson	$ 1,798,000	$ 1,547,511	$ 250,489
20	220510226003006	Jefferson	$ 1,069,000	$ 1,953,991	$ (884,991)
21	220510248005004	Jefferson	$ 1,069,000	$ 1,973,531	$ (904,531)
22	220510244002005	Jefferson	$ 1,255,000	$ 1,377,647	$ (122,647)
23	220510244002002	Jefferson	$ 1,907,000	$ 929,545	$ 977,455
24	220510244001008	Jefferson	$ 1,798,000	$ 1,681,973	$ 116,027
25	220510226001015	Jefferson	$ 1,891,000	$ 3,115,660	$ (1,224,660)
26	220510226001001	Jefferson	$ 6,173,000	$ 6,104,721	$ 68,279
27	220510226002009	Jefferson	$ 3,517,000	$ 4,054,358	$ (537,358)
28	220890623012008	St. Charles	$ 2,742,000	$ 2,503,631	$ 238,369
29	220890623012009	St. Charles	$ 6,072,000	$ 5,692,206	$ 379,794
30	220890625002011	St. Charles	$ 2,308,000	$ 5,373,047	$ (3,065,047)
31	220890625002012	St. Charles	$ 1,477,000	$ 3,425,331	$ (1,948,331)
32	220890625002013	St. Charles	$ 832,000	$ 2,151,518	$ (1,319,518)
33	220890625002027	St. Charles	$ 1,663,000	$ 1,741,288	$ (78,288)
34	220890625004015	St. Charles	$ 487,000	$ 1,316,601	$ (829,601)
35	220710099002013	Orleans	$ 771,000	$ 760,244	$ 10,756
36	220701010004000	Orleans	$ 1,033,000	$ 707,280	$ 325,720
37	220710076033031	Orleans	$ 1,566,000	$ 4,539,868	$ (2,973,868)
38	220710065003017	Orleans	$ 1,240,000	$ 1,440,936	$ (200,936)
39	220710054003028	Orleans	$ 1,298,000	$ 1,497,375	$ (199,375)
40	220710025012003	Orleans	$ 909,000	$ 646,063	$ 262,937
	Total		**$ 75,963,237**	**$ 88,029,277**	**$ (12,066,040)**

Table 1-9
Comparison of Non-Residential HAZUS-MH Depreciated Exposure Value to Corps Field Surveys Using Marshall and Swift Valuation Service 2002 Price Level (Dollars in Thousands)

Census Tracts & Study Areas	Area	Parish	Depreciated Exposure Value HAZUS-MH	Depreciated Replacement Value-Field Inventory	Difference
44.02	London Ave.	Orleans	$215	$0	$215
33.06	London Ave.	Orleans	$1,104	$0	$1,104
33.02	London Ave.	Orleans	$9,755	$9,221	$534
33.01	London Ave.	Orleans	$2,604	$10,297	($7,693)
41	London Ave.	Orleans	$13,931	$3,860	$10,071
44.01	London Ave.	Orleans	$956	$7,275	($6,319)
40	London Ave.	Orleans	$216	$22,525	($22,309)
37.01	London Ave.	Orleans	$4,204	$23,168	($18,964)
38	London Ave.	Orleans	$7,456	$28,124	($20,668)
42	London Ave.	Orleans	$28,495	$60,295	($31,800)
33.06	London Ave.	Orleans	$1,104	$0	$1,104
33.05	London Ave.	Orleans	$1,324	$6,812	($5,488)
33.07	London Ave.	Orleans	$166	$3,956	($3,790)
30	London Ave.	Orleans	$163	$2,138	($1,975)
35	London Ave.	Orleans	$636	$6,584	($5,948)
36	London Ave.	Orleans	$1,499	$6,541	($5,042)
37.02	London Ave.	Orleans	$9,629	$10,131	($502)
45	London Ave.	Orleans	$3,315	$10,191	($6,876)
39	London Ave.	Orleans	$1,594	$42,141	($40,547)
26	London Ave.	Orleans	$3,655	$7,716	($4,061)
27	London Ave.	Orleans	$1,958	$6,832	($4,874)
28	London Ave.	Orleans	$217	$3,438	($3,221)
29	London Ave.	Orleans	$864	$3,190	($2,326)
34	London Ave.	Orleans	$3,571	$8,632	($5,061)
17.01	Peoples Ave.	Orleans	$1,556	$26,436	($24,880)
23	Peoples Ave.	Orleans	$3,053	$14,957	($11,904)
25.02	Peoples Ave.	Orleans	$1,927	$1,686	$241
25.01	Peoples Ave.	Orleans	$2,112	$9,530	($7,418)
33.03	Peoples Ave.	Orleans	$592	$2,904	($2,312)
33.04	Peoples Ave.	Orleans	$1,008	$1,868	($860)
Hoey's Basin	Old Metairie	Jefferson	$79,000	$120,796	($41,796)
East Bank	Elmwood	Jefferson	$88,670	$83,526	$5,144
St. Bernard	Chalmette	St. Bernard	$76,083	$121,856	($45,773)
East Bank	Ormond	St. Charles	$28,332	$163,701	($135,369)
Total			**$380,964**	**$830,327**	**($449,363)**

The actual depreciated replacement values of residential occupancies calculated using field surveys and the Marshall and Swift Valuation Service for those portions of the five-parish area that were sampled were found to be approximately 16 percent higher than the depreciated exposure values calculated by the HAZUS-MH program. The actual depreciated replacement values of the non-residential occupancies in those portions of the five-parish area that were sampled were found to be approximately 118 percent higher than the depreciated exposure values calculated by the HAZUS-MH program. In order to account for this underestimation, the damages for each stage were increased by approximately 16 percent for residential occupancies and approximately 118 percent for non-residential occupancies. Table 1-10 shows the adjustment in the HAZUS-MH values to account for underestimated and updating to 2005 price levels.

TABLE 1-10
ADJUSTMENTS TO HAZUS-MH FOR UNDER ESTIMATE VALUES AND UPDATE TO 2005 PRICES

Category	Under Estimate Adjustment	Update from 2002 to 2005 Prices
Single Family Residential	1.16	1.19
Multi-Family Residential	1.16	1.16
Mobile Homes	1.16	1.19
Commercial	2.18	1.16
Industrial	2.18	1.17
Public	2.18	1.16
Vehicles	1.00	1.00

The results of the adjustments to the HAZUS-MH exposure values for under estimation of exposed property and to 2005 price levels is shown in Table 1-11. These values are an estimate of the aggregated depreciated replacement value for property in the five parish region. Note that only the portion of Plaquemines Parish in the immediate New Orleans is included.

Table 1-11
Adjusted Property Exposure Values

Exposure Category	Depreciated Replacement Value ($ millions 2005)
Single Family Residential	52,660.5
Multi-family Residential	12,820.7
Mobile Homes	163.2
Commercial	18,916.6
Industrial	3,804.1
Public	1,739.7
Vehicles	3,876.3
Total	93,981.0

Stage-Damage Relationships. The descriptions of the inputs to the GIS model have, thus far, included elevation data, structure inventory and valuation data, and depth-damage relationships. The model used these inputs to generate a stage-damage relationship for each census block. Flood damages are calculated at one-foot increments from the beginning damage elevation to an elevation where damages for all the structural categories have reached a maximum. In order to insure that this maximum had been reached, the maximum height of a slab foundation or of a pier foundation in each census block was added to the maximum depth of flooding (15 feet) included in the depth-damage relationships. Damages were calculated for seven damage categories including: single-family residential, multi-family residential, manufactured housing/mobile homes, commercial, industrial, public, agricultural, and vehicles.

Aggregated Stage-Damage by Drainage Basin

After being adjusted for uncertainty and updated to 2005 price-levels, the stage-damage relationships developed by the GIS model were used to calculate the flood damages that occurred in the five-parish area as a result of Hurricane Katrina.

The stage-damage relationships developed for each census block were aggregated into one stage-damage relationship for each drainage basin in the five-parish area. The approach to developing the drainage basins is covered in Volume VI. The locations of the drainage basins in the five-parish area are shown in Figure 1-3.

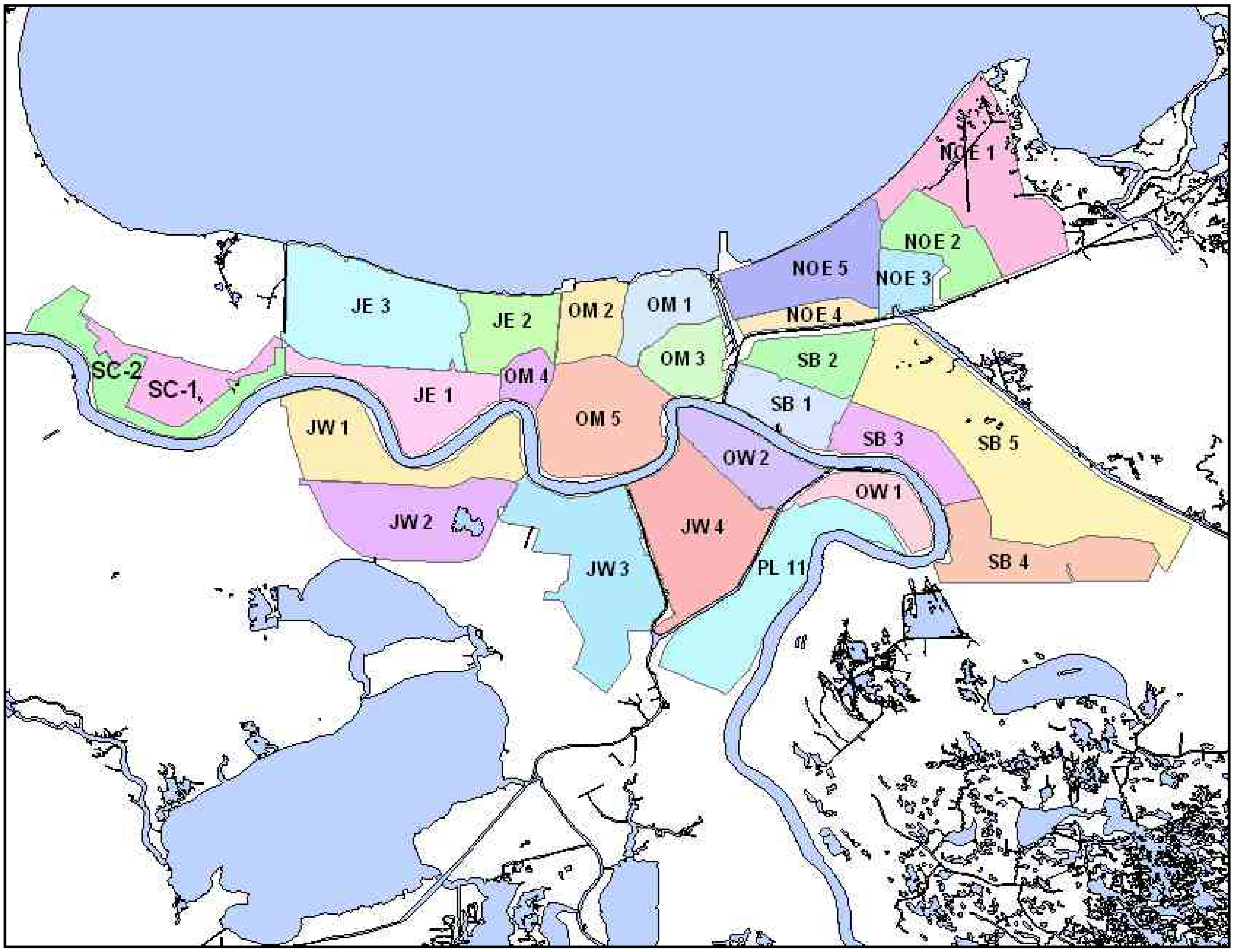

Figure 1-3. Drainage Basin Map

An example of the resulting stage-damage relationship for an individual drainage basin is shown in Table 1-12. These relationships were estimated for each of the drainage basins.

Table 1-12
Example Stage-Damage Relationships for a Drainage Basin ($million 2005)

Water Elevation NAVD88 (2004.65)	Basin Name	Single Family Residential	Multifamily Residential	Mobile Home	Commercial	Industrial	Public	Vehicles
-10	JE2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-9	JE2	0.2	0.0	0.0	0.7	0.0	0.0	0.0
-8	JE2	0.3	0.0	0.0	0.7	0.0	0.0	0.0
-7	JE2	1.2	0.0	0.0	1.1	0.0	0.0	0.1
-6	JE2	2.6	0.2	0.0	4.9	0.1	0.0	0.4
-5	JE2	22.4	2.9	0.0	10.5	1.5	1.4	13.1
-4	JE2	218.7	60.7	0.1	102.3	7.2	2.6	79.1
-3	JE2	953.8	317.9	0.4	668.6	50.2	26.9	172.6
-2	JE2	1,593.6	457.1	0.7	995.1	81.5	40.6	225.3
-1	JE2	1,826.1	508.3	1.1	1,126.4	99.9	47.3	248.4
0	JE2	2,033.8	560.4	1.1	1,194.6	122.7	49.1	266.5
1	JE2	2,224.2	588.4	1.2	1,225.5	133.2	50.4	283.4
2	JE2	2,400.8	617.6	1.2	1,243.3	137.7	50.9	300.4
3	JE2	2,550.7	650.6	1.3	1,285.0	141.4	53.0	312.2
4	JE2	2,691.0	683.0	1.3	1,336.2	146.1	57.3	322.6
5	JE2	2,853.5	721.6	1.3	1,378.9	152.7	62.5	329.0
6	JE2	3,006.5	749.3	1.3	1,413.7	158.5	75.5	332.1
7	JE2	3,071.6	766.4	1.3	1,443.8	164.2	84.7	332.7
8	JE2	3,105.4	786.0	1.3	1,462.9	167.9	87.6	332.8
9	JE2	3,132.4	821.3	1.3	1,530.2	170.4	91.2	332.8
10	JE2	3,156.0	846.0	1.3	1,573.3	171.9	94.5	332.8
11	JE2	3,173.7	852.7	1.3	1,586.9	172.6	95.7	332.8
12	JE2	3,188.4	857.7	1.3	1,593.5	173.2	96.3	332.8
13	JE2	3,199.7	860.7	1.3	1,597.4	173.5	97.4	332.8
14	JE2	3,207.6	862.9	1.3	1,600.3	173.9	98.9	332.8

Estimates of Flood Losses from Hurricane Katrina.

The estimates of Katrina direct property damage, except for infrastructure, were based on the 27 stage-damage relationships such as the show in Table 1-12. The Interior Drainage modeling, developed was part of IPET, provided the model stages for each basin in the five-parish area. The damages for each drainage basin were then combined in order to develop the total damages to the five-parish area. Table 1-13 shows the estimated average direct flood damage from Katrina by the basic damage categories for each of the flooded basins. These estimates do not include damage to infrastructure as it is not available by geographic area. The additional infrastructure damage is discussed in the next section.

Table 1-13
Estimates of Katrina Direct Flood Losses by Category and Drainage Basin ($million 2005)

Basin Name	Water Surface Elevation NAVD88 (2004.65)	Single Family Residential	Multifamily Residential	Mobile Home	Commercial	Industrial	Public	Vehicles	Total
JE2	-4.1	199.1	55.0	0.1	93.1	6.7	2.5	72.5	428.8
NOE1	3.8	0.3	0.2	0.1	0.8	8.9	0.0	0.1	10.2
NOE2	-0.3	76.3	26.4	0.0	2.8	0.8	0.0	9.5	115.7
NOE3	1.7	262.2	83.0	0.9	44.8	42.0	22.3	26.7	481.9
NOE4	7.6	3.8	2.1	0.7	46.9	2.7	0.4	0.5	57.1
NOE5	-0.8	3,019.3	580.1	1.0	648.3	64.7	50.9	272.3	4,636.6
OM1	2.6	1,600.3	260.2	1.0	86.3	4.3	17.9	160.1	2,130.2
OM2	3.2	1,196.5	191.1	0.1	84.6	6.8	7.1	109.5	1,595.7
OM3	3.8	1,344.4	351.5	0.1	97.9	6.2	9.8	155.9	1,965.8
OM4	2.3	283.4	9.6	0.0	22.4	3.5	0.1	22.7	341.8
OM5	2.6	1,379.5	826.4	0.1	663.7	166.7	56.1	284.3	3,376.8
SB1	10.5	1,679.0	326.4	1.2	331.9	44.9	28.0	150.7	2,562.1
SB3	10.9	1,904.1	120.5	15.2	138.8	60.3	15.0	130.1	2,383.9
SB4	11.2	367.8	14.7	34.3	30.5	6.5	4.5	34.1	492.3
Total		13,315.9	2,847.2	54.7	2,292.6	424.9	214.6	1,429.0	20,579.0

Damage to Infrastructure

Infrastructure damage was an important source of direct economic losses from Hurricane Katrina. This section tabulates (to the extent information was available) monetary costs for damages, measured by the cost of repair or replacement of significant infrastructure assets. The values are not reported by drainage basin and reflect only the impacts of Hurricane Katrina unless otherwise noted. As with other investigations for direct damages or costs attributable to Hurricane Katrina within the framework for IPET studies, the area of consideration was primarily limited to the five (5) parish area of Orleans, St. Bernard, Plaquemines, Jefferson, and St. Charles parishes.

The estimation of impacts to infrastructure from Hurricane Katrina is difficult to estimate for some categories of infrastructure due to the follow-on occurrence of Hurricane Rita. Most impacts from Hurricane Rita were incurred in areas west of the New Orleans metropolitan area with some additional damages imposed by associated rainfall and some reflooding due to weakened levees and previously saturated ground areas. Available information indicates that for the five (5) parishes, infrastructure damages were due mostly to Hurricane Katrina.

A primary objective for IPET studies was to estimate damages based on effects of flooding but acknowledge other effects such as wind and rainfall associated with hurricane conditions. For some infrastructure items, this posed little difficulty but for others it was extremely difficult or simply not practical. In the case of electrical utilities, a significant loss was due to the downing of utility poles and supported transmission lines plus the destruction of substations. Certainly, some of the loss of utility poles and lines was due to wind alone. In other cases, the saturation of soils compromised the foundational support and led to toppling of above-ground lines.

To provide some context of magnitude of overall hurricane impacts to infrastructure statistics on electric service were obtained from Entergy, the primary regional electric public utility. Table 1-14 shows the loss of customer base for each of the five parishes under study. The net total loss of customers (households and businesses) across the five parish area as of December 2005 was approximately 32 percent compared to the pre-Katrina levels. St. Bernard Parish incurred the greatest loss of neighborhood occupancy measured by percentages with a loss customers using electricity of over 99 percent from the pre-Katrina level. Orleans Parish exhibits the greatest absolute loss with total customers declining by more than 97,000 customers.

Table 1-14
Impact of Hurricane Katrina Electrical Utility Services – Change in Customer Base

Parish	Total Number of Customers Pre-Katrina	Total Number of Customers as of December 2005	Difference in Customer Base	Percentage Loss or Gain in Customer Base
Jefferson Parish	210,025	201,897	8,146	-3.9%
Orleans Parish	205,466	97,357	108,109	-52.6%
Plaquemines Parish	14,164	6,689	7,475	-52.8%
St. Bernard Parish	29,145	178	28,967	-99.4%
St. Charles Parish	21,082	20,935	147	-0.7%
Total	479,882	327,056	152,844	-31.8%

Sources: Entergy. (2006); FEMA, (2006a).

The dollar value of damage to infrastructure primarily is in terms of full replacement or repair costs in 2005 dollars.

The assessment of infrastructure direct damage followed both a top-down and bottom-up approach for inquiry and data compilation. Top-down inquiries involved internet searches for information in addition to contact with the Federal Emergency Management Agency (FEMA) and various state-level agencies within the State of Louisiana. Bottom-up research involved direct contact with representatives of municipalities and Parish governments in addition to contact with companies or entities who own or are charged with management and operation of significant infrastructure assets. Due to the variability of estimates over time as they are corrected or refined, efforts to compile information were iterative with initial estimation followed by subsequent investigation and contact with sources to determine current more current or presently available estimates.

Summary of Katrina Infrastructure Repair Cost

The total infrastructure damages from Katrina for the five parish area are summarized in Table 1-15. From the table, Katrina caused an estimated $6.0 to $6.7 billion dollars in damage to infrastructure in the area. The categories with the most damages are levees and floodwalls, roadway networks and assets of the regional electrical transmission grid. Together, hurricane-related flooding damages to these categories of infrastructure total $3.6 to $4.1 billion dollars.

Table 1-15
Impact of Hurricane Katrina to Infrastructure by Category

Infrastructure Category	$Millions 2005		
Roads, Pavements & Bridges	$890	To	$1,119
Railroad Line Access	$48	To	$65
Regional Airport Facilities	$67	To	$73
Electrical Distribution & Transmission Grid	$860	To	$980
Gas (Line) Distribution	$490	To	$515
Drainage, Sewage & Potable Water Services	$690	To	$740
Telecommunications Networks	$290	To	$320
Public Transit (Vehicles & Equipment)	$690	To	$730
Waterborne Navigation	$140	To	$170
Repair to Levee & Floodwall Systems	$1,800	To	$2,000
Total(s)	$5.965	To	$6,712

* Estimates for damages or losses primarily limited to flooding in the five-parish area defined for IPET studies with exception of estimates for regional airport facilities and damages to roads, pavements and bridges which includes damages to interstate bridges and connectors between the city of New Orleans and Slidell, Louisiana.
Sources: FEMA. (2006b); NEMIS. (2006); LRA. (2006); USACE. (2006b)

Considerable uncertainty still exists for some categories in Table 1-15, such as damages to roads and pavements. This is preliminary due to lagging nature and limited availability for some estimates. Roads, pavements, and roadway structures often do not exhibit immediate or obviously significant damage. This damage is revealed some period after the occurrence of inundation as vehicular traffic returns.

An additional damage category is debris removal although some of this cost may be included as part of the estimated direct property loss. Debris removal, disposal, and containment for the area will require movement of approximately 19 to 20 million cubic yards of material with a total estimated cost ranging from $716 to nearly $830 million dollars (USACE, 2006b).

Available estimates for damages or costs to infrastructure reveal significant impacts due to Hurricane Katrina. The damage to infrastructure will likely slow the recovery of population and business activities.

Comparison of Katrina Estimates for Direct Property Losses from Hypothetical Scenarios

Table 1-16 displays the estimated mean damages for each drainage basin for Katrina and the three hypothetical levee, floodwall, and pump performance scenarios. Figure 1-4 shows a comparison of the model Katrina direct property losses as a percent of depreciated replacement property value by for each census block for actual Katrina and Hypothetical Scenario #2.

Table 1-16
Comparison of Estimated Mean Losses from Katrina with Hypothetical Scenarios ($millions 2005)

	Katrina Model		Hypothetical Katrina Scenario #1 (Resilient Levees)		Hypothetical Katrina Scenario #2 (Resilient Levees and Pumps)		Hypothetical Katrina Scenario #3 (Resilient Floodwalls)	
Basin Name	Water Surface Elevation	Property Loss Estimate ($millions 2005)	Water Surface Elevation	Property Loss Estimate ($millions 2005)	Water Surface Elevation	Property Loss Estimate ($millions 2005)	Water Surface Elevation	Property Loss Estimate ($millions 2005)
JE2	-4.10	428.8	-4.10	428.8	-7.00	8.1	-4.10	428.8
NOE1	3.80	10.2	2.90	9.0	1.90	7.8	3.80	10.2
NOE2	-0.30	115.7	-1.00	116.3	-4.90	2.4	-0.30	115.7
NOE3	1.70	481.9	-2.90	54.6	-0.60	379.4	1.70	481.9
NOE4	7.60	57.1	7.10	56.7	7.00	56.6	7.60	57.1
NOE5	-0.80	4,636.6	-1.80	4,209.0	-3.90	3,123.5	-0.80	4,636.6
OM1	2.60	2,130.2	-0.90	1,695.0	-5.10	132.7	0.0	1,713.2
OM2	3.20	1,595.7	-2.50	962.1	-5.00	677.1	-2.70	930.9
OM3	3.80	1,965.8	3.10	1,740.8	2.90	1,674.3	3.80	1,965.8
OM4	2.30	341.8	0.10	149.8	-1.50	48.1	0.10	149.8
OM5	2.60	3,376.8	-0.80	924.6	-2.00	785.0	-0.40	1,203.9
SB1	10.50	2,562.1	4.20	1,774.9	3.90	1,700.2	10.50	2,562.1
SB3	10.90	2,383.9	3.70	1,412.1	3.70	1,412.1	10.90	2,383.9
SB4	11.20	492.3	6.60	253.3	6.40	232.2	11.20	492.3
Total		20,579.0		13,787.0		10,231.4		17,132.3

Note: The water surface elevation for JE2 is set to produce flood damages of zero assuming that the pumps could evacuate the rainwater.
Does not include infrastructure losses.

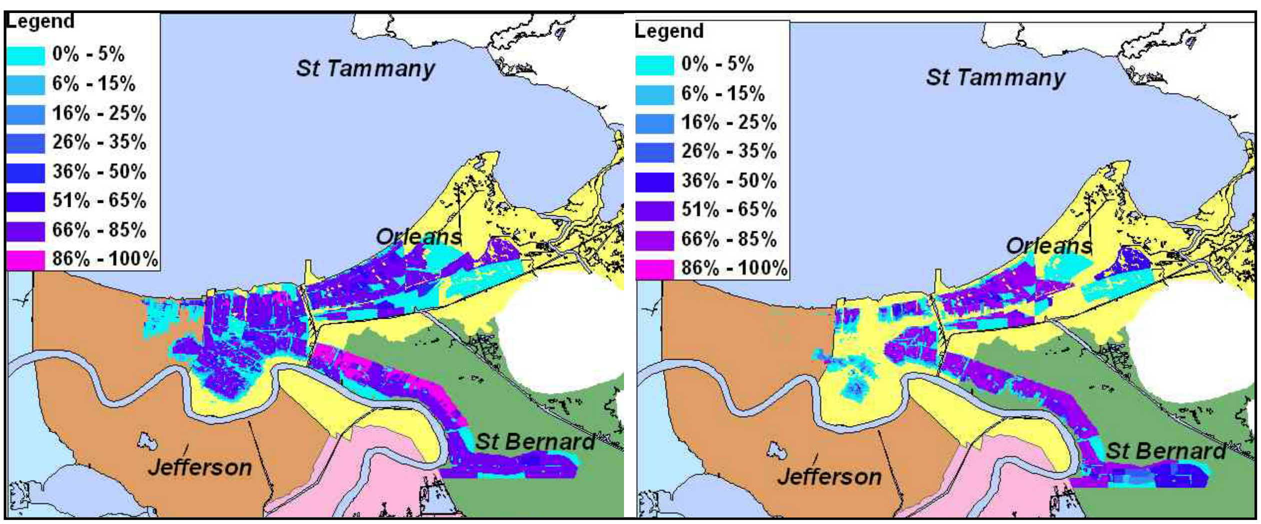

Figure 1-4. Percent of Property Damaged--Comparison of Model Results for Katrina Flooding (left) and Hypothetical Scenario #2, Resilient Levees and Pumps (right)

Comparison of Results to Other Published Estimates

In order to assess the accuracy of the model, the flood damages to residential properties calculated using the GIS model were compared to the actual FEMA-insured residential flood losses by zip code in the New Orleans area. To compensate for uninsured flood losses, the actual insured losses were increased by the percentage of uninsured homes that had incurred flood damages. Table 1-17 displays the total residential flood damages as calculated using the GIS model, the insured flood claims, and adjusted flood claims by zip code in the New Orleans area. The adjusted flood claims are approximately $1.5 billion (10 percent) less than the model estimates; however, the model estimates do not include Plaquemines Parish. The comparison of the published residential flood insurance claims with the model results suggests that the predicted damage estimates reasonably represent other third-party estimates.

Table 1-17
Comparison of Katrina Residential Flood Claims and Model Estimated Residential Losses ($millions 2005)

Parish	Zip Code	Area	Number of Claims	Insured Losses ($Millions)	Percent of Flooded Homes Insured	Adjusted Losses ($Millions)	Model Estimated Losses ($Millions)
Jefferson	70001	Metairie	5,351	202.8	81	250.3	118.9
Jefferson	70005	Metairie	4,607	264.4	81	326.4	178.5
Jefferson	70121	Jefferson	1,202	14.2	81	17.5	41.6
		Total	**11,160**	**481.3**		**594.2**	**339.0**
Orleans	70112	French Quarter	439	24.2	**68****	35.6	47.5
Orleans	70113	French Quarter	661	22.4	**68****	32.9	94.7
Orleans	70115	Uptown	3,726	132.5	**68****	194.8	323.0
Orleans	70116	New Orleans	1,535	43.6	65	67.1	165.4
Orleans	70117	9thWard/Bywater	5,393	360.5	43	838.4	1,322.8
Orleans	70118	Carrollton	4,522	249.3	**68****	366.6	531.2
Orleans	70119	Mid-City	6,604	518.1	51	1,015.8	1,005.0
Orleans	70122	Gentilly	9,282	961.1	69	1,393.0	1,861.8
Orleans	70124	Lakeview	7,399	1,225.4	78	1,571.0	1,389.1
Orleans	70125	Broadmoor	3,426	366.1	**68****	538.4	577.2
Orleans	70126	Eastern New Orleans	7,670	819.3	77	1,064.0	1,581.8
Orleans	70127	Eastern New Orleans	5,358	623.9	77	810.3	1,163.1
Orleans	70128	Eastern New Orleans	5,251	693.3	77	900.4	1,095.4
Orleans	70129	Eastern New Orleans	2,158	220.1	77	285.8	404.8
Orleans	70130	Garden District	844	10.4	**68****	15.3	0.0
Orleans	70148	New Orleans	-	-	**68****	0.0	0.0
		Total	**64,268**	**6,270.1**		**9,129.3**	**11,562.9**
Plaquemines	70041	Buras	878	82.4	35	235.4	*
Plaquemines	70083	Port Sulphur	618	45.5	35	130.1	*
Plaquemines	70091	Venice	143	14.4	35	41.2	*
Plaquemines	70040	Braithwaite	255	36.7	35	105.0	*
		Total	**1,894**	**179.1**		**511.7**	*
St. Bernard	70032	Arabi	2,626	313.1	65	481.7	376.6
St. Bernard	70043	Chalmette	8,175	1,114.0	65	1,713.8	1,484.4
St. Bernard	70075	Meraux	2,198	349.9	65	538.3	573.3
St. Bernard	70085	St. Bernard	1,077	135.3	65	208.1	126.1
St. Bernard	70092	Violet	1,775	230.5	65	354.7	517.4
		Total	**15,851**	**2,142.8**		**3,296.6**	**3,077.7**
Grand Total			**93,173**	**9,073.3**		**13,531.8**	**14,979.6**

Source: Mietrodt (2006)
Note 1: Asterisk (*) indicates the model value was not estimated for Katrina flooding.
Note 2: The double asterisk (**) indicates value is the average for the Parish.

Approach to Quantifying Uncertainty in Stage-Damage Estimates

The stage-damage estimates are developed for a range of flood elevations for 27 storage areas or drainage basins. The highest resolution of measurement of damageable property is the census block. Within each census block, estimates of the number and value of damageable property for residential, commercial, industrial, public and vehicles were developed. These values were combined with depth-percent damage for each of the occupancy categories to estimate economic losses at each level of flooding within the drainage basin. Several issues within this calculation contribute to uncertainty in estimated damage at each stage.

The approach to estimating damages is at a much higher level of aggregation than typically used by the Corps in evaluating a flood damage reduction project. Traditionally, Corps economists inventory all structures in the study area. This inventory includes information on the type of structure, its construction and its use. Each of these is important in selecting the appropriate damage function to apply to predict damages from different levels of flooding. Estimates of the depreciated replacement value for each structure are developed using tools such as Marshall & Swift Residential Estimator. The first floor elevation of each structure is measured using surveyors, topographic maps, or other methods. Using all of this information economists develop stage-damage relationships for a range of flood stages. Figure 1-5 shows the basic flow of data in developing stage-damage with uncertainty. These are aggregated damages from the individual structure damage for each flood stage evaluated. Each of the measurements that are part of this analysis introduces some error. For instance, the method of measuring the elevation of a specific point in the floodplain, the spot elevation, has an error based on the method. The Corps has developed tools and methods to quantify these errors and to combine them in a statistically valid way for this detailed method.

In the case of the IPET study, this detailed evaluation starting at the individual structure level is not feasible. Instead, the analysis starts at the census block. This means that structures and values have been aggregated to that level of resolution. Additionally, depths are representative for the entire census block. The basic approach to identifying and quantifying uncertainties is described below.

Uncertainty in the Depth of Flooding

The first issue is the error in the depth of flooding. Depth is based on the difference between a water surface elevation or stage of the water and the first floor elevation. The first floor elevation is based on the ground elevation plus the foundation height or

First Floor Elevation = Ground Elevation + Foundation Height

Therefore, several things can contribute to the error in depth of water above the first floor.

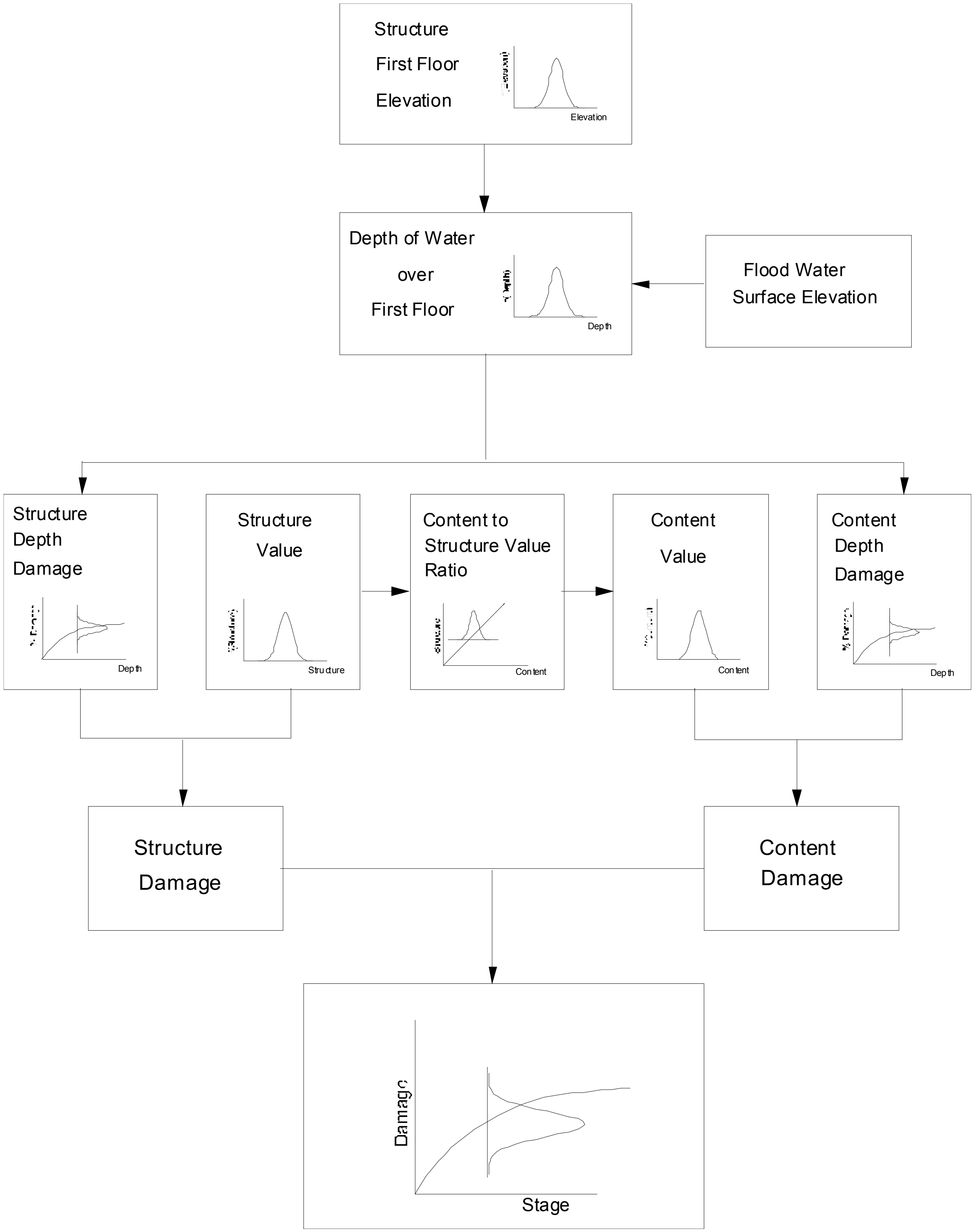

Figure 1-5. Example of Typical Corps Approach to Uncertainty in Stage-Damage

The accuracy of spot elevation for each point in the census block contributes some error. Each pixel in the raster image of the DEM has a ground elevation. The DEM used is that developed by IPET using the latest Lidar. At this point in time, this accuracy has not been officially quantified. Based on communication with the Datum and DEM developers an accuracy of 90% within +/- 1-foot was considered reasonable (Garster, 2006). Assuming that the error in ground elevation is normally distributed, the error in ground elevation has a mean of zero and a variance of 0.37. This represents a fundamental error that is common to all spot elevations. It is assumed that this error is same for all spot elevations.

A second source of error in ground elevate arises from representing the elevation in a census block by a single value. Because a census block represents a spatial area, the ground elevation is variable across the block. However, the ground elevation must be represented by a single value. For each census block, the mean, minimum, and maximum ground elevation is calculated from the spot elevations extracted from the DEM... This represents an additive error to the underlying ground elevation errors. Ideally, estimates of error in damages could be computed at the census block level using the elevation variability because each census block can have a different range of spot ground elevations. Given the time available, this approach is not feasible. Instead, a single average standard deviation is approximated to represent the variability of ground elevation across each census block. The range of spot elevations across each census block is assumed to represent a 99.5% confidence interval or approximately 6 standard deviations. Equation 1 represents the computation of the approximate standard deviation of ground elevation across each census block.

$$CBi_{,max} - CBi_{,min} / 6 \sim SD_i \qquad (1)$$

Equation 2 shows how these were averaged to develop a single approximate standard deviation for the variability of ground elevation.

$$\frac{\sum_{i}^{N}(CBi,\max - CBi,\min)/6}{N} \sim \text{the average standard deviation of ground elevations across all census blocks} \qquad (2)$$

For the approximate 20,000 census blocks in the five parishes, this value computed using (2) is 0.82 feet or variance of 0.67.

The variance in the ground elevation for a census block, assuming independence between the two sources of error, is the sum of the variances or

Variance of Error CB Elevation
= Variance Error Spot Elevation + Variance Spot CB Elevation (3)
= 0.37 + 0.67 = 1.04 and
Standard Deviation = $\sqrt{0.37+0.67}$ = 1.02 feet.

Note that this value is assumed constant across all census blocks.

From the above, the ground elevation for each census block can be represented by a normal distribution with the mean equal to the mean computed from the spot elevations and a standard deviation equal to 1.02 feet.

As noted above, the depth of flooding is the difference between the water stage and the first floor elevation, where the first floor elevation is equal to the ground elevation plus the foundation height. The uncertainty in the foundation height adds an additional error in the estimate of flood depth. Estimates of foundation height were based on previous Corps of Engineers surveys. Two types of foundations are common in the study area: pier and slab on grade. In the computation of damage, these heights and the proportion of structures with each foundation type were used to proportion the census block value of damageable property. However, this uncertainty and its contribution to the uncertainty in flood losses are not quantified. Therefore, the uncertainty in damage is underestimated.

Uncertainty in Depth-Damage Relationships

In traditional Corps of Engineers flood damage analysis, the depth of flooding provides the quantity to lookup a percentage of value damaged from depth-damage relationships. There are different relationships or curves depending on the type of structure, its construction, and its use. In addition to mean values, confidence intervals around the mean percent damage are established. These error bands typically are established by statistical means based on data and the method for estimating damage. Incorporating this uncertainty was not feasible with the IPET schedule and the nonlinear depth-damage functions. Therefore, this uncertainty and its contribution to the uncertainty in flood losses are not quantified. Therefore, the uncertainty in damage is underestimated.

Uncertainty in Value of Damageable Property

A final uncertainty that contributes to the uncertainty in flood damage is the value of the damageable property. As noted earlier, flood damages estimated by the Corps of Engineers are based on depreciated replacement values. The New Orleans District of the Corps of Engineers has conducted several flood damage reduction studies requiring quantification of the uncertainty in structure values. In general, they have relied on commercially available estimating software such as that developed by Marshall & Swift. Based on these previous studies, estimates of the standard deviation of the value, as a percentage of the mean value, were developed. These percentages are shown in Table 1-18.

Table 1-18 New Orleans District Standard Deviations of Structure Value as Percentage of the Mean Value	
Structure Type	**Standard Deviation as % of Mean**
Mobile Home	11.4
Residential	11.4
Multi-Family	11.6
Commercial	11.6
Public	11.6
Warehouse	11.6

Recall that the damage at each flood stage is the damage in a category at a stage summed across all census blocks in a drainage basin. That is mean damage at a stage is the sum of the mean of damage at that stage in each census block. The variance of each damage quantity is the squared product of value and the corresponding values from Table 1-18. If the uncertainty in damage at a stage is independent across the census blocks in a drainage basin, the variance of the total damage at a stage is the sum of the variances. In equation form, the variance in damage in a census block is

$$V [X_i] = (a X_i)^2 \quad (4)$$

where X_i is the damage in the i^{th} census block at a stage and n is the value from Table 1-18. Therefore, the variance in the sum of the damage in a drainage basin at a stage is

$$V[X_1 + X_2 + \ldots + X_n] = \Sigma V(X_i) = \Sigma(a X_i)^2 = a^2 \Sigma X_i^2 \quad (5)$$

Resultant Uncertainty

The foregoing describes two types of uncertainty. One type is the uncertainty in the depth of water resulting from each flood stage. The second type is uncertainty in the dollar damage. The first type is effectively the uncertainty in the stage at which damages begin or the zero damage stage. The uncertainty is represented a shifting in the entire stage-damage relationship by the amount of the error corresponding to the desired confidence. For a 90% confidence interval, this means shifting the stage-damage curve up by approximately 2 feet, for the upper limit, and shifting it down approximately 2 feet for the lower limit.

The results of the calculation in standard deviation in damages described above can be used to develop a confidence interval for damage at each stage. This incorporates the second type of uncertainty.

Ideally, the uncertainties would be conjoined during the damage computation process. However, as noted above this was not possible. Therefore, the 90% confidence interval is approximated by shifting the 5% lower limit stage-damage up by 2 feet and shifting the 95% upper limit down by 2 feet. Therefore, the confidence interval is only an approximation.

Table 1-19 shows the uncertainty in the estimated flooding losses from Hurricane Katrina by each drainage basin and the total. These values do not include infrastructure damage which from Table 1-15 represents an additional $6.0 to $6.7 million.

TABLE 1-19
ESTIMATED DIRECT PROPERTY LOSSES FROM FLOODING FROM HURRICANE KATRINA BY DRAINAGE BASIN ($MILLIONS 2005)

Drainage Basin Name	Water Surface Elevation Interior Drainage Model	5% Lower Confidence	Mean	95% Upper Confidence
JE2	-4.10	6.8	428.8	3,316.5
NOE1	3.80	6.4	10.2	12.7
NOE2	-0.30	71.1	115.7	131.3
NOE3	1.70	380.4	481.9	569.7
NOE4	7.60	50.8	57.1	63.6
NOE5	-0.80	3,567.0	4,636.6	5,142.1
OM1	2.60	1,788.9	2,130.2	2,429.9
OM2	3.20	1,382.4	1,595.7	1,797.0
OM3	3.80	1,288.4	1,965.8	2,419.2
OM4	2.30	159.3	341.8	681.7
OM5	2.60	1,878.7	3,376.8	5,306.3
SB1	10.50	2,418.8	2,562.1	2,658.5
SB3	10.90	2,153.4	2,383.9	2,515.8
SB4	11.20	434.1	492.3	516.6
Total		15,586.5	20,579.0	27,560.9

Table 1-20 shows an example of the stage-damage relationship for total property direct damage computed using the uncertainty methodology described above. Note that this does not include infrastructure damage it cannot be assigned to a particular drainage basin yet. The complete flood stage-total damage estimates with uncertainty for all drainage basins are provided in Attachment A. These values were provided for the Risk and Reliability analysis of all risk assessments of pre-Katrina conditions.

Table 1-20
Example 90% Confidence Interval for Direct Damage for a Drainage Basin ($millions 2005)

Water Elevation	Drainage Basin Name	5% LC	Mean	95% UC
-4	JE1	0	0	0
-3	JE1	0	0	1
-2	JE1	0	0	10
-1	JE1	0	1	51
0	JE1	0	9	226
1	JE1	1	49	430
2	JE1	8	218	1,128
3	JE1	47	420	1,530
4	JE1	211	1,093	2,095
5	JE1	410	1,490	2,671
6	JE1	1,058	2,049	3,339
7	JE1	1,451	2,617	3,697
8	JE1	2,004	3,278	4,223
9	JE1	2,564	3,633	4,707
10	JE1	3,217	4,150	5,202
11	JE1	3,569	4,630	5,589

Figure 1-6 shows a graphic of stage-damage for the Orleans Metro 5 (OM5) basin. Notice that, of the uncertainties quantified, the DEM error and error introduced by representing the elevation of a census block by a single value contribute the most. Only at high stages does the uncertainty in value contribute significantly to overall uncertainty. The vertical line shows the estimated Katrina peak stage in the basin.

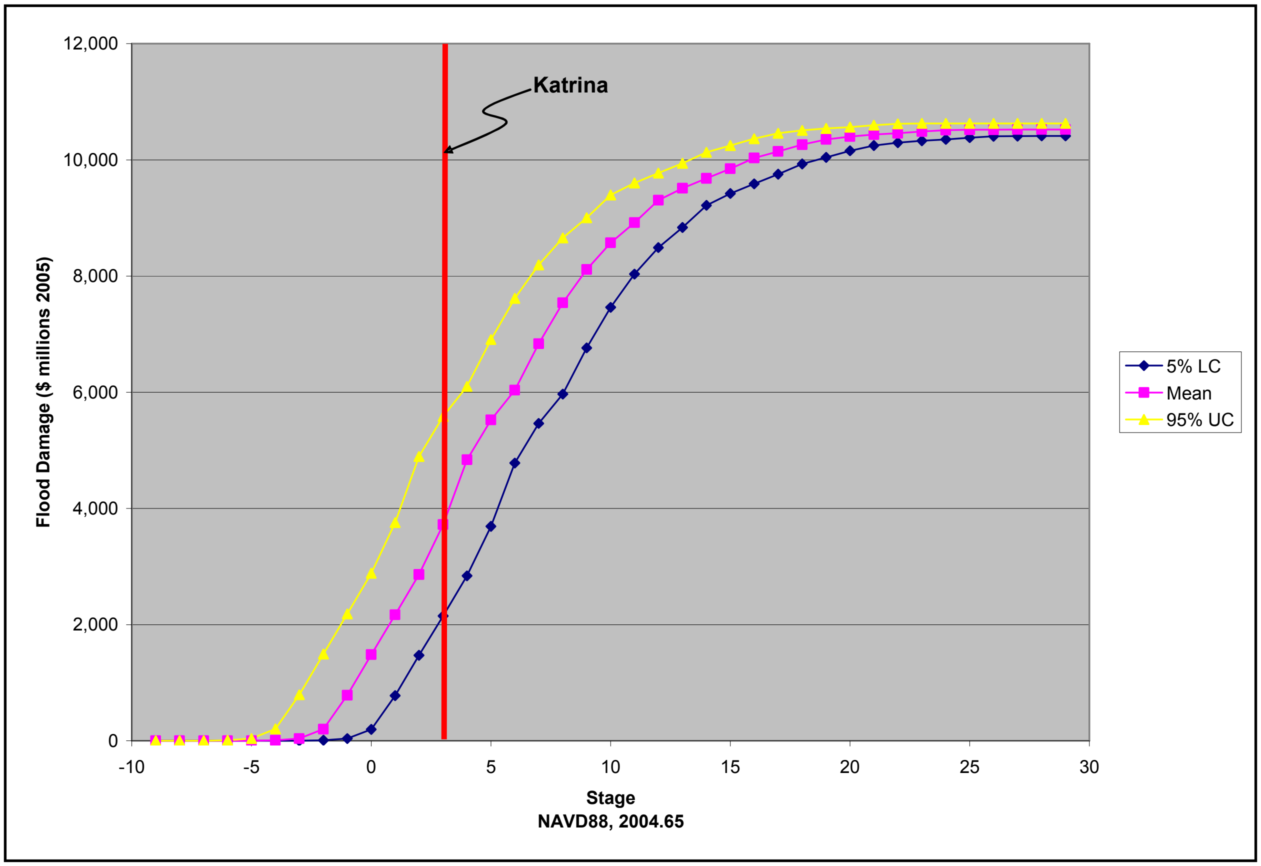

Figure 1-6. Stage-Damage with Uncertainty for Orleans Metro 5 (OM5) Drainage Basin—pre-Katrina Conditions

Post-Katrina Stage-Damage

Background

An objective of the direct economic damage analysis is to develop potential stage-damage curves that might represent the flood damage potential as of June 1, 2006. To do this requires accounting for the severity of the Katrina damage and the amount of property loss recovery since Katrina. In some areas flooded by Katrina, where water depths were low, recovery has been almost complete. In other areas where water depths were high, little recovery or reinvestment has taken place. It is extremely difficult and at the peril of the analyst to make general estimates the amount of recovery. Nonetheless, some guidance exists in terms of what others have assumed about recovery. The analysis conducted followed the basic parameters provided in the RAND Gulf States Policy Institute published a report titled "The Repopulation of New Orleans after Hurricane Katrina." (McCarthy, 2006). In developing estimates of repopulation over time, the authors relied on the depth of flooding as the basic determinant of the rate of population recovery. Table 1-21 shows the recovery rates by depth assumed in the RAND report. The use of these values resulted in an estimate of the March 2006 population of New Orleans of approximately 155,000 people. This is within the range of other estimates.

The June 2006 estimate of potential stage-property damage started with these assumptions. However, the range of depths of flooding was expanded to include more depth of flooding categories while preserving the basic concept.

Table 1-21
Estimated Repopulation Rates for New Orleans

Period	Depth of Flooding	Repopulation Rate (%)
December 2005	No flooding	65
	<2 feet	20
	2–4 feet	5
	>4 feet	1
March 2006	No flooding	100
	<2 feet	35
	2–4 feet	15
	>4 feet	5
September 2006	No flooding	110
	<2 feet	75
	2–4 feet	25
	>4 feet	10

Source: McCarthy, 2006.

Table 1-22 shows the depth categories and damage recovery rates assumed in developing the June 2006 stage-damage. A RAND category of <2 foot was subdivided into two categories: <1 foot and 1 to 2 feet. Additionally, the >4 feet category was subdivided into three categories: 4 to 6 feet; 6 to 8 feet; and >8 feet. These categories are consistent with those used in social, cultural and historic analysis of the impacts of Katrina the post-Katrina recovery. However, the values of recovery rates are to some degree arbitrary and other rates may be justified. For the estimate of the post Katrina stage-damage functions shown in this section, these rates are used.

Table 1-22
Assumed Property Recovery Rates by June 2006.

Period	Depth of Flooding	Property Recovery Rate (%)
June 2006	< 1 feet	95
	1 - 2 feet	50
	2 - 4 feet	20
	4 - 6 feet	5
	6 - 8 feet	1
	> 8 feet	0

Approach

The post-Katrina stage-damage tables and curves are estimated by the same drainage basin definitions as the pre-Katrina values. Additionally, the estimation started with the same census block approach. The Katrina depth grid was used to estimate the depth of flooding for each census block. These depths were then used to select the census blocks that incurred damages within each of the categories shown in Table 1-22. For instance, within the Orleans Metro 5 drainage basin, 1535 census blocks had flooding of 1 foot or less while over 10,000 census blocks were flooded. Table 1-23 shows the complete estimate of the number of the census blocks flooded by Katrina by depth category.

From these selected census blocks, damages at each stage were aggregated to the drainage basin level for each of the recovery category. This calculation determined the amount of the Katrina damage within each depth category. This was repeated for each of the Katrina flood depth categories.

For each resulting drainage basin stage-damage, the recovery factors from Table 1-22 were applied. The recovered potential damage value was then aggregated at each stage. This provides an estimate of the June 2006 potential property damage at each stage for all property damaged estimated to have occurred from Katrina: the Katrina recovery. The last step in the process was to adjust the potential pre-Katrina stage-damages by first subtracting the Katrina damage at each stage and then adding the potential recovered damage at each stage. This was necessary because the Katrina stage was not high enough to damage all the property in a drainage basin, at least for some drainage basins.

Table 1-22
Number of Census Blocks within Each Drainage basin Flooded by Katrina by Depth Category

Drainage basin Name	Count Of Census Blocks within Katrina Flood Depth Category					
	0-1 feet	1 to 2 feet	2 to 4 feet	4 to 6 feet	6 to 8 feet	> 8 feet
JE2	5	6	8	1	1	1
NOE2	1	2	2	10	19	7
NOE3	7	8	12	8	59	7
NOE4	18	3	0	0	0	0
NOE5	27	31	156	173	371	99
OM1	37	37	107	126	163	361
OM2	24	24	46	56	121	321
OM3	301	136	387	358	219	61
OM4	63	51	72	50	9	1
OM5	1535	346	871	957	640	35
SB1	31	25	91	153	200	375
SB3	62	32	49	117	173	44
SB4	5	37	62	50	13	0

Note: The number of census blocks reported for JE2 may understate the number flooded by rain water and pump back-flow.

Therefore, for some property, recovery from flooding was not necessary so it contributed its full damage potential to the post-Katrina, June 2006, stage-damage. Table 1-23 provides a comparison of the pre-Katrina damage potential and the June 2006 damage potential by stage for the OM2. The complete June 2006 flood stage-damage estimates with uncertainty, using this procedure, are provided as Attachment B. These values, including uncertainty, were provided for the Risk and Reliability analysis.

Figure 1-7 shows the pre- and post-Katrina stage-damage with uncertainty for Orleans Metro 5 (OM5).

Table 1-23
Example Stage-Damage Estimates for

Polder Name	Water Elevation	Pre-Katrina Stage-Damage	Post-Katrina Stage-Damage June 2006
OM2	-11	0.0	0.0
OM2	-10	0.0	0.0
OM2	-9	0.0	0.0
OM2	-8	0.0	0.0
OM2	-7	2.0	0.0
OM2	-6	69.9	0.0
OM2	-5	347.6	0.0
OM2	-4	677.1	0.0
OM2	-3	884.1	0.2
OM2	-2	1,040.1	1.8
OM2	-1	1,196.3	4.1
OM2	0	1,260.9	6.9
OM2	1	1,376.7	26.7
OM2	2	1,482.4	44.3
OM2	3	1,573.3	64.0
OM2	4	1,685.3	103.2

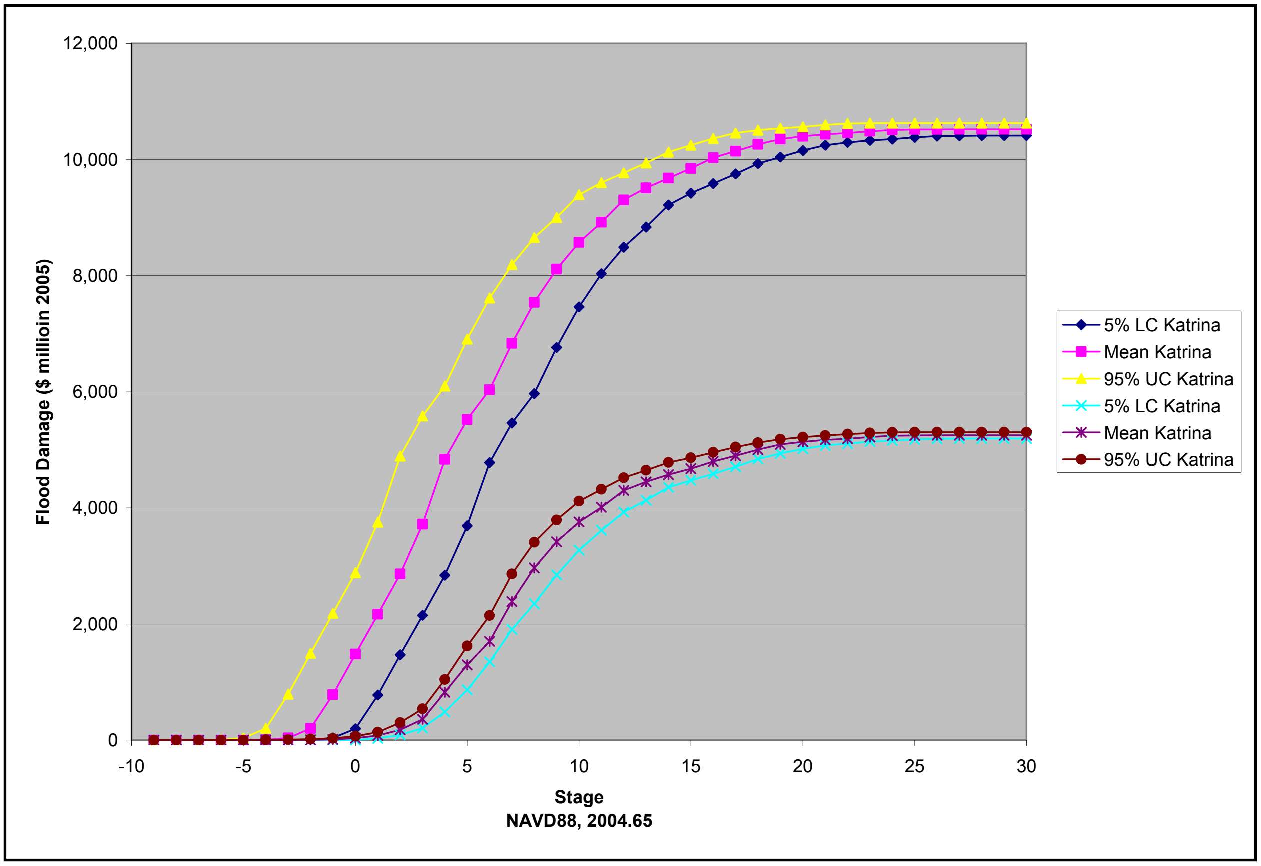

Figure 1-7. Stage-Damage with Uncertainty for Orleans Metro 5 (OM5) Drainage Basin—pre- and post-Katrina Conditions

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Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
-4	JE1	0	0	0
-3	JE1	0	0	1
-2	JE1	0	0	10
-1	JE1	0	1	51
0	JE1	0	9	226
1	JE1	1	49	430
2	JE1	8	218	1,128
3	JE1	47	420	1,530
4	JE1	211	1,093	2,095
5	JE1	410	1,490	2,671
6	JE1	1,058	2,049	3,339
7	JE1	1,451	2,617	3,697
8	JE1	2,004	3,278	4,223
9	JE1	2,564	3,633	4,707
10	JE1	3,217	4,150	5,202
11	JE1	3,569	4,630	5,589
12	JE1	4,078	5,122	5,812
13	JE1	4,554	5,506	5,943
14	JE1	5,042	5,728	6,096
15	JE1	5,424	5,858	6,175
16	JE1	5,644	6,007	6,243
17	JE1	5,772	6,085	6,315
18	JE1	5,919	6,152	6,386
19	JE1	5,996	6,223	6,439
20	JE1	6,061	6,293	6,483
21	JE1	6,131	6,345	6,503
22	JE1	6,200	6,388	6,520
23	JE1	6,252	6,408	6,531
24	JE1	6,293	6,425	6,537
25	JE1	6,313	6,436	6,539
26	JE1	6,330	6,442	6,539
27	JE1	6,341	6,443	6,539
28	JE1	6,347	6,444	6,539
29	JE1	6,348	6,444	6,539
30	JE1	6,348	6,444	6,539
31	JE1	6,348	6,444	6,539
32	JE1	6,348	6,444	6,539
33	JE1	6,348	6,444	6,539
34	JE1	6,348	6,444	6,539
35	JE1	6,348	6,444	6,539
-12	JE2	0	0	0
-11	JE2	0	0	1
-10	JE2	0	0	1

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
-9	JE2	0	1	3
-8	JE2	0	1	9
-7	JE2	1	2	54
-6	JE2	1	8	479
-5	JE2	2	52	2,223
-4	JE2	7	471	3,438
-3	JE2	50	2,190	3,905
-2	JE2	462	3,394	4,278
-1	JE2	2,157	3,857	4,557
0	JE2	3,350	4,228	4,803
1	JE2	3,810	4,506	5,047
2	JE2	4,179	4,752	5,292
3	JE2	4,456	4,994	5,555
4	JE2	4,701	5,237	5,794
5	JE2	4,941	5,499	5,922
6	JE2	5,183	5,737	6,002
7	JE2	5,444	5,865	6,140
8	JE2	5,680	5,944	6,238
9	JE2	5,807	6,080	6,278
10	JE2	5,886	6,176	6,306
11	JE2	6,019	6,216	6,325
12	JE2	6,114	6,243	6,340
13	JE2	6,153	6,263	6,349
14	JE2	6,180	6,278	6,355
15	JE2	6,200	6,287	6,359
16	JE2	6,215	6,292	6,362
17	JE2	6,224	6,296	6,363
18	JE2	6,229	6,299	6,363
19	JE2	6,233	6,300	6,364
20	JE2	6,236	6,301	6,364
21	JE2	6,237	6,301	6,364
22	JE2	6,238	6,301	6,364
23	JE2	6,238	6,301	6,364
24	JE2	6,238	6,301	6,364
25	JE2	6,238	6,301	6,364
26	JE2	6,238	6,301	6,364
27	JE2	6,238	6,301	6,364
28	JE2	6,238	6,301	6,364
-12	JE3	0	0	0
-11	JE3	0	0	0
-10	JE3	0	0	4
-9	JE3	0	0	38
-8	JE3	0	4	121
-7	JE3	0	36	527
-6	JE3	3	116	2,369

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
-5	JE3	33	515	6,223
-4	JE3	112	2,336	8,402
-3	JE3	503	6,174	9,215
-2	JE3	2,303	8,346	9,690
-1	JE3	6,125	9,156	10,107
0	JE3	8,291	9,630	10,360
1	JE3	9,098	10,046	10,563
2	JE3	9,570	10,297	10,800
3	JE3	9,984	10,500	11,224
4	JE3	10,235	10,735	11,572
5	JE3	10,436	11,157	11,745
6	JE3	10,670	11,503	11,876
7	JE3	11,090	11,675	12,020
8	JE3	11,435	11,805	12,098
9	JE3	11,606	11,948	12,122
10	JE3	11,734	12,025	12,135
11	JE3	11,876	12,049	12,147
12	JE3	11,952	12,062	12,154
13	JE3	11,977	12,074	12,158
14	JE3	11,990	12,081	12,160
15	JE3	12,001	12,085	12,162
16	JE3	12,008	12,087	12,163
17	JE3	12,012	12,089	12,163
18	JE3	12,014	12,090	12,163
19	JE3	12,016	12,090	12,163
20	JE3	12,017	12,091	12,163
21	JE3	12,018	12,091	12,163
22	JE3	12,018	12,091	12,163
23	JE3	12,018	12,091	12,163
24	JE3	12,018	12,091	12,163
25	JE3	12,018	12,091	12,163
26	JE3	12,018	12,091	12,163
27	JE3	12,018	12,091	12,163
28	JE3	12,018	12,091	12,163
-3	JW1	0	0	0
-2	JW1	0	0	0
-1	JW1	0	0	5
0	JW1	0	0	63
1	JW1	0	4	156
2	JW1	0	61	237
3	JW1	4	151	304
4	JW1	58	230	390
5	JW1	146	296	481
6	JW1	224	381	554
7	JW1	288	471	645

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
8	JW1	372	542	721
9	JW1	460	631	779
10	JW1	530	707	818
11	JW1	617	764	846
12	JW1	692	803	867
13	JW1	749	830	880
14	JW1	787	850	893
15	JW1	814	863	904
16	JW1	834	877	919
17	JW1	847	887	948
18	JW1	860	901	958
19	JW1	870	930	966
20	JW1	884	940	972
21	JW1	913	947	972
22	JW1	921	953	972
23	JW1	928	953	973
24	JW1	934	954	974
25	JW1	935	954	976
26	JW1	935	955	976
27	JW1	935	957	978
28	JW1	936	957	978
29	JW1	938	958	979
30	JW1	938	959	979
31	JW1	939	959	979
32	JW1	940	959	979
33	JW1	940	960	979
34	JW1	940	960	979
35	JW1	940	960	979
36	JW1	940	960	979
-9	JW2	0	0	0
-8	JW2	0	0	0
-7	JW2	0	0	1
-6	JW2	0	0	6
-5	JW2	0	1	48
-4	JW2	0	5	120
-3	JW2	1	44	185
-2	JW2	4	114	269
-1	JW2	40	178	329
0	JW2	108	262	366
1	JW2	172	321	392
2	JW2	254	356	403
3	JW2	312	383	409
4	JW2	347	393	417
5	JW2	373	399	426
6	JW2	384	407	436

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
7	JW2	389	416	444
8	JW2	397	426	450
9	JW2	405	434	454
10	JW2	415	439	457
11	JW2	423	443	457
12	JW2	429	446	458
13	JW2	432	446	458
14	JW2	435	447	458
15	JW2	435	447	459
16	JW2	436	447	459
17	JW2	436	447	459
18	JW2	436	447	459
19	JW2	436	447	459
20	JW2	436	447	459
21	JW2	436	447	459
22	JW2	436	447	459
23	JW2	436	447	459
24	JW2	436	447	459
25	JW2	436	447	459
26	JW2	436	447	459
27	JW2	436	447	459
28	JW2	436	447	459
29	JW2	436	447	459
30	JW2	436	447	459
31	JW2	436	447	459
-8	JW3	0	0	0
-7	JW3	0	0	0
-6	JW3	0	0	0
-5	JW3	0	0	18
-4	JW3	0	0	127
-3	JW3	0	16	326
-2	JW3	0	122	650
-1	JW3	15	314	1,226
0	JW3	117	635	1,960
1	JW3	302	1,206	2,783
2	JW3	620	1,933	3,698
3	JW3	1,186	2,750	4,594
4	JW3	1,907	3,660	5,205
5	JW3	2,716	4,550	5,515
6	JW3	3,621	5,158	5,675
7	JW3	4,506	5,466	5,794
8	JW3	5,111	5,625	5,903
9	JW3	5,417	5,743	6,000
10	JW3	5,575	5,851	6,103
11	JW3	5,692	5,947	6,214

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
12	JW3	5,799	6,049	6,291
13	JW3	5,894	6,159	6,357
14	JW3	5,995	6,236	6,402
15	JW3	6,104	6,301	6,423
16	JW3	6,180	6,345	6,437
17	JW3	6,245	6,366	6,443
18	JW3	6,288	6,380	6,446
19	JW3	6,309	6,385	6,446
20	JW3	6,323	6,388	6,447
21	JW3	6,328	6,389	6,447
22	JW3	6,331	6,389	6,447
23	JW3	6,332	6,390	6,447
24	JW3	6,332	6,390	6,447
25	JW3	6,332	6,390	6,447
26	JW3	6,332	6,390	6,447
27	JW3	6,332	6,390	6,447
28	JW3	6,332	6,390	6,447
29	JW3	6,332	6,390	6,447
30	JW3	6,332	6,390	6,447
31	JW3	6,332	6,390	6,447
32	JW3	6,332	6,390	6,447
-9	JW4	0	0	0
-8	JW4	0	0	0
-7	JW4	0	0	25
-6	JW4	0	0	88
-5	JW4	0	23	439
-4	JW4	0	83	1,310
-3	JW4	20	426	2,735
-2	JW4	79	1,288	3,620
-1	JW4	413	2,702	4,257
0	JW4	1,266	3,582	4,806
1	JW4	2,669	4,216	5,282
2	JW4	3,545	4,763	5,598
3	JW4	4,176	5,236	5,877
4	JW4	4,720	5,551	6,092
5	JW4	5,190	5,828	6,324
6	JW4	5,504	6,042	6,490
7	JW4	5,779	6,272	6,610
8	JW4	5,991	6,437	6,700
9	JW4	6,219	6,555	6,786
10	JW4	6,383	6,645	6,858
11	JW4	6,501	6,731	6,910
12	JW4	6,589	6,802	6,951
13	JW4	6,675	6,853	6,982
14	JW4	6,746	6,894	7,001

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
15	JW4	6,797	6,925	7,013
16	JW4	6,837	6,944	7,018
17	JW4	6,868	6,955	7,021
18	JW4	6,886	6,961	7,022
19	JW4	6,898	6,964	7,024
20	JW4	6,903	6,965	7,025
21	JW4	6,906	6,966	7,025
22	JW4	6,907	6,967	7,026
23	JW4	6,909	6,968	7,026
24	JW4	6,910	6,968	7,027
25	JW4	6,910	6,969	7,027
26	JW4	6,911	6,969	7,027
27	JW4	6,911	6,969	7,027
28	JW4	6,911	6,969	7,027
29	JW4	6,911	6,969	7,027
30	JW4	6,911	6,969	7,027
31	JW4	6,911	6,969	7,027
-3	NOE1	0	0	0
-2	NOE1	0	0	0
-1	NOE1	0	0	7
0	NOE1	0	0	9
1	NOE1	0	6	11
2	NOE1	0	8	12
3	NOE1	5	9	13
4	NOE1	7	11	13
5	NOE1	8	11	13
6	NOE1	9	11	13
7	NOE1	9	11	14
8	NOE1	9	11	14
9	NOE1	9	12	14
10	NOE1	9	12	14
11	NOE1	10	12	14
12	NOE1	10	12	14
13	NOE1	10	12	14
14	NOE1	10	12	14
15	NOE1	10	12	14
16	NOE1	10	12	14
17	NOE1	10	12	14
18	NOE1	10	12	14
19	NOE1	10	12	14
20	NOE1	10	12	14
21	NOE1	10	12	14
22	NOE1	10	12	14
23	NOE1	10	12	14
24	NOE1	10	12	14

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
-7	NOE2	0	0	1
-6	NOE2	0	0	22
-5	NOE2	0	1	32
-4	NOE2	0	19	106
-3	NOE2	0	29	123
-2	NOE2	17	98	125
-1	NOE2	26	114	129
0	NOE2	90	116	132
1	NOE2	106	121	133
2	NOE2	108	123	135
3	NOE2	112	124	137
4	NOE2	114	126	144
5	NOE2	115	128	149
6	NOE2	117	134	150
7	NOE2	119	139	151
8	NOE2	125	140	152
9	NOE2	129	141	153
10	NOE2	130	142	153
11	NOE2	131	143	153
12	NOE2	132	143	153
13	NOE2	132	143	153
14	NOE2	132	143	153
15	NOE2	132	143	153
16	NOE2	132	143	153
17	NOE2	132	143	153
18	NOE2	132	143	153
19	NOE2	132	143	153
20	NOE2	132	143	153
21	NOE2	132	143	153
22	NOE2	132	143	153
23	NOE2	132	143	153
24	NOE2	132	143	153
-8	NOE3	0	0	0
-7	NOE3	0	0	0
-6	NOE3	0	0	9
-5	NOE3	0	0	42
-4	NOE3	0	8	195
-3	NOE3	0	40	375
-2	NOE3	7	189	409
-1	NOE3	37	366	426
0	NOE3	183	400	524
1	NOE3	357	416	544
2	NOE3	390	510	581
3	NOE3	406	529	595
4	NOE3	496	564	613

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
5	NOE3	513	577	638
6	NOE3	547	594	649
7	NOE3	559	619	656
8	NOE3	576	630	669
9	NOE3	600	637	688
10	NOE3	610	649	690
11	NOE3	617	667	692
12	NOE3	629	668	699
13	NOE3	646	671	701
14	NOE3	647	677	702
15	NOE3	650	679	702
16	NOE3	655	680	702
17	NOE3	657	680	702
18	NOE3	658	680	702
19	NOE3	659	680	702
20	NOE3	659	680	702
21	NOE3	659	680	702
22	NOE3	659	680	702
23	NOE3	659	680	702
24	NOE3	659	680	702
25	NOE3	659	680	702
-2	NOE4	0	0	0
-1	NOE4	0	0	28
0	NOE4	0	0	36
1	NOE4	0	25	38
2	NOE4	0	33	53
3	NOE4	22	35	59
4	NOE4	29	49	60
5	NOE4	31	54	61
6	NOE4	45	56	62
7	NOE4	50	57	63
8	NOE4	51	57	64
9	NOE4	52	58	65
10	NOE4	53	60	65
11	NOE4	53	60	67
12	NOE4	55	61	68
13	NOE4	55	62	69
14	NOE4	56	63	71
15	NOE4	57	64	71
16	NOE4	58	65	71
17	NOE4	59	66	71
18	NOE4	60	66	71
19	NOE4	61	66	71
20	NOE4	61	66	71
21	NOE4	61	66	71

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
22	NOE4	61	66	71
23	NOE4	61	66	71
24	NOE4	61	66	71
-13	NOE5	0	0	0
-12	NOE5	0	0	1
-11	NOE5	0	0	6
-10	NOE5	0	1	46
-9	NOE5	0	5	250
-8	NOE5	1	43	981
-7	NOE5	5	241	2,355
-6	NOE5	39	962	3,125
-5	NOE5	233	2,317	3,529
-4	NOE5	943	3,083	4,168
-3	NOE5	2,278	3,484	4,610
-2	NOE5	3,042	4,121	4,991
-1	NOE5	3,440	4,561	5,119
0	NOE5	4,074	4,940	5,236
1	NOE5	4,512	5,066	5,486
2	NOE5	4,889	5,183	5,651
3	NOE5	5,014	5,430	5,731
4	NOE5	5,130	5,595	5,836
5	NOE5	5,375	5,674	5,938
6	NOE5	5,538	5,778	6,006
7	NOE5	5,617	5,878	6,035
8	NOE5	5,720	5,945	6,055
9	NOE5	5,818	5,974	6,069
10	NOE5	5,885	5,994	6,083
11	NOE5	5,914	6,007	6,087
12	NOE5	5,933	6,022	6,089
13	NOE5	5,946	6,026	6,096
14	NOE5	5,960	6,028	6,098
15	NOE5	5,964	6,035	6,099
16	NOE5	5,967	6,037	6,099
17	NOE5	5,973	6,037	6,099
18	NOE5	5,975	6,037	6,099
19	NOE5	5,976	6,037	6,099
20	NOE5	5,976	6,037	6,099
21	NOE5	5,976	6,037	6,099
22	NOE5	5,976	6,037	6,099
23	NOE5	5,976	6,037	6,099
24	NOE5	5,976	6,037	6,099
25	NOE5	5,976	6,037	6,099
-11	OM1	0	0	0
-10	OM1	0	0	0
-9	OM1	0	0	9

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
-8	OM1	0	0	104
-7	OM1	0	8	407
-6	OM1	0	103	791
-5	OM1	8	402	1,018
-4	OM1	101	783	1,282
-3	OM1	397	1,008	1,545
-2	OM1	774	1,270	1,728
-1	OM1	998	1,531	1,879
0	OM1	1,258	1,713	2,028
1	OM1	1,518	1,864	2,226
2	OM1	1,699	2,012	2,358
3	OM1	1,849	2,209	2,478
4	OM1	1,996	2,339	2,546
5	OM1	2,191	2,459	2,595
6	OM1	2,321	2,526	2,624
7	OM1	2,439	2,575	2,646
8	OM1	2,506	2,603	2,671
9	OM1	2,554	2,625	2,697
10	OM1	2,582	2,650	2,711
11	OM1	2,604	2,675	2,724
12	OM1	2,629	2,689	2,740
13	OM1	2,653	2,702	2,748
14	OM1	2,668	2,718	2,754
15	OM1	2,681	2,726	2,760
16	OM1	2,695	2,732	2,762
17	OM1	2,703	2,738	2,762
18	OM1	2,709	2,739	2,763
19	OM1	2,715	2,740	2,763
20	OM1	2,716	2,740	2,763
21	OM1	2,717	2,740	2,763
22	OM1	2,717	2,740	2,763
23	OM1	2,717	2,740	2,763
24	OM1	2,717	2,740	2,763
25	OM1	2,717	2,740	2,763
26	OM1	2,717	2,740	2,763
27	OM1	2,717	2,740	2,763
28	OM1	2,717	2,740	2,763
29	OM1	2,717	2,740	2,763
-10	OM2	0	0	0
-9	OM2	0	0	2
-8	OM2	0	0	71
-7	OM2	0	2	352
-6	OM2	0	70	684
-5	OM2	2	348	892
-4	OM2	68	677	1,050

Attachment A Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base				
Water Elevation NAVD88 (2004.65)	**Drainage Basin Name**	**5% LC**	**Mean**	**95% UC**
-3	OM2	343	884	1,208
-2	OM2	670	1,040	1,273
-1	OM2	876	1,196	1,392
0	OM2	1,030	1,261	1,499
1	OM2	1,184	1,377	1,591
2	OM2	1,248	1,482	1,704
3	OM2	1,362	1,573	1,782
4	OM2	1,466	1,685	1,857
5	OM2	1,556	1,763	1,881
6	OM2	1,667	1,835	1,899
7	OM2	1,744	1,859	1,917
8	OM2	1,813	1,877	1,933
9	OM2	1,837	1,894	1,946
10	OM2	1,855	1,910	1,954
11	OM2	1,871	1,922	1,963
12	OM2	1,887	1,931	1,970
13	OM2	1,899	1,939	1,973
14	OM2	1,907	1,945	1,974
15	OM2	1,915	1,949	1,974
16	OM2	1,921	1,950	1,975
17	OM2	1,924	1,950	1,975
18	OM2	1,925	1,951	1,976
19	OM2	1,926	1,951	1,976
20	OM2	1,927	1,951	1,976
21	OM2	1,927	1,951	1,976
22	OM2	1,927	1,951	1,976
23	OM2	1,927	1,951	1,976
24	OM2	1,927	1,951	1,976
25	OM2	1,927	1,951	1,976
26	OM2	1,927	1,951	1,976
27	OM2	1,927	1,951	1,976
28	OM2	1,927	1,951	1,976
29	OM2	1,927	1,951	1,976
30	OM2	1,927	1,951	1,976
31	OM2	1,927	1,951	1,976
-9	OM3	0	0	0
-8	OM3	0	0	1
-7	OM3	0	0	9
-6	OM3	0	1	32
-5	OM3	0	9	68
-4	OM3	1	30	157
-3	OM3	8	66	381
-2	OM3	28	154	669
-1	OM3	64	376	1,039
0	OM3	152	662	1,374

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
1	OM3	371	1,031	1,720
2	OM3	655	1,365	2,042
3	OM3	1,022	1,709	2,294
4	OM3	1,355	2,030	2,450
5	OM3	1,698	2,281	2,596
6	OM3	2,018	2,437	2,711
7	OM3	2,268	2,582	2,808
8	OM3	2,423	2,697	2,875
9	OM3	2,567	2,793	2,926
10	OM3	2,682	2,860	2,968
11	OM3	2,778	2,910	3,000
12	OM3	2,844	2,953	3,026
13	OM3	2,894	2,984	3,046
14	OM3	2,937	3,010	3,062
15	OM3	2,968	3,030	3,077
16	OM3	2,994	3,046	3,086
17	OM3	3,013	3,061	3,090
18	OM3	3,029	3,069	3,092
19	OM3	3,044	3,073	3,094
20	OM3	3,052	3,076	3,094
21	OM3	3,057	3,077	3,094
22	OM3	3,059	3,077	3,094
23	OM3	3,060	3,078	3,094
24	OM3	3,061	3,078	3,094
25	OM3	3,061	3,078	3,094
26	OM3	3,061	3,078	3,094
27	OM3	3,061	3,078	3,094
28	OM3	3,061	3,078	3,094
29	OM3	3,061	3,078	3,094
30	OM3	3,061	3,078	3,094
31	OM3	3,061	3,078	3,094
-7	OM4	0	0	3
-6	OM4	0	0	7
-5	OM4	0	3	10
-4	OM4	0	6	29
-3	OM4	2	9	72
-2	OM4	5	28	147
-1	OM4	8	68	227
0	OM4	26	142	317
1	OM4	65	219	430
2	OM4	137	308	630
3	OM4	212	420	803
4	OM4	300	618	894
5	OM4	411	790	969
6	OM4	607	880	997

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
7	OM4	777	954	1,029
8	OM4	866	982	1,051
9	OM4	940	1,013	1,072
10	OM4	967	1,035	1,092
11	OM4	998	1,055	1,113
12	OM4	1,018	1,076	1,128
13	OM4	1,039	1,096	1,137
14	OM4	1,059	1,111	1,149
15	OM4	1,080	1,119	1,157
16	OM4	1,094	1,131	1,163
17	OM4	1,102	1,139	1,169
18	OM4	1,114	1,146	1,172
19	OM4	1,122	1,151	1,173
20	OM4	1,128	1,153	1,173
21	OM4	1,133	1,155	1,174
22	OM4	1,135	1,155	1,174
23	OM4	1,137	1,156	1,174
24	OM4	1,137	1,156	1,174
25	OM4	1,137	1,156	1,174
26	OM4	1,137	1,156	1,174
27	OM4	1,138	1,156	1,174
28	OM4	1,138	1,156	1,174
29	OM4	1,138	1,156	1,174
30	OM4	1,138	1,156	1,174
31	OM4	1,138	1,156	1,174
32	OM4	1,138	1,156	1,174
33	OM4	1,138	1,156	1,174
34	OM4	1,138	1,156	1,174
-8	OM5	0	0	1
-7	OM5	0	0	1
-6	OM5	0	1	7
-5	OM5	0	1	39
-4	OM5	1	7	203
-3	OM5	1	38	793
-2	OM5	6	200	1,494
-1	OM5	37	785	2,184
0	OM5	198	1,483	2,882
1	OM5	777	2,167	3,754
2	OM5	1,472	2,860	4,893
3	OM5	2,150	3,721	5,582
4	OM5	2,837	4,837	6,099
5	OM5	3,689	5,522	6,907
6	OM5	4,782	6,034	7,614
7	OM5	5,462	6,835	8,191
8	OM5	5,970	7,538	8,657

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
9	OM5	6,762	8,112	9,005
10	OM5	7,462	8,574	9,395
11	OM5	8,034	8,920	9,603
12	OM5	8,492	9,306	9,772
13	OM5	8,836	9,512	9,941
14	OM5	9,217	9,680	10,132
15	OM5	9,421	9,847	10,246
16	OM5	9,588	10,032	10,364
17	OM5	9,753	10,144	10,460
18	OM5	9,932	10,260	10,507
19	OM5	10,042	10,354	10,543
20	OM5	10,156	10,401	10,564
21	OM5	10,248	10,436	10,596
22	OM5	10,295	10,458	10,621
23	OM5	10,330	10,488	10,626
24	OM5	10,351	10,513	10,629
25	OM5	10,381	10,518	10,629
26	OM5	10,404	10,520	10,629
27	OM5	10,409	10,521	10,629
28	OM5	10,411	10,521	10,629
29	OM5	10,412	10,521	10,629
30	OM5	10,412	10,521	10,629
31	OM5	10,412	10,521	10,629
32	OM5	10,412	10,521	10,629
-4	OW1	0	0	1
-3	OW1	0	0	26
-2	OW1	0	0	32
-1	OW1	0	23	43
0	OW1	0	28	48
1	OW1	20	39	62
2	OW1	25	43	156
3	OW1	35	57	183
4	OW1	39	143	187
5	OW1	52	166	194
6	OW1	129	170	205
7	OW1	150	176	208
8	OW1	153	187	210
9	OW1	159	189	212
10	OW1	169	192	222
11	OW1	171	194	227
12	OW1	174	203	229
13	OW1	176	207	230
14	OW1	183	209	232
15	OW1	187	210	233
16	OW1	189	211	233

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
17	OW1	190	212	233
18	OW1	191	213	233
19	OW1	192	213	233
20	OW1	192	213	233
21	OW1	192	213	233
22	OW1	192	213	233
23	OW1	192	213	233
24	OW1	192	213	233
25	OW1	192	213	233
26	OW1	192	213	233
27	OW1	192	213	233
28	OW1	192	213	233
29	OW1	192	213	233
30	OW1	192	213	233
31	OW1	192	213	233
32	OW1	192	213	233
33	OW1	192	213	233
34	OW1	192	213	233
35	OW1	192	213	233
36	OW1	192	213	233
-10	OW2	0	0	0
-9	OW2	0	0	0
-8	OW2	0	0	7
-7	OW2	0	0	62
-6	OW2	0	6	168
-5	OW2	0	58	427
-4	OW2	5	157	804
-3	OW2	54	412	1,190
-2	OW2	147	784	1,490
-1	OW2	397	1,165	1,766
0	OW2	764	1,465	2,021
1	OW2	1,141	1,737	2,235
2	OW2	1,439	1,992	2,436
3	OW2	1,709	2,205	2,637
4	OW2	1,962	2,405	2,826
5	OW2	2,174	2,604	3,000
6	OW2	2,373	2,792	3,140
7	OW2	2,572	2,965	3,255
8	OW2	2,758	3,105	3,358
9	OW2	2,930	3,219	3,469
10	OW2	3,069	3,321	3,524
11	OW2	3,182	3,431	3,558
12	OW2	3,284	3,486	3,583
13	OW2	3,394	3,520	3,603
14	OW2	3,448	3,544	3,619

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
15	OW2	3,482	3,564	3,630
16	OW2	3,506	3,580	3,639
17	OW2	3,526	3,591	3,646
18	OW2	3,542	3,600	3,658
19	OW2	3,553	3,607	3,659
20	OW2	3,561	3,619	3,660
21	OW2	3,568	3,620	3,664
22	OW2	3,580	3,621	3,664
23	OW2	3,581	3,625	3,665
24	OW2	3,582	3,625	3,665
25	OW2	3,586	3,625	3,665
26	OW2	3,586	3,626	3,665
27	OW2	3,586	3,626	3,665
28	OW2	3,586	3,626	3,665
29	OW2	3,586	3,626	3,665
30	OW2	3,586	3,626	3,665
31	OW2	3,586	3,626	3,665
-6	PL11	0	0	0
-5	PL11	0	0	4
-4	PL11	0	0	34
-3	PL11	0	4	93
-2	PL11	0	33	157
-1	PL11	3	90	223
0	PL11	32	152	252
1	PL11	87	217	300
2	PL11	148	245	373
3	PL11	211	293	449
4	PL11	239	365	490
5	PL11	285	440	549
6	PL11	357	481	575
7	PL11	431	539	601
8	PL11	472	566	623
9	PL11	530	591	631
10	PL11	556	612	640
11	PL11	581	620	654
12	PL11	601	629	661
13	PL11	609	643	666
14	PL11	618	649	669
15	PL11	631	655	672
16	PL11	638	658	674
17	PL11	643	661	677
18	PL11	646	663	677
19	PL11	649	665	677
20	PL11	651	665	678
21	PL11	653	666	678

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
22	PL11	654	666	678
23	PL11	654	666	678
24	PL11	654	666	678
25	PL11	654	666	678
26	PL11	654	666	678
27	PL11	654	666	678
28	PL11	654	666	678
29	PL11	654	666	678
30	PL11	654	666	678
31	PL11	654	666	678
32	PL11	654	666	678
33	PL11	654	666	678
34	PL11	654	666	678
35	PL11	654	666	678
-6	SB1	0	0	0
-5	SB1	0	0	9
-4	SB1	0	0	55
-3	SB1	0	9	200
-2	SB1	0	54	483
-1	SB1	8	196	887
0	SB1	53	477	1,276
1	SB1	193	877	1,512
2	SB1	471	1,263	1,739
3	SB1	867	1,497	2,004
4	SB1	1,249	1,723	2,181
5	SB1	1,482	1,983	2,328
6	SB1	1,707	2,160	2,426
7	SB1	1,963	2,306	2,504
8	SB1	2,138	2,403	2,566
9	SB1	2,284	2,480	2,606
10	SB1	2,381	2,542	2,642
11	SB1	2,457	2,582	2,675
12	SB1	2,518	2,617	2,702
13	SB1	2,558	2,650	2,719
14	SB1	2,592	2,677	2,733
15	SB1	2,626	2,694	2,743
16	SB1	2,651	2,708	2,752
17	SB1	2,669	2,718	2,756
18	SB1	2,682	2,726	2,758
19	SB1	2,692	2,730	2,758
20	SB1	2,699	2,731	2,759
21	SB1	2,704	2,732	2,759
22	SB1	2,705	2,733	2,759
23	SB1	2,706	2,733	2,760
24	SB1	2,707	2,733	2,760

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
25	SB1	2,707	2,733	2,760
26	SB1	2,707	2,734	2,760
27	SB1	2,707	2,734	2,760
28	SB1	2,707	2,734	2,760
29	SB1	2,707	2,734	2,760
30	SB1	2,707	2,734	2,760
31	SB1	2,707	2,734	2,760
32	SB1	2,707	2,734	2,760
33	SB1	2,707	2,734	2,760
34	SB1	2,707	2,734	2,760
35	SB1	2,707	2,734	2,760
2	SB2	0	0	0
3	SB2	0	0	0
4	SB2	0	0	0
5	SB2	0	0	0
6	SB2	0	0	21
7	SB2	0	0	23
8	SB2	0	19	25
9	SB2	0	21	27
10	SB2	16	22	27
11	SB2	18	24	27
12	SB2	20	24	28
13	SB2	21	24	28
14	SB2	21	25	29
15	SB2	22	25	30
16	SB2	22	26	30
17	SB2	22	26	30
18	SB2	23	27	32
19	SB2	23	27	32
20	SB2	24	29	33
21	SB2	24	29	33
22	SB2	25	29	33
23	SB2	25	29	33
24	SB2	26	29	33
25	SB2	26	29	33
26	SB2	26	29	33
27	SB2	26	29	33
28	SB2	26	29	33
29	SB2	26	29	33
30	SB2	26	29	33
31	SB2	26	29	33
32	SB2	26	29	33
33	SB2	26	29	33
34	SB2	26	29	33
35	SB2	26	29	33

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
36	SB2	26	29	33
-6	SB3	0	0	0
-5	SB3	0	0	0
-4	SB3	0	0	0
-3	SB3	0	0	4
-2	SB3	0	0	75
-1	SB3	0	4	226
0	SB3	0	71	649
1	SB3	3	218	1,169
2	SB3	66	633	1,547
3	SB3	209	1,150	1,747
4	SB3	618	1,525	1,860
5	SB3	1,130	1,724	1,963
6	SB3	1,503	1,836	2,102
7	SB3	1,700	1,939	2,216
8	SB3	1,812	2,077	2,325
9	SB3	1,914	2,190	2,421
10	SB3	2,052	2,298	2,484
11	SB3	2,165	2,393	2,519
12	SB3	2,271	2,456	2,538
13	SB3	2,366	2,491	2,553
14	SB3	2,428	2,510	2,569
15	SB3	2,462	2,524	2,583
16	SB3	2,481	2,540	2,592
17	SB3	2,496	2,554	2,597
18	SB3	2,511	2,563	2,603
19	SB3	2,525	2,568	2,606
20	SB3	2,534	2,573	2,608
21	SB3	2,539	2,577	2,609
22	SB3	2,544	2,579	2,610
23	SB3	2,548	2,580	2,610
24	SB3	2,549	2,580	2,610
25	SB3	2,551	2,581	2,610
26	SB3	2,551	2,581	2,610
27	SB3	2,551	2,581	2,610
28	SB3	2,551	2,581	2,610
29	SB3	2,551	2,581	2,610
30	SB3	2,551	2,581	2,610
31	SB3	2,551	2,581	2,610
32	SB3	2,551	2,581	2,610
33	SB3	2,551	2,581	2,610
34	SB3	2,551	2,581	2,610
0	SB4	0	0	0
1	SB4	0	0	8
2	SB4	0	0	34

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
3	SB4	0	7	93
4	SB4	0	33	196
5	SB4	7	90	303
6	SB4	31	190	397
7	SB4	87	295	448
8	SB4	184	388	475
9	SB4	287	439	502
10	SB4	378	465	508
11	SB4	429	491	514
12	SB4	455	497	527
13	SB4	481	503	539
14	SB4	487	516	549
15	SB4	493	528	556
16	SB4	505	538	561
17	SB4	516	545	564
18	SB4	526	549	565
19	SB4	533	553	566
20	SB4	538	554	566
21	SB4	541	554	566
22	SB4	542	554	566
23	SB4	543	555	566
24	SB4	543	555	566
25	SB4	543	555	566
26	SB4	543	555	566
27	SB4	543	555	566
28	SB4	543	555	566
29	SB4	543	555	566
30	SB4	543	555	566
31	SB4	543	555	566
32	SB4	543	555	566
33	SB4	543	555	566
34	SB4	543	555	566
35	SB4	543	555	566
36	SB4	543	555	566
0	SB5	0	0	0
1	SB5	0	0	2
2	SB5	0	0	12
3	SB5	0	2	32
4	SB5	0	11	36
5	SB5	1	30	41
6	SB5	10	33	43
7	SB5	27	38	44
8	SB5	31	40	44
9	SB5	35	40	45
10	SB5	36	41	46

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
11	SB5	37	41	47
12	SB5	37	43	48
13	SB5	38	44	49
14	SB5	39	44	49
15	SB5	40	45	50
16	SB5	41	46	51
17	SB5	41	47	51
18	SB5	42	47	51
19	SB5	43	47	51
20	SB5	43	47	51
21	SB5	43	47	51
22	SB5	43	47	51
23	SB5	43	47	51
24	SB5	43	47	51
25	SB5	43	47	51
26	SB5	43	47	51
27	SB5	43	47	51
28	SB5	43	47	51
29	SB5	43	47	51
30	SB5	43	47	51
31	SB5	43	47	51
32	SB5	43	47	51
33	SB5	43	47	51
34	SB5	43	47	51
35	SB5	43	47	51
36	SB5	43	47	51
0	SC1	0	0	21
1	SC1	0	0	91
2	SC1	0	19	120
3	SC1	0	85	128
4	SC1	17	113	135
5	SC1	79	121	138
6	SC1	106	127	138
7	SC1	114	130	139
8	SC1	119	130	141
9	SC1	122	131	145
10	SC1	122	132	148
11	SC1	123	136	150
12	SC1	124	139	151
13	SC1	128	141	153
14	SC1	131	143	154
15	SC1	133	144	155
16	SC1	134	145	155
17	SC1	135	146	155
18	SC1	136	146	155

Attachment A
Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
19	SC1	137	146	155
20	SC1	137	146	155
21	SC1	137	146	155
22	SC1	137	146	155
23	SC1	137	146	155
24	SC1	137	146	155
25	SC1	137	146	155
26	SC1	137	146	155
27	SC1	137	146	155
28	SC1	137	146	155
29	SC1	137	146	155
30	SC1	137	146	155
31	SC1	137	146	155
32	SC1	137	146	155
33	SC1	137	146	155
34	SC1	137	146	155
35	SC1	137	146	155
36	SC1	137	146	155
-1	SC2	0	0	12
0	SC2	0	0	180
1	SC2	0	10	303
2	SC2	0	169	406
3	SC2	9	290	502
4	SC2	158	390	680
5	SC2	277	485	853
6	SC2	373	661	994
7	SC2	468	832	1,176
8	SC2	642	973	1,384
9	SC2	812	1,151	1,563
10	SC2	951	1,355	1,651
11	SC2	1,126	1,532	1,724
12	SC2	1,327	1,619	1,781
13	SC2	1,501	1,690	1,822
14	SC2	1,586	1,746	1,843
15	SC2	1,656	1,787	1,866
16	SC2	1,710	1,807	1,898
17	SC2	1,752	1,830	1,920
18	SC2	1,772	1,861	1,936
19	SC2	1,794	1,883	1,946
20	SC2	1,824	1,898	1,953
21	SC2	1,845	1,908	1,958
22	SC2	1,860	1,915	1,960
23	SC2	1,870	1,920	1,961
24	SC2	1,877	1,922	1,962
25	SC2	1,882	1,923	1,963

Attachment A Model Estimated Stage-damage with uncertainty—Pre-Katrina Property Base				
Water Elevation NAVD88 (2004.65)	**Drainage Basin Name**	**5% LC**	**Mean**	**95% UC**
26	SC2	1,883	1,923	1,963
27	SC2	1,884	1,924	1,963
28	SC2	1,885	1,925	1,963
29	SC2	1,886	1,925	1,963
30	SC2	1,886	1,925	1,963
31	SC2	1,886	1,925	1,963
32	SC2	1,886	1,925	1,963
33	SC2	1,886	1,925	1,963
34	SC2	1,886	1,925	1,963
35	SC2	1,886	1,925	1,963
36	SC2	1,886	1,925	1,963

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
-4	JE1	0	0	0
-3	JE1	0	0	1
-2	JE1	0	0	10
-1	JE1	0	1	51
0	JE1	0	9	226
1	JE1	1	49	430
2	JE1	8	218	1,128
3	JE1	47	420	1,530
4	JE1	211	1,093	2,095
5	JE1	410	1,490	2,671
6	JE1	1,058	2,049	3,339
7	JE1	1,451	2,617	3,697
8	JE1	2,004	3,278	4,223
9	JE1	2,564	3,633	4,707
10	JE1	3,217	4,150	5,202
11	JE1	3,569	4,630	5,589
12	JE1	4,078	5,122	5,812
13	JE1	4,554	5,506	5,943
14	JE1	5,042	5,728	6,096
15	JE1	5,424	5,858	6,175
16	JE1	5,644	6,007	6,243
17	JE1	5,772	6,085	6,315
18	JE1	5,919	6,152	6,386
19	JE1	5,996	6,223	6,439
20	JE1	6,061	6,293	6,483
21	JE1	6,131	6,345	6,503
22	JE1	6,200	6,388	6,520
23	JE1	6,252	6,408	6,531
24	JE1	6,293	6,425	6,537
25	JE1	6,313	6,436	6,539
26	JE1	6,330	6,442	6,539
27	JE1	6,341	6,443	6,539
28	JE1	6,347	6,444	6,539
29	JE1	6,348	6,444	6,539
30	JE1	6,348	6,444	6,539
31	JE1	6,348	6,444	6,539
32	JE1	6,348	6,444	6,539
33	JE1	6,348	6,444	6,539
34	JE1	6,348	6,444	6,539
-12	JE2	0	0	0
-11	JE2	0	0	1
-10	JE2	0	0	1
-9	JE2	0	1	3

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
-8	JE2	0	1	9
-7	JE2	1	2	54
-6	JE2	1	8	479
-5	JE2	2	52	2,223
-4	JE2	7	471	3,438
-3	JE2	50	2,190	3,905
-2	JE2	462	3,394	4,278
-1	JE2	2,157	3,857	4,557
0	JE2	3,350	4,228	4,803
1	JE2	3,810	4,505	5,047
2	JE2	4,179	4,748	5,292
3	JE2	4,456	4,986	5,555
4	JE2	4,701	5,225	5,794
5	JE2	4,941	5,485	5,922
6	JE2	5,183	5,722	6,002
7	JE2	5,444	5,850	6,140
8	JE2	5,680	5,929	6,238
9	JE2	5,807	6,064	6,278
10	JE2	5,886	6,160	6,306
11	JE2	6,019	6,200	6,325
12	JE2	6,114	6,227	6,340
13	JE2	6,153	6,246	6,349
14	JE2	6,180	6,261	6,355
15	JE2	6,200	6,270	6,359
16	JE2	6,215	6,275	6,362
17	JE2	6,224	6,279	6,363
18	JE2	6,229	6,282	6,363
19	JE2	6,233	6,283	6,364
20	JE2	6,236	6,284	6,364
21	JE2	6,237	6,284	6,364
22	JE2	6,238	6,284	6,364
23	JE2	6,238	6,284	6,364
24	JE2	6,238	6,284	6,364
25	JE2	6,238	6,284	6,364
26	JE2	6,238	6,284	6,364
27	JE2	6,238	6,284	6,364
28	JE2	6,238	6,284	6,364
-12	JE3	0	0	0
-11	JE3	0	0	0
-10	JE3	0	0	4
-9	JE3	0	0	38
-8	JE3	0	4	121
-7	JE3	0	36	527
-6	JE3	3	116	2,369
-5	JE3	33	515	6,223

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
-4	JE3	112	2,336	8,402
-3	JE3	503	6,174	9,215
-2	JE3	2,303	8,346	9,690
-1	JE3	6,125	9,156	10,107
0	JE3	8,291	9,630	10,360
1	JE3	9,098	10,046	10,563
2	JE3	9,570	10,297	10,800
3	JE3	9,984	10,500	11,224
4	JE3	10,235	10,735	11,572
5	JE3	10,436	11,157	11,745
6	JE3	10,670	11,503	11,876
7	JE3	11,090	11,675	12,020
8	JE3	11,435	11,805	12,098
9	JE3	11,606	11,948	12,122
10	JE3	11,734	12,025	12,135
11	JE3	11,876	12,049	12,147
12	JE3	11,952	12,062	12,154
13	JE3	11,977	12,074	12,158
14	JE3	11,990	12,081	12,160
15	JE3	12,001	12,085	12,162
16	JE3	12,008	12,087	12,163
17	JE3	12,012	12,089	12,163
18	JE3	12,014	12,090	12,163
19	JE3	12,016	12,090	12,163
20	JE3	12,017	12,091	12,163
21	JE3	12,018	12,091	12,163
22	JE3	12,018	12,091	12,163
23	JE3	12,018	12,091	12,163
24	JE3	12,018	12,091	12,163
25	JE3	12,018	12,091	12,163
26	JE3	12,018	12,091	12,163
27	JE3	12,018	12,091	12,163
28	JE3	12,018	12,091	12,163
-4	JW1	0	0	0
-3	JW1	0	0	0
-2	JW1	0	0	0
-1	JW1	0	0	5
0	JW1	0	0	63
1	JW1	0	4	156
2	JW1	0	61	237
3	JW1	4	151	304
4	JW1	58	230	390
5	JW1	146	296	481
6	JW1	224	381	554
7	JW1	288	471	645

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
8	JW1	372	542	721
9	JW1	460	631	779
10	JW1	530	707	818
11	JW1	617	764	846
12	JW1	692	803	867
13	JW1	749	830	880
14	JW1	787	850	893
15	JW1	814	863	904
16	JW1	834	877	919
17	JW1	847	887	948
18	JW1	860	901	958
19	JW1	870	930	966
20	JW1	884	940	972
21	JW1	913	947	972
22	JW1	921	953	972
23	JW1	928	953	973
24	JW1	934	954	974
25	JW1	935	954	976
26	JW1	935	955	976
27	JW1	935	957	978
28	JW1	936	957	978
29	JW1	938	958	979
30	JW1	938	959	979
31	JW1	939	959	979
32	JW1	940	959	979
33	JW1	940	960	979
34	JW1	940	960	979
35	JW1	940	960	979
36	JW1	940	960	979
-9	JW2	0	0	0
-8	JW2	0	0	0
-7	JW2	0	0	1
-6	JW2	0	0	6
-5	JW2	0	1	48
-4	JW2	0	5	120
-3	JW2	1	44	185
-2	JW2	4	114	269
-1	JW2	40	178	329
0	JW2	108	262	366
1	JW2	172	321	392
2	JW2	254	356	403
3	JW2	312	383	409
4	JW2	347	393	417
5	JW2	373	399	426
6	JW2	384	407	436

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
7	JW2	389	416	444
8	JW2	397	426	450
9	JW2	405	434	454
10	JW2	415	439	457
11	JW2	423	443	457
12	JW2	429	446	458
13	JW2	432	446	458
14	JW2	435	447	458
15	JW2	435	447	459
16	JW2	436	447	459
17	JW2	436	447	459
18	JW2	436	447	459
19	JW2	436	447	459
20	JW2	436	447	459
21	JW2	436	447	459
22	JW2	436	447	459
23	JW2	436	447	459
24	JW2	436	447	459
25	JW2	436	447	459
26	JW2	436	447	459
27	JW2	436	447	459
28	JW2	436	447	459
29	JW2	436	447	459
30	JW2	436	447	459
31	JW2	436	447	459
-8	JW3	0	0	0
-7	JW3	0	0	0
-6	JW3	0	0	0
-5	JW3	0	0	18
-4	JW3	0	0	127
-3	JW3	0	16	326
-2	JW3	0	122	650
-1	JW3	15	314	1,226
0	JW3	117	635	1,960
1	JW3	302	1,206	2,783
2	JW3	620	1,933	3,698
3	JW3	1,186	2,750	4,594
4	JW3	1,907	3,660	5,205
5	JW3	2,716	4,550	5,515
6	JW3	3,621	5,158	5,675
7	JW3	4,506	5,466	5,794
8	JW3	5,111	5,625	5,903
9	JW3	5,417	5,743	6,000
10	JW3	5,575	5,851	6,103
11	JW3	5,692	5,947	6,214

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
12	JW3	5,799	6,049	6,291
13	JW3	5,894	6,159	6,357
14	JW3	5,995	6,236	6,402
15	JW3	6,104	6,301	6,423
16	JW3	6,180	6,345	6,437
17	JW3	6,245	6,366	6,443
18	JW3	6,288	6,380	6,446
19	JW3	6,309	6,385	6,446
20	JW3	6,323	6,388	6,447
21	JW3	6,328	6,389	6,447
22	JW3	6,331	6,389	6,447
23	JW3	6,332	6,390	6,447
24	JW3	6,332	6,390	6,447
25	JW3	6,332	6,390	6,447
26	JW3	6,332	6,390	6,447
27	JW3	6,332	6,390	6,447
28	JW3	6,332	6,390	6,447
29	JW3	6,332	6,390	6,447
30	JW3	6,332	6,390	6,447
31	JW3	6,332	6,390	6,447
32	JW3	6,332	6,390	6,447
-9	JW4	0	0	0
-8	JW4	0	0	0
-7	JW4	0	0	25
-6	JW4	0	0	88
-5	JW4	0	23	439
-4	JW4	0	83	1,310
-3	JW4	20	426	2,735
-2	JW4	79	1,288	3,620
-1	JW4	413	2,702	4,257
0	JW4	1,266	3,582	4,806
1	JW4	2,669	4,216	5,282
2	JW4	3,545	4,763	5,598
3	JW4	4,176	5,236	5,877
4	JW4	4,720	5,551	6,092
5	JW4	5,190	5,828	6,324
6	JW4	5,504	6,042	6,490
7	JW4	5,779	6,272	6,610
8	JW4	5,991	6,437	6,700
9	JW4	6,219	6,555	6,786
10	JW4	6,383	6,645	6,858
11	JW4	6,501	6,731	6,910
12	JW4	6,589	6,802	6,951
13	JW4	6,675	6,853	6,982
14	JW4	6,746	6,894	7,001

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
15	JW4	6,797	6,925	7,013
16	JW4	6,837	6,944	7,018
17	JW4	6,868	6,955	7,021
18	JW4	6,886	6,961	7,022
19	JW4	6,898	6,964	7,024
20	JW4	6,903	6,965	7,025
21	JW4	6,906	6,966	7,025
22	JW4	6,907	6,967	7,026
23	JW4	6,909	6,968	7,026
24	JW4	6,910	6,968	7,027
25	JW4	6,910	6,969	7,027
26	JW4	6,911	6,969	7,027
27	JW4	6,911	6,969	7,027
28	JW4	6,911	6,969	7,027
29	JW4	6,911	6,969	7,027
30	JW4	6,911	6,969	7,027
-3	NOE1	0	0	0
-2	NOE1	0	0	0
-1	NOE1	0	0	0
0	NOE1	0	0	0
1	NOE1	0	0	0
2	NOE1	0	0	0
3	NOE1	0	0	0
4	NOE1	0	0	0
5	NOE1	0	0	0
6	NOE1	0	0	0
7	NOE1	0	0	0
8	NOE1	0	0	0
9	NOE1	0	0	0
10	NOE1	0	0	0
11	NOE1	0	0	0
12	NOE1	0	0	0
13	NOE1	0	0	0
14	NOE1	0	0	0
15	NOE1	0	0	0
16	NOE1	0	0	0
17	NOE1	0	0	0
18	NOE1	0	0	0
19	NOE1	0	0	0
20	NOE1	0	0	0
21	NOE1	0	0	0
22	NOE1	0	0	0
23	NOE1	0	0	0
24	NOE1	0	0	0
-7	NOE2	0	0	0

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
-6	NOE2	0	0	0
-5	NOE2	0	0	0
-4	NOE2	0	0	0
-3	NOE2	0	0	0
-2	NOE2	0	1	1
-1	NOE2	0	1	1
0	NOE2	1	1	1
1	NOE2	1	1	1
2	NOE2	1	1	1
3	NOE2	1	1	1
4	NOE2	1	1	1
5	NOE2	1	1	1
6	NOE2	1	1	1
7	NOE2	1	1	1
8	NOE2	1	1	1
9	NOE2	1	1	1
10	NOE2	1	1	1
11	NOE2	1	1	1
12	NOE2	1	1	1
13	NOE2	1	1	1
14	NOE2	1	1	1
15	NOE2	1	1	1
16	NOE2	1	1	1
17	NOE2	1	1	1
18	NOE2	1	1	1
19	NOE2	1	1	1
20	NOE2	1	1	1
21	NOE2	1	1	1
22	NOE2	1	1	1
23	NOE2	1	1	1
24	NOE2	1	1	1
-8	NOE3	0	0	0
-7	NOE3	0	0	0
-6	NOE3	0	0	0
-5	NOE3	0	0	0
-4	NOE3	0	0	0
-3	NOE3	0	0	0
-2	NOE3	0	2	3
-1	NOE3	0	4	4
0	NOE3	2	5	6
1	NOE3	5	6	7
2	NOE3	17	22	25
3	NOE3	19	25	28
4	NOE3	28	31	34
5	NOE3	30	33	37

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
6	NOE3	31	34	37
7	NOE3	31	34	36
8	NOE3	32	35	37
9	NOE3	34	36	39
10	NOE3	35	38	40
11	NOE3	37	40	42
12	NOE3	38	40	42
13	NOE3	39	41	43
14	NOE3	40	42	44
15	NOE3	41	43	44
16	NOE3	41	43	44
17	NOE3	41	43	44
18	NOE3	41	43	44
19	NOE3	41	43	44
20	NOE3	41	43	44
21	NOE3	41	43	44
22	NOE3	41	43	44
23	NOE3	41	43	44
24	NOE3	41	43	44
25	NOE3	41	43	44
-2	NOE4	0	0	0
-1	NOE4	0	0	13
0	NOE4	0	0	29
1	NOE4	0	13	19
2	NOE4	0	19	32
3	NOE4	13	21	35
4	NOE4	20	34	42
5	NOE4	22	39	44
6	NOE4	32	40	44
7	NOE4	36	41	45
8	NOE4	37	41	46
9	NOE4	37	42	47
10	NOE4	38	43	47
11	NOE4	39	43	48
12	NOE4	40	44	49
13	NOE4	40	44	49
14	NOE4	40	45	51
15	NOE4	41	46	51
16	NOE4	42	47	52
17	NOE4	42	48	52
18	NOE4	44	48	52
19	NOE4	44	48	52
20	NOE4	44	48	52
21	NOE4	44	48	52
22	NOE4	44	48	52

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
23	NOE4	44	48	52
24	NOE4	44	48	52
-13	NOE5	0	0	0
-12	NOE5	0	0	0
-11	NOE5	0	0	0
-10	NOE5	0	0	0
-9	NOE5	0	0	0
-8	NOE5	0	0	0
-7	NOE5	0	2	17
-6	NOE5	0	10	32
-5	NOE5	3	25	39
-4	NOE5	13	42	57
-3	NOE5	41	63	84
-2	NOE5	108	146	177
-1	NOE5	170	225	253
0	NOE5	268	325	345
1	NOE5	320	359	389
2	NOE5	357	378	412
3	NOE5	432	468	494
4	NOE5	466	508	530
5	NOE5	491	518	542
6	NOE5	508	530	551
7	NOE5	517	541	555
8	NOE5	533	554	564
9	NOE5	549	564	573
10	NOE5	559	569	578
11	NOE5	567	576	583
12	NOE5	576	585	591
13	NOE5	579	587	594
14	NOE5	582	589	596
15	NOE5	588	595	601
16	NOE5	590	597	603
17	NOE5	591	598	604
18	NOE5	592	598	604
19	NOE5	592	598	604
20	NOE5	592	598	604
21	NOE5	592	598	604
22	NOE5	592	598	604
23	NOE5	592	598	604
24	NOE5	592	598	604
25	NOE5	592	598	604
-11	OM1	0	0	0
-10	OM1	0	0	0
-9	OM1	0	0	0
-8	OM1	0	0	0

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
-7	OM1	0	0	0
-6	OM1	0	0	0
-5	OM1	0	0	0
-4	OM1	0	0	0
-3	OM1	0	1	1
-2	OM1	2	3	5
-1	OM1	6	9	11
0	OM1	12	17	20
1	OM1	24	29	35
2	OM1	44	52	60
3	OM1	75	89	100
4	OM1	112	131	143
5	OM1	168	188	199
6	OM1	204	222	230
7	OM1	223	235	241
8	OM1	230	239	245
9	OM1	236	242	249
10	OM1	240	246	251
11	OM1	244	251	256
12	OM1	250	255	260
13	OM1	256	261	265
14	OM1	264	269	272
15	OM1	268	273	276
16	OM1	273	276	279
17	OM1	276	279	282
18	OM1	277	280	283
19	OM1	278	281	283
20	OM1	279	281	283
21	OM1	279	281	283
22	OM1	279	281	283
23	OM1	279	281	283
24	OM1	279	281	283
25	OM1	279	281	283
26	OM1	279	281	283
27	OM1	279	281	283
28	OM1	279	281	283
29	OM1	279	281	283
-10	OM2	0	0	0
-9	OM2	0	0	0
-8	OM2	0	0	0
-7	OM2	0	0	0
-6	OM2	0	0	0
-5	OM2	0	0	0
-4	OM2	0	0	0
-3	OM2	0	0	0

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
-2	OM2	1	2	2
-1	OM2	3	4	5
0	OM2	6	7	8
1	OM2	23	27	31
2	OM2	37	44	51
3	OM2	55	64	73
4	OM2	90	103	114
5	OM2	126	143	152
6	OM2	171	188	195
7	OM2	180	191	197
8	OM2	188	195	200
9	OM2	192	198	203
10	OM2	195	201	206
11	OM2	198	204	208
12	OM2	203	208	212
13	OM2	208	213	217
14	OM2	214	218	221
15	OM2	217	221	223
16	OM2	218	221	224
17	OM2	219	222	224
18	OM2	220	222	225
19	OM2	220	223	225
20	OM2	220	223	225
21	OM2	220	223	225
22	OM2	220	223	225
23	OM2	220	223	225
24	OM2	220	223	225
25	OM2	220	223	225
26	OM2	220	223	225
27	OM2	220	223	225
28	OM2	220	223	225
29	OM2	220	223	225
30	OM2	220	223	225
-9	OM3	0	0	0
-8	OM3	0	0	0
-7	OM3	0	0	0
-6	OM3	0	0	0
-5	OM3	0	0	0
-4	OM3	0	0	0
-3	OM3	0	0	1
-2	OM3	0	1	5
-1	OM3	1	5	13
0	OM3	4	16	33
1	OM3	15	41	68
2	OM3	42	87	130

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
3	OM3	100	167	224
4	OM3	192	288	347
5	OM3	340	456	519
6	OM3	482	582	648
7	OM3	607	692	752
8	OM3	696	774	826
9	OM3	766	833	872
10	OM3	812	866	899
11	OM3	847	888	915
12	OM3	870	903	926
13	OM3	892	920	939
14	OM3	914	937	953
15	OM3	931	951	965
16	OM3	947	963	976
17	OM3	961	976	986
18	OM3	971	984	992
19	OM3	979	988	994
20	OM3	983	990	996
21	OM3	985	991	997
22	OM3	986	992	997
23	OM3	987	992	998
24	OM3	987	992	998
25	OM3	987	992	998
26	OM3	987	992	998
27	OM3	987	992	998
28	OM3	987	992	998
29	OM3	987	992	998
30	OM3	987	992	998
31	OM3	987	992	998
32	OM3	987	992	998
-7	OM4	0	0	0
-6	OM4	0	0	0
-5	OM4	0	0	0
-4	OM4	0	0	0
-3	OM4	0	0	0
-2	OM4	0	1	4
-1	OM4	0	2	6
0	OM4	1	7	16
1	OM4	4	14	27
2	OM4	13	29	58
3	OM4	30	59	113
4	OM4	77	158	229
5	OM4	150	288	354
6	OM4	252	366	415
7	OM4	350	430	464

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
8	OM4	396	449	481
9	OM4	436	470	497
10	OM4	449	480	507
11	OM4	464	491	518
12	OM4	474	501	525
13	OM4	487	514	533
14	OM4	501	526	544
15	OM4	513	532	550
16	OM4	522	540	555
17	OM4	529	547	561
18	OM4	537	553	565
19	OM4	544	558	569
20	OM4	548	560	570
21	OM4	551	562	571
22	OM4	552	562	571
23	OM4	553	562	571
24	OM4	553	562	571
25	OM4	553	562	571
26	OM4	553	562	571
27	OM4	553	562	571
28	OM4	553	562	571
29	OM4	553	562	571
30	OM4	553	562	571
31	OM4	553	562	571
32	OM4	553	562	571
33	OM4	553	562	571
34	OM4	553	562	571
-8	OM5	0	0	0
-7	OM5	0	0	0
-6	OM5	0	0	0
-5	OM5	0	0	0
-4	OM5	0	0	3
-3	OM5	0	0	8
-2	OM5	0	2	17
-1	OM5	1	11	30
0	OM5	5	35	68
1	OM5	28	79	137
2	OM5	91	177	303
3	OM5	207	358	538
4	OM5	485	827	1,043
5	OM5	866	1,297	1,622
6	OM5	1,348	1,701	2,147
7	OM5	1,908	2,387	2,861
8	OM5	2,349	2,967	3,407
9	OM5	2,847	3,415	3,791

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
10	OM5	3,271	3,758	4,118
11	OM5	3,614	4,013	4,320
12	OM5	3,927	4,303	4,519
13	OM5	4,133	4,449	4,650
14	OM5	4,354	4,572	4,786
15	OM5	4,473	4,675	4,865
16	OM5	4,588	4,800	4,959
17	OM5	4,708	4,897	5,049
18	OM5	4,843	5,004	5,124
19	OM5	4,939	5,092	5,185
20	OM5	5,016	5,137	5,218
21	OM5	5,077	5,171	5,250
22	OM5	5,110	5,191	5,272
23	OM5	5,141	5,220	5,289
24	OM5	5,163	5,243	5,301
25	OM5	5,180	5,248	5,304
26	OM5	5,192	5,250	5,305
27	OM5	5,195	5,251	5,305
28	OM5	5,196	5,251	5,305
29	OM5	5,196	5,251	5,305
30	OM5	5,196	5,251	5,305
31	OM5	5,196	5,251	5,305
32	OM5	5,196	5,251	5,305
33	OM5	5,196	5,251	5,305
-4	OW1	0	0	1
-3	OW1	0	0	26
-2	OW1	0	0	32
-1	OW1	0	23	43
0	OW1	0	28	48
1	OW1	20	39	62
2	OW1	25	43	156
3	OW1	35	57	183
4	OW1	39	143	187
5	OW1	52	166	194
6	OW1	129	170	205
7	OW1	150	176	208
8	OW1	153	187	210
9	OW1	159	189	212
10	OW1	169	192	222
11	OW1	171	194	227
12	OW1	174	203	229
13	OW1	176	207	230
14	OW1	183	209	232
15	OW1	187	210	233
16	OW1	189	211	233

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
17	OW1	190	212	233
18	OW1	191	213	233
19	OW1	192	213	233
20	OW1	192	213	233
21	OW1	192	213	233
22	OW1	192	213	233
23	OW1	192	213	233
24	OW1	192	213	233
25	OW1	192	213	233
26	OW1	192	213	233
27	OW1	192	213	233
28	OW1	192	213	233
29	OW1	192	213	233
30	OW1	192	213	233
31	OW1	192	213	233
32	OW1	192	213	233
33	OW1	192	213	233
34	OW1	192	213	233
35	OW1	192	213	233
36	OW1	192	213	233
-10	OW2	0	0	0
-9	OW2	0	0	0
-8	OW2	0	0	7
-7	OW2	0	0	62
-6	OW2	0	6	168
-5	OW2	0	58	427
-4	OW2	5	157	804
-3	OW2	54	412	1,190
-2	OW2	147	784	1,490
-1	OW2	397	1,165	1,766
0	OW2	764	1,465	2,021
1	OW2	1,141	1,737	2,235
2	OW2	1,439	1,992	2,436
3	OW2	1,709	2,205	2,637
4	OW2	1,962	2,405	2,826
5	OW2	2,174	2,604	3,000
6	OW2	2,373	2,792	3,140
7	OW2	2,572	2,965	3,255
8	OW2	2,758	3,105	3,358
9	OW2	2,930	3,219	3,469
10	OW2	3,069	3,321	3,524
11	OW2	3,182	3,431	3,558
12	OW2	3,284	3,486	3,583
13	OW2	3,394	3,520	3,603
14	OW2	3,448	3,544	3,619

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
15	OW2	3,482	3,564	3,630
16	OW2	3,506	3,580	3,639
17	OW2	3,526	3,591	3,646
18	OW2	3,542	3,600	3,658
19	OW2	3,553	3,607	3,659
20	OW2	3,561	3,619	3,660
21	OW2	3,568	3,620	3,664
22	OW2	3,580	3,621	3,664
23	OW2	3,581	3,625	3,665
24	OW2	3,582	3,625	3,665
25	OW2	3,586	3,625	3,665
26	OW2	3,586	3,626	3,665
27	OW2	3,586	3,626	3,665
28	OW2	3,586	3,626	3,665
29	OW2	3,586	3,626	3,665
30	OW2	3,586	3,626	3,665
31	OW2	3,586	3,626	3,665
-6	PL11	0	0	0
-5	PL11	0	0	4
-4	PL11	0	0	34
-3	PL11	0	4	93
-2	PL11	0	33	157
-1	PL11	3	90	223
0	PL11	32	152	252
1	PL11	87	217	300
2	PL11	148	245	373
3	PL11	211	293	449
4	PL11	239	365	490
5	PL11	285	440	549
6	PL11	357	481	575
7	PL11	431	539	601
8	PL11	472	566	623
9	PL11	530	591	631
10	PL11	556	612	640
11	PL11	581	620	654
12	PL11	601	629	661
13	PL11	609	643	666
14	PL11	618	649	669
15	PL11	631	655	672
16	PL11	638	658	674
17	PL11	643	661	677
18	PL11	646	663	677
19	PL11	649	665	677
20	PL11	651	665	678
21	PL11	653	666	678

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
22	PL11	654	666	678
23	PL11	654	666	678
24	PL11	654	666	678
25	PL11	654	666	678
26	PL11	654	666	678
27	PL11	654	666	678
28	PL11	654	666	678
29	PL11	654	666	678
30	PL11	654	666	678
31	PL11	654	666	678
32	PL11	654	666	678
33	PL11	654	666	678
34	PL11	654	666	678
35	PL11	654	666	678
-6	SB1	0	0	0
-5	SB1	0	0	0
-4	SB1	0	0	0
-3	SB1	0	0	0
-2	SB1	0	0	0
-1	SB1	0	0	0
0	SB1	0	0	1
1	SB1	1	5	8
2	SB1	3	8	11
3	SB1	7	11	15
4	SB1	13	17	22
5	SB1	24	33	38
6	SB1	42	53	60
7	SB1	67	78	85
8	SB1	88	99	106
9	SB1	107	116	122
10	SB1	117	125	130
11	SB1	123	129	134
12	SB1	128	133	138
13	SB1	133	138	142
14	SB1	137	141	144
15	SB1	141	144	147
16	SB1	144	147	149
17	SB1	147	149	151
18	SB1	149	151	153
19	SB1	150	152	154
20	SB1	151	153	154
21	SB1	152	153	155
22	SB1	152	154	155
23	SB1	153	154	156
24	SB1	153	154	156

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
25	SB1	153	154	156
26	SB1	153	154	156
27	SB1	153	154	156
28	SB1	153	154	156
29	SB1	153	154	156
30	SB1	153	154	156
31	SB1	153	154	156
32	SB1	153	154	156
33	SB1	153	154	156
34	SB1	153	154	156
35	SB1	153	154	156
2	SB2	0	0	0
3	SB2	0	0	0
4	SB2	0	0	0
5	SB2	0	0	0
6	SB2	0	0	21
7	SB2	0	0	23
8	SB2	0	19	25
9	SB2	0	21	27
10	SB2	16	22	27
11	SB2	18	24	27
12	SB2	20	24	28
13	SB2	21	24	28
14	SB2	21	25	29
15	SB2	22	25	30
16	SB2	22	26	30
17	SB2	22	26	30
18	SB2	23	27	32
19	SB2	23	27	32
20	SB2	24	29	33
21	SB2	24	29	33
22	SB2	25	29	33
23	SB2	25	29	33
24	SB2	26	29	33
25	SB2	26	29	33
26	SB2	26	29	33
27	SB2	26	29	33
28	SB2	26	29	33
29	SB2	26	29	33
30	SB2	26	29	33
31	SB2	26	29	33
32	SB2	26	29	33
33	SB2	26	29	33
34	SB2	26	29	33
35	SB2	26	29	33

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
36	SB2	26	29	33
-6	SB3	0	0	0
-5	SB3	0	0	0
-4	SB3	0	0	0
-3	SB3	0	0	0
-2	SB3	0	0	0
-1	SB3	0	0	0
0	SB3	0	0	0
1	SB3	0	0	1
2	SB3	0	4	9
3	SB3	2	10	16
4	SB3	10	23	29
5	SB3	22	33	38
6	SB3	36	44	51
7	SB3	56	64	73
8	SB3	102	117	131
9	SB3	162	185	205
10	SB3	214	239	259
11	SB3	245	271	285
12	SB3	265	286	296
13	SB3	280	294	302
14	SB3	288	298	305
15	SB3	294	301	308
16	SB3	300	307	313
17	SB3	307	315	320
18	SB3	314	320	325
19	SB3	318	324	329
20	SB3	322	327	332
21	SB3	325	330	334
22	SB3	327	331	335
23	SB3	328	333	336
24	SB3	329	333	337
25	SB3	329	333	337
26	SB3	329	333	337
27	SB3	329	333	337
28	SB3	329	333	337
29	SB3	329	333	337
30	SB3	329	333	337
31	SB3	329	333	337
32	SB3	329	333	337
33	SB3	329	333	337
34	SB3	329	333	337
0	SB4	0	0	0
1	SB4	0	0	0
2	SB4	0	0	0

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
3	SB4	0	0	2
4	SB4	0	1	8
5	SB4	0	6	22
6	SB4	4	22	45
7	SB4	14	48	73
8	SB4	39	81	99
9	SB4	66	101	115
10	SB4	87	106	116
11	SB4	98	113	118
12	SB4	104	114	121
13	SB4	110	115	123
14	SB4	110	117	124
15	SB4	111	119	126
16	SB4	115	123	128
17	SB4	118	125	129
18	SB4	121	126	130
19	SB4	122	127	130
20	SB4	124	127	130
21	SB4	124	127	130
22	SB4	125	128	130
23	SB4	125	128	130
24	SB4	125	128	130
25	SB4	125	128	130
26	SB4	125	128	130
27	SB4	125	128	130
28	SB4	125	128	130
29	SB4	125	128	130
30	SB4	125	128	130
31	SB4	125	128	130
32	SB4	125	128	130
33	SB4	125	128	130
34	SB4	125	128	130
35	SB4	125	128	130
36	SB4	125	128	130
0	SB5	0	0	0
1	SB5	0	0	2
2	SB5	0	0	12
3	SB5	0	2	32
4	SB5	0	11	36
5	SB5	1	30	41
6	SB5	10	33	43
7	SB5	27	38	44
8	SB5	31	40	44
9	SB5	35	40	45
10	SB5	36	41	46

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
11	SB5	37	41	47
12	SB5	37	43	48
13	SB5	38	44	49
14	SB5	39	44	49
15	SB5	40	45	50
16	SB5	41	46	51
17	SB5	41	47	51
18	SB5	42	47	51
19	SB5	43	47	51
20	SB5	43	47	51
21	SB5	43	47	51
22	SB5	43	47	51
23	SB5	43	47	51
24	SB5	43	47	51
25	SB5	43	47	51
26	SB5	43	47	51
27	SB5	43	47	51
28	SB5	43	47	51
29	SB5	43	47	51
30	SB5	43	47	51
31	SB5	43	47	51
32	SB5	43	47	51
33	SB5	43	47	51
34	SB5	43	47	51
35	SB5	43	47	51
36	SB5	43	47	51
0	SC1	0	0	21
1	SC1	0	0	91
2	SC1	0	19	120
3	SC1	0	85	128
4	SC1	17	113	135
5	SC1	79	121	138
6	SC1	106	127	138
7	SC1	114	130	139
8	SC1	119	130	141
9	SC1	122	131	145
10	SC1	122	132	148
11	SC1	123	136	150
12	SC1	124	139	151
13	SC1	128	141	153
14	SC1	131	143	154
15	SC1	133	144	155
16	SC1	134	145	155
17	SC1	135	146	155
18	SC1	136	146	155

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
19	SC1	137	146	155
20	SC1	137	146	155
21	SC1	137	146	155
22	SC1	137	146	155
23	SC1	137	146	155
24	SC1	137	146	155
25	SC1	137	146	155
26	SC1	137	146	155
27	SC1	137	146	155
28	SC1	137	146	155
29	SC1	137	146	155
30	SC1	137	146	155
31	SC1	137	146	155
32	SC1	137	146	155
33	SC1	137	146	155
34	SC1	137	146	155
35	SC1	137	146	155
36	SC1	137	146	155
-1	SC2	0	0	12
0	SC2	0	0	180
1	SC2	0	10	303
2	SC2	0	169	406
3	SC2	9	290	502
4	SC2	158	390	680
5	SC2	277	485	853
6	SC2	373	661	994
7	SC2	468	832	1,176
8	SC2	642	973	1,384
9	SC2	812	1,151	1,563
10	SC2	951	1,355	1,651
11	SC2	1,126	1,532	1,724
12	SC2	1,327	1,619	1,781
13	SC2	1,501	1,690	1,822
14	SC2	1,586	1,746	1,843
15	SC2	1,656	1,787	1,866
16	SC2	1,710	1,807	1,898
17	SC2	1,752	1,830	1,920
18	SC2	1,772	1,861	1,936
19	SC2	1,794	1,883	1,946
20	SC2	1,824	1,898	1,953
21	SC2	1,845	1,908	1,958
22	SC2	1,860	1,915	1,960
23	SC2	1,870	1,920	1,961
24	SC2	1,877	1,922	1,962
25	SC2	1,882	1,923	1,963

Attachment B
Model Estimated Stage-Damage With Uncertainty—Estimated Post-Katrina Property Base

Water Elevation NAVD88 (2004.65)	Drainage Basin Name	5% LC	Mean	95% UC
26	SC2	1,883	1,923	1,963
27	SC2	1,884	1,924	1,963
28	SC2	1,885	1,925	1,963
29	SC2	1,886	1,925	1,963
30	SC2	1,886	1,925	1,963
31	SC2	1,886	1,925	1,963
32	SC2	1,886	1,925	1,963
33	SC2	1,886	1,925	1,963
34	SC2	1,886	1,925	1,963
35	SC2	1,886	1,925	1,963
36	SC2	1,886	1,925	1,963

Appendix 2
Human Health & Safety Consequences
Human Health Effects

This appendix describes the search strategies used to identify currently identified and potential future human health effects of Hurricane Katrina.

Search Methods and Results

We took a multi-pronged approach to the literature search, because:

1. The search was to include both empirical literature that described the exposures and health/mental health effects of Hurricane Katrina *and* empirical literature that described exposures and health/mental health effects of similar past disasters (e.g., hurricanes, floods).

2. The search was to cover both the scientific (peer-reviewed) literature and the "grey" literature.

Because of the limited time between the occurrence of the storm and the conduct of the review, it was clear that the scientific literature describing Hurricane Katrina and its effects would be quite limited. The grey literature, on the other hand, is enormous but anecdotal.

Our approach to this dilemma was as follows. First, we used findings from the post-Hurricane Katrina scientific literature to identify documented effects, and we used grey literature descriptions of these documented effects to provide additional details about them. Second, we used the similar-disaster scientific literature to identify likely other effects of Hurricane Katrina, and grey literature to add details. Third, we used the grey literature to identify potential other effects that were not mentioned in the Hurricane Katrina-specific or the similar-disaster literatures. Finally, we searched what might be thought of as the "pre" literature, i.e., we contacted investigators who we knew were currently conducting studies of Hurricane Katrina and its impact, to learn some details of what they were studying and any early findings.

Peer-Reviewed Literature

As noted above, the basic purpose of the literature review is to provide as rich a description as possible of the actual exposures and health and mental health outcomes of Hurricane Katrina observed to date, and also a forecast of additional health and mental health consequences that may not yet have become evident. We searched five major literature review databases:

- PubMed, medical and public health literature
- Medline, medical and public health literature
- PsychInfo, psychiatric and psychological literature
- SocialSci, social science literature
- TGG Health & Wellness, health and wellness literature

For all databases except PubMed, the Abt Associates library staff performed searches of "Hurricane Katrina and (health or mental health)." Research staff reviewed the resulting lists of summary information about each selected item and identified specific items to be downloaded. Table 2-1 shows the results of this process.

Table 2-1
RESULTS OF LITERATURE REVIEW

Literature review database	Number of results selected by broad search	Number of results downloaded	
		Health	Mental Health
Medline	95	47	29
PsychInfo	5	0[a]	5
SocialSci	7	2	7
Health & Wellness	110	86	32

[a] One article had many references of interest; four were accessed from the Internet.

As anticipated, a search using the standard literature review databases yielded just a handful of results. Also as expected, the vast majority of published literature with respect to exposures and health effects is from the Centers for Disease Control and Prevention (CDC), which quickly established surveillance centers in affected areas to identify and report reliably on morbidity and mortality outcomes.

For PubMed, the searches were performed directly from Reference Manager, the database in which all results were collected. After performing a set of initial searches, using terms known to be associated with hurricanes, we reviewed the CDC reports and broadened our set of search terms. Each term was linked with the phrase "Hurricane Katrina" to increase the specificity of the results. The final terms, and number of results, are shown in Table 2-2.

The results are relevant for people who moved to New Orleans as part of the relief and reconstruction efforts as well as for those living there when Hurricane Katrina hit. As many as 40,000 active-duty military and National Guard (Manjoo 2005), 1,580 Army Corps of Engineers workers (Cloud 2005), 148 CDC public health workers such as epidemiologists(CDC 2005h), approximately 500 SAMHSA mental health and substance abuse counselors(SAMHSA 2006), some 800 firefighters from New York and Illinois (Longman 2005), 303 New York police officers (Baker 2005), a sheriff and 33 deputies from Michigan (Lipton et al. 2005), and 38 Public Health Service physicians and nurses(Altman & Chang 2005) were dispatched to the region.

The CDC surveillance methods have two significant limitations. First, they involve the geographic areas most directly impacted by the hurricane: Louisiana, Mississippi, Alabama, and Texas. Before the hurricane struck, about three-quarters of New Orleans residents heeded the recommendation to evacuate, and dispersed, planning to stay with family or friends or in hotels during the height of the storm. It appears from anecdotal reports and evacuee dispersion data(Kent 2005) that most of these people stayed within a moderate driving distance from their point of origin. However, many sanctuaries were also damaged by the storm or not available for extended stays. As a result, many of these evacuees needed to move again.

Second, of the additional 50,000-100,000 New Orleans residents stranded in the city, most were relocated in large groups (i.e., hundreds or thousands). Although the four-state region that CDC focused on got the largest share of evacuees – almost a quarter of a million were immediately housed in Houston(CDC 2005f) – every state received some evacuees. Currently available data do not distinguish between evacuees from New Orleans and from other areas of Louisiana, but FEMA reports that approximately 800,000 Louisiana citizens requested FEMA assistance[1] by September 20, 2005 from every state.(Kent 2005) These data suggest that the majority of Louisiana residents who evacuated are not currently under surveillance by CDC.

[1] Applications for FEMA assistance could be requested to cover expenses associated with disruptions other than leaving one's home. For example, college students arriving for their first year who had to turn away from New Orleans were encouraged by at least one institution to apply for assistance to pay for the cost of, for example, additional travel and ruined clothing.(Minton 2006) Therefore, it is possible that some applications do not reflect evacuations.

Table 2-2
PEER-REVIEWED LITERATURE SEARCH TERMS AND RESULTS

Date	Search term used with phrase ("Hurricane Katrina" and)	Number of results
4/13/2006	Health	48
4/13/2006	Disease	25
Causes of disease		
4/13/2006	Vector	0
4/13/2006	Insect	0
4/13/2006	Chemical	1
4/13/2006	Toxin	0
4/13/2006	Pathogen	0
4/13/2006	Carbon monoxide	1
Mortality		
4/13/2006	Drown	0
4/13/2006	Homicide	1
4/13/2006	Suicide	0
4/13/2006	Injury	12
4/13/2006	Cardiovascular	0
4/13/2006	Sepsis	0
4/13/2006	Alcoholism	0
4/13/2006	Cerebral palsy	0
4/13/2006	Suffocation	0
4/13/2006	Pneumonia	0
Currently Evident Morbidity/Injury		
4/13/2006	Poison	0
4/13/2006	Wound	6
4/13/2006	Laceration	0
4/13/2006	Strain	0
4/13/2006	Hernia	0
4/13/2006	Broken bone	0
Currently Evident Morbidity/Illness		
4/13/2006	Nausea	0
4/13/2006	Gastrointestinal	0
4/13/2006	Respiratory	3
4/13/2006	Dermatolog [-y, -ic]	0
4/13/2006	Cardiovascular	0
4/13/2006	Norovirus	2
4/13/2006	Infection	7
4/13/2006	Cellulites	0
4/13/2006	Bite [insect or animal]	0
4/13/2006	Headache	0
4/13/2006	Hypertension	1
4/13/2006	Altitude sickness	1
4/13/2006	Dehydration	0
Potential future morbidity or mortality:		
4/13/2006	Tuberculosis	0
4/13/2006	Asthma	0

Similar-Disaster Scientific Literature

In order to determine the types of health effects that have been found to be associated with prior hurricanes, floods, and similar events, we researched the major federal agencies responsible for hurricane preparedness and response:

- National Hurricane Center
- National Oceanic & Atmospheric Administration (NOAA)
- Centers for Disease Control and Prevention (CDC)
- American Red Cross

As we anticipated, CDC had the most thorough information, with numerous fact sheets for the public:

- Prevent Illness
- Keep Food & Water Safe
- Environmental Concerns
- Animal & Insect Hazards
- When the Power Goes Out
- Returning Home after a Hurricane
- Prevent Injury
- Clean Up Safely
- Hurricane Katrina & Other 2005 Hurricanes

CDC also provides fact sheets for groups with specific concerns such as:

- Response & Cleanup Workers
- Evacuation Centers
- Volunteers

Finally, CDC also makes information from other federal agencies available. This includes, for example, a report on the effects of the Murphy Oil Spill, which had been prepared by the U.S. Department of Health and Human Services' Agency for Toxic Substances and Disease Registry (ATSDR).

On the mental health side, we searched the PILOTS database, maintained at Dartmouth College by the National Center for Posttraumatic Stress Disorder (NC.PTSD). PILOTS is an electronic index to the worldwide literature on post-traumatic stress disorder (PTSD) and other mental-health consequences of exposure to traumatic events. The database is updated bimonthly, and it currently contains more than 28,000 references, almost all of which include abstracts.

We searched PILOTS for mental health information using keywords "disaster" and each of the following: hurricane, flood, tsunami, mental health, PTSD, depression, and substance abuse. Table 2-3 shows the number of relevant articles identified in each of these categories (relevance was assessed from the title and abstract of each article; "hurricane" and "flood" each produced more than 100 articles, many of which were clearly not relevant). The terms "mental health" and "PTSD" produced far too many hits to be useful.

Table 2-3 PILOTS data base search results	
Topic: Disaster And …	**Number of Relevant Articles**
Hurricane	49
Flood	21
Tsunami	2
Depression	61
Substance Abuse	6

The data set that resulted from these activities provides a comprehensive description of the potential health and mental health effects that existing empirical evidence suggests may result from Hurricane Katrina-related exposures.

Grey Literature

To identify and collect evidence of potential health effects of Hurricane Katrina not identified via CDC's surveillance system, we turned to the "grey literature." There are many shades of grey, from high-quality reporting with solid fact-checking to immediate reports based on little more than hearsay. We established a rigorous, systematic approach that ranked types of sources (e.g., magazines, newspapers) and, within types, grouped specific sources. The searches were parallel. When possible, we cite numerous sources. In the rare cases where sources conflicted – e.g., on the number of Level I trauma centers "nearest" New Orleans – we found independent confirmation.

Magazine search

To select a broad set of news magazines, we selected two lists. One, www.magazine-directory.com, has 320 titles, some specialized and many general-interest. The other, www.magazines.com, has over 1,500 titles, but a sub-request for news magazines brought the list to 77. Many of the titles are on both lists; we ultimately searched over 360 news magazines. The magazine search took place on April 5, 2006.

Although many of the magazines are widely respected for their journalistic quality, many have a distinct political identity or target audience. The magazines reviewed represent a broad range of political spectrums and readership, as demonstrated in Table 2-4. Reviewing a broad range of magazines was essential to collecting diverse information.

Since Hurricane Katrina evacuees have been dispersed across the country, we thought there might be some interesting articles in regional magazines. By searching the Internet site Google for "regional magazines", we found www.bookmarket.com, which claims to list all regional magazines published in the U.S. We examined all 187 magazines listed. Some, which were extremely specialized within a geographical region (e.g., "Divorce Chicago," "Florida Small Business"), we did not investigate further. Many were promotional, or "lifestyle," magazines. By definition, these magazines do not run articles that present the region in a negative light. Many ran articles about local volunteers helping on hurricane relief efforts; none had substantive commentary on health effects. Of the remaining magazines, we searched for "Katrina" in internal searches, when these were available, and, if not, reviewed the entire website.

Seven regional magazines had articles with adequately specific results to be included in the database. They are listed in Table 2-4.

Finally, some additional sources were identified through methods similar to the "snowball technique." Some websites provide links to other sources of interest. These sources are also listed in Table 2-4.

Table 2-4
IDENTIFICATION AND SELECTION OF MAGAZINE ARTICLES

Title	Description	Number of articles downloaded
News Magazines		
The Atlantic	"Contemporary issues"	44
Baltimore Afro-American Newspaper	"Black owned and operated newspaper has crusaded for racial equality and economic advancement"	0
Discover	"General interest magazine devoted to the world of science and technology"	0
Ebony	"Magazine for African-American men and women"	
The Economist	"International newsweekly on politics, business, finance"	0
Essence	"For the African-American woman who is looking for a source of useful, provocative information"	0
Independent Review	"Devoted to excellence in the critical analysis of government policy and current affairs"	1
Frontpage	"World news politics and features. Lots of conservative commentaries."	0
Harper's Magazine	"Original journalism"	1
The Humanist	"Magazine of critical inquiry and social concern"	0
Jet	"Written for an African-American audience and focuses on news and features that fuse Black history and contemporary living"	0
MacLean's	"Weekly wrap-up and analysis of news events"	0
Mother Jones	"A magazine of provocative and unexpected articles"	7
Ms. Magazine	"Feminist"	0
National Geographic	"Rare look at the drama of humanity and the wonders of nature"	0
National Review	"Premier journal of conservative political opinion"	0
Newsweek	"A weekly news magazine that reports and analyzes today's most important events"	24[a]
People Magazine	"Amazing stories about ordinary people"	4
Reason	"Covers politics, culture, and ideas"	0
Saturday Evening Post	"Family magazine"	0
Salon	"This Internet media company produces 10 original content sites"	12[b]
Science Magazine	"Covers the most important research in all fields of science"	0[c]
Smithsonian	"Regularly covers topics such as Americana …and contemporary society"	0
The Nation	"Unconventional wisdom since 1865"	8
The New Republic	"One of America's opinion magazines"	0
The New Yorker	"Commentaries and reporting on politics, culture, and events" (Amazon.com)	21
The Week	"The best of U.S. and international media"	0
The Weekly Standard	"Commentary and articles"	0
Time	"Insightful analysis of today's important events"	8

Table 2-4
IDENTIFICATION AND SELECTION OF MAGAZINE ARTICLES

Title	Description	Number of articles downloaded
U.S. News and Weekly Report	"Articles on national and world events"	12
Regional Magazines		
Atlanta Magazine		2
Chicago Magazine		1
Louisiana Life		5
New Orleans Magazine		2
New Orleans Tribune		2
New York Magazine		1
Texas Monthly		0
Other sources identified through snowball technique		
Center on Budget and Policy Priorities	"Nonpartisan research organization and policy institute that conducts research and analysis"	1
EndHomelessness.org	"A nonprofit organization whose mission is to mobilize the nonprofit, public and private sectors of society in an alliance to end homelessness"	1
MercyCorps.org	A voluntary organization that provides disaster relief	9
PBS.org	The public broadcasting system	2
RedCross.org	A voluntary organization that provides disaster relief	770
The Henry J. Kaiser Family Foundation	"Non-profit, private operating foundation focusing on the major health care issues facing the nation"	10

[a] Many articles found in Newsweek were credited to MSNBC.
[b] Searched for "Katrina and health"; narrowed results to 61.
[c] Searched in "medicine, diseases" section.

Newspaper search

As with the magazine search, the objective of the newspaper search was to get (a) the highest-quality, most reliable reports of health effects and (b) thorough coverage of regions to which evacuees were dispersed, as the health effects could differ by region. We implemented a hierarchical approach to the search. First, we selected the top three newspapers in the U.S.[2] Second, we selected six nationally ranked newspapers from regions with a heavy influx of evacuees. Third, we recognized that evacuees may have different health outcomes in different areas, due to climatic and other regional characteristics or due to the evacuees' differing impact on local health systems. We selected newspapers from four additional cities, based on the rate of applications for FEMA assistance per 10,000 people in the state and unique geographic characteristics. For example, we knew from CDC reports that altitude sickness was common among evacuees in Colorado. The selection criteria are demonstrated in Table 2-5.

[2] Columbia Journalism Review, November/December 1999. Available at *http://archives.cjr.org/year/99/6/best.asp*. Accessed 4/5/2006.

Table 2-5 **IDENTIFICATION OF NEWSPAPERS**		
Newspaper	**National Ranking**	**Applications for FEMA assistance per 10,000 people**
Top three newspapers		
The New York Times	1	
Washington Post	2	
Wall Street Journal	3	
Nationally ranked newspapers from regions with a heavy influx of evacuees		
Los Angeles Times	4	
Dallas Morning News	5	
Chicago Tribune	6	
St. Petersburg Times	9	
The Atlanta Journal-Constitution	19	
(New Orleans) Times-Picayune	"singled out for 'most improved'"	
Newspapers from selected regions		
Detroit Free Press	n/a	78.9/10,000
(Memphis) Commercial Appeal	n/a	32.4/10,000 in Tennessee; 145.5/10,000 in Memphis
Anchorage Daily News	n/a	2.5/10,000
(Denver) Rocky Mountain News	n/a	6.8/10,000

Because the number of newspaper articles was potentially extremely large, we developed a set of parameters designed for high specificity and low sensitivity. They are represented in Table 2-6.

Table 2-6 **IDENTIFICATION AND SELECTION OF NEWSPAPER ARTICLES**	
Set 1: Causes of Disease	"Hurricane Katrina" and (vector or chemical or toxin or pathogen or "carbon monoxide" or insect)
Set 2: Mortality	"Hurricane Katrina" and (drowning or homicide or suicide or injury or "underlying cardiovascular" or disease or sepsis or "chronic alcoholism" or "cerebral palsy" or suffocation or pneumonia)
Set 3: Morbidity / Injury	"Hurricane Katrina" and (poisoning or wounds or lacerations or strains or sprains or hernia or "broken bones")
Set 4: Morbidity / Illness	"Hurricane Katrina" and (gastrointestinal or nausea or vomiting or diarrhea or "acute respiratory" or cough or fever or "skin infection" or rash or cardiovascular or norovirus or infection or cellulitis or bites or "heart attack" or headache or hypertension or pneumonia or "altitude sickness" or dehydration or tuberculosis)

Pre-Literature Search

As noted above, in addition to the searches of already published literature (grey or otherwise), we also attempted to anticipate future literature by identifying studies that were currently in the field but had not yet disseminated findings. To do so we talked with knowledgeable colleagues in the public health and mental health fields and with officials at several relevant funding sources (e.g., NIMH, SAMHSA) to get a sense of what is going on in the field, and what might be currently in the pipeline. Because these studies represent the intellectual property of the investigators, we provide only general descriptions of the study aims.

Appendix 3
Human Health & Safety Consequences
Loss of Life Modeling

This appendix provides graphs and tables that display the flood stage–fatality results for each drainage basin. The flood stage is defined in terms of the high water elevation (NAV88 (2004.65)). Two graphs for each drainage basin are first presented in Exhibits 3-1 through 3-26. The first graph for any drainage basin (labeled "a") provides the results for the pre-Katrina demographic and structural conditions. The second graph (labeled "b") shows the results for the post-Katrina (June 2006) demographic and structural conditions. In each graph we provide the expected number of fatalities at each elevation as well as the 90th percent confidence interval. These same results are then presented in tabular form along with additional distributional information.

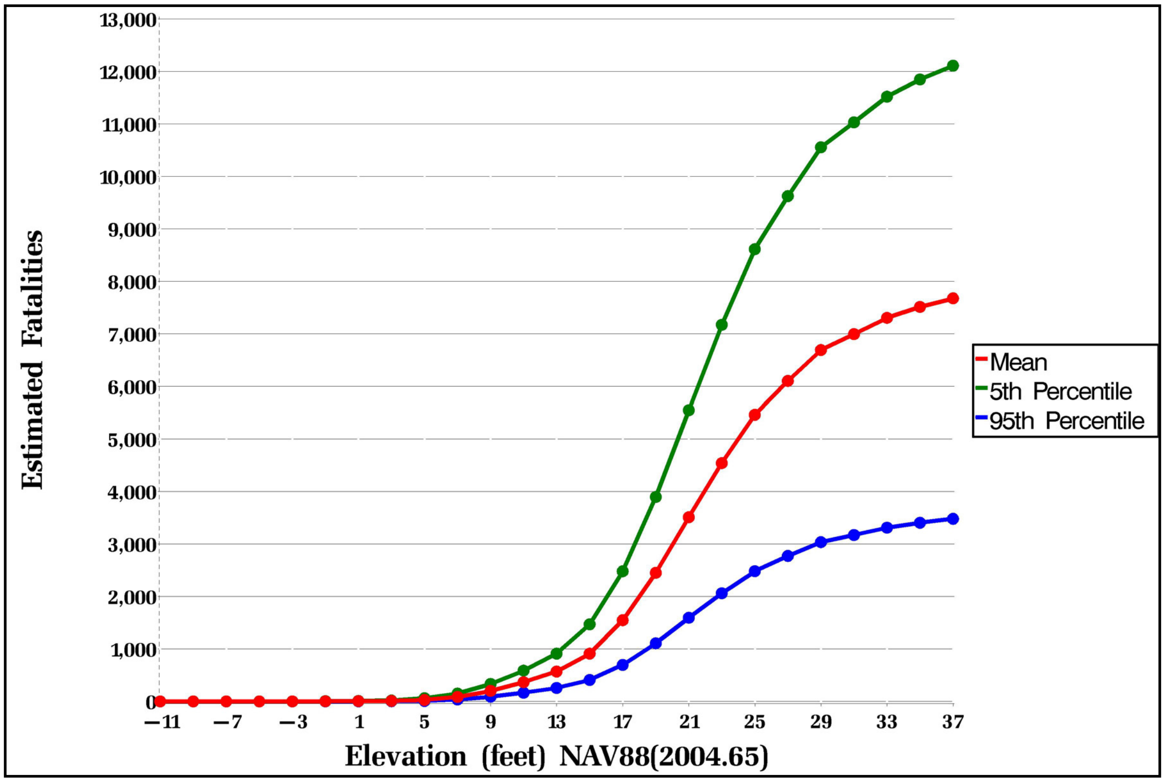

Exhibit 3-1a: Jefferson East Drainage Basin 1—Pre-Katrina

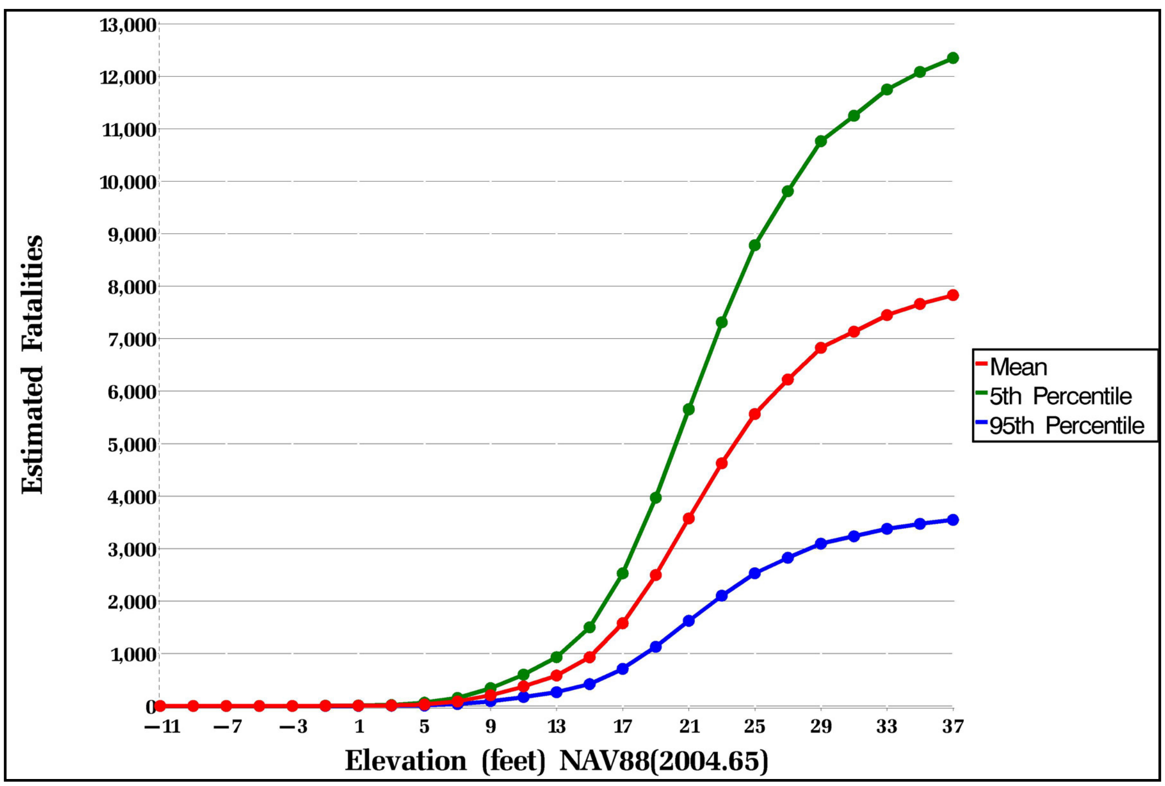

Exhibit 3-1b: Jefferson East Drainage Basin 1—Post-Katrina

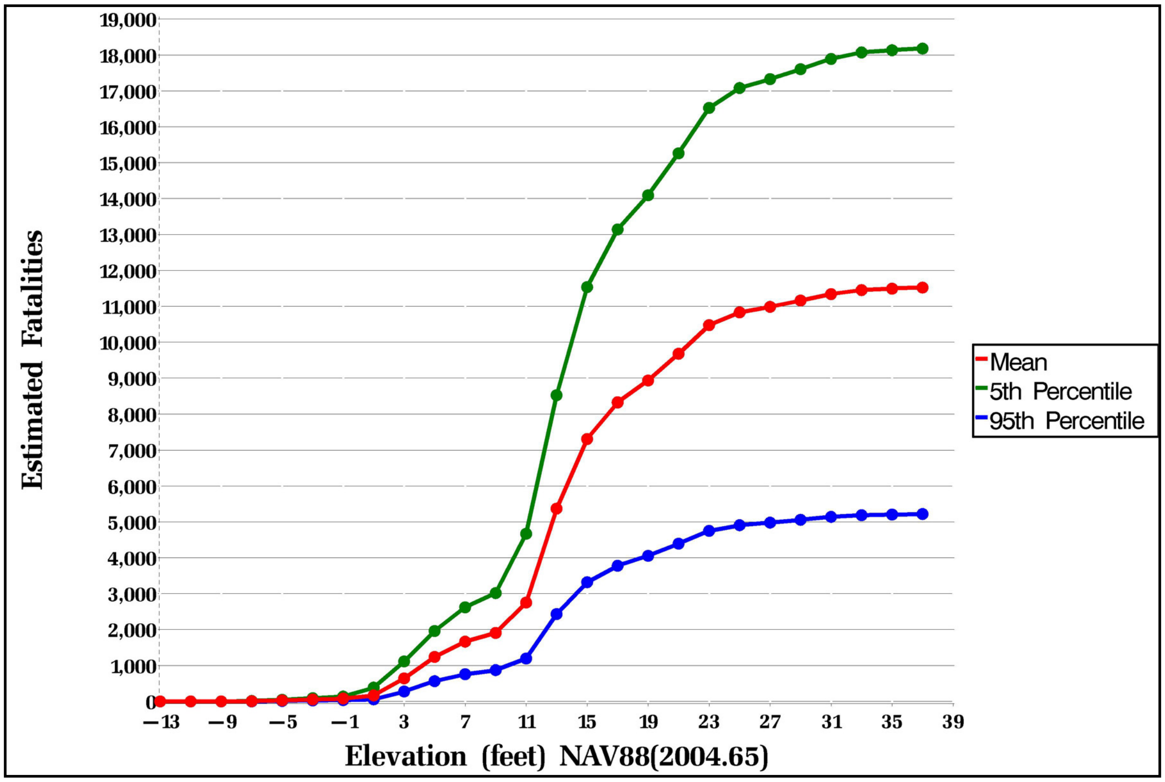

Exhibit 3-2a: Jefferson East Drainage Basin 2—Pre-Katrina

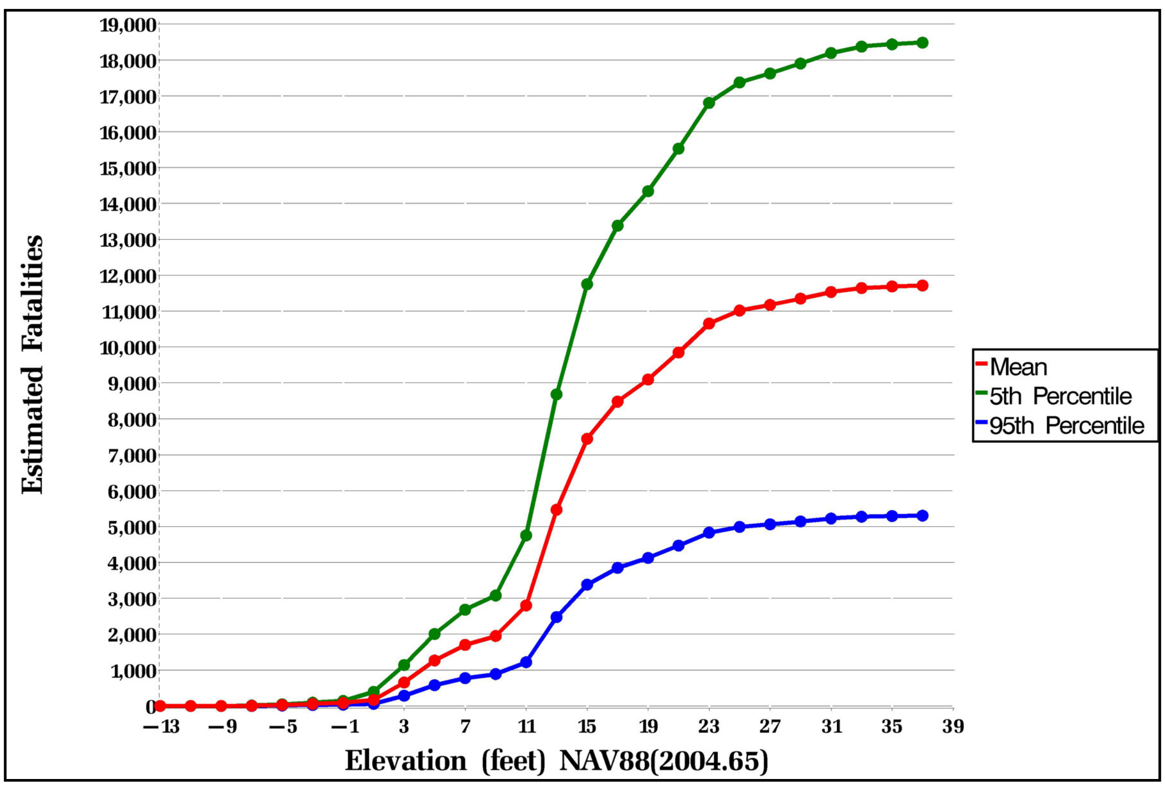

Exhibit 3-2b: Jefferson East Drainage Basin 2—Post-Katrina

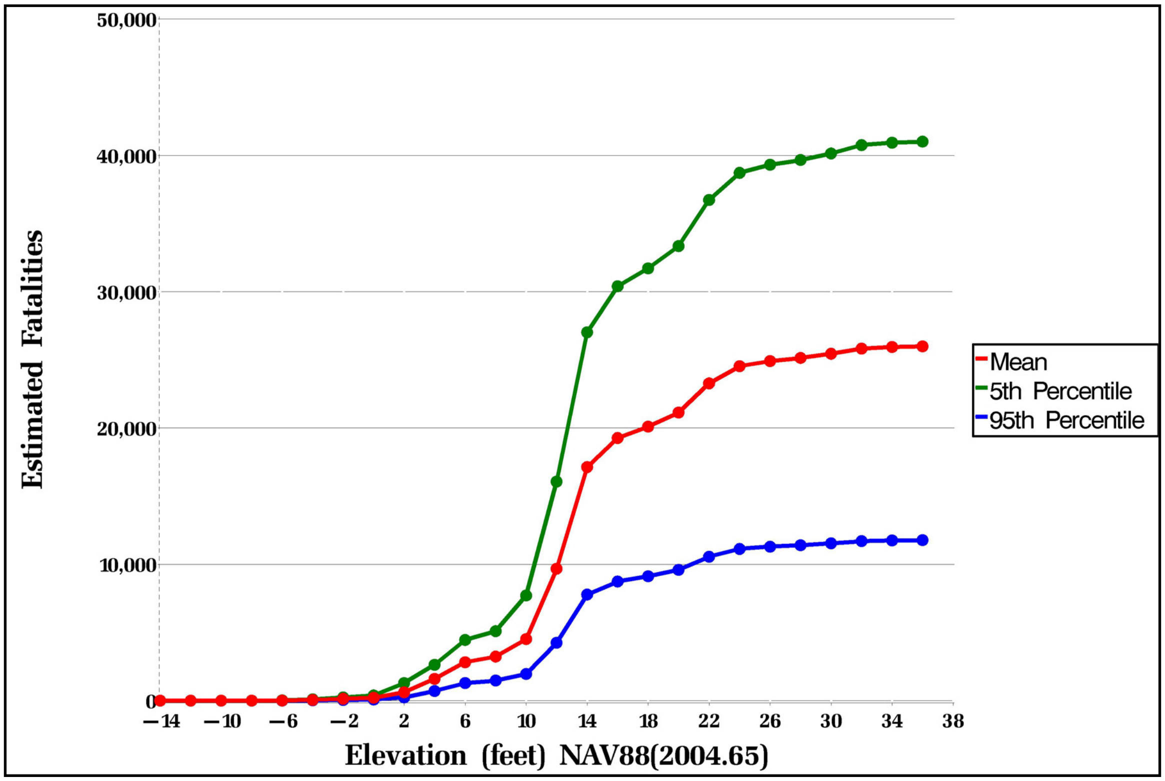

Exhibit 3-3a: Jefferson East Drainage Basin 3—Pre-Katrina

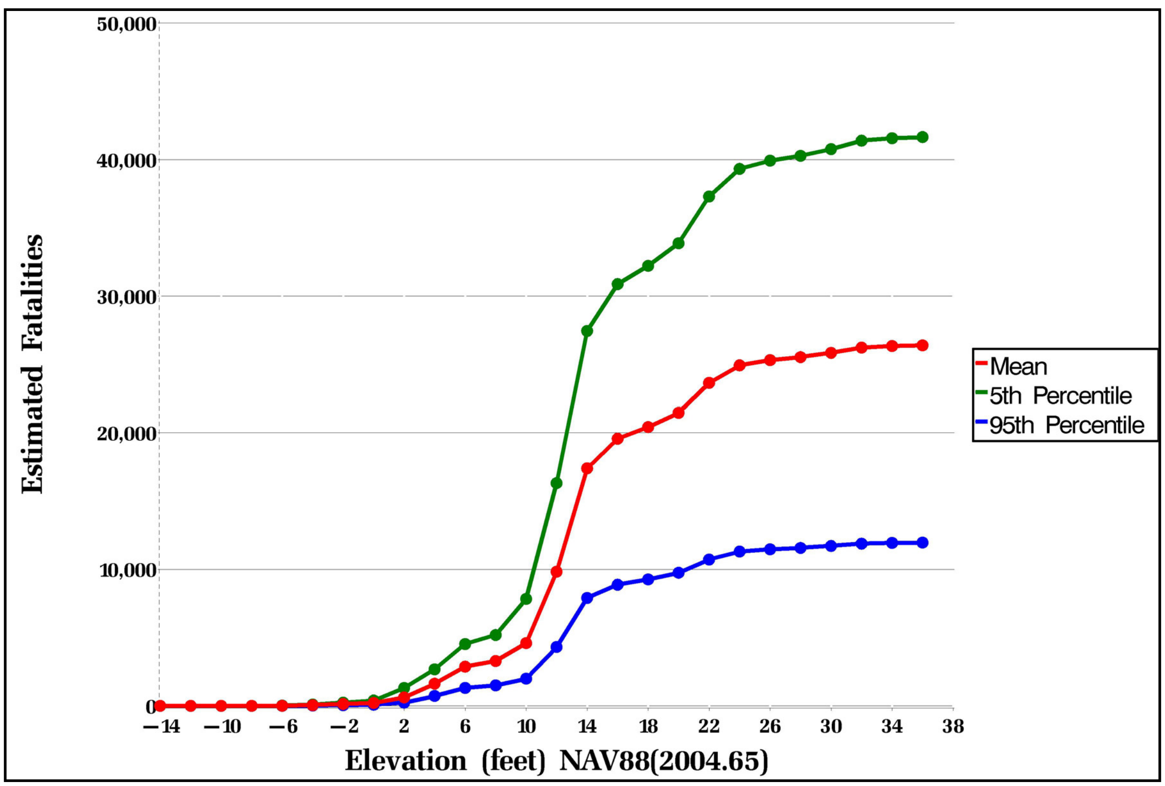

Exhibit 3-3b: Jefferson East Drainage Basin 3—Post-Katrina

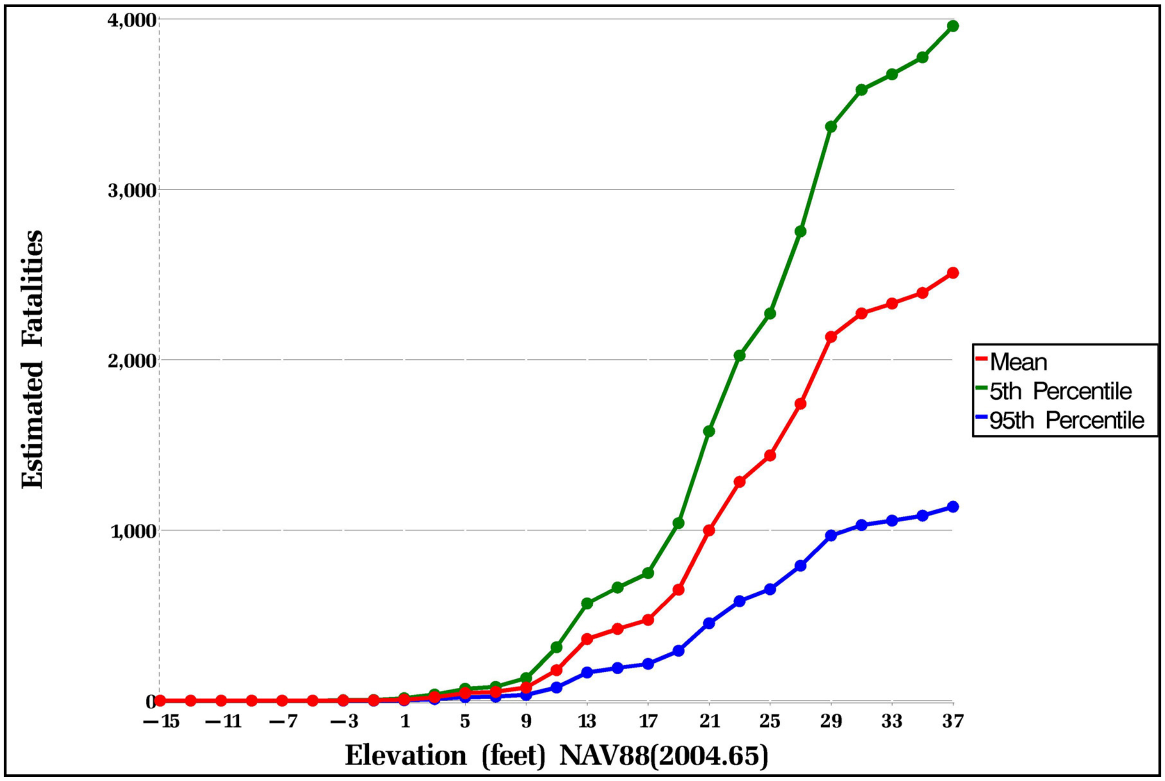

Exhibit 3-4a: Jefferson West Drainage Basin 1—Pre-Katrina

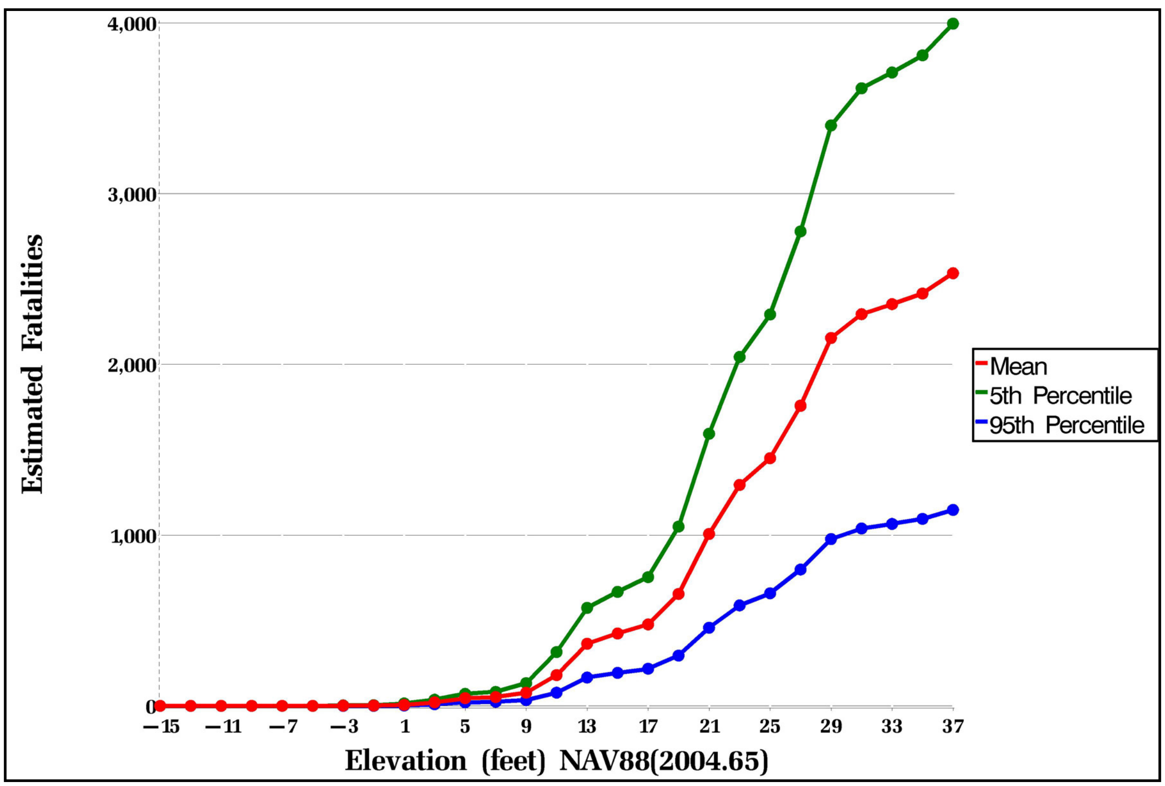

Exhibit 3-4b: Jefferson West Drainage Basin 1—Post-Katrina

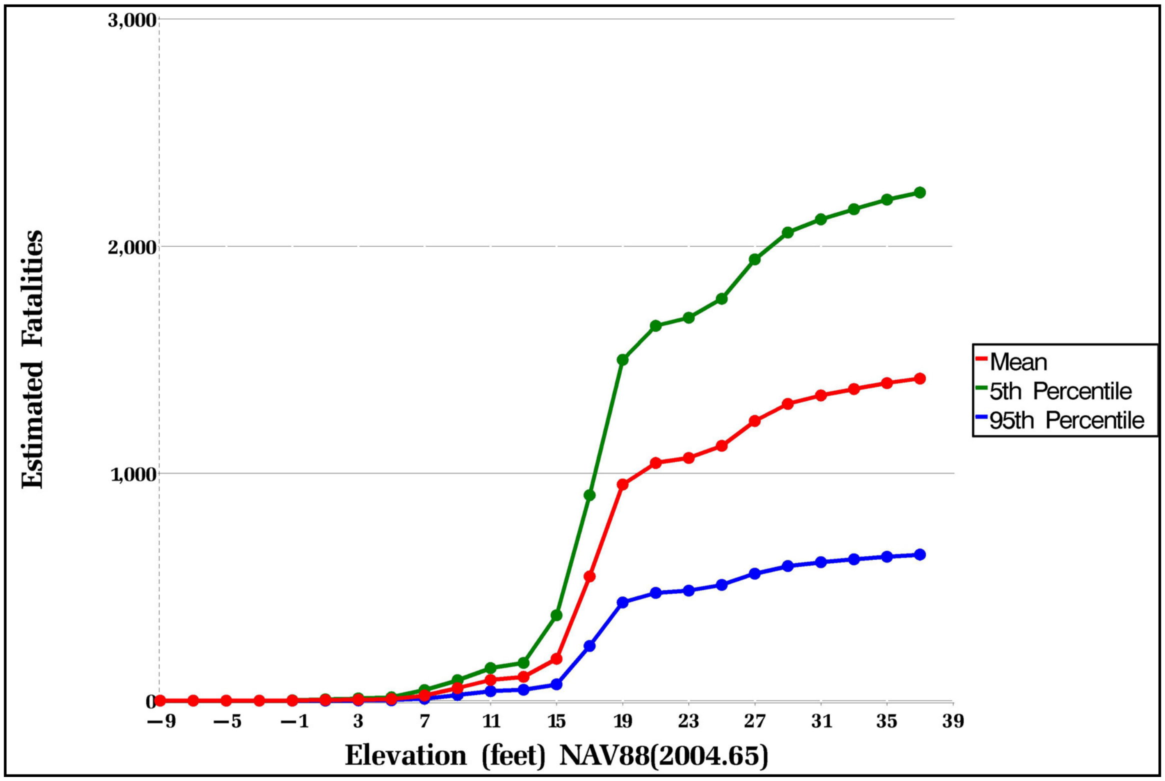

Exhibit 3-5a: Jefferson West Drainage Basin 2—Pre-Katrina

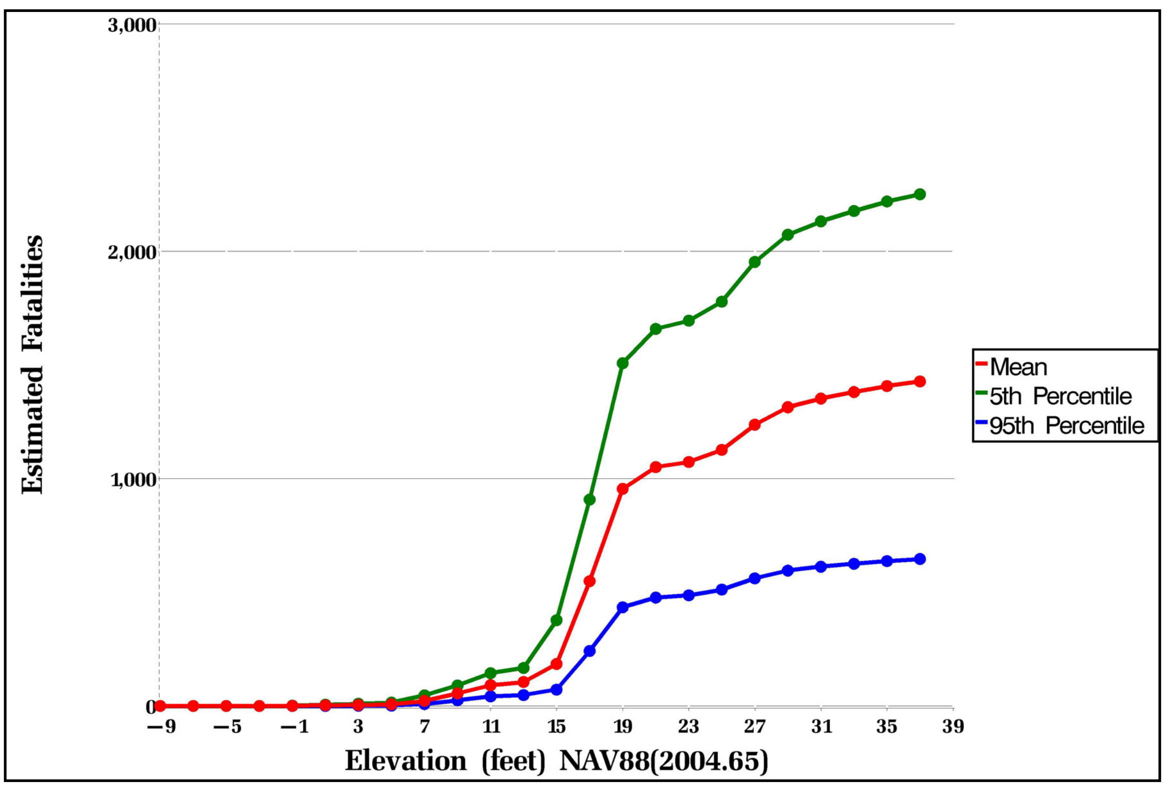

Exhibit 3-5b: Jefferson West Drainage Basin 2—Post-Katrina

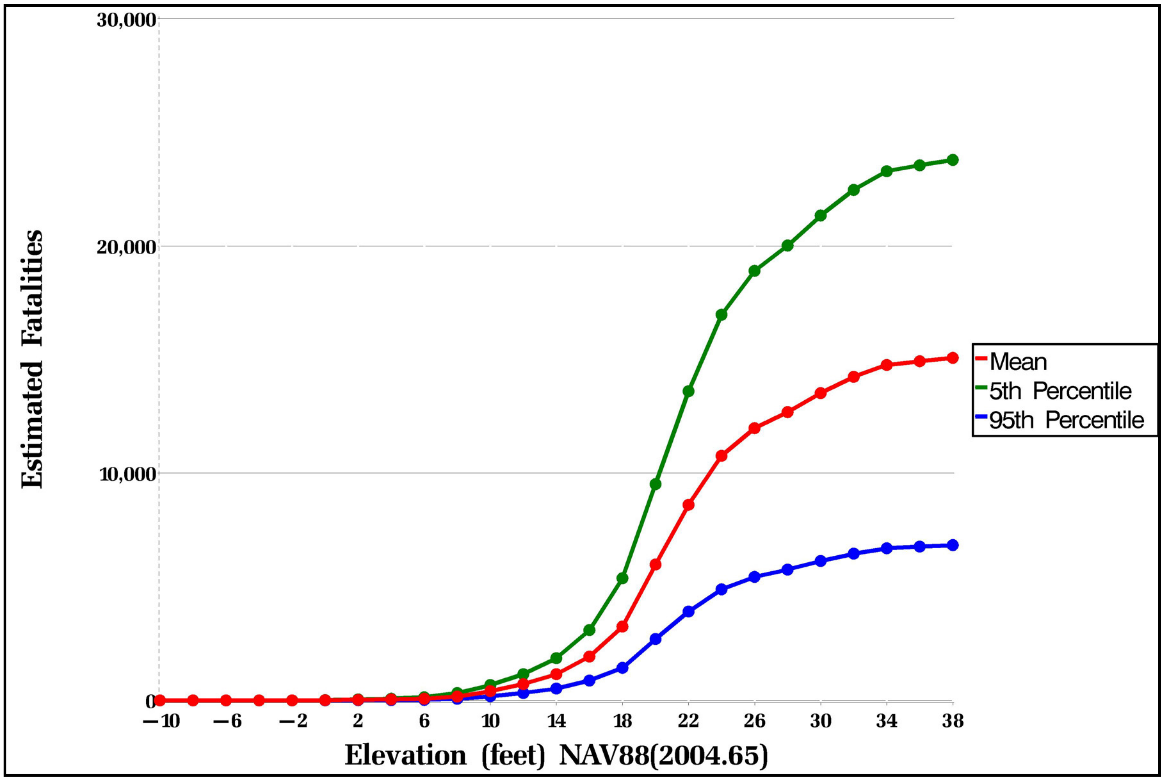

Exhibit 3-6a: Jefferson West Drainage Basin 3—Pre-Katrina

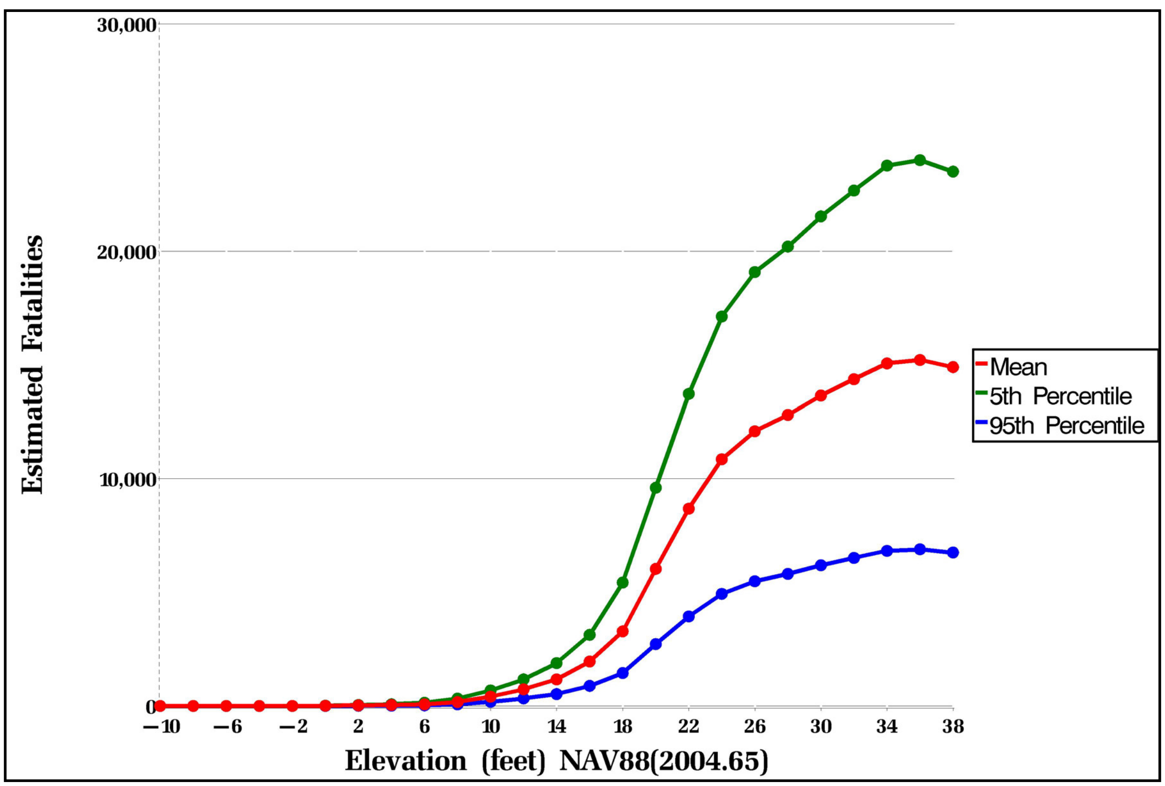

Exhibit 3-6b: Jefferson West Drainage Basin 3—Post-Katrina

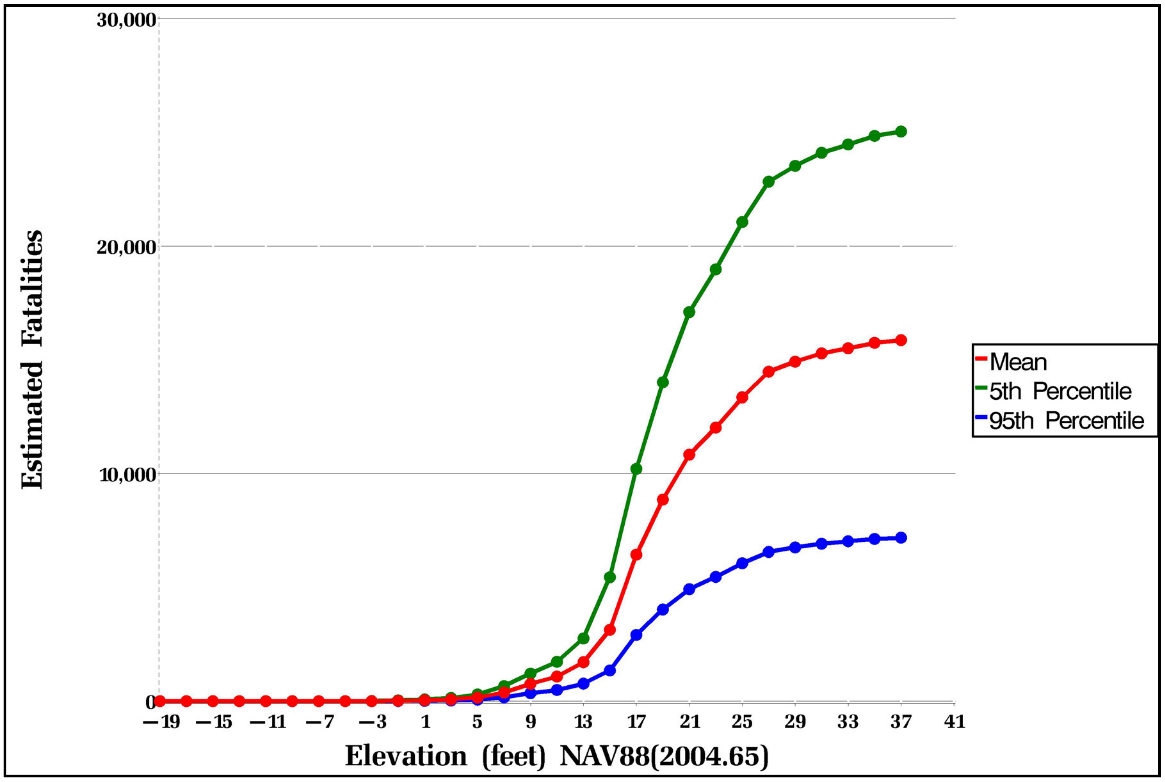

Exhibit 3-7a: Jefferson West Drainage Basin 4—Pre-Katrina

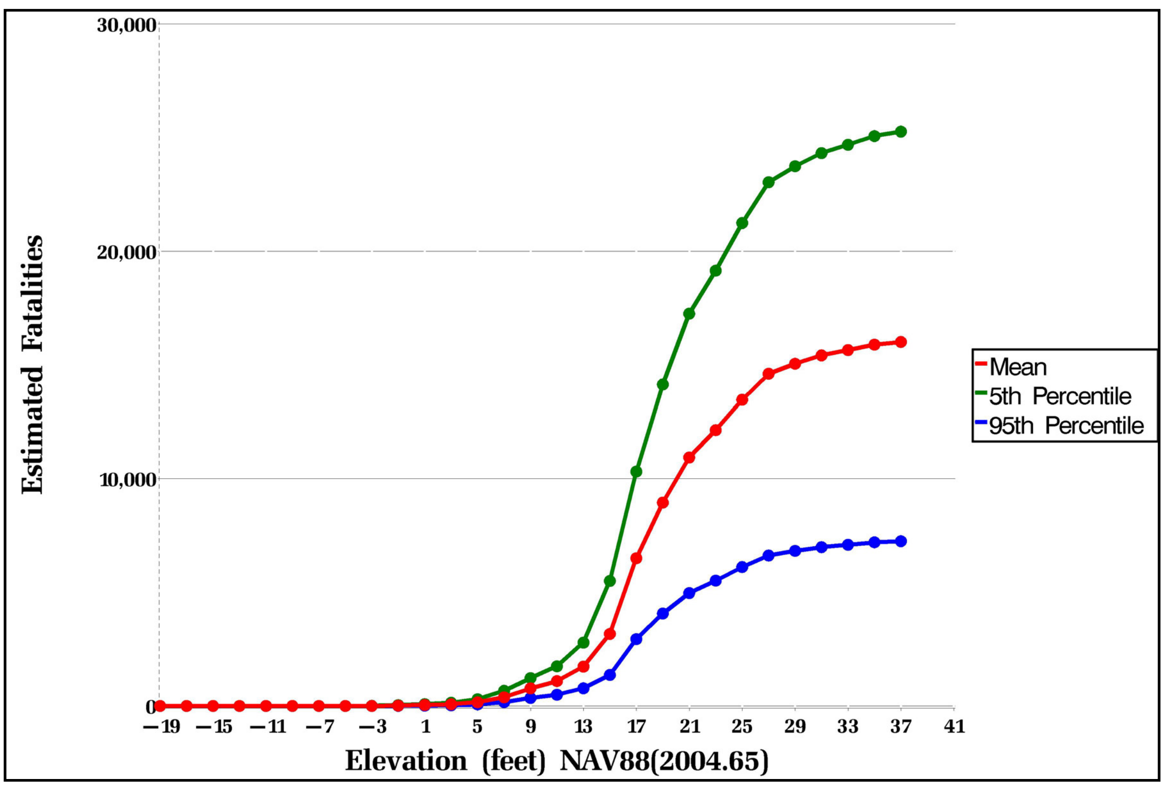

Exhibit 3-7b: Jefferson West Drainage Basin 4—Post-Katrina

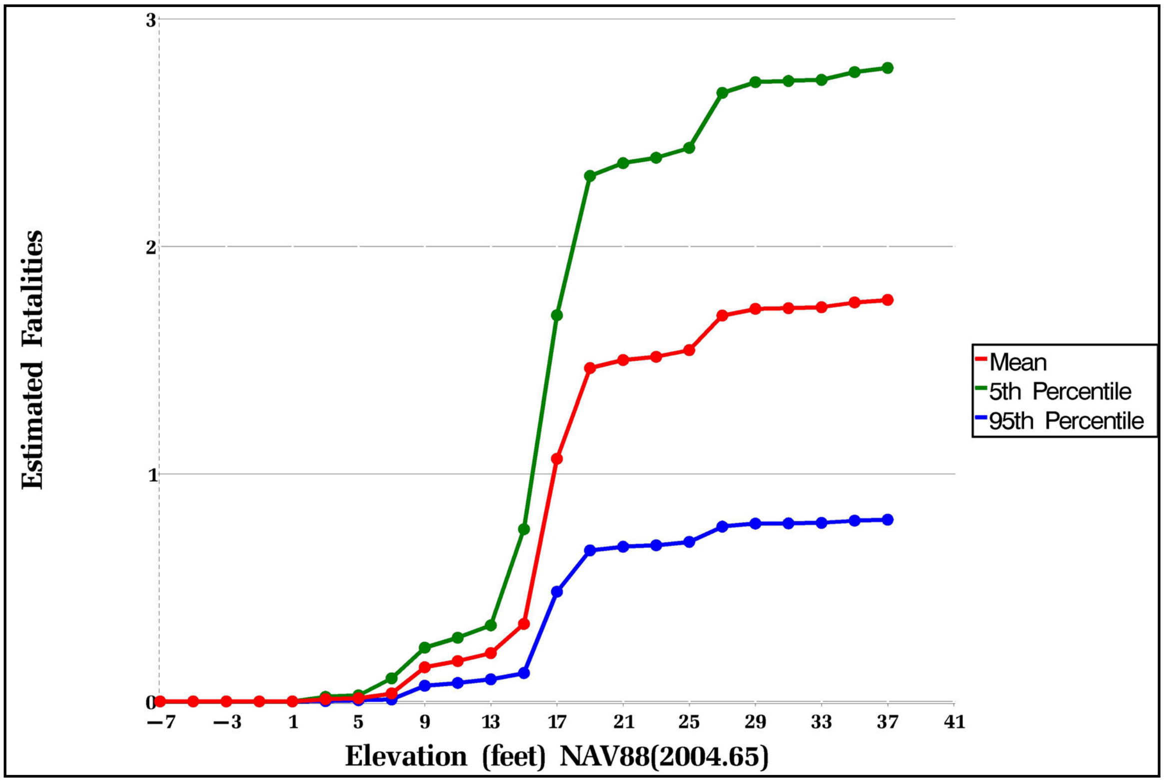

Exhibit 3-8a: New Orleans East Drainage Basin 1—Pre-Katrina

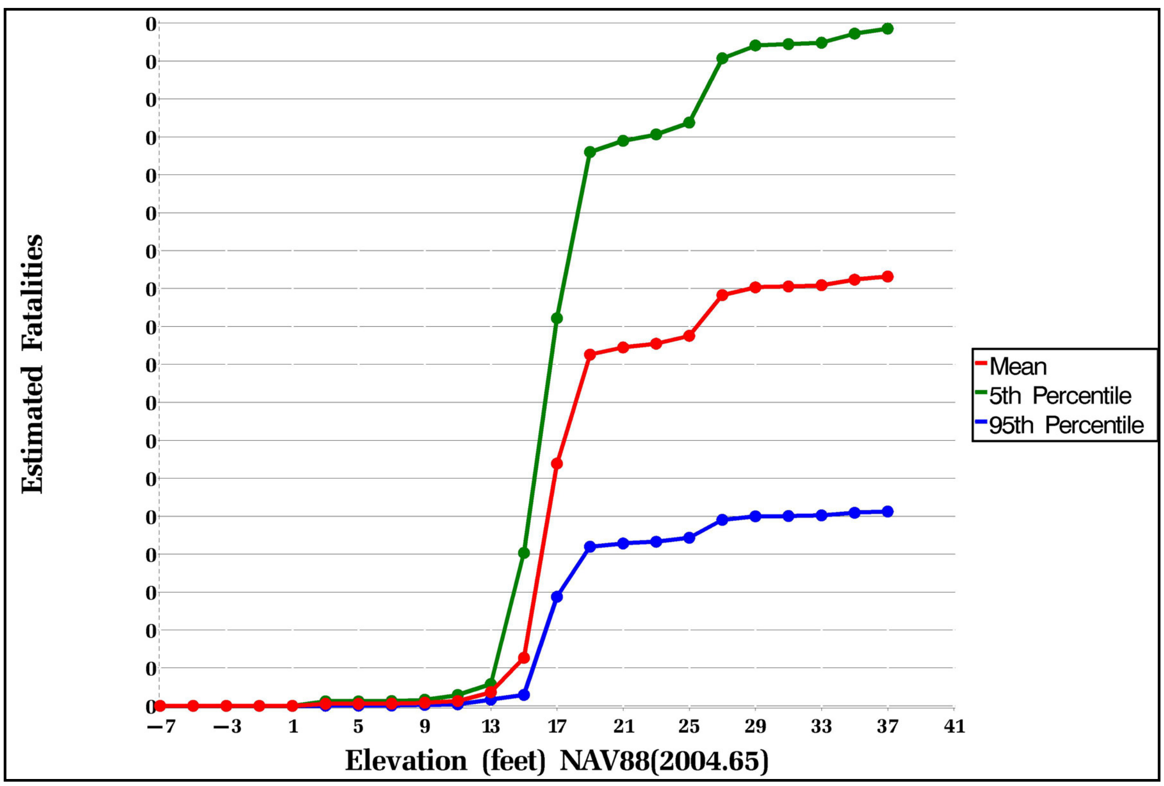

Exhibit 3-8b: New Orleans East Drainage Basin 1—Post-Katrina

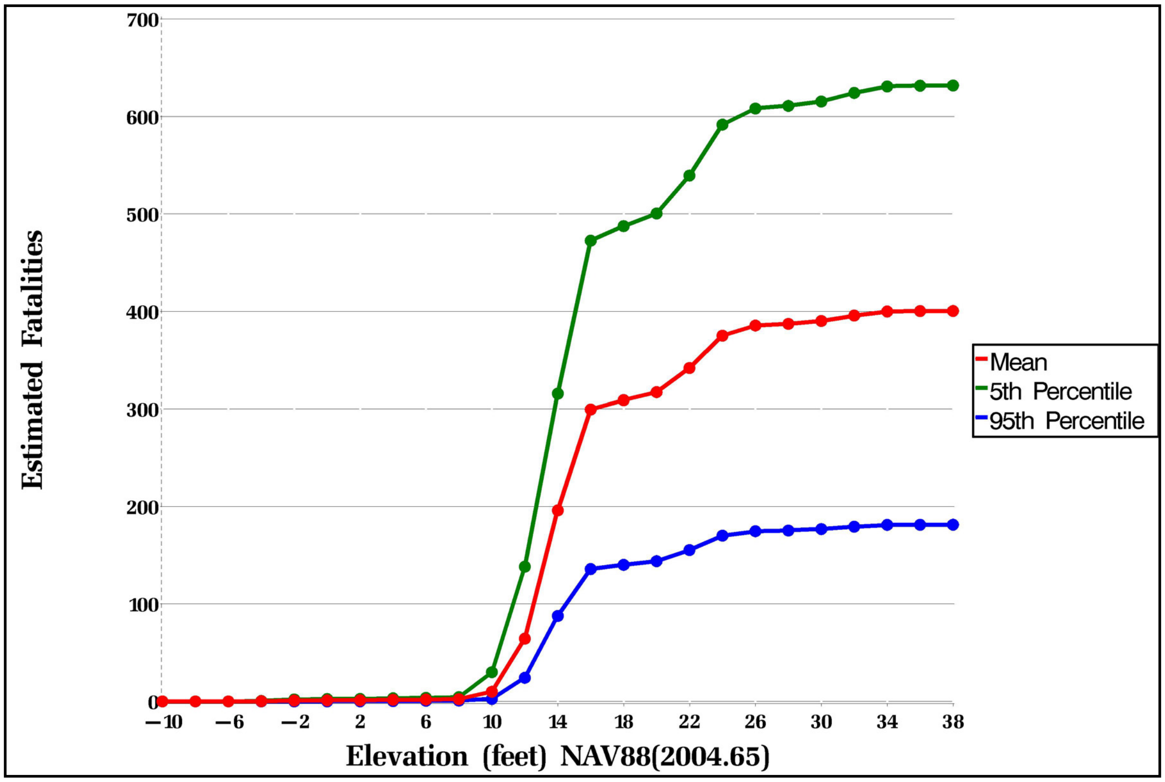

Exhibit 3-9a: New Orleans East Drainage Basin 2—Pre-Katrina

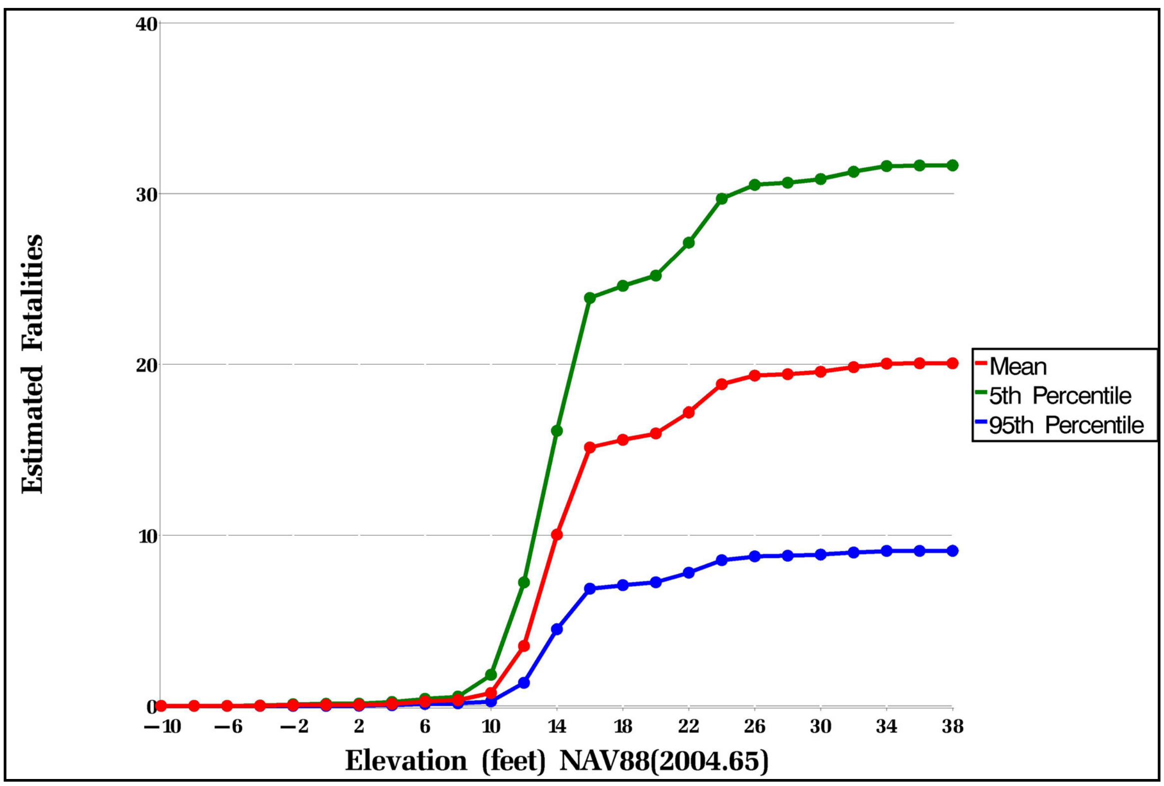

Exhibit 3-9b: New Orleans East Drainage Basin 2—Post-Katrina

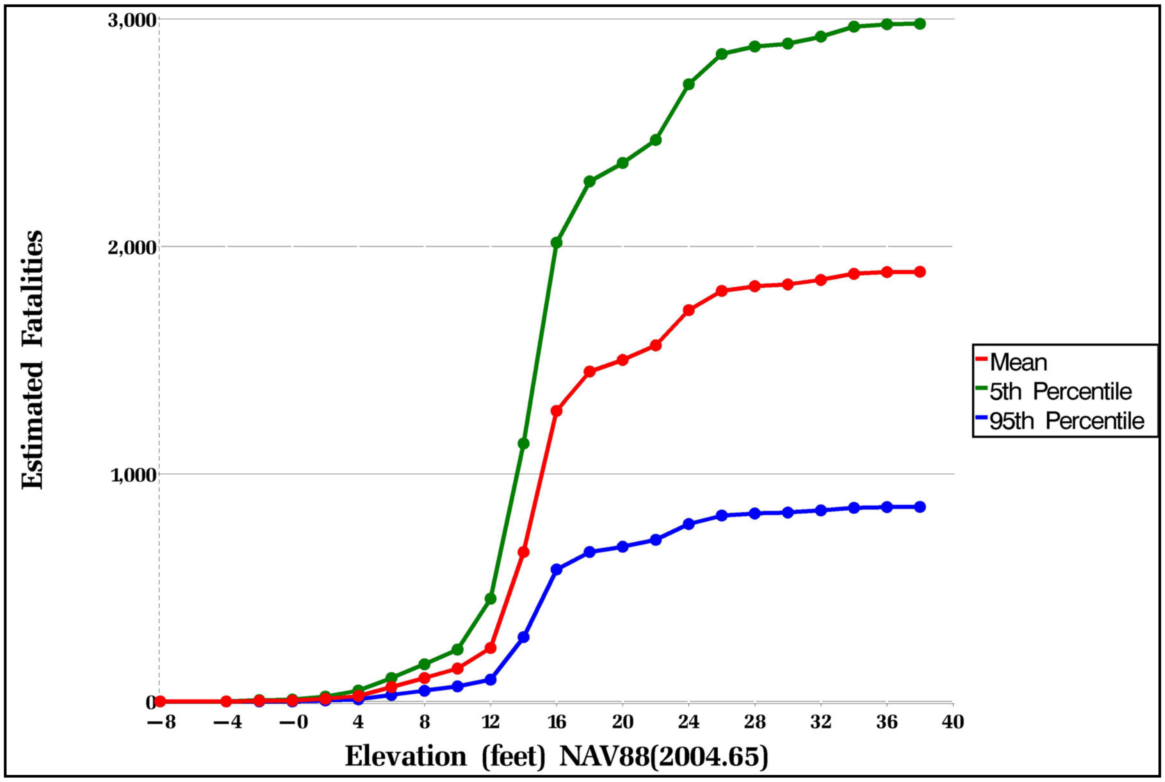

Exhibit 3-10a: New Orleans East Drainage Basin 3—Pre-Katrina

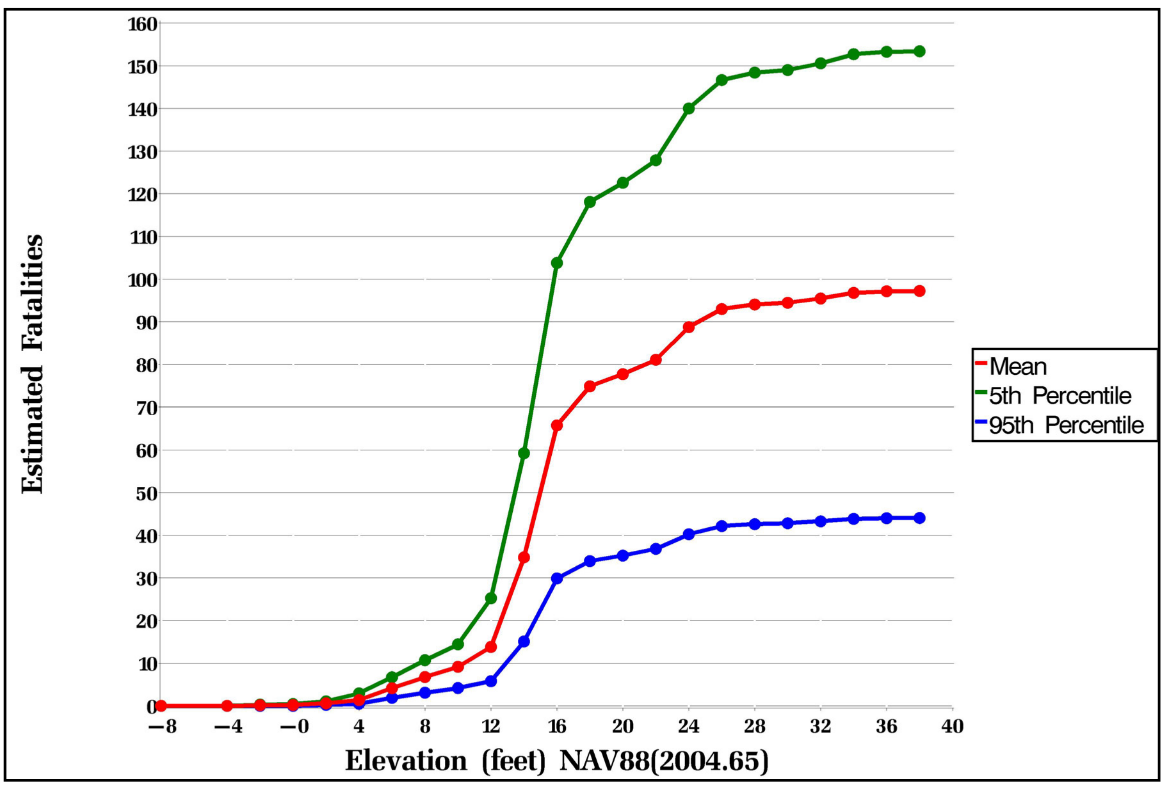

Exhibit 3-10b: New Orleans East Drainage Basin 3—Post-Katrina

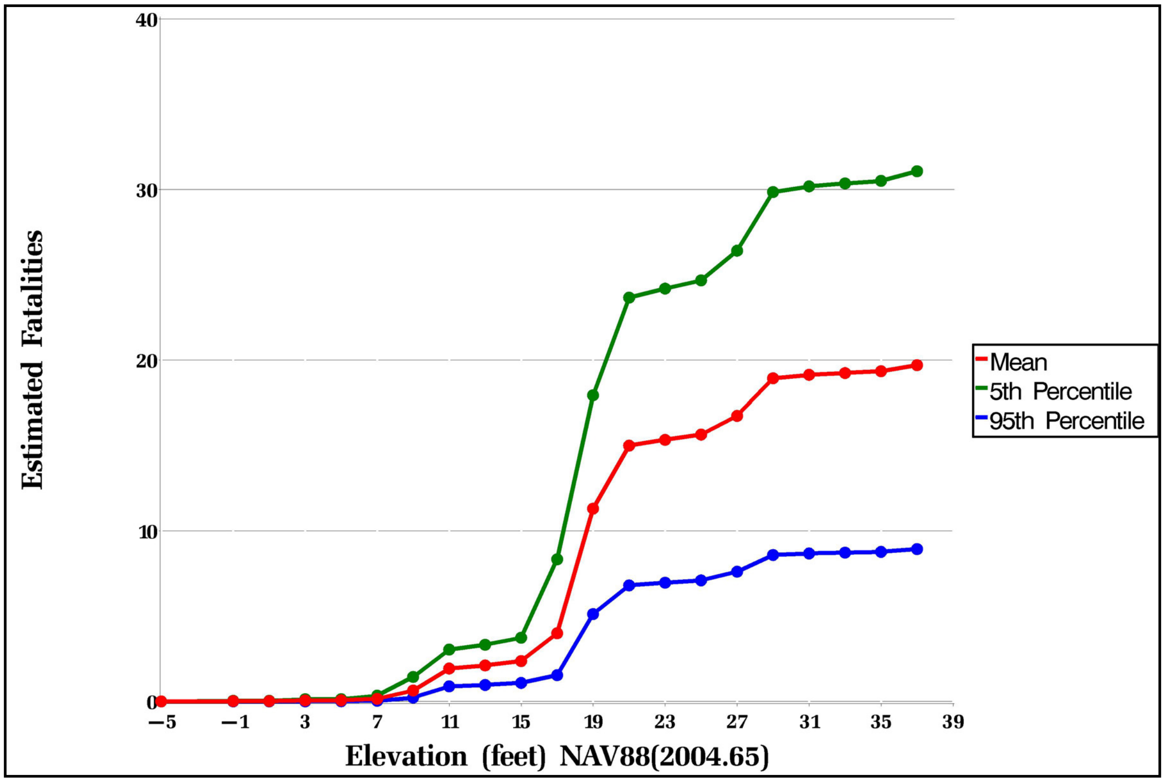

Exhibit 3-11a: New Orleans East Drainage Basin 4—Pre-Katrina

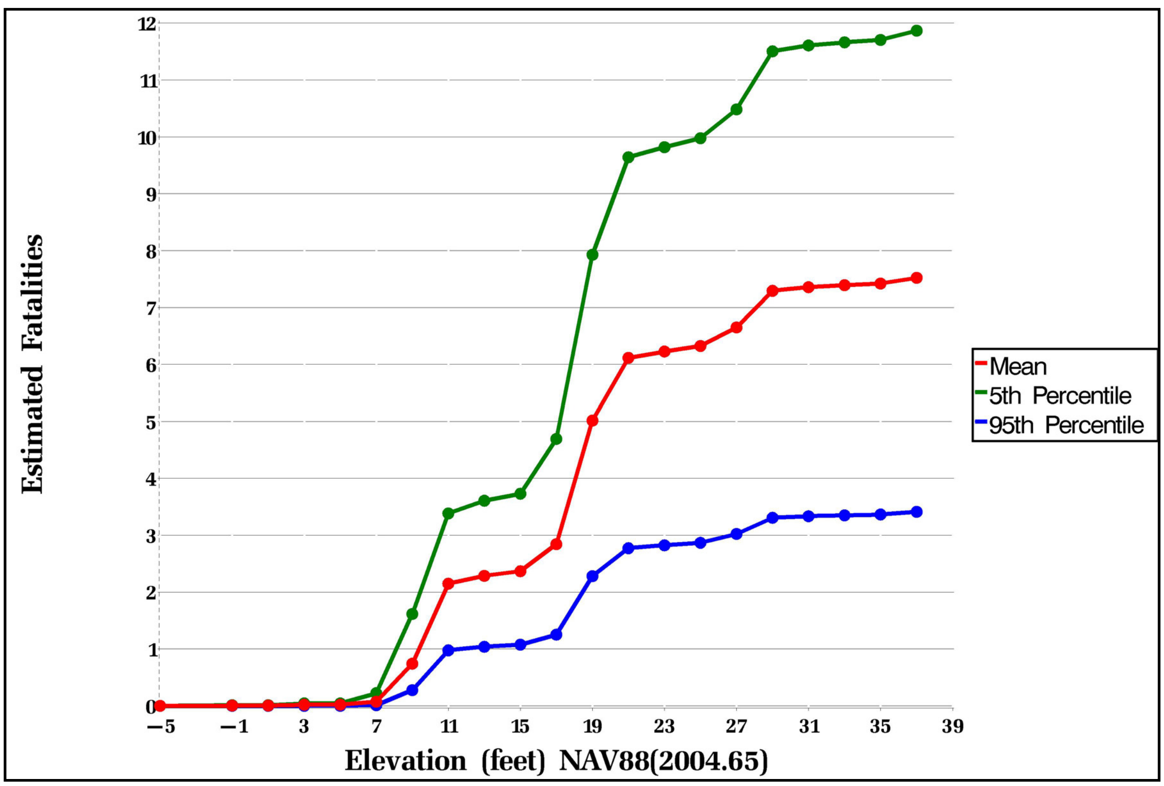

Exhibit 3-11b: New Orleans East Drainage Basin 4—Post-Katrina

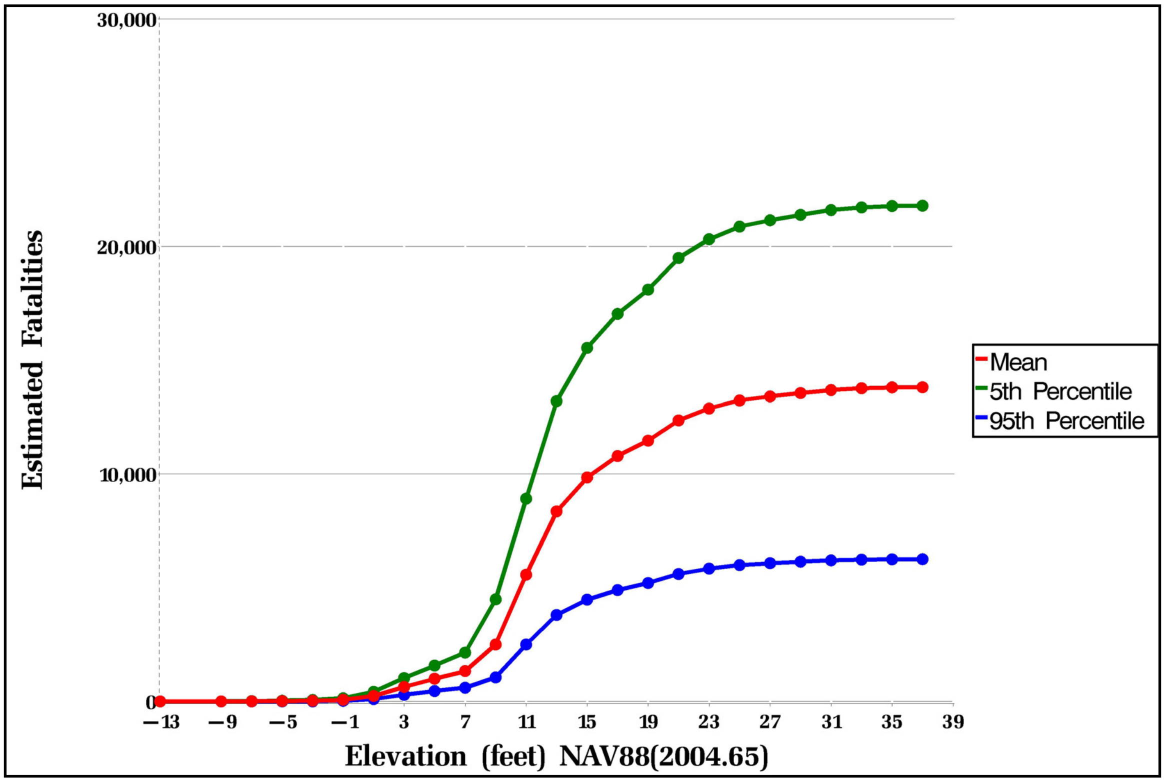

Exhibit 3-12a: New Orleans East Drainage Basin 5—Pre-Katrina

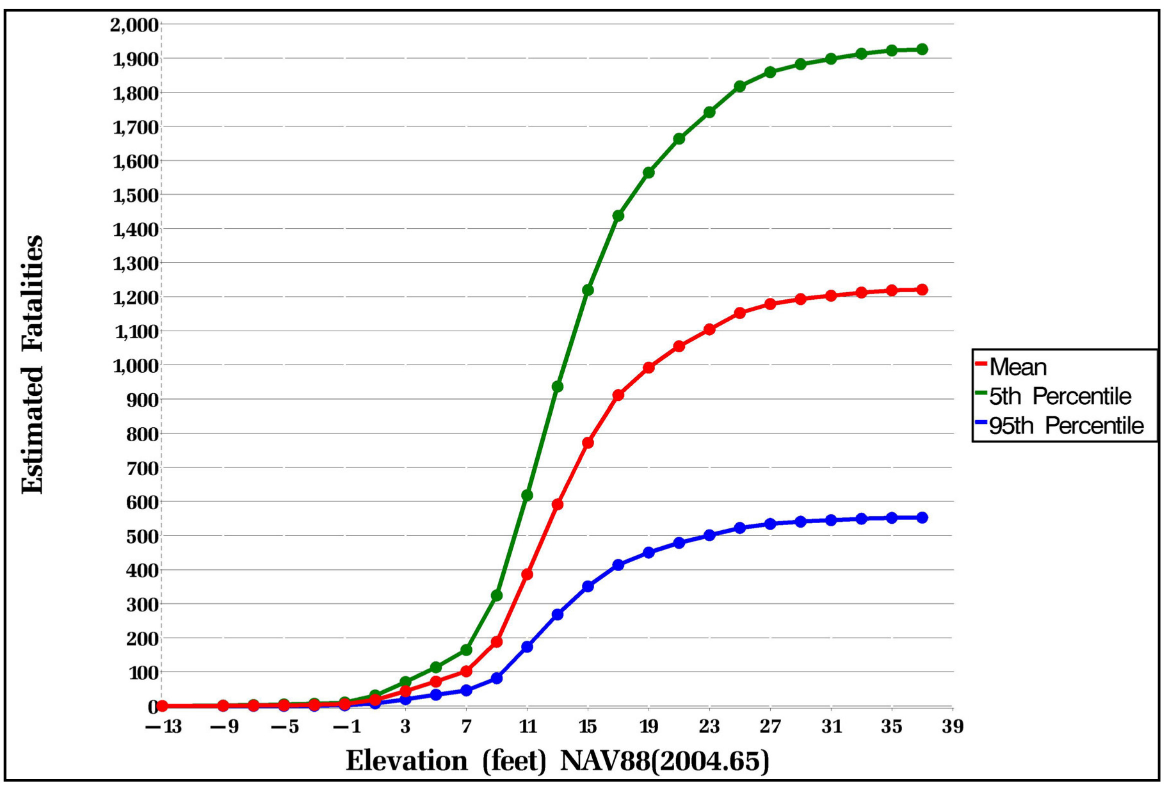

Exhibit 3-12b: New Orleans East Drainage Basin 5—Post-Katrina

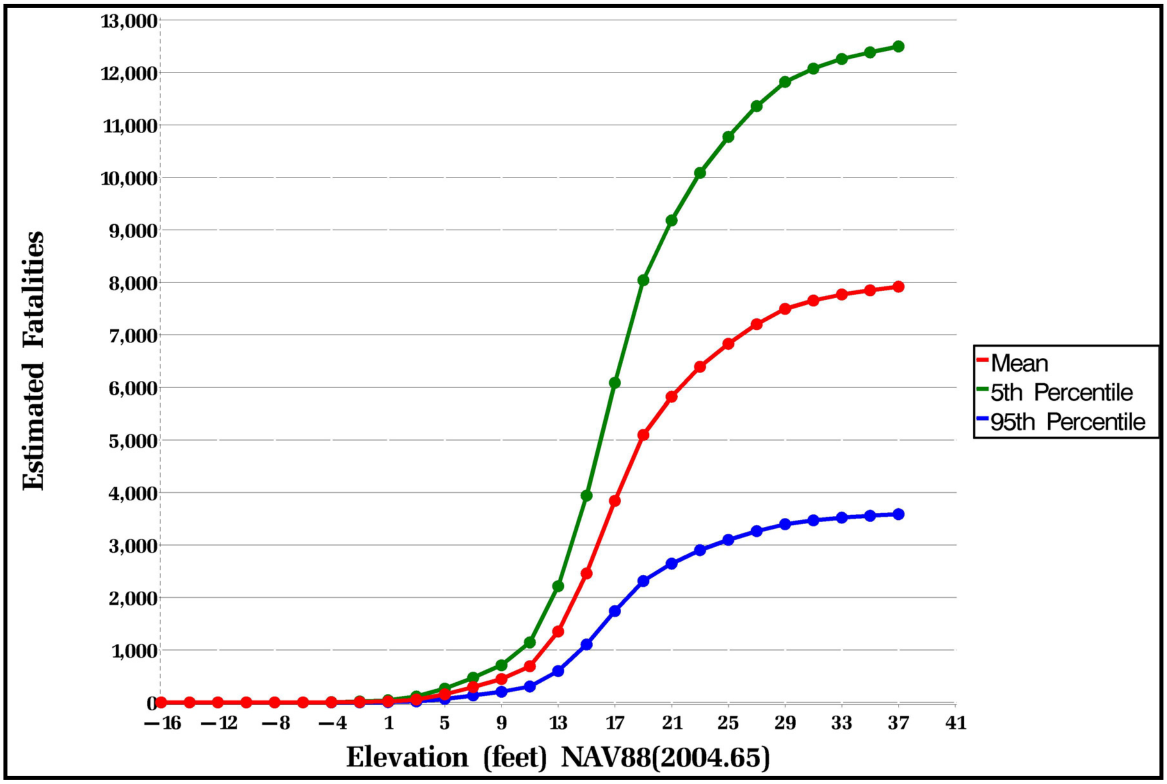

Exhibit 3-13a: Orleans Main Drainage Basin 1—Pre-Katrina

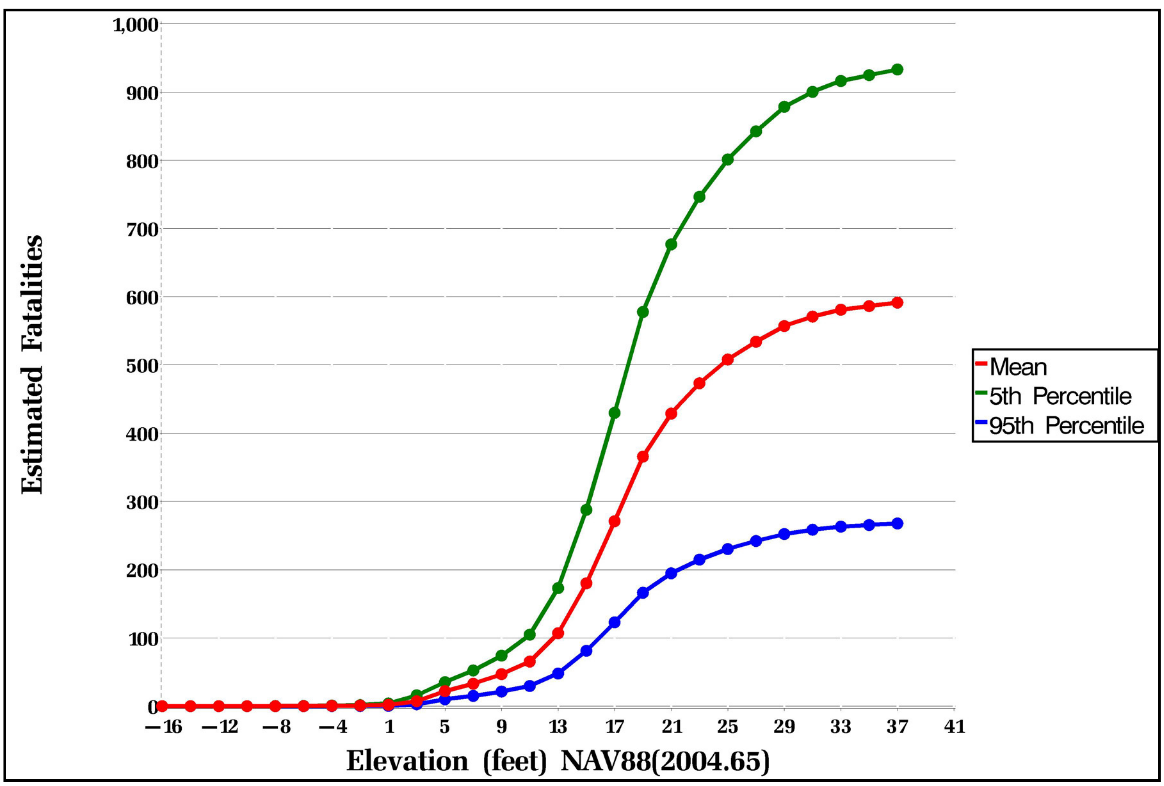

Exhibit 3-13b: Orleans Main Drainage Basin 1—Post-Katrina

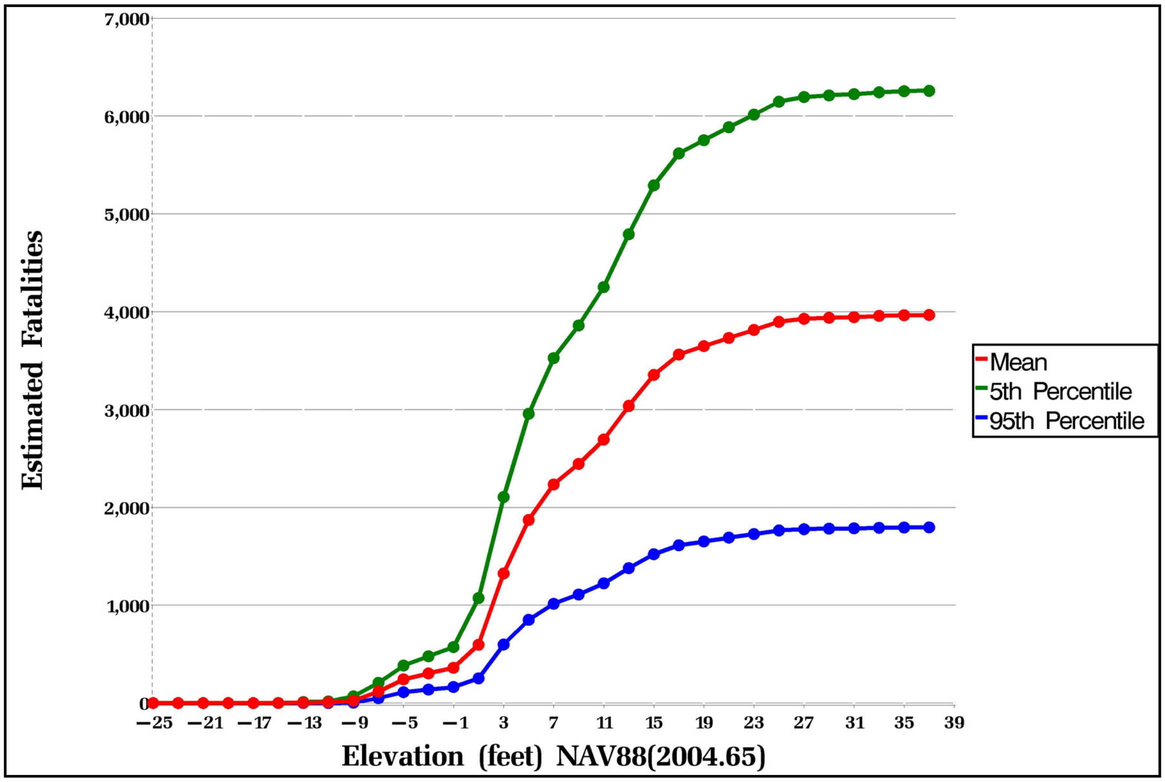

Exhibit 3-14a: Orleans Main Drainage Basin 2—Pre-Katrina

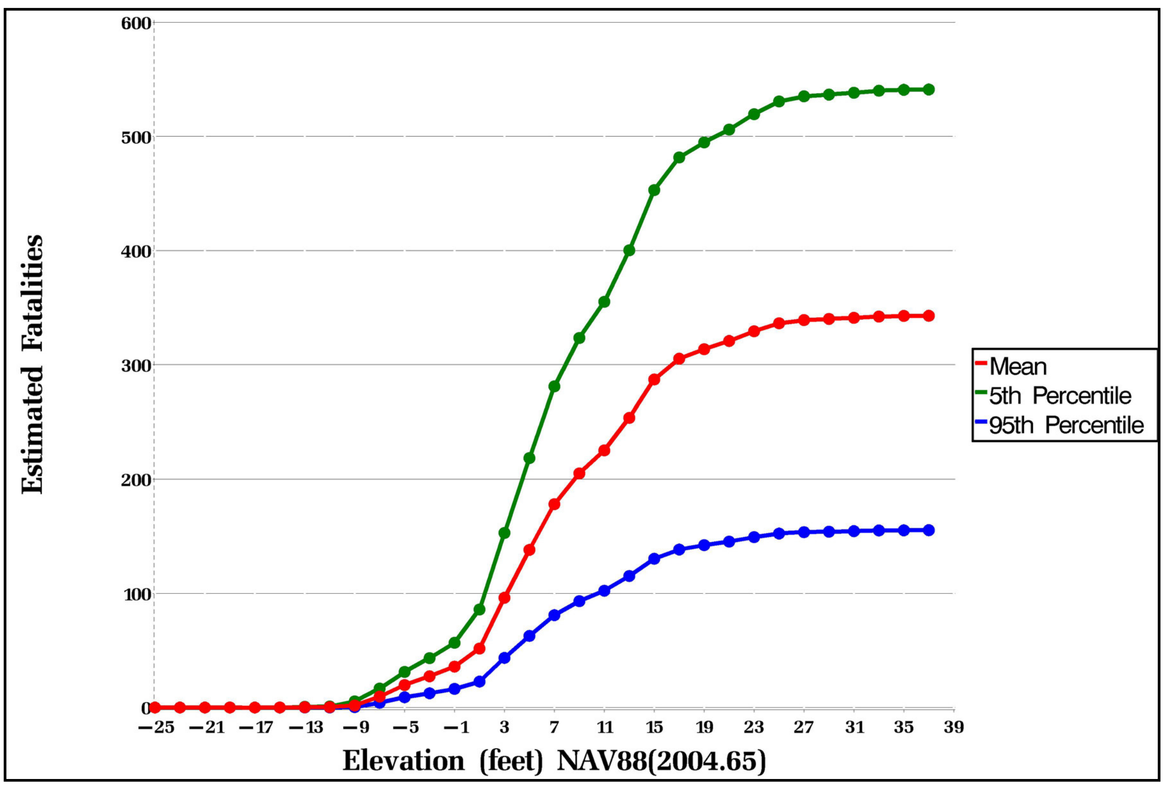

Exhibit 3-14b: Orleans Main Drainage Basin 2—Post-Katrina

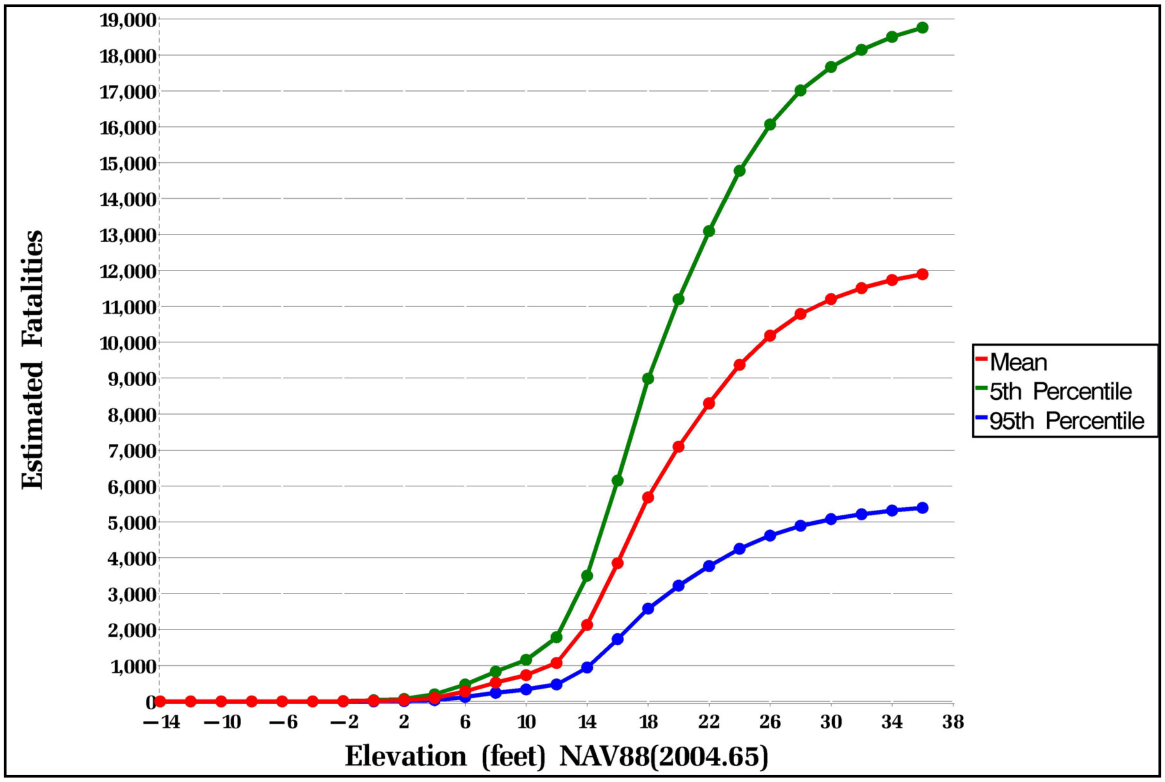

Exhibit 3-15a: Orleans Main Drainage Basin 3—Pre-Katrina

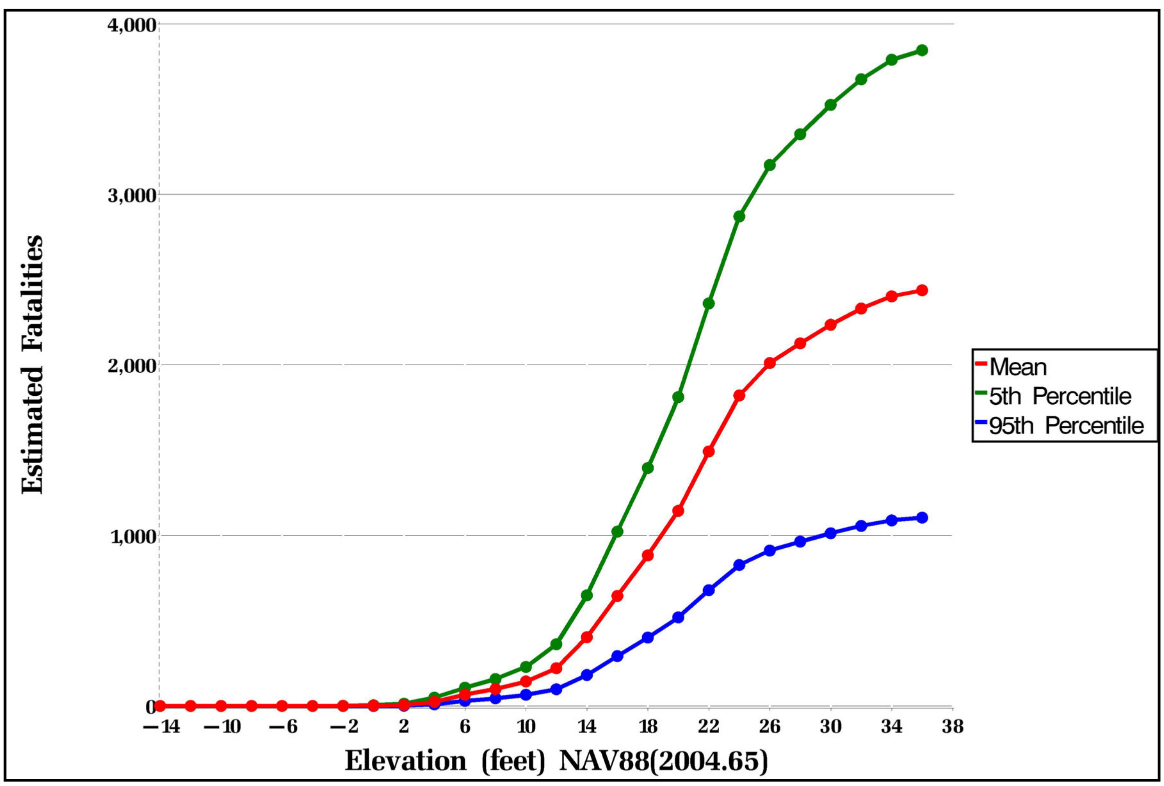

Exhibit 3-15b: Orleans Main Drainage Basin 3—Post-Katrina

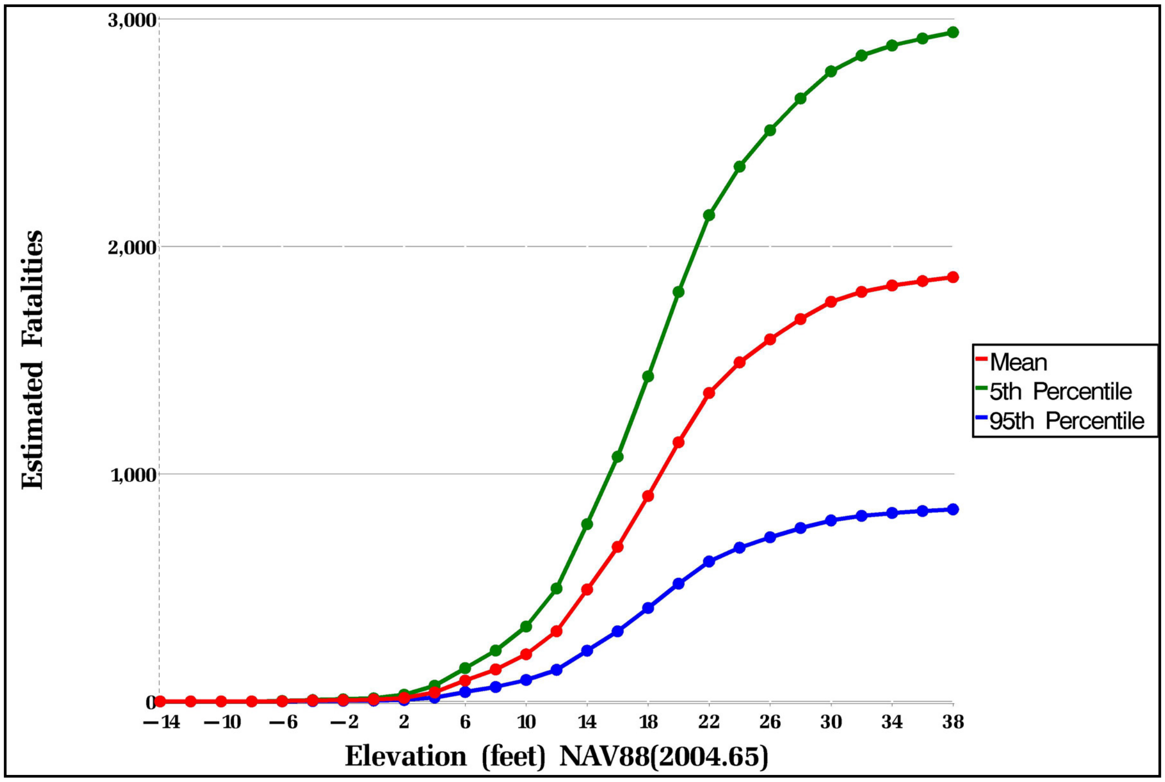

Exhibit 3-16a: Orleans Main Drainage Basin 4—Pre-Katrina

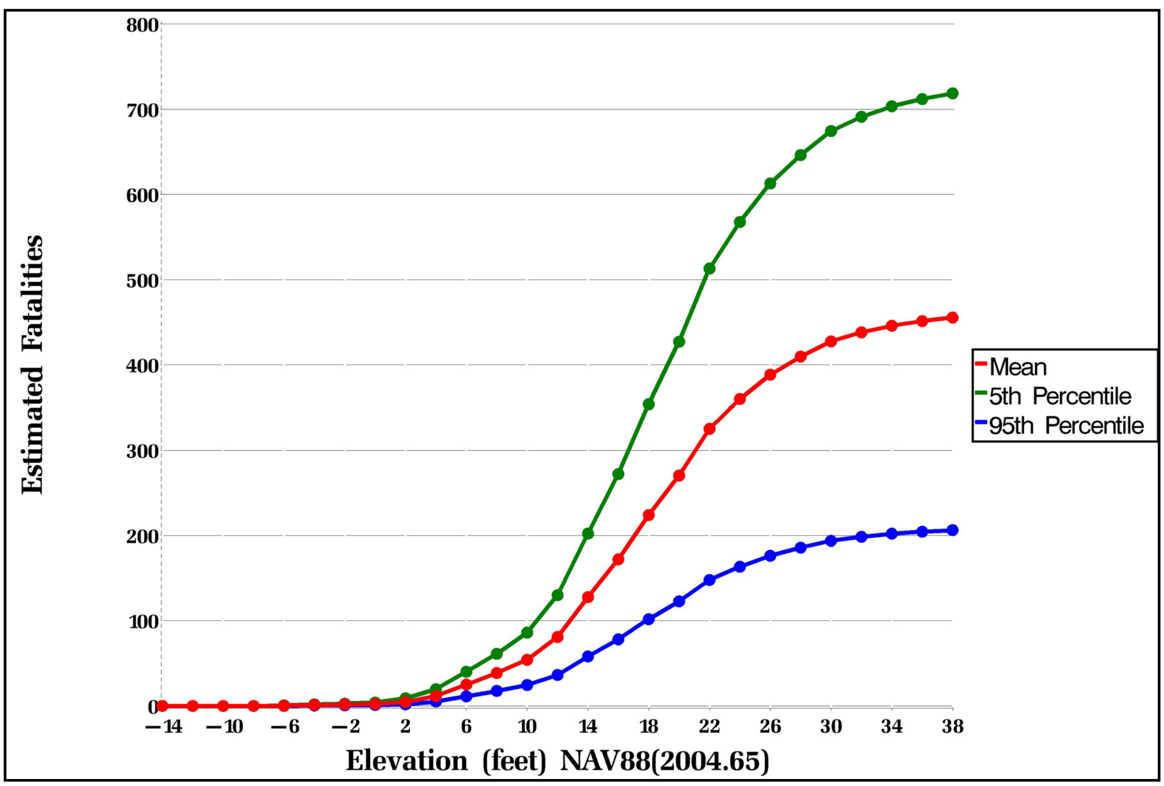

Exhibit 3-16b: Orleans Main Drainage Basin 4—Post-Katrina

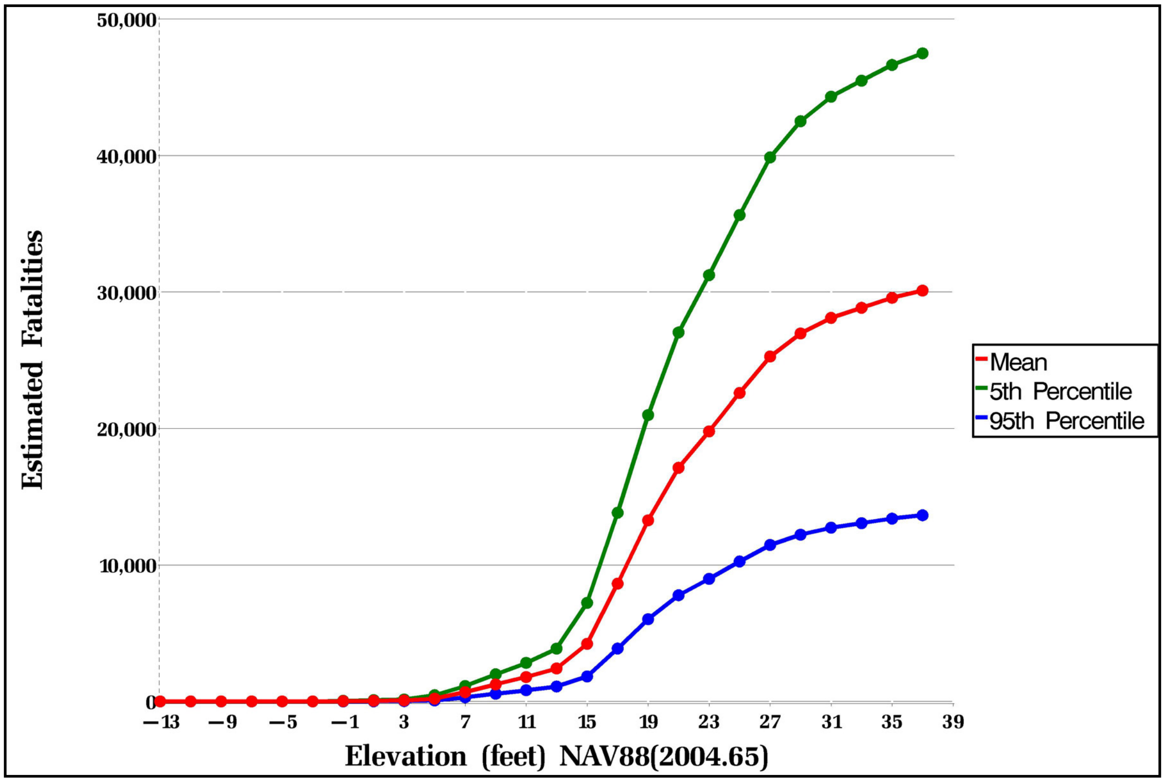

Exhibit 3-17a: Orleans Main Drainage Basin 5—Pre-Katrina

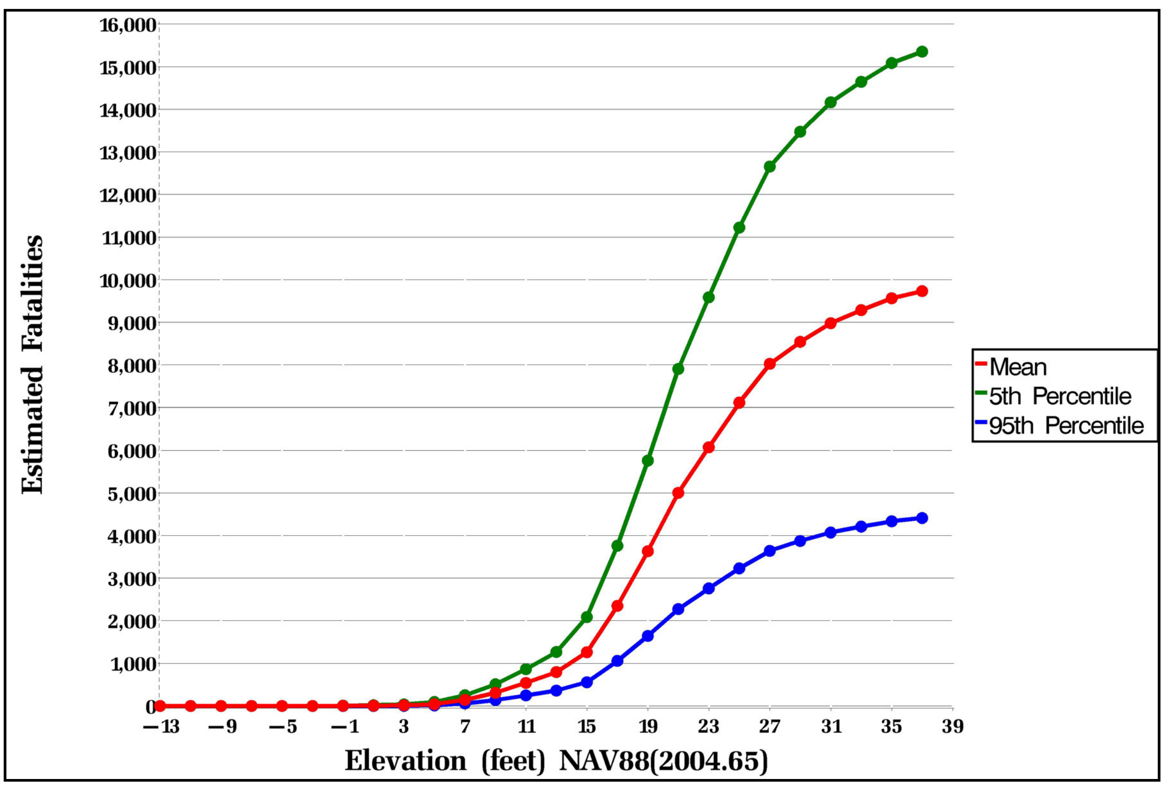

Exhibit 3-17b: Orleans Main Drainage Basin 5—Post-Katrina

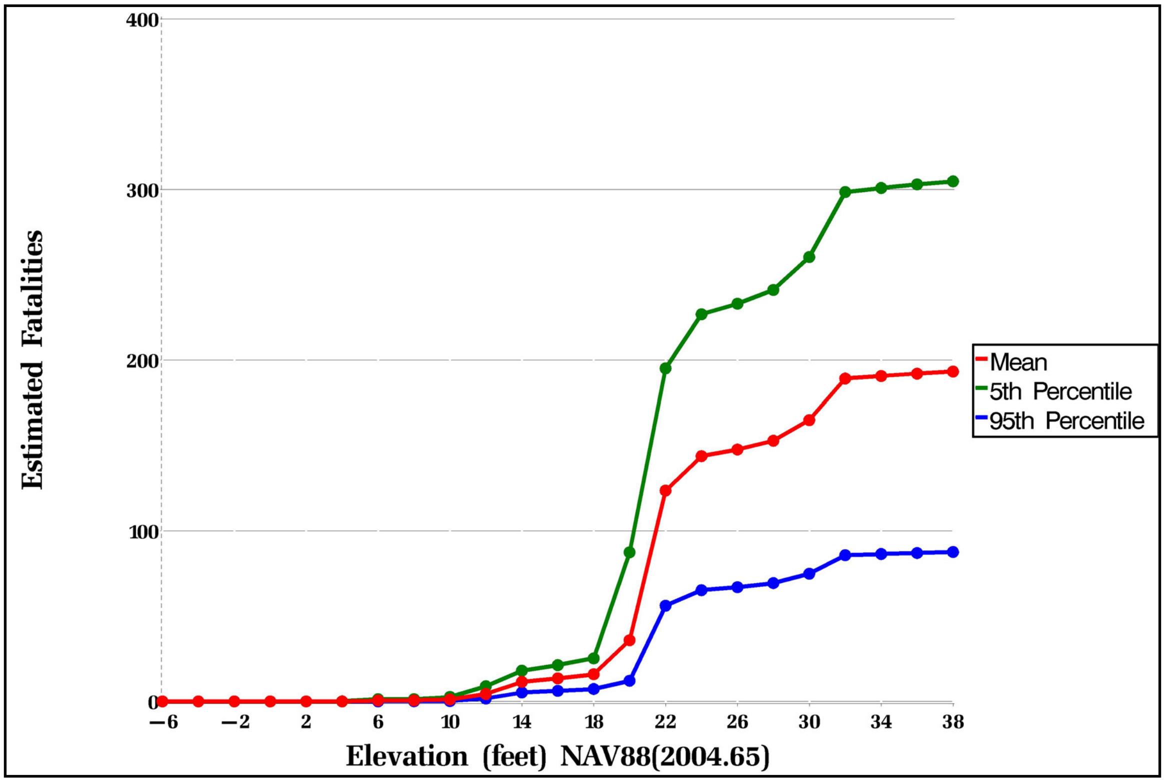

Exhibit 3-18a: Orleans West Bank Drainage Basin 1—Pre-Katrina

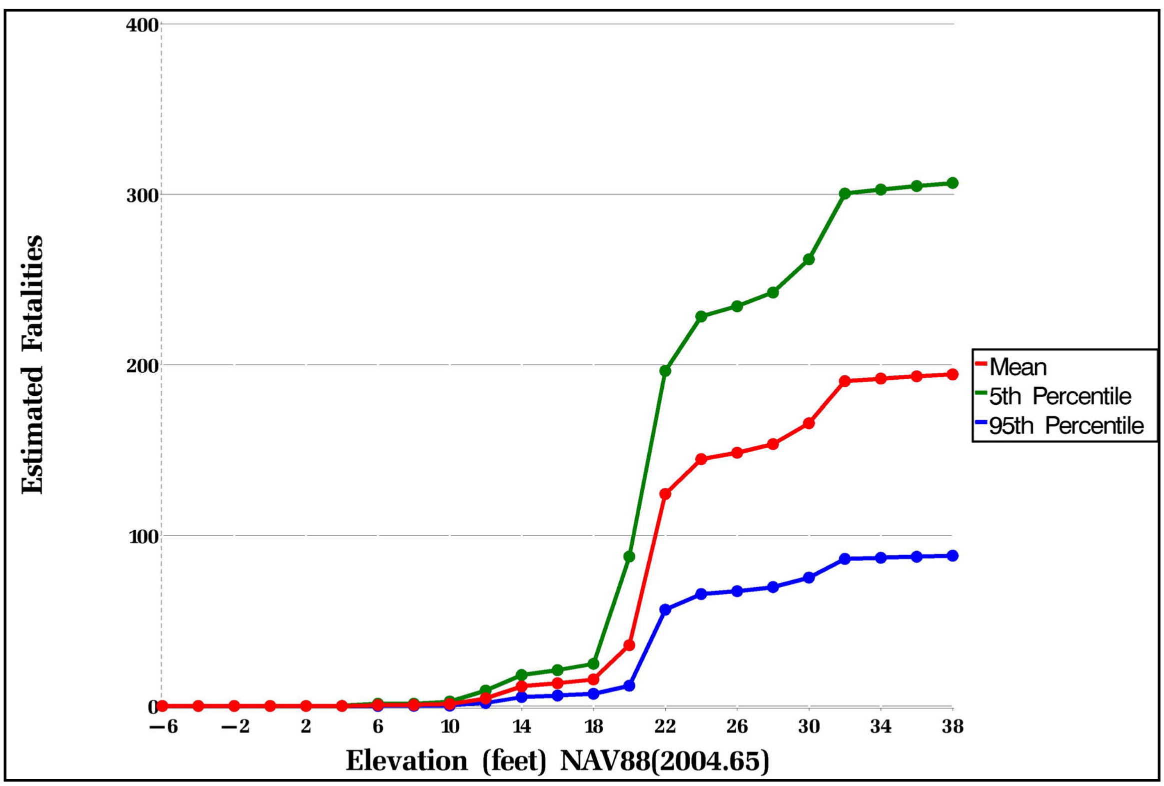

Exhibit 3-18b: Orleans West Bank Drainage Basin 1—Post-Katrina

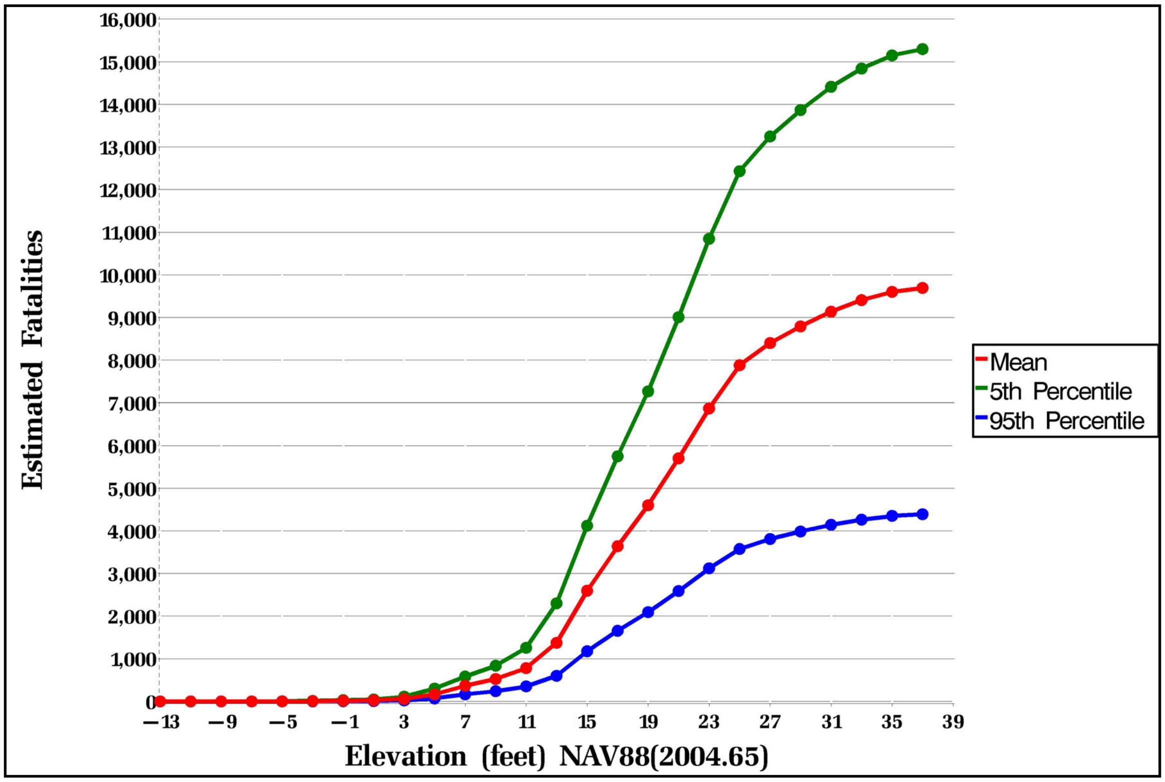

Exhibit 3-19a: Orleans West Bank Drainage Basin 2—Pre-Katrina

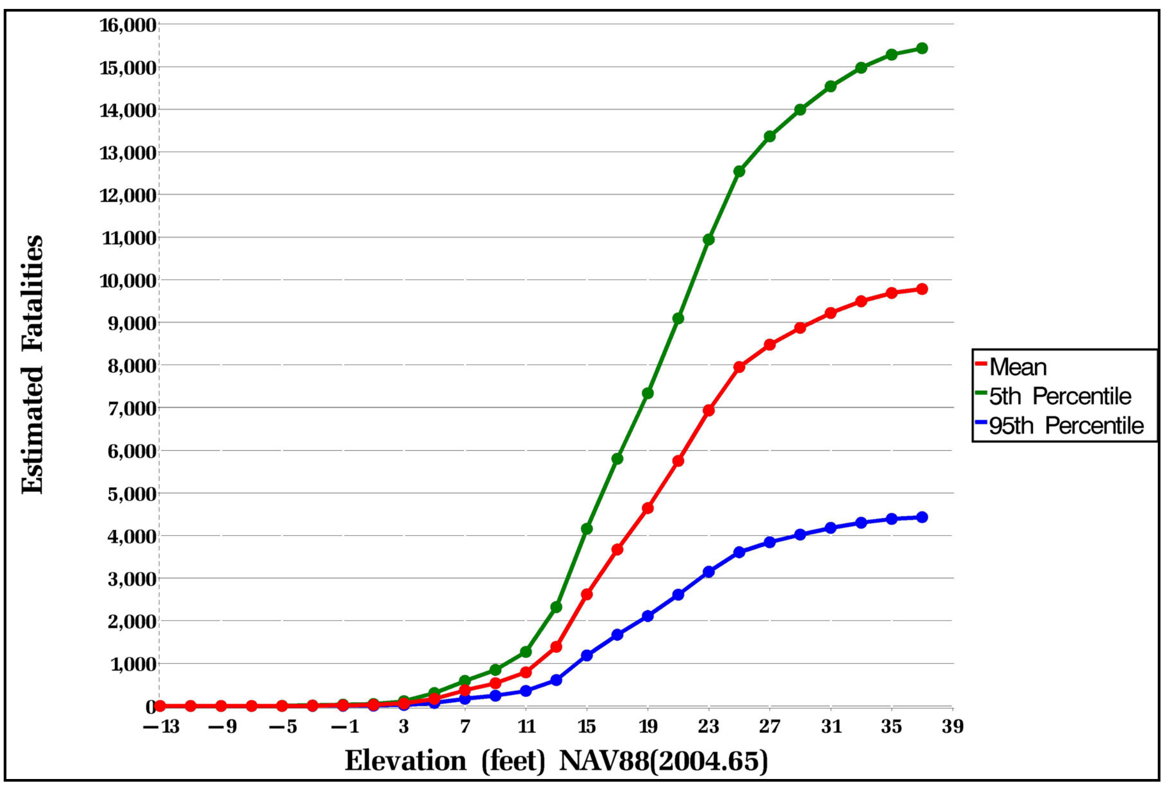

Exhibit 3-19b: Orleans West Bank Drainage Basin 2—Post-Katrina

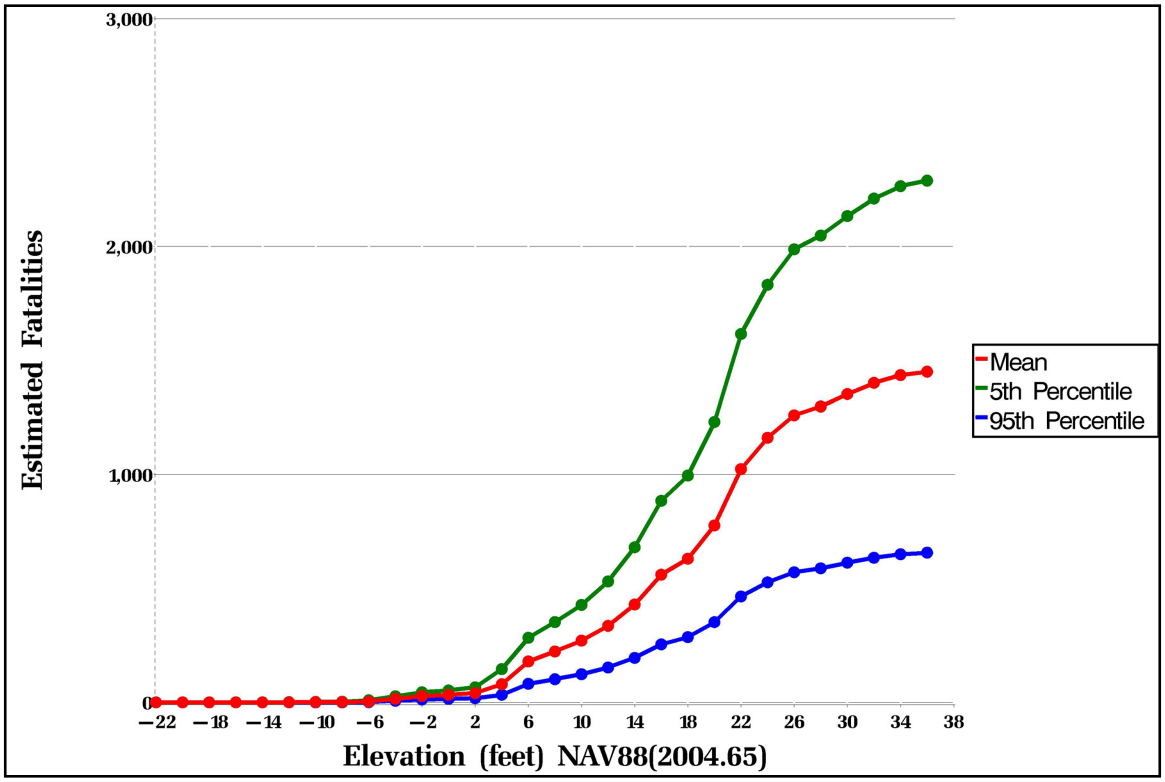

Exhibit 3-20a: Plaquemines Area Drainage Basin 1—Pre-Katrina

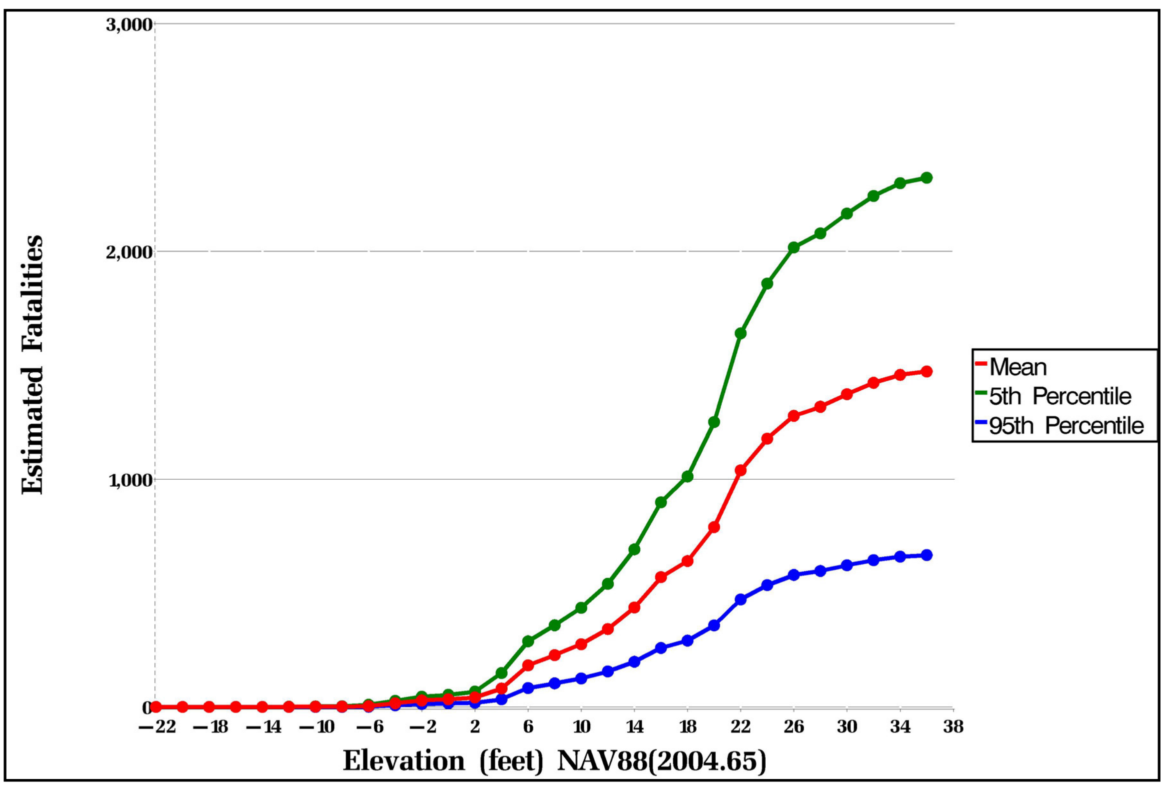

Exhibit 3-20b: Plaquemines Area Drainage Basin 1—Post-Katrina

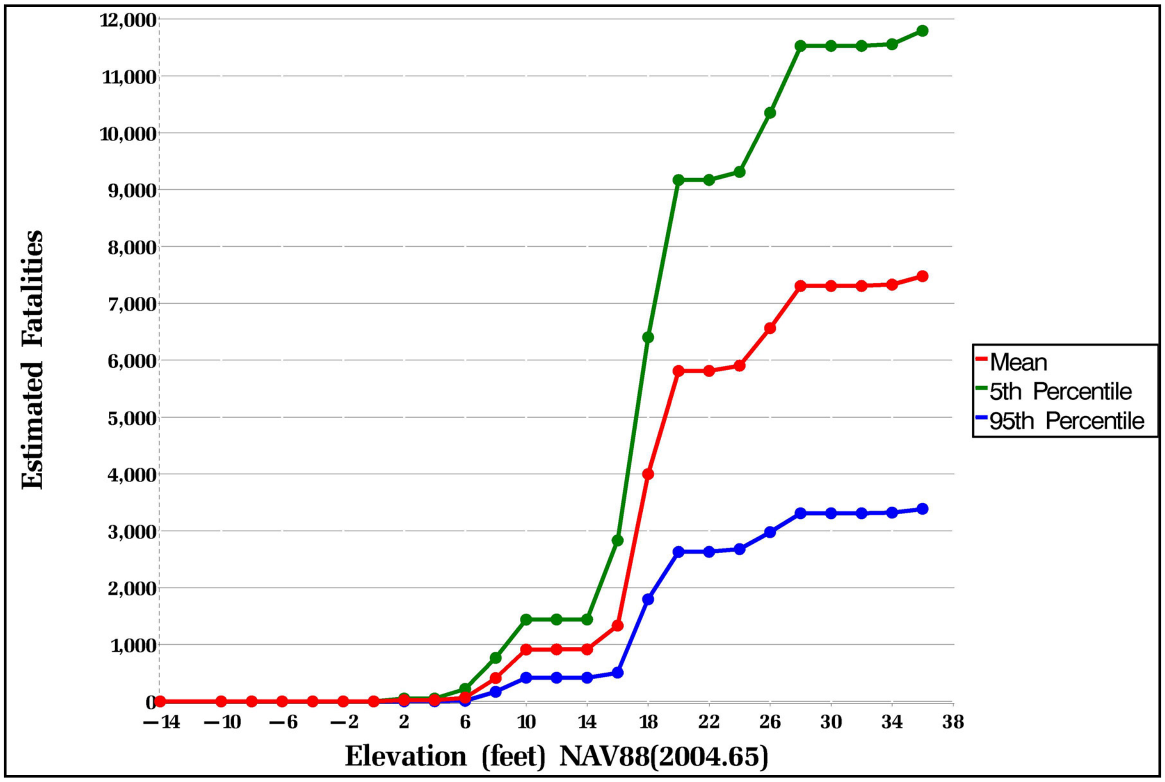

Exhibit 3-21a: St. Bernard Drainage Basin 1—Pre-Katrina

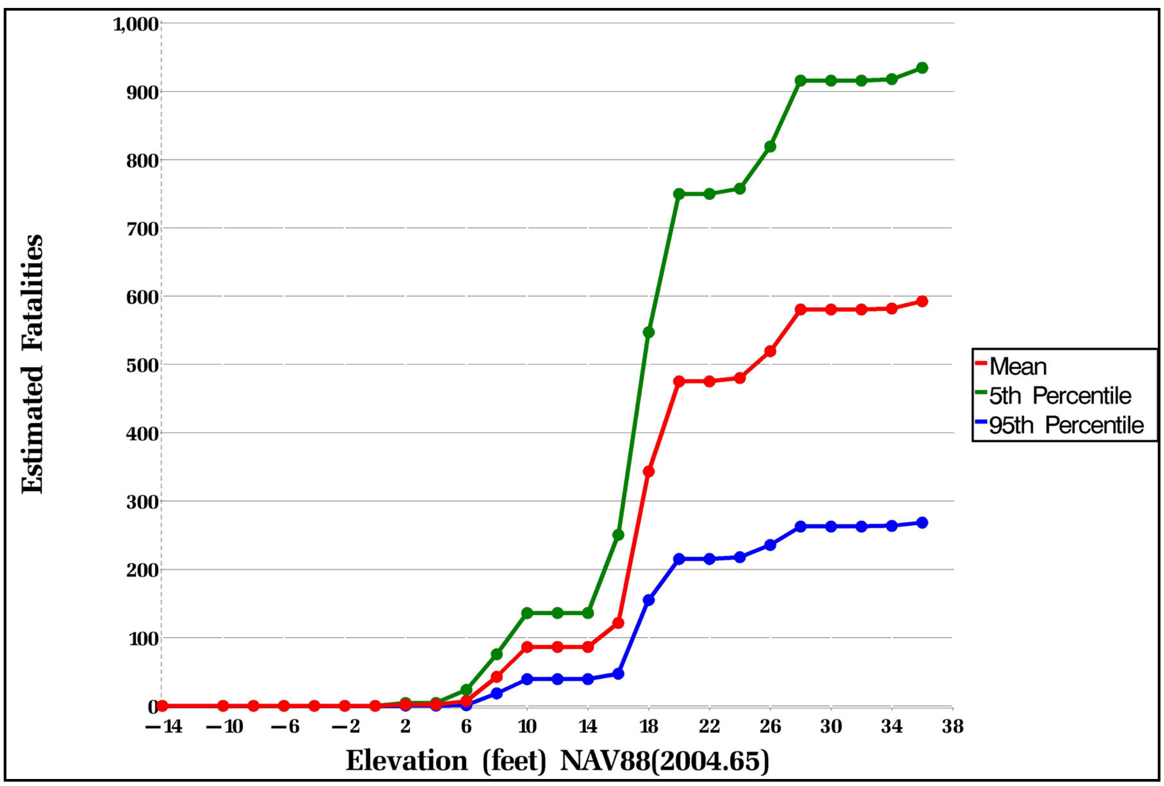

Exhibit 3-21b: St. Bernard Drainage Basin 1—Post-Katrina

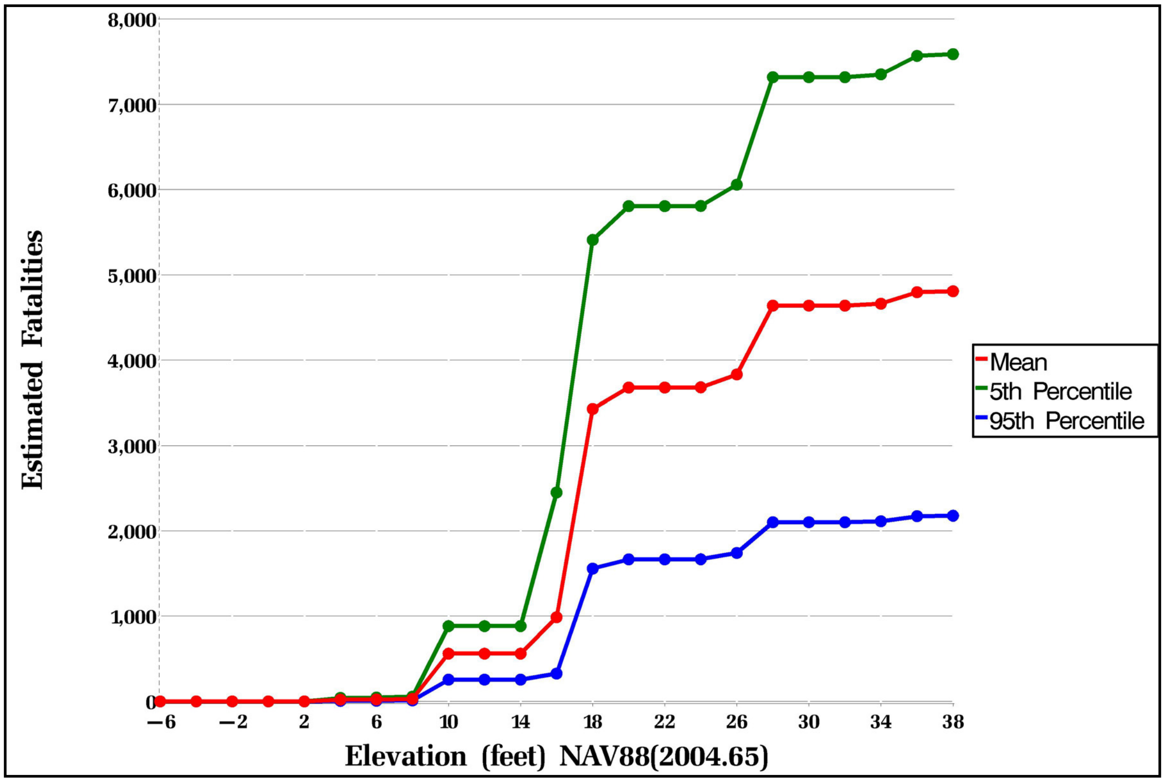

Exhibit 3-22a: St. Bernard Drainage Basin 3—Pre-Katrina

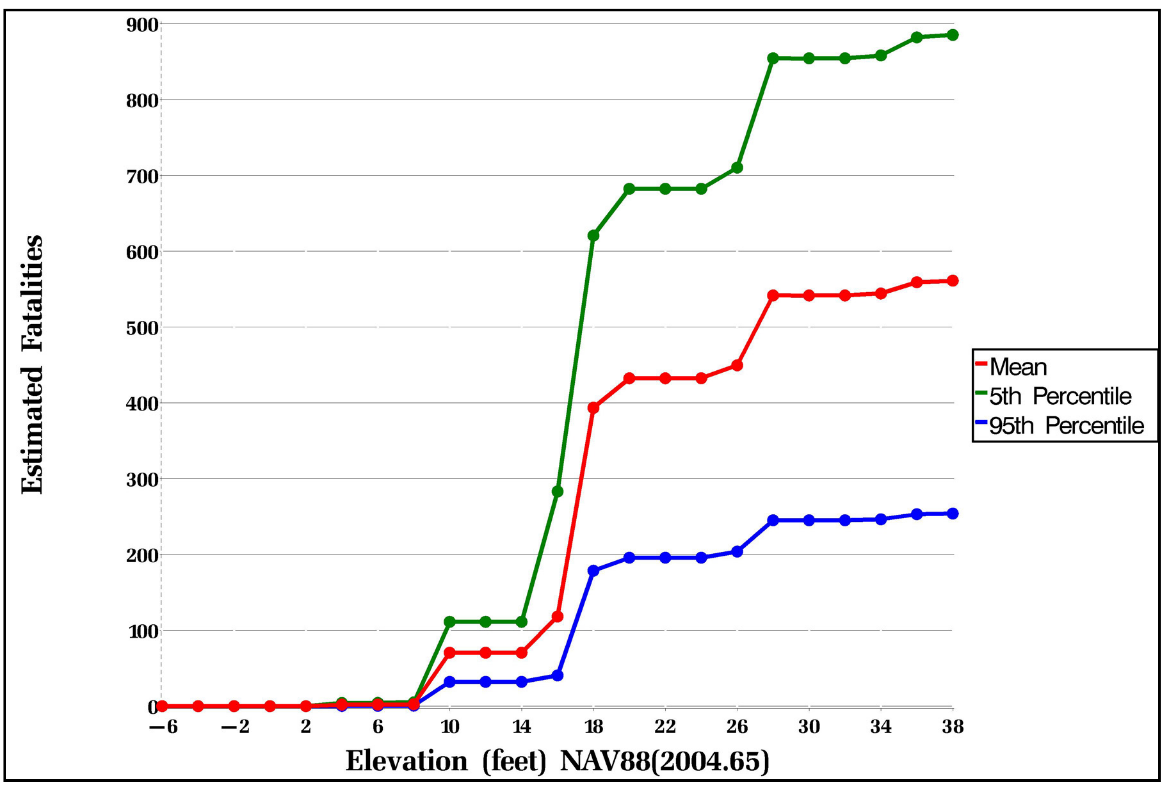

Exhibit 3-22b: St. Bernard Drainage Basin 3—Post-Katrina

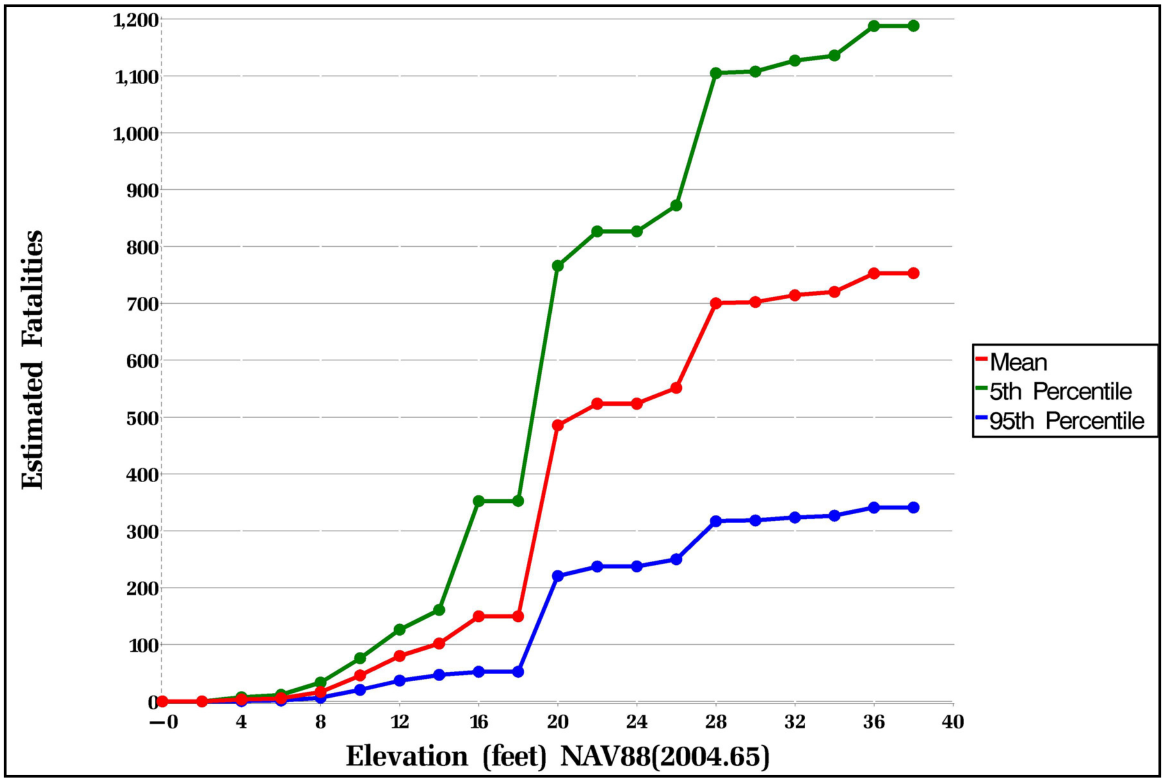

Exhibit 3-23a: St. Bernard Drainage Basin 4—Pre-Katrina

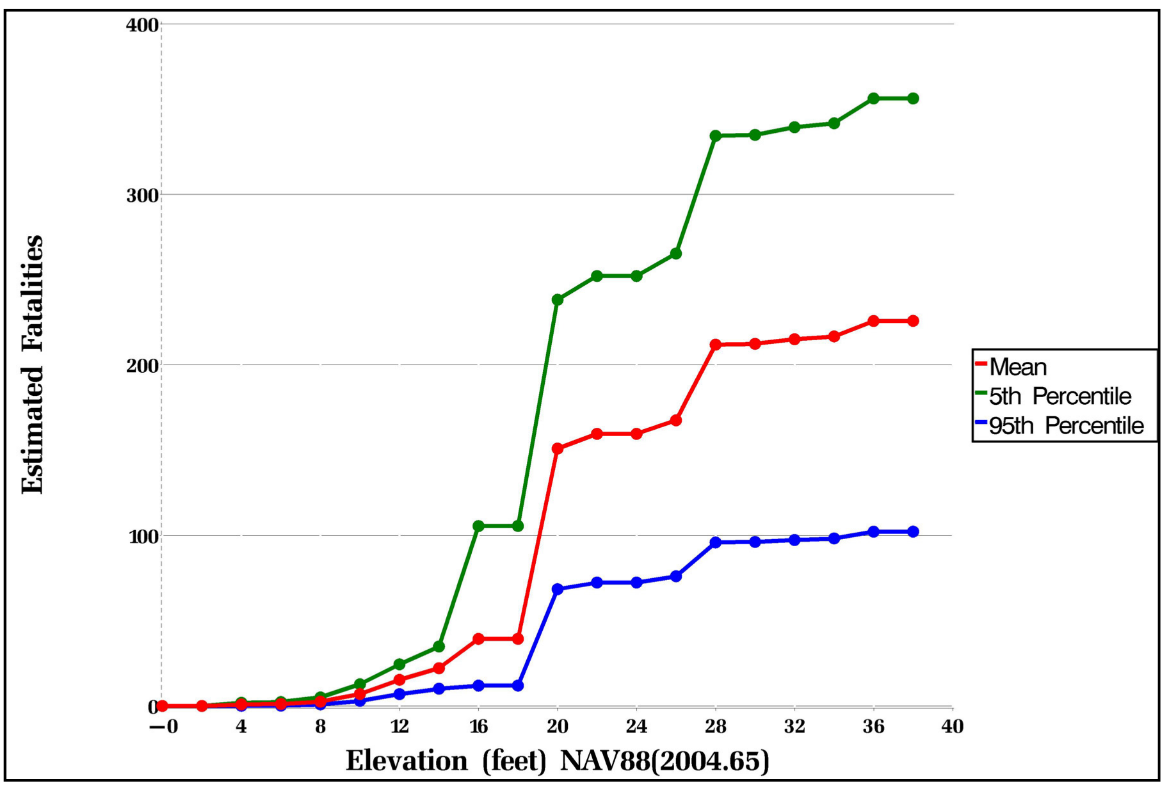

Exhibit 3-23b: St. Bernard Drainage Basin 4—Post-Katrina

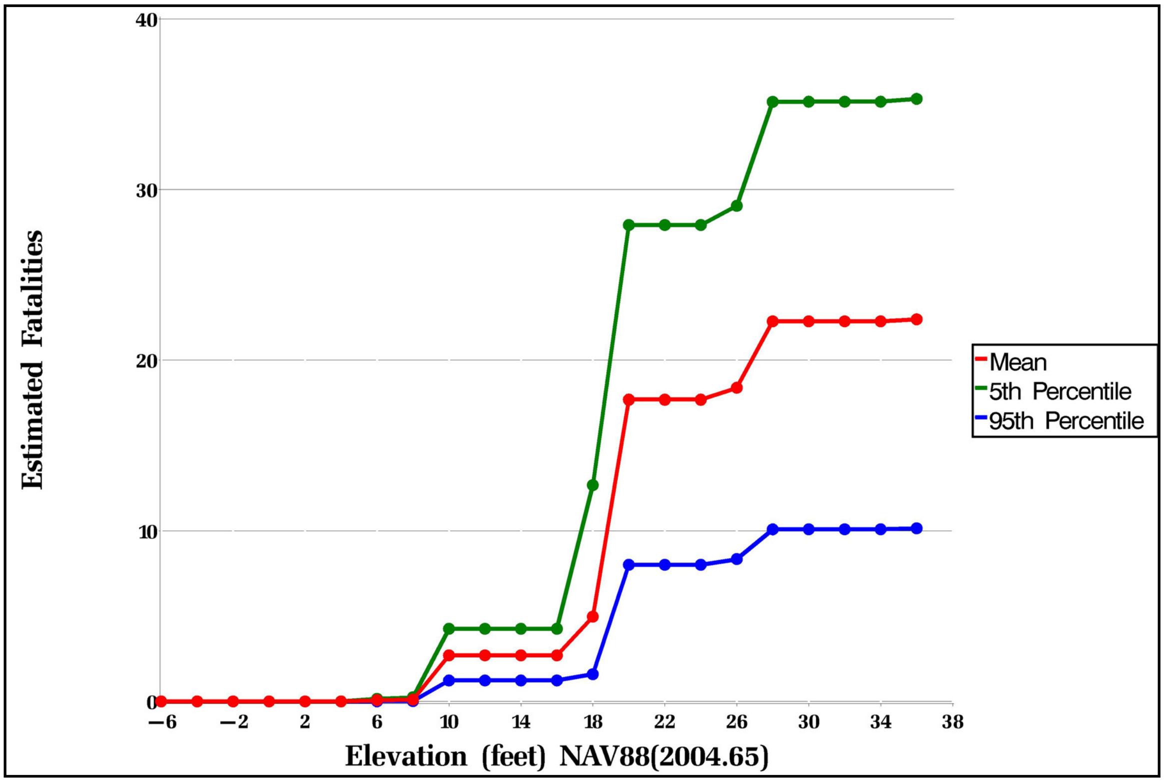

Exhibit 3-24a: St. Bernard Drainage Basin 5—Pre-Katrina

[No Post-Katrina figure necessary. Estimated Post-Katrina fatalities were zero.]

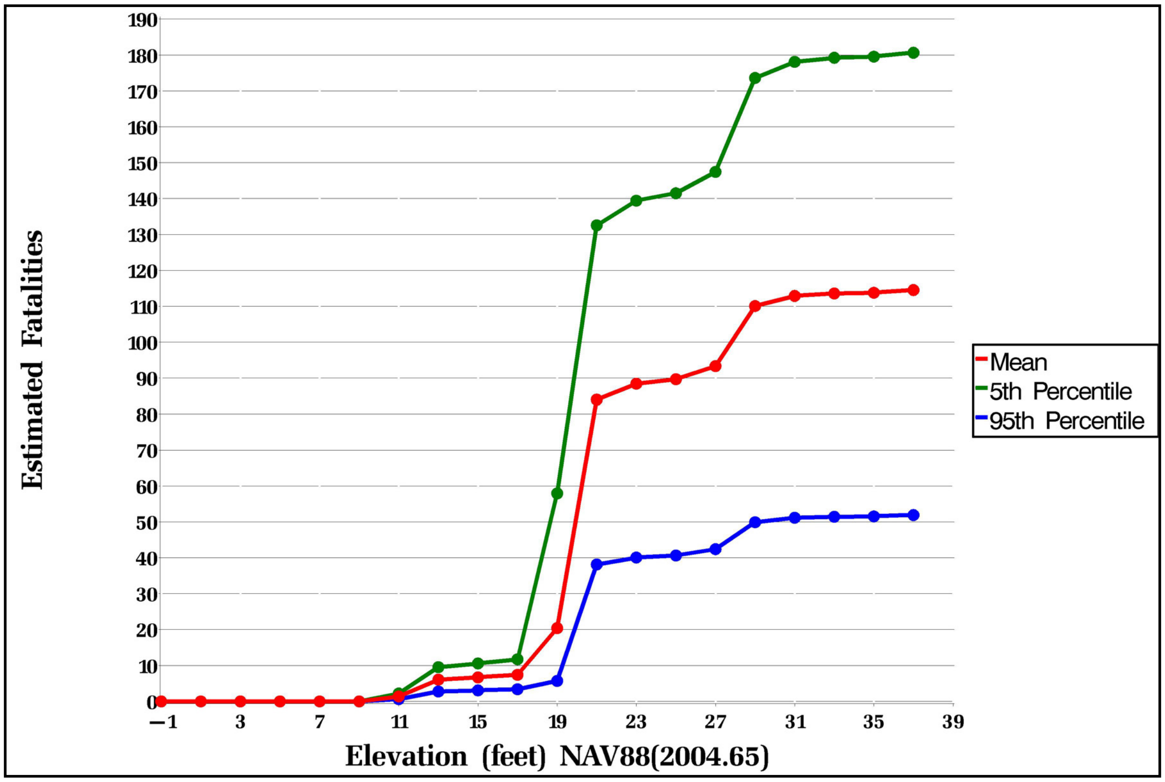

Exhibit 3-25a: St. Charles Drainage Basin 1—Pre-Katrina

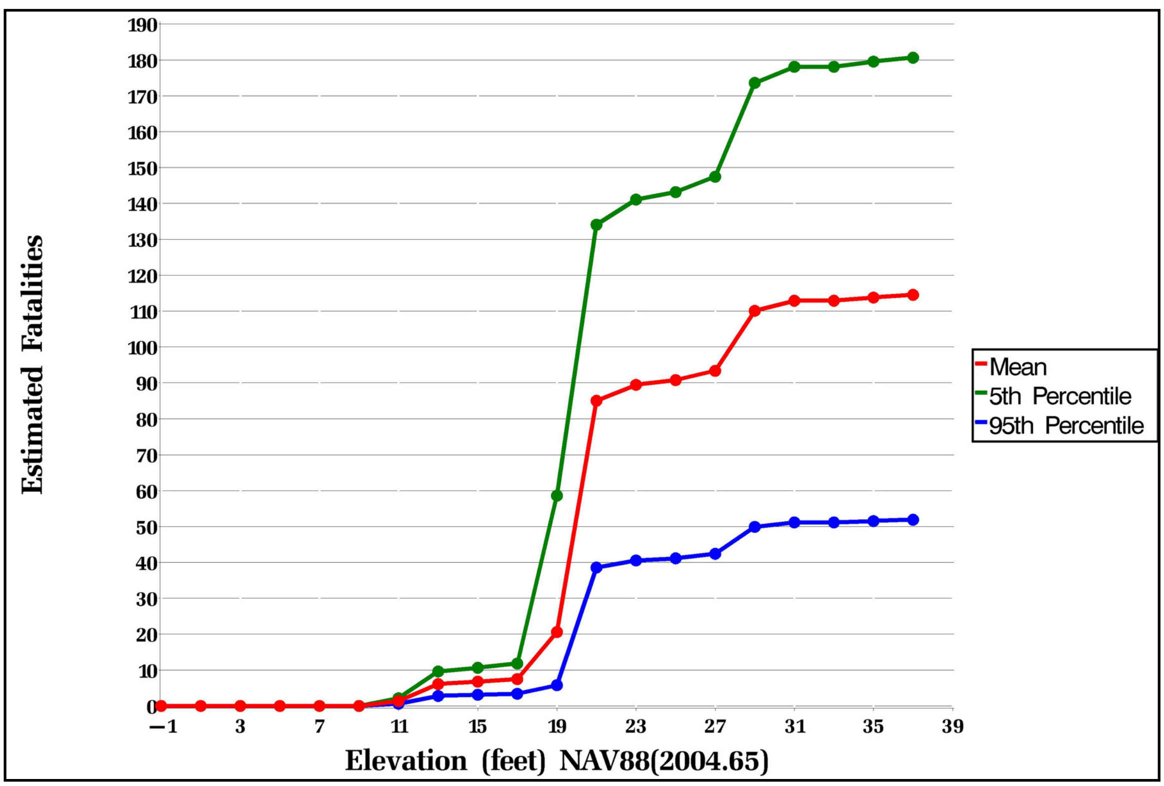

Exhibit 3-25b: St. Charles Drainage Basin 1—Post-Katrina

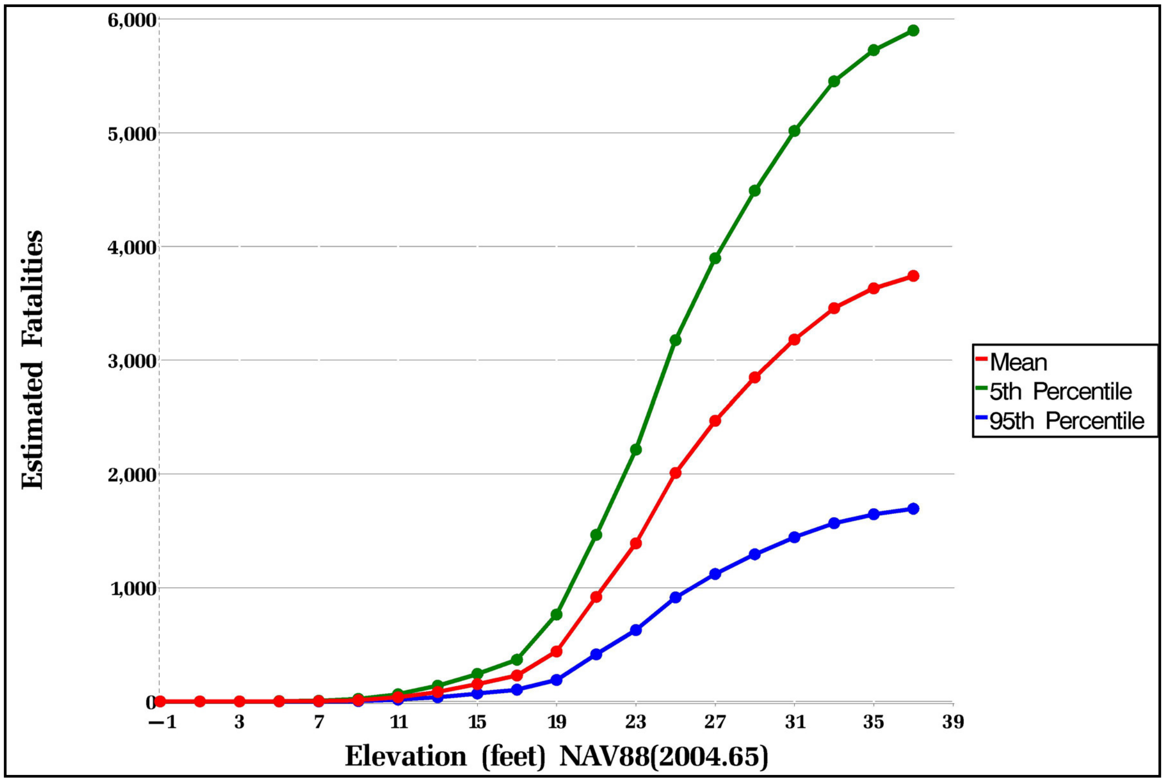

Exhibit 3-26b: St. Charles Drainage Basin 2—Pre-Katrina

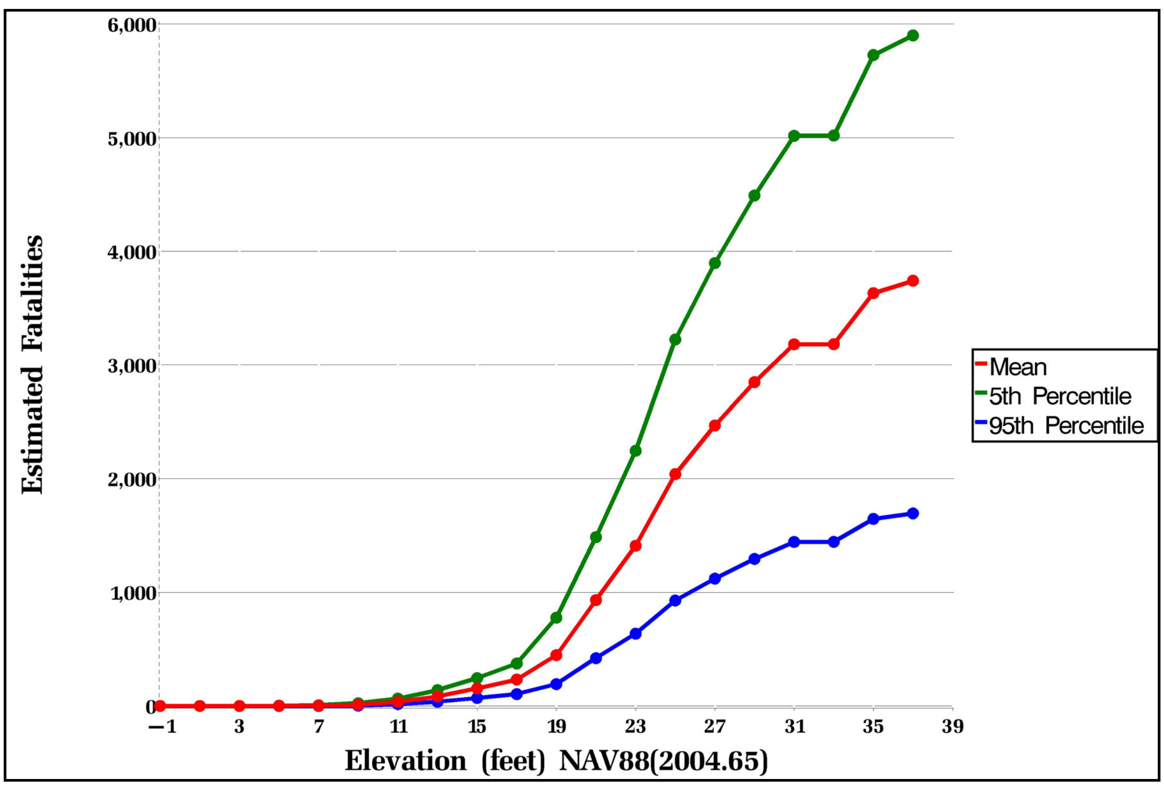

Exhibit 3-26: St. Charles Drainage Basin 2—Post-Katrina

Hurricane-Related Flood Stage vs. Fatality Estimations for Each Drainage Basin in Greater New Orleans

Pre-Katrina flood stage–fatality results for each drainage basin are presented first in the tables 3-1a through 3-26a, and post-Katrina stage-fatality results in the tables labeled 3-1b through 3-26b.

Table 3-1a: Estimated Fatalities by Flood Water Elevation for Jefferson East Drainage Basin #1 – Pre-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles *5th*	*25th*	*50th*	*75th*	*95th*
-10.7	0.0	0.0	0.0	0.0	0.0	0.0
-8.7	0.0	0.0	0.0	0.0	0.0	0.0
-6.7	0.0	0.0	0.0	0.0	0.0	0.0
-4.7	0.0	0.0	0.0	0.0	0.0	0.0
-2.7	0.7	0.3	0.5	0.7	0.9	1.2
-0.7	3.2	1.5	2.4	3.2	3.9	5.0
1.3	5.6	2.4	4.0	5.4	6.9	9.4
3.3	9.4	3.9	6.6	8.8	11.6	16.1
5.3	27.1	8.7	15.3	22.5	33.9	62.2
7.3	85.4	36.8	60.7	81.1	105.0	149.7
9.3	200.3	89.2	146.3	194.2	247.0	332.6
11.3	367.4	166.3	272.9	362.0	454.2	587.8
13.3	569.8	257.8	423.1	562.1	705.0	911.5
15.3	911.0	408.8	672.3	894.4	1,125.5	1,471.4
17.3	1,547.2	695.7	1,146.5	1,525.1	1,913.1	2,480.8
19.3	2,451.0	1,107.4	1,826.4	2,424.7	3,033.9	3,898.3
21.3	3,511.0	1,594.9	2,625.4	3,486.3	4,340.8	5,551.3
23.3	4,542.5	2,063.2	3,402.9	4,517.1	5,620.3	7,174.4
25.3	5,462.8	2,482.0	4,094.8	5,442.9	6,761.1	8,615.8
27.3	6,104.0	2,773.2	4,574.6	6,083.1	7,555.2	9,627.9
29.3	6,693.7	3,035.8	5,014.8	6,674.7	8,290.6	10,558.7
31.3	6,994.9	3,173.4	5,240.0	6,973.9	8,662.2	11,033.4
33.3	7,305.7	3,312.7	5,472.6	7,285.0	9,050.6	11,524.1
35.3	7,514.4	3,406.2	5,627.4	7,493.9	9,307.4	11,852.2
37.3	7,677.8	3,480.5	5,749.1	7,657.6	9,510.5	12,113.5

Table 3-1b: Estimated Fatalities by Flood Water Elevation for Jefferson East Drainage Basin #1 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles 5th	25th	50th	75th	95th
-10.7	0.0	0.0	0.0	0.0	0.0	0.0
-8.7	0.0	0.0	0.0	0.0	0.0	0.0
-6.7	0.0	0.0	0.0	0.0	0.0	0.0
-4.7	0.0	0.0	0.0	0.0	0.0	0.0
-2.7	0.7	0.3	0.5	0.7	0.9	1.2
-0.7	3.3	1.5	2.4	3.2	4.0	5.1
1.3	5.7	2.5	4.1	5.5	7.0	9.6
3.3	9.6	4.0	6.7	9.0	11.8	16.4
5.3	27.6	8.8	15.6	23.0	34.6	63.4
7.3	87.0	37.5	61.9	82.7	107.0	152.6
9.3	204.2	90.9	149.1	198.0	251.8	339.1
11.3	374.8	169.6	278.3	369.2	463.3	599.6
13.3	581.6	263.2	431.8	573.7	719.6	930.4
15.3	929.7	417.2	686.2	912.8	1,148.6	1,501.5
17.3	1,577.6	709.4	1,169.0	1,555.1	1,950.6	2,529.3
19.3	2,498.2	1,128.8	1,861.6	2,471.5	3,092.2	3,973.3
21.3	3,577.9	1,625.3	2,675.3	3,552.7	4,423.5	5,656.9
23.3	4,629.8	2,102.9	3,468.3	4,604.0	5,728.3	7,312.3
25.3	5,568.2	2,530.0	4,173.7	5,547.7	6,891.4	8,781.8
27.3	6,223.0	2,827.1	4,663.5	6,201.4	7,702.4	9,815.4
29.3	6,826.7	3,096.1	5,114.5	6,807.3	8,455.4	10,768.5
31.3	7,133.9	3,236.4	5,344.1	7,112.5	8,834.3	11,252.6
33.3	7,450.8	3,378.5	5,581.3	7,429.7	9,230.4	11,753.1
35.3	7,663.7	3,473.9	5,739.5	7,642.8	9,492.7	12,087.9
37.3	7,831.1	3,550.0	5,864.0	7,810.5	9,700.4	12,355.4

Table 3-2a: Estimated Fatalities by Flood Water Elevation for Jefferson East Drainage Basin #2 – Pre-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-12.6	0.0	0.0	0.0	0.0	0.0	0.0
-10.6	0.9	0.1	0.4	0.7	1.2	1.9
-8.6	0.9	0.1	0.4	0.7	1.2	1.9
-6.6	4.9	1.3	2.3	3.5	6.1	13.2
-4.6	27.7	12.6	20.6	27.3	34.3	44.5
-2.6	55.5	24.8	40.8	53.9	68.2	90.4
-0.6	81.7	35.4	58.6	78.1	100.3	137.1
1.4	166.2	57.6	97.7	135.6	202.2	386.7
3.4	641.1	277.1	458.7	612.9	788.1	1,114.1
5.4	1,239.7	564.8	927.4	1,229.3	1,533.7	1,961.8
7.4	1,664.3	758.8	1,247.5	1,657.3	2,058.9	2,623.5
9.4	1,910.5	871.0	1,429.4	1,897.2	2,362.6	3,018.2
11.4	2,752.4	1,196.2	1,988.5	2,654.0	3,390.3	4,669.4
13.4	5,371.8	2,431.6	4,006.3	5,321.6	6,648.9	8,522.4
15.4	7,311.5	3,320.8	5,480.8	7,281.2	9,047.2	11,534.2
17.4	8,327.7	3,780.0	6,239.8	8,300.0	10,310.8	13,140.5
19.4	8,934.2	4,056.5	6,692.7	8,905.2	11,060.7	14,093.1
21.4	9,678.2	4,395.1	7,248.8	9,645.2	11,980.7	15,264.0
23.4	10,476.6	4,751.8	7,846.9	10,446.9	12,976.8	16,526.7
25.4	10,830.0	4,909.1	8,109.9	10,800.2	13,414.9	17,084.1
27.4	10,986.2	4,980.4	8,226.9	10,955.5	13,608.2	17,331.5
29.4	11,159.9	5,059.6	8,356.5	11,127.5	13,822.9	17,607.2
31.4	11,341.7	5,141.0	8,492.5	11,311.8	14,049.9	17,894.2
33.4	11,451.9	5,188.1	8,573.4	11,421.1	14,190.0	18,074.0
35.4	11,493.8	5,207.6	8,604.2	11,462.7	14,242.7	18,136.2
37.4	11,522.5	5,220.7	8,625.8	11,491.5	14,278.4	18,181.6

Table 3-2b: Estimated Fatalities by Flood Water Elevation for Jefferson East Drainage Basin #2 – Post-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-12.6	0.0	0.0	0.0	0.0	0.0	0.0
-10.6	0.9	0.1	0.4	0.7	1.2	1.9
-8.6	0.9	0.1	0.4	0.7	1.2	1.9
-6.6	4.9	1.3	2.4	3.6	6.2	13.4
-4.6	28.3	12.8	21.0	27.8	34.9	45.4
-2.6	56.7	25.3	41.6	55.1	69.6	92.3
-0.6	83.5	36.2	59.9	79.8	102.5	140.2
1.4	169.8	58.9	99.8	138.6	206.5	394.7
3.4	655.0	283.0	468.5	625.9	805.2	1,139.2
5.4	1,269.1	578.2	949.3	1,258.5	1,570.0	2,008.1
7.4	1,702.2	775.8	1,276.1	1,695.0	2,106.2	2,683.1
9.4	1,949.2	888.9	1,458.3	1,936.0	2,410.5	3,079.5
11.4	2,803.3	1,218.4	2,025.4	2,703.3	3,453.1	4,755.4
13.4	5,470.3	2,476.5	4,079.6	5,419.2	6,770.6	8,679.1
15.4	7,448.1	3,382.9	5,583.4	7,417.2	9,215.8	11,749.4
17.4	8,480.7	3,849.8	6,353.9	8,452.2	10,500.6	13,382.3
19.4	9,093.0	4,128.3	6,811.9	9,062.9	11,257.3	14,343.7
21.4	9,846.2	4,471.3	7,374.4	9,812.3	12,188.5	15,529.2
23.4	10,654.4	4,832.5	7,979.9	10,624.0	13,196.7	16,807.4
25.4	11,015.4	4,993.1	8,248.7	10,985.1	13,644.5	17,376.3
27.4	11,173.2	5,064.9	8,367.1	11,142.0	13,839.7	17,626.6
29.4	11,348.4	5,145.1	8,497.6	11,315.6	14,056.4	17,904.3
31.4	11,531.9	5,227.2	8,634.8	11,501.5	14,285.6	18,194.4
33.4	11,643.3	5,274.8	8,716.7	11,612.1	14,427.3	18,376.2
35.4	11,686.0	5,294.7	8,748.0	11,654.3	14,480.9	18,439.4
37.4	11,714.9	5,307.9	8,769.8	11,683.3	14,516.7	18,485.1

Table 3-3a: Estimated Fatalities by Flood Water Elevation for Jefferson East Drainage Basin #3 – Pre-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles 5th	25th	50th	75th	95th
-14	0.0	0.0	0.0	0.0	0.0	0.0
-12	0.0	0.0	0.0	0.0	0.0	0.0
-10	0.0	0.0	0.0	0.0	0.0	0.0
-8	0.7	0.1	0.3	0.6	0.9	1.5
-6	9.2	2.6	4.9	7.6	11.7	21.2
-4	53.4	22.4	37.3	50.3	65.7	92.4
-2	131.7	51.4	87.3	121.2	163.7	235.8
0	206.5	81.3	137.0	189.7	256.3	383.8
2	610.2	232.2	389.3	529.8	736.5	1,293.8
4	1,598.9	711.0	1,171.0	1,556.9	1,971.5	2,631.4
6	2,821.0	1,287.7	2,116.1	2,808.6	3,490.9	4,449.8
8	3,230.3	1,472.5	2,420.7	3,210.6	3,995.6	5,100.2
10	4,517.8	1,958.2	3,254.8	4,347.4	5,561.3	7,712.1
12	9,678.2	4,245.7	7,046.7	9,399.3	11,941.9	16,070.2
14	17,135.7	7,781.9	12,846.3	17,064.3	21,200.9	27,028.6
16	19,271.4	8,739.9	14,437.8	19,214.5	23,869.9	30,401.5
18	20,111.5	9,121.3	15,067.7	20,054.6	24,912.3	31,725.4
20	21,141.3	9,602.1	15,844.6	21,068.9	26,164.0	33,350.9
22	23,281.7	10,563.0	17,439.6	23,204.0	28,827.8	36,734.0
24	24,546.4	11,129.8	18,380.7	24,476.8	30,403.6	38,723.4
26	24,918.9	11,295.4	18,656.4	24,852.4	30,872.6	39,318.9
28	25,142.7	11,397.5	18,827.8	25,076.4	31,144.3	39,667.8
30	25,447.8	11,538.3	19,056.5	25,376.3	31,520.6	40,148.8
32	25,825.6	11,701.6	19,334.0	25,755.5	32,001.3	40,761.7
34	25,945.7	11,755.7	19,423.1	25,875.8	32,151.2	40,940.0
36	25,994.6	11,777.0	19,458.9	25,925.1	32,213.6	41,019.5

Table 3-3b: Estimated Fatalities by Flood Water Elevation for Jefferson East Drainage Basin #3 – Post-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-14	0.0	0.0	0.0	0.0	0.0	0.0
-12	0.0	0.0	0.0	0.0	0.0	0.0
-10	0.0	0.0	0.0	0.0	0.0	0.0
-8	0.7	0.1	0.3	0.6	0.9	1.5
-6	9.3	2.6	5.0	7.8	11.8	21.6
-4	54.3	22.7	37.9	51.1	66.8	94.0
-2	134.0	52.2	88.8	123.3	166.4	239.7
0	210.0	82.7	139.3	192.9	260.7	390.3
2	620.7	236.2	395.9	539.0	749.2	1,316.5
4	1,627.3	723.5	1,191.8	1,584.6	2,006.6	2,678.1
6	2,873.3	1,311.5	2,155.4	2,860.8	3,555.5	4,532.5
8	3,289.0	1,499.4	2,464.5	3,269.1	4,068.1	5,193.0
10	4,594.7	1,992.0	3,311.1	4,423.0	5,656.0	7,836.8
12	9,829.0	4,311.8	7,156.5	9,545.7	12,127.9	16,321.2
14	17,404.6	7,904.2	13,047.5	17,332.0	21,533.1	27,452.3
16	19,576.4	8,878.2	14,666.6	19,518.3	24,247.1	30,883.2
18	20,426.8	9,264.3	15,303.7	20,368.9	25,302.2	32,222.3
20	21,471.4	9,752.1	16,092.2	21,397.7	26,572.1	33,871.2
22	23,643.5	10,727.4	17,710.5	23,564.6	29,275.8	37,304.7
24	24,929.2	11,303.4	18,667.4	24,858.5	30,877.7	39,327.2
26	25,307.2	11,471.5	18,947.1	25,239.5	31,353.8	39,931.6
28	25,533.9	11,574.8	19,120.7	25,466.6	31,628.8	40,285.0
30	25,843.4	11,717.7	19,352.7	25,770.8	32,010.6	40,772.9
32	26,227.0	11,883.5	19,634.5	26,155.9	32,498.7	41,395.3
34	26,349.1	11,938.4	19,725.0	26,278.0	32,651.0	41,576.4
36	26,398.5	11,960.0	19,761.1	26,327.8	32,714.1	41,656.7

Table 3-4a: Estimated Fatalities by Flood Water Elevation for Jefferson West Drainage Basin #1 – Pre-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles 5th	25th	50th	75th	95th
-14.9	0.0	0.0	0.0	0.0	0.0	0.0
-12.9	0.0	0.0	0.0	0.0	0.0	0.0
-10.9	0.0	0.0	0.0	0.0	0.0	0.0
-8.9	0.0	0.0	0.0	0.0	0.0	0.0
-6.9	0.2	0.0	0.1	0.2	0.3	0.4
-4.9	0.2	0.0	0.1	0.2	0.3	0.4
-2.9	1.2	0.2	0.6	1.1	1.7	2.7
-0.9	1.8	0.4	0.9	1.6	2.3	3.6
1.1	6.0	2.0	3.4	4.8	7.4	14.4
3.1	20.5	8.8	14.6	19.5	25.2	36.1
5.1	44.3	20.3	33.2	44.0	54.8	69.9
7.1	51.3	23.5	38.4	50.7	63.4	81.3
9.1	76.2	33.1	54.5	72.9	93.7	132.2
11.1	179.0	77.0	127.7	170.7	220.0	313.4
13.1	361.6	164.8	271.0	359.7	447.2	570.4
15.1	421.2	191.9	315.9	419.5	521.2	663.8
17.1	474.0	215.9	354.3	470.7	586.1	749.3
19.1	650.9	292.6	482.7	642.0	805.0	1,042.3
21.1	999.4	454.3	746.9	992.2	1,236.0	1,581.3
23.1	1,284.4	583.7	962.7	1,280.0	1,590.1	2,025.7
25.1	1,439.0	653.9	1,077.6	1,431.9	1,780.7	2,272.1
27.1	1,742.7	791.8	1,304.7	1,731.7	2,155.1	2,754.4
29.1	2,135.2	969.3	1,599.7	2,127.9	2,643.7	3,369.5
31.1	2,273.2	1,030.4	1,702.5	2,267.0	2,816.1	3,585.6
33.1	2,331.2	1,056.9	1,745.7	2,324.7	2,887.6	3,677.0
35.1	2,393.6	1,085.8	1,792.9	2,386.0	2,964.0	3,776.1
37.1	2,510.9	1,138.2	1,880.6	2,504.0	3,110.2	3,960.6

Table 3-4b: Estimated Fatalities by Flood Water Elevation for Jefferson West Drainage Basin #1 – Post-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-14.9	0.0	0.0	0.0	0.0	0.0	0.0
-12.9	0.0	0.0	0.0	0.0	0.0	0.0
-10.9	0.0	0.0	0.0	0.0	0.0	0.0
-8.9	0.0	0.0	0.0	0.0	0.0	0.0
-6.9	0.2	0.0	0.1	0.2	0.3	0.4
-4.9	0.2	0.0	0.1	0.2	0.3	0.4
-2.9	1.3	0.2	0.6	1.1	1.7	2.7
-0.9	1.8	0.4	0.9	1.6	2.3	3.6
1.1	6.0	2.0	3.4	4.8	7.4	14.5
3.1	20.7	8.9	14.7	19.6	25.4	36.4
5.1	44.6	20.4	33.4	44.2	55.1	70.3
7.1	51.6	23.6	38.6	50.9	63.7	81.7
9.1	76.6	33.2	54.8	73.2	94.2	133.0
11.1	180.3	77.6	128.6	171.9	221.6	315.6
13.1	364.1	166.0	272.9	362.2	450.4	574.4
15.1	424.3	193.3	318.2	422.6	525.0	668.6
17.1	477.6	217.5	357.0	474.2	590.6	755.1
19.1	656.1	295.0	486.5	647.1	811.4	1,050.6
21.1	1,008.1	458.2	753.3	1,000.8	1,246.7	1,594.9
23.1	1,295.5	588.8	971.0	1,291.0	1,603.8	2,043.1
25.1	1,451.9	659.8	1,087.2	1,444.7	1,796.7	2,292.5
27.1	1,758.4	798.9	1,316.5	1,747.3	2,174.6	2,779.1
29.1	2,154.8	978.3	1,614.5	2,147.5	2,668.0	3,400.5
31.1	2,294.4	1,040.0	1,718.4	2,288.1	2,842.3	3,619.0
33.1	2,353.0	1,066.8	1,762.0	2,346.3	2,914.5	3,711.3
35.1	2,416.0	1,096.0	1,809.7	2,408.3	2,991.7	3,811.5
37.1	2,534.5	1,148.9	1,898.2	2,527.5	3,139.3	3,997.7

Table 3-5a: Estimated Fatalities by Flood Water Elevation for Jefferson West Drainage Basin #2 – Pre-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles 5th	25th	50th	75th	95th
-9.1	0.0	0.0	0.0	0.0	0.0	0.0
-7.1	0.0	0.0	0.0	0.0	0.0	0.0
-5.1	0.0	0.0	0.0	0.0	0.0	0.0
-3.1	0.0	0.0	0.0	0.0	0.0	0.0
-1.1	0.6	0.1	0.2	0.5	0.8	1.2
0.9	2.6	0.3	1.2	2.2	3.6	5.7
2.9	4.6	0.9	2.2	4.0	6.2	9.7
4.9	7.1	1.8	3.9	6.3	9.3	14.8
6.9	22.2	8.4	14.2	19.4	27.1	46.4
8.9	55.1	24.8	40.6	53.9	68.0	89.8
10.9	90.9	41.6	68.1	90.4	112.4	143.1
12.9	104.9	47.9	78.5	104.0	129.6	165.8
14.9	183.9	71.7	120.9	163.7	221.9	375.8
16.9	546.9	240.7	398.7	532.0	675.0	904.4
18.9	951.5	432.4	713.2	948.1	1,177.6	1,500.6
20.9	1,046.4	474.4	783.6	1,043.4	1,296.2	1,650.3
22.9	1,068.5	484.5	800.6	1,065.4	1,323.5	1,685.7
24.9	1,121.5	509.6	840.4	1,117.6	1,388.3	1,769.0
26.9	1,231.1	558.9	922.2	1,227.0	1,524.6	1,942.2
28.9	1,306.5	592.4	978.7	1,302.8	1,618.5	2,060.8
30.9	1,343.7	609.2	1,006.2	1,339.9	1,664.4	2,119.1
32.9	1,371.8	621.9	1,027.3	1,367.9	1,699.0	2,163.7
34.9	1,398.1	633.8	1,046.9	1,394.2	1,731.6	2,205.4
36.9	1,418.0	642.9	1,061.5	1,414.2	1,756.7	2,237.2

Table 3-5b: Estimated Fatalities by Flood Water Elevation for Jefferson West Drainage Basin #2 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles *5th*	*25th*	*50th*	*75th*	*95th*
-9.1	0.0	0.0	0.0	0.0	0.0	0.0
-7.1	0.0	0.0	0.0	0.0	0.0	0.0
-5.1	0.0	0.0	0.0	0.0	0.0	0.0
-3.1	0.0	0.0	0.0	0.0	0.0	0.0
-1.1	0.6	0.1	0.2	0.5	0.8	1.2
0.9	2.6	0.3	1.2	2.2	3.6	5.7
2.9	4.6	0.9	2.2	4.0	6.2	9.7
4.9	7.2	1.8	3.9	6.3	9.3	14.8
6.9	22.3	8.5	14.3	19.5	27.3	46.7
8.9	55.5	24.9	40.9	54.3	68.5	90.4
10.9	91.6	41.9	68.7	91.1	113.3	144.2
12.9	105.6	48.2	79.0	104.7	130.5	166.9
14.9	185.0	72.2	121.7	164.8	223.2	377.7
16.9	549.5	241.9	400.6	534.5	678.2	908.6
18.9	955.8	434.4	716.4	952.4	1,182.9	1,507.4
20.9	1,051.8	476.8	787.6	1,048.7	1,302.8	1,658.7
22.9	1,074.1	487.1	804.8	1,071.0	1,330.4	1,694.4
24.9	1,127.5	512.3	845.0	1,123.6	1,395.8	1,778.5
26.9	1,238.1	562.0	927.4	1,233.9	1,533.2	1,953.2
28.9	1,314.3	595.9	984.5	1,310.5	1,628.1	2,073.0
30.9	1,351.9	612.9	1,012.4	1,348.1	1,674.5	2,132.0
32.9	1,380.3	625.8	1,033.7	1,376.5	1,709.6	2,177.2
34.9	1,406.9	637.8	1,053.5	1,403.0	1,742.6	2,219.3
36.9	1,427.0	647.0	1,068.3	1,423.2	1,767.8	2,251.4

Table 3-6a: Estimated Fatalities by Flood Water Elevation for Jefferson West Drainage Basin #3 – Pre-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles 5th	25th	50th	75th	95th
-10.2	0.0	0.0	0.0	0.0	0.0	0.0
-8.2	0.0	0.0	0.0	0.0	0.0	0.0
-6.2	0.0	0.0	0.0	0.0	0.0	0.0
-4.2	0.1	0.0	0.0	0.1	0.1	0.2
-2.2	0.7	0.1	0.3	0.5	0.9	2.1
-0.2	7.5	2.8	4.9	6.9	9.4	13.6
1.8	22.2	7.6	13.5	19.8	28.1	41.9
3.8	39.3	12.7	23.2	34.9	50.1	75.1
5.8	70.4	23.2	42.3	63.2	89.5	136.0
7.8	171.7	69.4	115.8	157.9	211.7	322.9
9.8	406.6	181.1	297.3	394.3	501.0	673.8
11.8	722.0	327.0	535.9	710.6	892.2	1,156.1
13.8	1,152.0	517.5	851.3	1,130.9	1,423.1	1,858.9
15.8	1,932.1	871.4	1,433.4	1,904.7	2,388.4	3,094.8
17.8	3,249.8	1,431.1	2,369.9	3,160.4	4,010.6	5,379.5
19.8	5,980.1	2,699.6	4,454.5	5,914.1	7,403.4	9,521.2
21.8	8,609.6	3,911.1	6,442.9	8,554.4	10,648.3	13,610.5
23.8	10,764.9	4,890.5	8,069.3	10,725.2	13,321.8	16,980.2
25.8	11,985.5	5,438.2	8,978.3	11,946.7	14,840.5	18,911.3
27.8	12,691.3	5,761.3	9,506.4	12,648.1	15,716.6	20,024.9
29.8	13,530.1	6,138.5	10,134.1	13,487.6	16,752.4	21,347.3
31.8	14,246.1	6,461.1	10,670.8	14,204.7	17,644.8	22,474.1
33.8	14,767.7	6,694.5	11,058.2	14,728.7	18,292.7	23,299.4
35.8	14,930.3	6,768.6	11,178.6	14,889.9	18,496.3	23,556.3
37.8	15,081.1	6,835.7	11,290.9	15,040.8	18,683.6	23,794.4

Table 3-6b: Estimated Fatalities by Flood Water Elevation for Jefferson West Drainage Basin #3 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles 5th	25th	50th	75th	95th
-10.2	0.0	0.0	0.0	0.0	0.0	0.0
-8.2	0.0	0.0	0.0	0.0	0.0	0.0
-6.2	0.0	0.0	0.0	0.0	0.0	0.0
-4.2	0.1	0.0	0.0	0.1	0.1	0.2
-2.2	0.7	0.1	0.3	0.5	1.0	2.1
-0.2	7.6	2.9	5.0	7.0	9.5	13.9
1.8	22.5	7.7	13.7	20.1	28.5	42.3
3.8	39.7	12.9	23.4	35.3	50.6	75.9
5.8	71.2	23.5	42.9	64.0	90.5	137.6
7.8	174.2	70.5	117.5	160.2	214.8	327.6
9.8	412.7	183.9	301.9	400.4	508.6	683.7
11.8	732.5	331.7	543.6	720.7	905.1	1,173.0
13.8	1,168.9	525.4	863.8	1,147.7	1,444.2	1,885.8
15.8	1,955.5	881.9	1,450.9	1,928.0	2,417.5	3,131.5
17.8	3,284.8	1,447.0	2,396.3	3,194.9	4,054.3	5,433.7
19.8	6,034.3	2,724.2	4,495.0	5,967.8	7,470.9	9,606.9
21.8	8,684.9	3,945.2	6,499.1	8,629.1	10,741.2	13,729.8
23.8	10,860.9	4,934.2	8,141.1	10,820.9	13,440.4	17,131.0
25.8	12,095.4	5,488.1	9,060.7	12,056.3	14,976.6	19,084.9
27.8	12,807.8	5,814.2	9,593.7	12,763.9	15,860.7	20,208.3
29.8	13,653.1	6,194.4	10,226.3	13,610.3	16,904.7	21,541.5
31.8	14,375.7	6,519.9	10,768.0	14,333.9	17,805.3	22,678.5
33.8	15,067.3	6,830.7	11,281.2	15,026.6	18,666.1	23,772.5
35.8	15,219.4	6,898.4	11,394.4	15,178.7	18,854.9	24,012.7
37.8	14,902.7	6,755.7	11,159.5	14,863.2	18,459.8	23,512.3

Table 3-7a: Estimated Fatalities by Flood Water Elevation for Jefferson West Drainage Basin #4 – Pre-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles *5th*	*25th*	*50th*	*75th*	*95th*
-19.2	0.0	0.0	0.0	0.0	0.0	0.0
-17.2	0.0	0.0	0.0	0.0	0.0	0.0
-15.2	0.0	0.0	0.0	0.0	0.0	0.0
-13.2	0.0	0.0	0.0	0.0	0.0	0.0
-11.2	0.0	0.0	0.0	0.0	0.0	0.0
-9.2	0.0	0.0	0.0	0.0	0.0	0.0
-7.2	0.1	0.0	0.0	0.1	0.1	0.2
-5.2	0.8	0.1	0.4	0.7	1.1	1.7
-3.2	3.3	0.7	1.7	2.8	4.3	6.7
-1.2	17.9	4.6	9.6	15.6	23.3	35.8
0.8	39.9	12.0	22.9	35.3	51.2	77.6
2.8	74.7	27.4	47.7	68.1	93.7	138.5
4.8	159.2	65.4	108.9	147.8	196.3	292.7
6.8	379.7	164.6	271.2	362.0	466.9	659.8
8.8	763.5	348.7	570.0	755.5	943.8	1,211.0
10.8	1,080.6	489.3	802.7	1,066.0	1,336.8	1,728.1
12.8	1,713.1	770.3	1,266.0	1,683.4	2,117.0	2,758.9
14.8	3,140.0	1,348.7	2,248.3	3,005.6	3,861.8	5,452.3
16.8	6,444.0	2,917.5	4,806.9	6,386.3	7,975.9	10,221.3
18.8	8,869.6	4,031.8	6,642.0	8,816.9	10,971.5	14,013.3
20.8	10,845.2	4,927.6	8,128.7	10,806.9	13,424.3	17,106.9
22.8	12,033.4	5,467.9	9,019.6	11,991.4	14,893.0	18,981.9
24.8	13,354.9	6,063.6	10,002.6	13,309.3	16,531.7	21,064.3
26.8	14,480.2	6,565.6	10,845.5	14,439.9	17,938.7	22,839.8
28.8	14,920.7	6,763.8	11,175.5	14,879.1	18,482.6	23,535.8
30.8	15,284.1	6,927.9	11,444.8	15,242.1	18,931.8	24,111.9
32.8	15,513.5	7,033.9	11,617.2	15,469.8	19,215.2	24,475.6
34.8	15,751.0	7,138.6	11,793.0	15,708.6	19,515.8	24,853.8
36.8	15,869.8	7,190.6	11,881.0	15,826.5	19,664.7	25,048.0

Table 3-7b: Estimated Fatalities by Flood Water Elevation for Jefferson West Drainage Basin #4 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles *5th*	*25th*	*50th*	*75th*	*95th*
-19.2	0.0	0.0	0.0	0.0	0.0	0.0
-17.2	0.0	0.0	0.0	0.0	0.0	0.0
-15.2	0.0	0.0	0.0	0.0	0.0	0.0
-13.2	0.0	0.0	0.0	0.0	0.0	0.0
-11.2	0.0	0.0	0.0	0.0	0.0	0.0
-9.2	0.0	0.0	0.0	0.0	0.0	0.0
-7.2	0.1	0.0	0.0	0.1	0.1	0.2
-5.2	0.8	0.2	0.4	0.7	1.1	1.7
-3.2	3.3	0.7	1.7	2.9	4.4	6.8
-1.2	18.0	4.7	9.7	15.7	23.5	36.1
0.8	40.4	12.1	23.2	35.7	51.8	78.5
2.8	75.6	27.8	48.4	69.0	94.9	140.3
4.8	161.4	66.4	110.5	149.8	199.0	296.5
6.8	384.5	166.7	274.7	366.5	472.8	668.1
8.8	773.1	353.1	577.2	765.0	955.7	1,226.3
10.8	1,093.9	495.2	812.6	1,079.1	1,353.2	1,749.4
12.8	1,733.3	779.5	1,281.2	1,703.5	2,142.3	2,791.1
14.8	3,172.1	1,362.8	2,271.5	3,037.0	3,901.3	5,504.9
16.8	6,503.2	2,944.3	4,851.0	6,445.0	8,049.2	10,315.1
18.8	8,949.8	4,068.1	6,702.0	8,896.9	11,069.9	14,139.3
20.8	10,939.3	4,970.6	8,199.1	10,901.0	13,541.2	17,255.0
22.8	12,140.3	5,516.6	9,099.9	12,098.0	15,025.5	19,150.4
24.8	13,470.5	6,116.0	10,089.1	13,424.4	16,674.6	21,247.1
26.8	14,607.2	6,623.2	10,940.6	14,566.5	18,096.1	23,040.4
28.8	15,052.2	6,823.4	11,274.2	15,010.0	18,645.4	23,743.7
30.8	15,419.7	6,989.3	11,546.4	15,377.4	19,099.7	24,326.0
32.8	15,651.7	7,096.6	11,720.6	15,607.5	19,386.2	24,693.4
34.8	15,891.0	7,202.1	11,897.8	15,848.2	19,689.3	25,074.8
36.8	16,011.1	7,254.6	11,986.8	15,967.4	19,839.8	25,271.1

Table 3-8a: Estimated Fatalities by Flood Water Elevation for New Orleans East Drainage Basin #1 – Pre-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles				
		5th	*25th*	*50th*	*75th*	*95th*
-7.2	0.0	0.0	0.0	0.0	0.0	0.0
-5.2	0.0	0.0	0.0	0.0	0.0	0.0
-3.2	0.0	0.0	0.0	0.0	0.0	0.0
-1.2	0.0	0.0	0.0	0.0	0.0	0.0
0.8	0.0	0.0	0.0	0.0	0.0	0.0
2.8	0.0	0.0	0.0	0.0	0.0	0.0
4.8	0.0	0.0	0.0	0.0	0.0	0.0
6.8	0.0	0.0	0.0	0.0	0.0	0.1
8.8	0.2	0.1	0.1	0.1	0.2	0.2
10.8	0.2	0.1	0.1	0.2	0.2	0.3
12.8	0.2	0.1	0.2	0.2	0.3	0.3
14.8	0.3	0.1	0.2	0.3	0.4	0.8
16.8	1.1	0.5	0.8	1.1	1.3	1.7
18.8	1.5	0.7	1.1	1.5	1.8	2.3
20.8	1.5	0.7	1.1	1.5	1.9	2.4
22.8	1.5	0.7	1.1	1.5	1.9	2.4
24.8	1.5	0.7	1.2	1.5	1.9	2.4
26.8	1.7	0.8	1.3	1.7	2.1	2.7
28.8	1.7	0.8	1.3	1.7	2.1	2.7
30.8	1.7	0.8	1.3	1.7	2.1	2.7
32.8	1.7	0.8	1.3	1.7	2.1	2.7
34.8	1.8	0.8	1.3	1.7	2.2	2.8
36.8	1.8	0.8	1.3	1.8	2.2	2.8

Table 3-8b: Estimated Fatalities by Flood Water Elevation for New Orleans East Drainage Basin #1 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles *5th*	*25th*	*50th*	*75th*	*95th*
-7.2	0.0	0.0	0.0	0.0	0.0	0.0
-5.2	0.0	0.0	0.0	0.0	0.0	0.0
-3.2	0.0	0.0	0.0	0.0	0.0	0.0
-1.2	0.0	0.0	0.0	0.0	0.0	0.0
0.8	0.0	0.0	0.0	0.0	0.0	0.0
2.8	0.0	0.0	0.0	0.0	0.0	0.0
4.8	0.0	0.0	0.0	0.0	0.0	0.0
6.8	0.0	0.0	0.0	0.0	0.0	0.0
8.8	0.0	0.0	0.0	0.0	0.0	0.0
10.8	0.0	0.0	0.0	0.0	0.0	0.0
12.8	0.0	0.0	0.0	0.0	0.0	0.0
14.8	0.0	0.0	0.0	0.0	0.0	0.0
16.8	0.1	0.0	0.0	0.1	0.1	0.1
18.8	0.1	0.0	0.1	0.1	0.1	0.1
20.8	0.1	0.0	0.1	0.1	0.1	0.1
22.8	0.1	0.0	0.1	0.1	0.1	0.2
24.8	0.1	0.0	0.1	0.1	0.1	0.2
26.8	0.1	0.0	0.1	0.1	0.1	0.2
28.8	0.1	0.1	0.1	0.1	0.1	0.2
30.8	0.1	0.1	0.1	0.1	0.1	0.2
32.8	0.1	0.1	0.1	0.1	0.1	0.2
34.8	0.1	0.1	0.1	0.1	0.1	0.2
36.8	0.1	0.1	0.1	0.1	0.1	0.2

Table 3-9a: Estimated Fatalities by Flood Water Elevation for New Orleans East Drainage Basin #2 – Pre-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles 5th	25th	50th	75th	95th
-10.4	0.0	0.0	0.0	0.0	0.0	0.0
-8.4	0.0	0.0	0.0	0.0	0.0	0.0
-6.4	0.0	0.0	0.0	0.0	0.0	0.0
-4.4	0.2	0.0	0.1	0.2	0.3	0.5
-2.4	0.9	0.1	0.4	0.7	1.2	1.9
-0.4	1.1	0.1	0.5	0.9	1.5	2.4
1.6	1.1	0.1	0.5	1.0	1.6	2.5
3.6	1.6	0.4	0.8	1.4	2.0	3.2
5.6	1.9	0.6	1.1	1.7	2.4	3.6
7.6	2.4	0.8	1.5	2.1	3.0	4.4
9.6	10.0	2.5	4.3	6.3	12.8	30.0
11.6	64.4	24.2	41.0	55.7	77.2	138.3
13.6	196.1	87.8	144.9	192.9	242.6	315.7
15.6	299.6	135.8	224.4	298.8	371.1	472.6
17.6	309.1	140.1	231.5	308.3	382.9	487.6
19.6	317.2	144.0	237.6	316.1	392.7	500.5
21.6	341.9	155.3	256.3	340.8	423.2	539.5
23.6	375.1	170.1	281.0	374.1	464.7	591.7
25.6	385.5	174.6	288.6	384.4	477.6	608.4
27.6	387.2	175.5	289.9	386.2	479.8	611.0
29.6	390.2	176.9	292.2	389.2	483.4	615.6
31.6	395.7	179.4	296.3	394.6	490.2	624.3
33.6	399.9	181.2	299.4	398.8	495.6	631.0
35.6	400.3	181.4	299.7	399.3	496.1	631.7
37.6	400.5	181.4	299.8	399.4	496.3	632.0

Table 3-9b: Estimated Fatalities by Flood Water Elevation for New Orleans East Drainage Basin #2 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles				
		5th	*25th*	*50th*	*75th*	*95th*
-10.4	0.0	0.0	0.0	0.0	0.0	0.0
-8.4	0.0	0.0	0.0	0.0	0.0	0.0
-6.4	0.0	0.0	0.0	0.0	0.0	0.0
-4.4	0.0	0.0	0.0	0.0	0.0	0.0
-2.4	0.0	0.0	0.0	0.0	0.1	0.1
-0.4	0.1	0.0	0.0	0.0	0.1	0.1
1.6	0.1	0.0	0.0	0.1	0.1	0.1
3.6	0.1	0.0	0.1	0.1	0.1	0.2
5.6	0.3	0.1	0.2	0.2	0.3	0.4
7.6	0.3	0.2	0.2	0.3	0.4	0.5
9.6	0.8	0.3	0.4	0.6	0.9	1.8
11.6	3.5	1.4	2.3	3.1	4.2	7.2
13.6	10.0	4.5	7.4	9.9	12.4	16.1
15.6	15.2	6.9	11.3	15.1	18.8	23.9
17.6	15.6	7.1	11.7	15.6	19.3	24.6
19.6	16.0	7.2	12.0	15.9	19.8	25.2
21.6	17.2	7.8	12.9	17.1	21.3	27.1
23.6	18.8	8.5	14.1	18.8	23.3	29.7
25.6	19.3	8.8	14.5	19.3	24.0	30.5
27.6	19.4	8.8	14.5	19.4	24.1	30.6
29.6	19.6	8.9	14.7	19.5	24.2	30.9
31.6	19.8	9.0	14.9	19.8	24.6	31.3
33.6	20.0	9.1	15.0	20.0	24.8	31.6
35.6	20.1	9.1	15.0	20.0	24.9	31.7
37.6	20.1	9.1	15.0	20.0	24.9	31.7

Table 3-10a: Estimated Fatalities by Flood Water Elevation for New Orleans East Drainage Basin #3 – Pre-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles				
		5th	*25th*	*50th*	*75th*	*95th*
-8.3	0.0	0.0	0.0	0.0	0.0	0.0
-4.3	0.0	0.0	0.0	0.0	0.0	0.0
-2.3	2.6	0.2	1.1	2.2	3.6	5.8
-0.3	3.6	0.3	1.5	3.1	5.0	8.1
1.7	11.7	4.3	7.5	10.7	14.6	21.4
3.7	23.7	9.1	15.3	21.1	29.1	47.9
5.7	63.2	28.5	46.7	61.9	78.1	102.6
7.7	103.0	46.9	76.8	101.9	127.4	163.7
9.7	144.5	66.0	108.2	143.4	178.6	228.4
11.7	235.0	95.6	160.2	215.8	285.7	451.9
13.7	657.0	282.7	471.4	630.1	808.9	1,134.4
15.7	1,278.5	580.6	958.3	1,273.2	1,582.0	2,016.9
17.7	1,449.5	657.3	1,085.9	1,445.5	1,795.5	2,286.6
19.7	1,501.1	680.6	1,124.3	1,496.8	1,859.4	2,367.4
21.7	1,564.9	710.8	1,172.8	1,559.5	1,936.8	2,468.5
23.7	1,720.1	780.4	1,288.4	1,714.7	2,129.7	2,713.8
25.7	1,804.7	818.1	1,351.4	1,799.9	2,235.5	2,846.9
27.7	1,825.1	826.9	1,366.3	1,820.2	2,261.5	2,880.2
29.7	1,833.2	831.0	1,372.5	1,828.2	2,271.0	2,892.4
31.7	1,852.9	840.2	1,387.5	1,847.7	2,295.1	2,923.2
33.7	1,879.8	851.7	1,407.3	1,874.7	2,329.3	2,966.9
35.7	1,887.2	855.0	1,412.7	1,882.0	2,338.6	2,977.9
37.7	1,888.5	855.5	1,413.7	1,883.5	2,340.4	2,980.3

Table 3-10b: Estimated Fatalities by Flood Water Elevation for New Orleans East Drainage Basin #3 – Post-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-8.3	0.0	0.0	0.0	0.0	0.0	0.0
-4.3	0.0	0.0	0.0	0.0	0.0	0.0
-2.3	0.1	0.0	0.1	0.1	0.2	0.3
-0.3	0.2	0.0	0.1	0.2	0.3	0.4
1.7	0.6	0.2	0.4	0.5	0.7	1.1
3.7	1.3	0.5	0.8	1.2	1.7	2.9
5.7	4.1	1.9	3.1	4.1	5.1	6.7
7.7	6.8	3.1	5.1	6.7	8.4	10.7
9.7	9.1	4.2	6.9	9.1	11.3	14.4
11.7	13.8	5.8	9.7	13.0	16.9	25.2
13.7	34.8	15.1	25.1	33.5	42.9	59.3
15.7	65.8	29.9	49.3	65.5	81.4	103.8
17.7	74.9	33.9	56.1	74.7	92.7	118.1
19.7	77.7	35.2	58.2	77.5	96.3	122.6
21.7	81.1	36.8	60.7	80.8	100.4	127.9
23.7	88.8	40.3	66.5	88.5	109.9	140.0
25.7	93.0	42.1	69.6	92.7	115.2	146.7
27.7	94.0	42.6	70.4	93.8	116.5	148.4
29.7	94.5	42.8	70.7	94.2	117.0	149.0
31.7	95.5	43.3	71.5	95.2	118.2	150.6
33.7	96.8	43.8	72.4	96.5	119.9	152.7
35.7	97.1	44.0	72.7	96.9	120.4	153.3
37.7	97.2	44.0	72.8	97.0	120.5	153.4

Table 3-11a: Estimated Fatalities by Flood Water Elevation for New Orleans East Drainage Basin #4 – Pre-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles 5th	25th	50th	75th	95th
-5.4	0.0	0.0	0.0	0.0	0.0	0.0
-1.4	0.0	0.0	0.0	0.0	0.0	0.0
0.6	0.0	0.0	0.0	0.0	0.0	0.0
2.6	0.1	0.0	0.0	0.0	0.1	0.1
4.6	0.1	0.0	0.0	0.1	0.1	0.1
6.6	0.2	0.0	0.1	0.1	0.2	0.3
8.6	0.6	0.2	0.4	0.5	0.8	1.4
10.6	1.9	0.9	1.4	1.9	2.4	3.0
12.6	2.1	1.0	1.6	2.1	2.6	3.3
14.6	2.4	1.1	1.8	2.4	2.9	3.7
16.6	4.0	1.5	2.6	3.5	4.8	8.3
18.6	11.3	5.1	8.4	11.2	14.0	17.9
20.6	15.0	6.8	11.2	15.0	18.6	23.7
22.6	15.3	7.0	11.5	15.3	19.0	24.2
24.6	15.6	7.1	11.7	15.6	19.4	24.7
26.6	16.7	7.6	12.6	16.7	20.7	26.4
28.6	18.9	8.6	14.2	18.9	23.5	29.9
30.6	19.1	8.7	14.3	19.1	23.7	30.2
32.6	19.2	8.7	14.4	19.2	23.8	30.4
34.6	19.3	8.8	14.5	19.3	24.0	30.5
36.6	19.7	8.9	14.8	19.7	24.4	31.1

Table 3-11b: Estimated Fatalities by Flood Water Elevation for New Orleans East Drainage Basin #4 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles 5th	25th	50th	75th	95th
-5.4	0.0	0.0	0.0	0.0	0.0	0.0
-1.4	0.0	0.0	0.0	0.0	0.0	0.0
0.6	0.0	0.0	0.0	0.0	0.0	0.0
2.6	0.0	0.0	0.0	0.0	0.0	0.0
4.6	0.0	0.0	0.0	0.0	0.0	0.0
6.6	0.1	0.0	0.0	0.0	0.1	0.2
8.6	0.7	0.3	0.5	0.6	0.9	1.6
10.6	2.1	1.0	1.6	2.1	2.7	3.4
12.6	2.3	1.0	1.7	2.3	2.8	3.6
14.6	2.4	1.1	1.8	2.4	2.9	3.7
16.6	2.8	1.3	2.1	2.8	3.5	4.7
18.6	5.0	2.3	3.8	5.0	6.2	7.9
20.6	6.1	2.8	4.6	6.1	7.6	9.6
22.6	6.2	2.8	4.7	6.2	7.7	9.8
24.6	6.3	2.9	4.7	6.3	7.8	10.0
26.6	6.6	3.0	5.0	6.6	8.2	10.5
28.6	7.3	3.3	5.5	7.3	9.0	11.5
30.6	7.4	3.3	5.5	7.3	9.1	11.6
32.6	7.4	3.4	5.5	7.4	9.2	11.7
34.6	7.4	3.4	5.6	7.4	9.2	11.7
36.6	7.5	3.4	5.6	7.5	9.3	11.9

Table 3-12a: Estimated Fatalities by Flood Water Elevation for New Orleans East Drainage Basin #5 – Pre-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-12.7	0.0	0.0	0.0	0.0	0.0	0.0
-8.7	1.9	0.2	0.8	1.6	2.6	4.1
-6.7	6.4	0.6	2.7	5.4	8.9	14.3
-4.7	15.1	1.3	6.3	12.8	20.7	33.4
-2.7	29.8	4.6	14.3	25.6	40.1	63.4
-0.7	68.3	24.1	42.1	61.0	86.0	135.8
1.3	239.6	103.2	170.2	227.3	294.4	421.5
3.3	639.8	288.8	473.4	628.0	790.7	1,030.7
5.3	998.7	456.4	748.2	991.3	1,235.0	1,577.7
7.3	1,333.9	599.9	986.2	1,311.9	1,648.0	2,147.4
9.3	2,503.1	1,058.7	1,766.5	2,367.2	3,068.4	4,488.7
11.3	5,571.3	2,502.7	4,132.0	5,496.7	6,893.4	8,919.1
13.3	8,364.1	3,799.9	6,264.0	8,322.5	10,348.4	13,204.3
15.3	9,850.8	4,475.0	7,380.5	9,816.5	12,194.2	15,537.8
17.3	10,796.8	4,898.7	8,088.4	10,760.9	13,369.1	17,037.0
19.3	11,474.2	5,208.9	8,594.8	11,435.7	14,204.3	18,100.4
21.3	12,361.0	5,605.7	9,260.0	12,326.6	15,310.3	19,498.7
23.3	12,882.8	5,841.3	9,649.8	12,847.2	15,959.2	20,320.8
25.3	13,235.2	5,999.8	9,910.5	13,199.6	16,394.6	20,877.6
27.3	13,406.6	6,077.4	10,039.4	13,371.2	16,606.5	21,151.6
29.3	13,557.3	6,145.8	10,150.7	13,520.6	16,795.2	21,390.1
31.3	13,687.8	6,203.5	10,246.7	13,651.3	16,960.5	21,601.4
33.3	13,762.9	6,235.6	10,302.6	13,726.4	17,053.9	21,719.9
35.3	13,803.5	6,253.6	10,333.0	13,766.2	17,105.9	21,782.0
37.3	13,811.1	6,256.5	10,339.2	13,774.7	17,115.8	21,795.8

Table 3-12b: Estimated Fatalities by Flood Water Elevation for New Orleans East Drainage Basin #5 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles *5th*	*25th*	*50th*	*75th*	*95th*
-12.7	0.0	0.0	0.0	0.0	0.0	0.0
-8.7	0.6	0.1	0.3	0.5	0.9	1.4
-6.7	1.3	0.1	0.5	1.1	1.8	2.9
-4.7	2.1	0.2	0.9	1.8	2.9	4.7
-2.7	3.1	0.4	1.4	2.6	4.2	6.7
-0.7	5.2	1.6	3.0	4.6	6.7	10.3
1.3	17.7	7.6	12.6	16.8	21.7	30.7
3.3	43.3	19.4	31.9	42.3	53.4	70.6
5.3	71.5	32.7	53.5	70.9	88.4	113.3
7.3	101.7	45.6	75.0	99.8	125.6	164.4
9.3	188.2	81.3	135.1	180.6	231.6	324.3
11.3	386.3	173.7	286.4	381.0	477.9	618.3
13.3	591.6	268.6	442.2	587.3	731.6	936.3
15.3	772.4	351.0	578.5	768.7	955.7	1,219.6
17.3	911.5	414.0	682.8	908.5	1,128.4	1,437.5
19.3	991.7	450.2	742.8	988.3	1,228.1	1,564.5
21.3	1,054.6	478.5	790.1	1,051.5	1,306.0	1,663.5
23.3	1,104.2	501.0	827.2	1,100.9	1,367.4	1,741.7
25.3	1,152.5	522.4	863.2	1,149.3	1,427.5	1,817.8
27.3	1,178.7	534.3	882.6	1,175.5	1,460.0	1,859.3
29.3	1,193.1	540.8	893.2	1,189.9	1,478.1	1,882.6
31.3	1,203.1	545.3	900.8	1,199.9	1,490.6	1,898.4
33.3	1,212.3	549.4	907.6	1,209.0	1,502.2	1,913.1
35.3	1,218.6	552.2	912.3	1,215.3	1,510.0	1,922.9
37.3	1,220.7	553.0	913.8	1,217.4	1,512.7	1,926.3

Table 3-13a: Estimated Fatalities by Flood Water Elevation for Orleans Main Drainage Basin #1 – Pre-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-15.5	0.0	0.0	0.0	0.0	0.0	0.0
-13.5	0.0	0.0	0.0	0.0	0.0	0.0
-11.5	0.0	0.0	0.0	0.0	0.0	0.0
-9.5	0.0	0.0	0.0	0.0	0.0	0.0
-7.5	0.5	0.2	0.4	0.5	0.6	0.8
-5.5	0.7	0.3	0.5	0.6	0.9	1.2
-3.5	3.3	0.9	1.8	2.9	4.3	6.6
-1.5	8.4	1.5	4.0	7.2	11.2	17.6
0.5	19.9	4.3	10.4	17.4	26.1	40.9
2.5	54.9	19.6	33.9	48.5	68.8	112.9
4.5	154.9	68.0	112.0	148.8	190.8	262.7
6.5	292.6	132.8	217.2	287.7	361.5	468.9
8.5	446.5	203.3	333.0	441.5	552.1	709.5
10.5	687.8	303.1	501.2	667.7	848.0	1,143.3
12.5	1,351.7	598.6	989.6	1,318.5	1,668.5	2,216.6
14.5	2,458.9	1,103.2	1,821.2	2,423.8	3,041.1	3,942.6
16.5	3,842.3	1,741.6	2,869.9	3,810.9	4,756.1	6,087.3
18.5	5,097.8	2,314.5	3,821.4	5,076.2	6,305.9	8,042.2
20.5	5,822.1	2,644.8	4,362.1	5,801.8	7,207.3	9,183.0
22.5	6,392.5	2,901.7	4,788.9	6,370.5	7,915.3	10,087.8
24.5	6,829.5	3,098.4	5,115.9	6,807.8	8,455.6	10,775.3
26.5	7,202.1	3,265.8	5,395.1	7,182.4	8,920.4	11,361.2
28.5	7,495.4	3,397.9	5,613.1	7,474.7	9,284.5	11,824.1
30.5	7,656.1	3,471.2	5,733.1	7,634.7	9,483.1	12,077.8
32.5	7,771.1	3,522.6	5,818.5	7,750.1	9,627.2	12,261.1
34.5	7,850.5	3,558.4	5,877.8	7,829.5	9,725.8	12,385.9
36.5	7,920.2	3,588.6	5,929.3	7,898.6	9,814.1	12,500.8

Table 3-13b: Estimated Fatalities by Flood Water Elevation for Orleans Main Drainage Basin #1 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles *5th*	*25th*	*50th*	*75th*	*95th*
-15.5	0.0	0.0	0.0	0.0	0.0	0.0
-13.5	0.0	0.0	0.0	0.0	0.0	0.0
-11.5	0.0	0.0	0.0	0.0	0.0	0.0
-9.5	0.0	0.0	0.0	0.0	0.0	0.0
-7.5	0.1	0.1	0.1	0.1	0.2	0.2
-5.5	0.2	0.1	0.1	0.2	0.2	0.3
-3.5	0.5	0.2	0.3	0.4	0.6	0.8
-1.5	0.8	0.3	0.5	0.7	1.1	1.6
0.5	1.9	0.5	1.0	1.6	2.4	4.0
2.5	7.3	2.7	4.5	6.2	8.9	15.9
4.5	22.1	10.0	16.4	21.8	27.3	35.2
6.5	32.9	15.0	24.6	32.6	40.7	52.4
8.5	46.9	21.4	35.1	46.5	57.9	74.2
10.5	65.4	29.5	48.5	64.5	80.9	104.9
12.5	107.1	47.8	79.0	105.1	132.3	173.0
14.5	180.3	81.2	134.0	178.1	222.9	287.9
16.5	271.3	122.9	202.5	269.0	335.7	430.0
18.5	366.0	166.3	274.2	364.3	452.9	577.7
20.5	429.0	194.9	321.5	427.6	531.1	676.8
22.5	473.1	214.8	354.5	471.6	585.7	746.5
24.5	507.9	230.4	380.4	506.3	629.0	801.2
26.5	534.1	242.3	400.1	532.6	661.5	842.5
28.5	557.0	252.5	417.2	555.5	690.0	878.5
30.5	570.8	258.8	427.5	569.2	707.0	900.4
32.5	580.8	263.3	434.9	579.3	719.6	916.4
34.5	586.3	265.7	438.9	584.7	726.3	925.0
36.5	591.4	268.0	442.7	589.8	732.8	933.3

Table 3-14a: Estimated Fatalities by Flood Water Elevation for Orleans Main Drainage Basin #2 – Pre-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-24.9	0.0	0.0	0.0	0.0	0.0	0.0
-22.9	0.0	0.0	0.0	0.0	0.0	0.0
-20.9	0.0	0.0	0.0	0.0	0.0	0.0
-18.9	0.0	0.0	0.0	0.0	0.0	0.0
-16.9	0.0	0.0	0.0	0.0	0.0	0.0
-14.9	0.2	0.0	0.1	0.2	0.3	0.5
-12.9	4.5	0.5	1.9	3.9	6.2	10.0
-10.9	8.0	1.1	3.6	6.8	10.8	17.2
-8.9	24.0	4.9	10.1	16.8	30.9	68.3
-6.9	117.4	50.5	83.3	111.5	144.2	207.6
-4.9	243.0	111.0	182.0	241.3	300.4	383.9
-2.9	303.6	138.8	227.7	302.2	375.7	478.4
-0.9	360.6	163.9	268.9	356.7	446.0	572.5
1.1	597.4	252.4	421.3	564.6	732.2	1,073.4
3.1	1,325.1	598.7	987.5	1,311.2	1,640.2	2,107.0
5.1	1,872.7	850.8	1,402.8	1,862.5	2,317.3	2,958.5
7.1	2,236.1	1,015.5	1,675.6	2,228.8	2,768.1	3,526.1
9.1	2,446.7	1,111.0	1,833.4	2,438.4	3,028.7	3,858.1
11.1	2,695.4	1,224.0	2,020.3	2,685.2	3,335.6	4,251.1
13.1	3,037.7	1,380.2	2,276.9	3,027.0	3,759.7	4,791.8
15.1	3,353.4	1,522.2	2,511.7	3,342.0	4,152.8	5,291.1
17.1	3,561.9	1,614.5	2,667.7	3,551.9	4,412.0	5,618.1
19.1	3,647.9	1,653.6	2,731.7	3,638.0	4,518.3	5,754.1
21.1	3,731.6	1,691.8	2,794.4	3,721.3	4,622.2	5,886.5
23.1	3,813.1	1,728.5	2,855.8	3,802.7	4,723.0	6,014.6
25.1	3,896.3	1,766.1	2,917.1	3,885.9	4,827.2	6,147.8
27.1	3,926.6	1,779.0	2,939.4	3,916.1	4,865.6	6,196.1
29.1	3,937.2	1,784.0	2,947.5	3,926.7	4,878.9	6,212.6
31.1	3,944.8	1,787.2	2,953.1	3,934.3	4,888.3	6,225.4
33.1	3,956.8	1,792.8	2,962.1	3,946.1	4,903.1	6,243.5
35.1	3,964.0	1,795.8	2,967.5	3,953.5	4,912.5	6,255.4
37.1	3,966.0	1,796.5	2,969.0	3,955.7	4,915.1	6,258.8

Table 3-14b: Estimated Fatalities by Flood Water Elevation for Orleans Main Drainage Basin #2 – Post-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-24.9	0.0	0.0	0.0	0.0	0.0	0.0
-22.9	0.0	0.0	0.0	0.0	0.0	0.0
-20.9	0.0	0.0	0.0	0.0	0.0	0.0
-18.9	0.0	0.0	0.0	0.0	0.0	0.0
-16.9	0.0	0.0	0.0	0.0	0.0	0.0
-14.9	0.0	0.0	0.0	0.0	0.0	0.0
-12.9	0.3	0.0	0.1	0.2	0.4	0.6
-10.9	0.4	0.1	0.2	0.4	0.6	1.0
-8.9	1.8	0.4	0.7	1.2	2.4	5.4
-6.9	9.6	4.1	6.8	9.1	11.8	16.7
-4.9	19.7	9.0	14.7	19.5	24.4	31.2
-2.9	27.4	12.5	20.5	27.2	33.9	43.3
-0.9	35.8	16.3	26.8	35.6	44.3	56.7
1.1	51.7	22.7	37.6	50.2	63.7	85.9
3.1	96.2	43.5	71.7	95.1	119.0	153.0
5.1	138.2	62.8	103.3	137.2	170.8	218.5
7.1	178.2	81.0	133.6	177.3	220.4	281.1
9.1	205.2	93.2	153.7	204.5	254.0	323.6
11.1	225.2	102.3	168.8	224.4	278.7	355.2
13.1	253.8	115.2	190.2	252.7	314.0	400.3
15.1	287.1	130.4	215.1	286.2	355.6	453.1
17.1	305.4	138.5	228.7	304.5	378.3	481.7
19.1	313.7	142.2	234.9	312.8	388.6	494.9
21.1	320.8	145.4	240.3	319.9	397.4	506.1
23.1	329.4	149.3	246.7	328.5	408.0	519.6
25.1	336.4	152.5	251.8	335.5	416.8	530.8
27.1	339.1	153.6	253.9	338.2	420.2	535.2
29.1	340.2	154.1	254.6	339.2	421.5	536.8
31.1	341.1	154.5	255.3	340.2	422.6	538.3
33.1	342.3	155.1	256.3	341.4	424.2	540.1
35.1	342.8	155.3	256.6	341.9	424.8	541.0
37.1	343.0	155.4	256.7	342.1	425.0	541.2

Table 3-15a: Estimated Fatalities by Flood Water Elevation for Orleans Main Drainage Basin #3 – Pre-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-13.9	0.0	0.0	0.0	0.0	0.0	0.0
-11.9	0.0	0.0	0.0	0.0	0.0	0.0
-9.9	0.0	0.0	0.0	0.0	0.0	0.0
-7.9	0.0	0.0	0.0	0.0	0.0	0.0
-5.9	0.0	0.0	0.0	0.0	0.0	0.0
-3.9	0.5	0.1	0.3	0.4	0.7	1.1
-1.9	4.7	1.1	2.4	4.1	6.2	9.7
0.1	15.6	2.9	7.5	13.4	20.9	32.9
2.1	33.2	7.8	17.8	29.2	43.4	68.0
4.1	92.9	33.2	57.1	81.0	115.8	196.3
6.1	277.5	121.8	200.9	267.2	342.0	470.0
8.1	522.2	238.1	389.3	515.9	645.6	829.9
10.1	732.1	334.3	547.3	725.3	904.7	1,158.8
12.1	1,071.7	471.4	779.8	1,039.2	1,320.6	1,788.3
14.1	2,132.5	943.5	1,560.1	2,079.5	2,632.0	3,501.1
16.1	3,852.8	1,735.3	2,864.5	3,807.1	4,765.6	6,153.0
18.1	5,684.3	2,584.5	4,255.6	5,648.4	7,030.4	8,983.9
20.1	7,096.0	3,224.1	5,315.9	7,065.0	8,777.8	11,199.4
22.1	8,299.5	3,769.1	6,223.2	8,266.0	10,270.1	13,093.8
24.1	9,369.4	4,254.8	7,017.9	9,337.8	11,598.8	14,776.4
26.1	10,184.5	4,621.2	7,629.2	10,149.8	12,611.0	16,067.4
28.1	10,785.4	4,892.3	8,078.4	10,753.6	13,359.5	17,015.1
30.1	11,200.9	5,078.7	8,390.7	11,169.1	13,876.0	17,669.6
32.1	11,505.4	5,216.1	8,615.7	11,474.2	14,251.6	18,146.8
34.1	11,732.1	5,318.0	8,784.9	11,700.4	14,532.3	18,509.0
36.1	11,894.6	5,391.2	8,905.4	11,862.8	14,736.0	18,767.1

Table 3-15b: Estimated Fatalities by Flood Water Elevation for Orleans Main Drainage Basin #3 – Post-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	**Fatalities**	***5th***	***25th***	***50th***	***75th***	***95th***
-13.9	0.0	0.0	0.0	0.0	0.0	0.0
-11.9	0.0	0.0	0.0	0.0	0.0	0.0
-9.9	0.0	0.0	0.0	0.0	0.0	0.0
-7.9	0.0	0.0	0.0	0.0	0.0	0.0
-5.9	0.0	0.0	0.0	0.0	0.0	0.0
-3.9	0.1	0.0	0.0	0.0	0.1	0.2
-1.9	0.6	0.2	0.4	0.5	0.7	1.1
0.1	2.2	0.5	1.1	1.9	2.9	4.5
2.1	5.5	1.2	2.7	4.6	7.2	12.7
4.1	23.7	9.1	15.2	20.9	29.0	49.1
6.1	66.5	30.3	49.5	65.4	82.2	106.6
8.1	99.0	45.1	73.7	97.7	122.4	157.5
10.1	143.8	65.4	107.1	142.1	177.7	228.9
12.1	221.2	98.3	162.3	215.8	272.9	362.8
14.1	403.6	181.3	298.4	397.0	498.9	649.2
16.1	645.9	292.9	482.4	640.3	799.2	1,023.5
18.1	884.0	402.0	661.5	878.0	1,092.9	1,397.0
20.1	1,145.5	520.2	856.3	1,137.0	1,416.1	1,811.6
22.1	1,494.2	679.1	1,119.1	1,485.2	1,848.5	2,360.7
24.1	1,820.5	827.1	1,364.5	1,814.1	2,253.1	2,871.5
26.1	2,011.0	912.5	1,506.4	2,004.4	2,490.0	3,173.0
28.1	2,126.4	964.7	1,592.8	2,119.7	2,633.2	3,354.3
30.1	2,235.9	1,013.9	1,675.0	2,229.7	2,769.2	3,526.9
32.1	2,331.3	1,057.1	1,746.1	2,325.0	2,888.0	3,676.9
34.1	2,402.9	1,089.3	1,799.4	2,396.2	2,976.4	3,790.8
36.1	2,438.2	1,105.3	1,825.6	2,431.7	3,020.4	3,846.9

Table 3-16a: Estimated Fatalities by Flood Water Elevation for Orleans Main Drainage Basin #4 – Pre-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	**Fatalities**	***5th***	***25th***	***50th***	***75th***	***95th***
-14.4	0.0	0.0	0.0	0.0	0.0	0.0
-12.4	0.0	0.0	0.0	0.0	0.0	0.0
-10.4	0.0	0.0	0.0	0.0	0.0	0.0
-8.4	0.1	0.0	0.0	0.1	0.2	0.3
-6.4	0.6	0.1	0.2	0.3	0.9	2.2
-4.4	3.9	1.8	2.9	3.8	4.8	6.1
-2.4	5.7	2.6	4.2	5.6	7.0	9.0
-0.4	8.2	3.7	6.0	8.0	10.1	13.4
1.6	15.1	6.1	10.1	13.7	18.5	29.5
3.6	39.4	17.0	28.0	37.4	48.4	69.1
5.6	91.6	41.5	68.0	90.3	113.2	146.3
7.6	140.5	63.8	104.7	138.8	173.7	223.8
9.6	207.5	94.2	154.7	205.3	256.7	329.5
11.6	308.8	138.8	228.5	304.0	381.8	496.7
13.6	492.1	223.2	367.5	487.8	608.9	779.8
15.6	679.8	308.7	507.9	674.7	841.0	1,076.4
17.6	904.0	410.9	676.6	898.2	1,118.0	1,428.6
19.6	1,139.9	517.9	853.5	1,134.0	1,410.7	1,800.1
21.6	1,355.2	615.8	1,015.6	1,350.6	1,677.5	2,137.8
23.6	1,490.1	676.4	1,116.3	1,485.0	1,845.2	2,351.4
25.6	1,591.4	722.1	1,192.1	1,586.3	1,970.4	2,511.1
27.6	1,680.8	762.6	1,259.1	1,675.7	2,081.5	2,651.2
29.6	1,756.5	796.2	1,315.6	1,751.6	2,175.8	2,770.7
31.6	1,800.3	816.3	1,348.1	1,795.2	2,229.9	2,840.1
33.6	1,828.3	828.8	1,369.0	1,823.5	2,264.9	2,884.6
35.6	1,847.7	837.5	1,383.4	1,842.8	2,289.1	2,915.2
37.6	1,864.8	845.2	1,396.1	1,859.8	2,310.7	2,942.6

Table 3-16b: Estimated Fatalities by Flood Water Elevation for Orleans Main Drainage Basin #4 – Post-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-14.4	0.0	0.0	0.0	0.0	0.0	0.0
-12.4	0.0	0.0	0.0	0.0	0.0	0.0
-10.4	0.0	0.0	0.0	0.0	0.0	0.0
-8.4	0.0	0.0	0.0	0.0	0.1	0.1
-6.4	0.2	0.0	0.1	0.1	0.3	0.7
-4.4	1.2	0.5	0.9	1.2	1.5	1.9
-2.4	1.7	0.8	1.3	1.7	2.1	2.8
-0.4	2.4	1.1	1.8	2.4	3.0	4.0
1.6	4.6	1.8	3.1	4.1	5.6	8.9
3.6	11.7	5.2	8.5	11.3	14.4	19.7
5.6	25.0	11.3	18.6	24.7	31.0	40.1
7.6	38.7	17.6	28.9	38.3	47.8	61.2
9.6	54.2	24.6	40.4	53.6	67.1	86.1
11.6	80.9	36.4	59.9	79.7	100.1	130.1
13.6	127.8	58.1	95.5	126.8	158.1	202.3
15.6	172.1	78.2	128.6	170.8	212.8	272.3
17.6	224.1	101.9	167.9	223.0	277.4	353.9
19.6	270.5	122.9	202.6	269.0	334.7	427.3
21.6	325.3	147.8	243.8	324.2	402.6	513.0
23.6	359.9	163.5	269.7	358.8	445.6	567.8
25.6	388.5	176.3	291.0	387.3	481.0	613.0
27.6	409.7	185.9	306.9	408.5	507.4	646.3
29.6	427.6	193.9	320.2	426.4	529.7	674.4
31.6	438.2	198.6	328.1	437.0	542.8	691.3
33.6	446.0	202.2	334.0	444.8	552.5	703.6
35.6	451.4	204.6	337.9	450.2	559.2	712.1
37.6	455.6	206.4	341.1	454.3	564.5	718.8

Table 3-17a: Estimated Fatalities by Flood Water Elevation for Orleans Main Drainage Basin #5 – Pre-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-12.9	0.0	0.0	0.0	0.0	0.0	0.0
-10.9	0.0	0.0	0.0	0.0	0.0	0.0
-8.9	0.0	0.0	0.0	0.0	0.0	0.0
-6.9	0.0	0.0	0.0	0.0	0.0	0.0
-4.9	0.0	0.0	0.0	0.0	0.0	0.0
-2.9	3.9	1.7	2.9	3.8	4.8	6.4
-0.9	21.9	5.6	11.6	19.0	28.6	44.1
1.1	42.4	9.0	21.0	36.6	56.3	87.9
3.1	71.4	16.0	37.6	62.3	93.7	146.2
5.1	201.6	66.5	116.3	168.6	251.3	457.3
7.1	674.0	298.1	490.4	651.1	830.6	1,130.5
9.1	1,246.1	567.1	927.5	1,229.3	1,540.4	1,985.3
11.1	1,789.0	817.0	1,338.7	1,774.3	2,211.4	2,827.7
13.1	2,420.7	1,093.0	1,795.5	2,385.5	2,992.3	3,877.9
15.1	4,224.2	1,830.4	3,038.6	4,062.1	5,199.5	7,230.6
17.1	8,635.8	3,879.9	6,400.2	8,517.3	10,682.4	13,830.9
19.1	13,277.3	6,030.5	9,925.0	13,178.5	16,414.0	21,002.6
21.1	17,135.9	7,781.2	12,846.3	17,061.9	21,202.8	27,033.7
23.1	19,801.1	8,990.6	14,845.4	19,721.0	24,498.2	31,234.0
25.1	22,593.0	10,261.7	16,936.2	22,509.0	27,956.1	35,636.8
27.1	25,263.2	11,467.3	18,925.0	25,177.2	31,281.6	39,868.9
29.1	26,955.2	12,226.1	20,193.4	26,879.6	33,385.1	42,519.9
31.1	28,096.5	12,736.0	21,044.1	28,018.1	34,804.4	44,319.9
33.1	28,841.0	13,073.6	21,601.4	28,760.4	35,725.7	45,495.5
35.1	29,571.6	13,405.1	22,143.9	29,488.0	36,627.3	46,646.6
37.1	30,104.4	13,646.9	22,541.5	30,024.9	37,292.6	47,496.8

Table 3-17b: Estimated Fatalities by Flood Water Elevation for Orleans Main Drainage Basin #5 – Post-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-12.9	0.0	0.0	0.0	0.0	0.0	0.0
-10.9	0.0	0.0	0.0	0.0	0.0	0.0
-8.9	0.0	0.0	0.0	0.0	0.0	0.0
-6.9	0.0	0.0	0.0	0.0	0.0	0.0
-4.9	0.0	0.0	0.0	0.0	0.0	0.0
-2.9	0.3	0.1	0.2	0.2	0.3	0.5
-0.9	3.6	0.5	1.6	3.1	4.8	7.7
1.1	8.3	1.3	3.8	7.1	11.2	17.8
3.1	16.5	2.9	8.1	14.2	22.1	34.7
5.1	41.4	11.8	22.5	35.2	52.9	93.2
7.1	141.6	60.6	99.9	133.8	174.0	251.4
9.1	308.6	137.7	226.3	300.3	380.5	508.4
11.1	541.9	246.7	403.6	535.3	669.8	862.9
13.1	795.5	361.1	592.6	786.1	983.3	1,266.4
15.1	1,262.3	556.7	921.5	1,227.4	1,556.7	2,087.6
17.1	2,349.1	1,056.6	1,742.8	2,317.6	2,905.4	3,759.5
19.1	3,631.8	1,644.8	2,709.4	3,598.4	4,495.2	5,761.4
21.1	5,004.1	2,272.8	3,748.6	4,976.8	6,191.6	7,903.8
23.1	6,075.0	2,759.9	4,551.2	6,047.5	7,514.5	9,587.5
25.1	7,115.5	3,231.2	5,334.0	7,086.3	8,804.0	11,224.6
27.1	8,023.4	3,641.6	6,010.0	7,996.2	9,936.4	12,657.4
29.1	8,540.8	3,874.6	6,397.1	8,514.0	10,574.8	13,474.6
31.1	8,980.6	4,072.0	6,726.0	8,956.5	11,125.1	14,164.3
33.1	9,284.9	4,209.5	6,954.2	9,259.1	11,502.4	14,646.7
35.1	9,564.1	4,335.6	7,162.0	9,537.1	11,846.1	15,087.0
37.1	9,733.0	4,411.6	7,286.9	9,707.0	12,058.1	15,356.1

Table 3-18a: Estimated Fatalities by Flood Water Elevation for Orleans West Bank Drainage Basin #1 – Pre-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles *5th*	*25th*	*50th*	*75th*	*95th*
-6.3	0.0	0.0	0.0	0.0	0.0	0.0
-4.3	0.0	0.0	0.0	0.0	0.0	0.0
-2.3	0.0	0.0	0.0	0.0	0.0	0.0
-0.3	0.0	0.0	0.0	0.0	0.0	0.0
1.7	0.0	0.0	0.0	0.0	0.0	0.0
3.7	0.0	0.0	0.0	0.0	0.0	0.1
5.7	0.6	0.1	0.2	0.5	0.8	1.3
7.7	0.6	0.1	0.3	0.5	0.8	1.3
9.7	1.1	0.2	0.5	0.9	1.4	2.6
11.7	4.4	1.7	2.9	3.9	5.3	8.9
13.7	11.4	5.2	8.6	11.3	14.1	18.0
15.7	13.5	6.2	10.1	13.4	16.7	21.3
17.7	15.9	7.3	11.9	15.8	19.7	25.2
19.7	35.9	12.1	20.7	28.5	42.8	87.5
21.7	123.6	56.2	92.6	123.0	153.0	195.2
23.7	143.9	65.2	107.8	143.5	178.2	226.9
25.7	147.8	67.0	110.7	147.4	183.0	233.1
27.7	152.9	69.4	114.5	152.4	189.3	241.2
29.7	165.0	74.9	123.6	164.3	204.2	260.5
31.7	189.2	85.8	141.7	188.7	234.5	298.6
33.7	190.7	86.4	142.8	190.2	236.3	301.0
35.7	192.1	87.0	143.8	191.6	238.0	303.1
37.7	193.3	87.6	144.8	192.7	239.4	304.9

Table 3-18b: Estimated Fatalities by Flood Water Elevation for Orleans West Bank Drainage Basin #1 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles				
		5th	*25th*	*50th*	*75th*	*95th*
-6.3	0.0	0.0	0.0	0.0	0.0	0.0
-4.3	0.0	0.0	0.0	0.0	0.0	0.0
-2.3	0.0	0.0	0.0	0.0	0.0	0.0
-0.3	0.0	0.0	0.0	0.0	0.0	0.0
1.7	0.0	0.0	0.0	0.0	0.0	0.0
3.7	0.0	0.0	0.0	0.0	0.0	0.1
5.7	0.6	0.1	0.2	0.5	0.8	1.3
7.7	0.6	0.1	0.3	0.5	0.8	1.3
9.7	1.1	0.2	0.5	0.9	1.4	2.6
11.7	4.4	1.8	2.9	4.0	5.4	9.0
13.7	11.5	5.3	8.6	11.4	14.2	18.1
15.7	13.4	6.1	10.0	13.3	16.5	21.1
17.7	15.6	7.1	11.6	15.4	19.3	24.7
19.7	35.7	11.9	20.4	28.1	42.6	87.7
21.7	124.5	56.6	93.2	123.9	154.0	196.5
23.7	144.8	65.7	108.5	144.4	179.4	228.4
25.7	148.6	67.4	111.3	148.2	184.1	234.4
27.7	153.7	69.8	115.2	153.2	190.3	242.5
29.7	166.0	75.4	124.3	165.2	205.4	262.0
31.7	190.5	86.3	142.6	190.0	236.0	300.6
33.7	192.0	87.0	143.7	191.4	237.8	302.9
35.7	193.3	87.6	144.7	192.8	239.5	305.0
37.7	194.5	88.2	145.7	193.9	240.9	306.8

Table 3-19a: Estimated Fatalities by Flood Water Elevation for Orleans West Bank Drainage Basin #2 – Pre-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-12.7	0.0	0.0	0.0	0.0	0.0	0.0
-10.7	0.0	0.0	0.0	0.0	0.0	0.0
-8.7	0.0	0.0	0.0	0.0	0.0	0.0
-6.7	0.2	0.0	0.1	0.2	0.3	0.5
-4.7	1.8	0.3	0.9	1.6	2.4	3.9
-2.7	6.5	2.5	4.2	5.9	8.1	11.7
-0.7	14.7	4.7	8.7	13.1	18.7	28.1
1.3	25.6	9.7	16.6	23.4	32.0	46.7
3.3	56.3	21.5	36.2	50.4	69.8	113.0
5.3	166.5	70.7	116.8	156.6	204.2	300.7
7.3	366.8	167.1	273.3	362.3	453.5	582.9
9.3	527.3	240.2	393.4	521.6	651.9	837.4
11.3	780.9	351.3	577.5	767.5	964.7	1,257.7
13.3	1,376.0	602.9	999.0	1,333.5	1,696.0	2,301.3
15.3	2,596.5	1,175.7	1,937.0	2,571.5	3,214.3	4,122.5
17.3	3,639.5	1,656.3	2,724.4	3,615.8	4,501.4	5,750.9
19.3	4,602.1	2,092.9	3,447.2	4,574.7	5,693.3	7,269.1
21.3	5,702.7	2,590.6	4,271.2	5,671.4	7,056.4	9,009.5
23.3	6,873.4	3,122.1	5,152.7	6,843.6	8,506.4	10,846.2
25.3	7,880.2	3,577.0	5,902.8	7,854.0	9,758.9	12,434.2
27.3	8,398.7	3,810.5	6,292.0	8,373.4	10,400.7	13,247.8
29.3	8,791.6	3,987.7	6,585.2	8,765.9	10,889.5	13,869.0
31.3	9,137.0	4,142.7	6,843.4	9,111.8	11,319.1	14,412.4
33.3	9,409.6	4,265.6	7,046.7	9,383.6	11,655.7	14,844.0
35.3	9,602.5	4,352.7	7,189.5	9,576.6	11,896.1	15,150.8
37.3	9,694.9	4,393.7	7,258.4	9,669.1	12,012.6	15,297.7

Table 3-19b: Estimated Fatalities by Flood Water Elevation for Orleans West Bank Drainage Basin #2 – Post-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-12.7	0.0	0.0	0.0	0.0	0.0	0.0
-10.7	0.0	0.0	0.0	0.0	0.0	0.0
-8.7	0.0	0.0	0.0	0.0	0.0	0.0
-6.7	0.2	0.0	0.1	0.2	0.3	0.5
-4.7	1.8	0.3	0.9	1.6	2.4	4.0
-2.7	6.5	2.5	4.3	6.0	8.2	11.8
-0.7	14.8	4.8	8.8	13.2	18.9	28.4
1.3	25.9	9.8	16.8	23.7	32.4	47.2
3.3	56.9	21.7	36.6	50.8	70.5	114.0
5.3	168.2	71.4	118.0	158.2	206.2	303.7
7.3	370.5	168.8	276.0	366.0	458.1	588.8
9.3	532.7	242.6	397.4	526.9	658.5	845.8
11.3	788.6	354.8	583.2	775.0	974.1	1,269.9
13.3	1,388.9	608.6	1,008.4	1,346.0	1,712.0	2,322.9
15.3	2,620.9	1,186.7	1,955.1	2,595.6	3,244.4	4,161.3
17.3	3,674.0	1,671.8	2,750.3	3,650.2	4,544.0	5,805.4
19.3	4,644.8	2,112.5	3,479.2	4,617.3	5,746.5	7,336.9
21.3	5,754.2	2,614.0	4,309.7	5,722.6	7,120.1	9,090.8
23.3	6,935.0	3,150.0	5,198.9	6,905.0	8,582.6	10,943.5
25.3	7,950.5	3,608.9	5,955.4	7,923.9	9,845.9	12,545.0
27.3	8,474.1	3,844.8	6,348.5	8,448.5	10,494.0	13,366.5
29.3	8,870.1	4,023.3	6,644.1	8,844.2	10,986.8	13,992.9
31.3	9,218.7	4,179.7	6,904.6	9,193.3	11,420.3	14,541.3
33.3	9,493.8	4,303.8	7,109.8	9,467.6	11,760.0	14,976.9
35.3	9,688.7	4,391.8	7,254.0	9,662.6	12,002.8	15,286.7
37.3	9,781.9	4,433.1	7,323.5	9,755.8	12,120.3	15,434.9

Table 3-20a: Estimated Fatalities by Flood Water Elevation for Plaquemines Area Drainage Basin #1 – Pre-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-22	0.0	0.0	0.0	0.0	0.0	0.0
-20	0.0	0.0	0.0	0.0	0.0	0.0
-18	0.0	0.0	0.0	0.0	0.0	0.0
-16	0.0	0.0	0.0	0.0	0.0	0.0
-14	0.0	0.0	0.0	0.0	0.0	0.0
-12	0.7	0.3	0.5	0.6	0.8	1.2
-10	1.2	0.4	0.7	1.1	1.6	2.3
-8	1.5	0.5	0.9	1.3	1.8	2.7
-6	3.6	1.0	1.8	2.7	4.5	9.5
-4	16.0	7.1	11.7	15.5	19.7	26.6
-2	28.3	12.9	21.2	28.1	35.0	44.6
0	33.5	15.3	25.1	33.3	41.4	52.7
2	41.1	18.5	30.4	40.3	50.7	66.3
4	79.8	33.5	55.7	74.8	97.6	146.5
6	179.8	81.9	134.7	178.7	222.3	283.9
8	223.7	102.0	167.6	222.5	276.7	353.0
10	271.0	123.5	203.0	269.4	335.2	428.0
12	336.4	153.3	251.9	334.2	416.0	531.4
14	430.1	195.5	321.4	426.8	532.1	680.9
16	561.1	255.1	420.5	559.0	694.5	884.9
18	630.7	286.8	472.3	627.4	780.3	995.7
20	777.0	352.3	580.4	770.9	961.9	1,231.2
22	1,024.5	465.3	768.1	1,020.3	1,267.5	1,616.1
24	1,161.8	527.5	870.3	1,157.8	1,438.2	1,832.1
26	1,260.1	571.3	943.9	1,256.5	1,560.9	1,987.5
28	1,298.5	588.8	972.9	1,294.8	1,608.4	2,048.4
30	1,352.3	613.4	1,012.9	1,348.5	1,675.1	2,133.3
32	1,401.4	635.3	1,049.7	1,397.5	1,736.0	2,210.4
34	1,435.7	650.8	1,075.0	1,431.9	1,778.4	2,265.0
36	1,450.5	657.3	1,085.9	1,446.6	1,797.3	2,289.0

Table 3-20b: Estimated Fatalities by Flood Water Elevation for Plaquemines Area Drainage Basin #1 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles				
		5th	*25th*	*50th*	*75th*	*95th*
-22	0.0	0.0	0.0	0.0	0.0	0.0
-20	0.0	0.0	0.0	0.0	0.0	0.0
-18	0.0	0.0	0.0	0.0	0.0	0.0
-16	0.0	0.0	0.0	0.0	0.0	0.0
-14	0.0	0.0	0.0	0.0	0.0	0.0
-12	0.7	0.3	0.5	0.7	0.9	1.2
-10	1.3	0.4	0.8	1.1	1.6	2.4
-8	1.5	0.5	0.9	1.3	1.9	2.8
-6	3.7	1.1	1.9	2.7	4.6	9.7
-4	16.3	7.2	11.9	15.8	20.1	27.1
-2	28.8	13.2	21.6	28.6	35.6	45.4
0	34.1	15.6	25.6	33.9	42.2	53.6
2	41.8	18.8	30.9	41.0	51.6	67.5
4	81.1	34.0	56.6	76.0	99.2	148.9
6	182.8	83.3	137.0	181.7	226.1	288.7
8	227.5	103.7	170.5	226.3	281.4	359.0
10	275.8	125.7	206.6	274.1	341.1	435.5
12	342.3	156.0	256.4	340.1	423.4	540.8
14	437.3	198.8	326.8	434.0	541.0	692.2
16	570.2	259.2	427.3	568.1	705.8	899.2
18	641.2	291.6	480.2	637.9	793.4	1,012.3
20	790.2	358.3	590.3	784.2	978.0	1,251.9
22	1,039.7	472.1	779.5	1,035.4	1,286.2	1,639.9
24	1,178.6	535.1	883.0	1,174.6	1,459.1	1,858.6
26	1,278.9	579.8	957.9	1,275.2	1,584.2	2,017.2
28	1,318.1	597.7	987.5	1,314.3	1,632.7	2,079.3
30	1,372.9	622.7	1,028.3	1,369.0	1,700.6	2,165.7
32	1,422.5	644.9	1,065.5	1,418.5	1,762.1	2,243.6
34	1,457.4	660.7	1,091.2	1,453.5	1,805.2	2,299.2
36	1,472.5	667.3	1,102.4	1,468.5	1,824.5	2,323.7

Table 3-21a: Estimated Fatalities by Flood Water Elevation for St. Bernard Drainage Basin #1 – Pre-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-13.9	0.0	0.0	0.0	0.0	0.0	0.0
-9.9	0.0	0.0	0.0	0.0	0.0	0.0
-7.9	0.0	0.0	0.0	0.0	0.0	0.0
-5.9	0.0	0.0	0.0	0.0	0.0	0.0
-3.9	0.0	0.0	0.0	0.0	0.0	0.0
-1.9	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.0	0.0	0.0	0.0	0.0	0.0
2.1	23.4	2.6	10.1	19.9	31.9	51.1
4.1	23.6	2.8	10.3	20.0	32.2	51.4
6.1	68.4	9.7	23.3	41.7	92.2	218.3
8.1	409.7	170.2	283.3	380.4	499.8	766.1
10.1	913.0	415.3	684.0	909.7	1,130.0	1,438.9
12.1	915.2	416.2	685.6	911.9	1,132.8	1,442.3
14.1	915.2	416.2	685.6	911.9	1,132.8	1,442.3
16.1	1,333.0	505.4	854.3	1,161.0	1,600.6	2,833.2
18.1	4,000.7	1,797.2	2,967.9	3,948.7	4,950.7	6,401.7
20.1	5,808.8	2,631.8	4,348.8	5,793.6	7,197.8	9,169.3
22.1	5,809.4	2,632.1	4,349.4	5,794.3	7,198.6	9,170.2
24.1	5,903.3	2,681.9	4,424.0	5,883.0	7,306.5	9,311.3
26.1	6,562.7	2,980.2	4,919.4	6,536.8	8,121.6	10,352.8
28.1	7,305.4	3,309.4	5,468.7	7,285.9	9,053.2	11,529.0
30.1	7,305.5	3,309.4	5,468.8	7,286.0	9,053.3	11,529.2
32.1	7,305.5	3,309.4	5,468.8	7,286.0	9,053.3	11,529.2
34.1	7,328.6	3,322.8	5,487.6	7,308.6	9,077.9	11,559.4
36.1	7,477.5	3,390.2	5,599.1	7,455.7	9,261.8	11,797.4

Table 3-21b: Estimated Fatalities by Flood Water Elevation for St. Bernard Drainage Basin #1 – Post-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	**Fatalities**	***5th***	***25th***	***50th***	***75th***	***95th***
-13.9	0.0	0.0	0.0	0.0	0.0	0.0
-9.9	0.0	0.0	0.0	0.0	0.0	0.0
-7.9	0.0	0.0	0.0	0.0	0.0	0.0
-5.9	0.0	0.0	0.0	0.0	0.0	0.0
-3.9	0.0	0.0	0.0	0.0	0.0	0.0
-1.9	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.0	0.0	0.0	0.0	0.0	0.0
2.1	2.0	0.3	0.9	1.7	2.7	4.2
4.1	2.0	0.3	0.9	1.7	2.7	4.3
6.1	7.0	1.0	2.2	3.8	9.6	23.3
8.1	42.5	18.2	30.1	40.3	52.2	75.6
10.1	86.2	39.1	64.5	85.9	106.7	135.9
12.1	86.3	39.2	64.6	86.0	106.8	136.0
14.1	86.3	39.2	64.6	86.0	106.8	136.0
16.1	121.6	47.1	79.5	107.8	146.6	250.6
18.1	343.5	155.1	255.8	339.8	425.2	547.0
20.1	475.0	215.2	355.7	473.8	588.6	749.9
22.1	475.1	215.2	355.7	473.8	588.7	749.9
24.1	480.1	217.9	359.7	478.5	594.5	757.6
26.1	519.2	235.8	389.2	517.1	642.6	819.2
28.1	580.3	262.9	434.4	578.8	719.2	915.8
30.1	580.3	262.9	434.4	578.8	719.2	915.8
32.1	580.3	262.9	434.4	578.8	719.2	915.8
34.1	581.9	263.8	435.8	580.3	720.8	918.0
36.1	592.4	268.6	443.6	590.8	733.7	934.5

Table 3-22a: Estimated Fatalities by Flood Water Elevation for St. Bernard Drainage Basin #3 – Pre-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles *5th*	*25th*	*50th*	*75th*	*95th*
-6.4	0.0	0.0	0.0	0.0	0.0	0.0
-4.4	0.0	0.0	0.0	0.0	0.0	0.0
-2.4	0.0	0.0	0.0	0.0	0.0	0.0
-0.4	0.0	0.0	0.0	0.0	0.0	0.0
1.6	0.0	0.0	0.0	0.0	0.0	0.0
3.6	20.7	5.9	11.5	18.1	26.8	40.9
5.6	23.2	7.5	13.7	20.6	29.6	44.4
7.6	30.4	11.3	19.5	27.7	38.0	55.7
9.6	560.7	255.2	420.2	558.6	694.0	883.6
11.6	560.7	255.2	420.2	558.6	694.0	883.6
13.6	560.8	255.2	420.2	558.7	694.1	883.7
15.6	988.0	327.3	559.1	772.0	1,180.4	2,450.5
17.6	3,431.0	1,558.3	2,570.4	3,419.3	4,246.7	5,410.8
19.6	3,679.3	1,667.1	2,754.7	3,669.6	4,559.0	5,807.8
21.6	3,679.3	1,667.1	2,754.7	3,669.6	4,559.0	5,807.8
23.6	3,680.8	1,668.1	2,755.8	3,670.9	4,560.8	5,808.8
25.6	3,832.7	1,741.0	2,869.2	3,808.8	4,740.0	6,058.4
27.6	4,638.6	2,101.3	3,472.3	4,626.2	5,748.2	7,320.4
29.6	4,638.6	2,101.3	3,472.3	4,626.2	5,748.2	7,320.4
31.6	4,638.6	2,101.3	3,472.3	4,626.2	5,748.2	7,320.4
33.6	4,662.1	2,113.9	3,491.8	4,649.6	5,775.5	7,353.0
35.6	4,796.5	2,173.2	3,590.5	4,783.6	5,943.5	7,569.4
37.6	4,809.6	2,178.7	3,600.4	4,796.8	5,960.2	7,590.2

Table 3-22b: Estimated Fatalities by Flood Water Elevation for St. Bernard Drainage Basin #3 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles				
		5th	*25th*	*50th*	*75th*	*95th*
-6.4	0.0	0.0	0.0	0.0	0.0	0.0
-4.4	0.0	0.0	0.0	0.0	0.0	0.0
-2.4	0.0	0.0	0.0	0.0	0.0	0.0
-0.4	0.0	0.0	0.0	0.0	0.0	0.0
1.6	0.0	0.0	0.0	0.0	0.0	0.0
3.6	2.0	0.3	0.9	1.7	2.7	4.2
5.6	2.1	0.4	1.0	1.8	2.8	4.4
7.6	2.5	0.7	1.3	2.2	3.2	4.9
9.6	70.6	32.1	52.9	70.4	87.4	111.3
11.6	70.6	32.1	52.9	70.4	87.4	111.3
13.6	70.6	32.1	52.9	70.4	87.4	111.3
15.6	118.4	40.6	69.3	95.2	141.0	283.3
17.6	393.5	178.8	294.9	392.1	487.0	620.6
19.6	432.3	195.9	323.7	431.1	535.6	682.4
21.6	432.3	195.9	323.7	431.1	535.6	682.4
23.6	432.4	196.0	323.7	431.3	535.8	682.4
25.6	449.5	204.1	336.6	446.8	556.0	710.4
27.6	541.6	245.4	405.5	540.2	671.1	854.8
29.6	541.6	245.4	405.5	540.2	671.1	854.8
31.6	541.6	245.4	405.5	540.2	671.1	854.8
33.6	544.2	246.7	407.6	542.7	674.2	858.4
35.6	559.1	253.3	418.5	557.5	692.7	882.3
37.6	561.2	254.2	420.1	559.7	695.4	885.6

Table 3-23a: Estimated Fatalities by Flood Water Elevation for St. Bernard Drainage Basin #4 – Pre-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles 5th	25th	50th	75th	95th
-0.2	0.0	0.0	0.0	0.0	0.0	0.0
1.8	0.0	0.0	0.0	0.0	0.0	0.0
3.8	3.4	0.4	1.5	2.9	4.7	7.4
5.8	5.6	1.5	3.1	4.9	7.2	11.6
7.8	16.6	6.6	10.9	14.9	20.3	33.2
9.8	45.8	20.4	33.5	44.5	56.4	75.9
11.8	79.9	36.6	59.9	79.4	98.9	126.4
13.8	102.0	46.6	76.4	101.4	126.2	161.0
15.8	149.7	52.2	88.8	121.8	178.3	352.5
17.8	149.8	52.2	88.8	121.8	178.4	352.8
19.8	485.8	220.7	364.1	484.1	601.4	766.0
21.8	523.6	237.4	391.9	522.2	648.8	826.5
23.8	523.8	237.6	392.1	522.4	648.9	826.5
25.8	551.2	250.2	411.9	547.2	681.6	872.4
27.8	700.1	317.2	524.2	698.2	867.4	1,105.0
29.8	702.3	318.4	526.0	700.4	870.0	1,107.8
31.8	714.2	323.6	534.7	712.3	884.9	1,127.2
33.8	720.2	326.9	539.6	717.9	891.8	1,136.1
35.8	752.6	341.0	563.5	750.6	932.5	1,188.0
37.8	753.1	341.4	563.8	751.0	933.0	1,188.4

Table 3-23b: Estimated Fatalities by Flood Water Elevation for St. Bernard Drainage Basin #4 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles *5th*	*25th*	*50th*	*75th*	*95th*
-0.2	0.0	0.0	0.0	0.0	0.0	0.0
1.8	0.0	0.0	0.0	0.0	0.0	0.0
3.8	0.9	0.1	0.4	0.7	1.2	1.9
5.8	1.1	0.2	0.6	1.0	1.5	2.3
7.8	2.5	1.0	1.6	2.3	3.2	5.0
9.8	7.0	3.0	4.9	6.6	8.6	12.7
11.8	15.3	7.0	11.4	15.1	18.9	24.5
13.8	22.2	10.1	16.6	22.1	27.4	34.9
15.8	39.4	11.9	20.5	28.6	48.0	105.6
17.8	39.4	11.9	20.5	28.6	48.0	105.6
19.8	151.1	68.6	113.2	150.6	187.1	238.3
21.8	159.8	72.4	119.6	159.3	198.0	252.2
23.8	159.8	72.4	119.6	159.3	198.0	252.2
25.8	167.7	76.1	125.3	166.4	207.3	265.4
27.8	211.9	96.0	158.6	211.3	262.5	334.4
29.8	212.4	96.3	159.0	211.8	263.1	335.0
31.8	215.1	97.4	161.0	214.5	266.5	339.5
33.8	216.7	98.3	162.3	216.0	268.4	341.8
35.8	225.8	102.3	169.0	225.2	279.8	356.4
37.8	225.9	102.3	169.1	225.3	279.9	356.5

Table 3-24a: Estimated Fatalities by Flood Water Elevation for St. Bernard Drainage Basin #5 – Pre-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-5.9	0.0	0.0	0.0	0.0	0.0	0.0
-3.9	0.0	0.0	0.0	0.0	0.0	0.0
-1.9	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.0	0.0	0.0	0.0	0.0	0.0
2.1	0.0	0.0	0.0	0.0	0.0	0.0
4.1	0.0	0.0	0.0	0.0	0.0	0.0
6.1	0.1	0.0	0.0	0.1	0.1	0.2
8.1	0.1	0.0	0.0	0.1	0.1	0.2
10.1	2.7	1.2	2.0	2.7	3.3	4.3
12.1	2.7	1.2	2.0	2.7	3.3	4.3
14.1	2.7	1.2	2.0	2.7	3.3	4.3
16.1	2.7	1.2	2.0	2.7	3.3	4.3
18.1	5.0	1.6	2.7	3.8	6.0	12.7
20.1	17.7	8.0	13.2	17.6	21.9	27.9
22.1	17.7	8.0	13.2	17.6	21.9	27.9
24.1	17.7	8.0	13.2	17.6	21.9	27.9
26.1	18.4	8.3	13.8	18.3	22.7	29.1
28.1	22.3	10.1	16.7	22.2	27.6	35.2
30.1	22.3	10.1	16.7	22.2	27.6	35.2
32.1	22.3	10.1	16.7	22.2	27.6	35.2
34.1	22.3	10.1	16.7	22.2	27.6	35.2
36.1	22.4	10.2	16.8	22.3	27.7	35.3

Table 24b: No post-Katrina data is necessary. Estimated post-Katrina fatalities for St. Bernard Drainage Basin #5 were zero.

Table 3-25a: Estimated Fatalities by Flood Water Elevation for St. Charles Drainage Basin #1 – Pre-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-1.1	0.0	0.0	0.0	0.0	0.0	0.0
0.9	0.0	0.0	0.0	0.0	0.0	0.0
2.9	0.0	0.0	0.0	0.0	0.0	0.0
4.9	0.0	0.0	0.0	0.0	0.0	0.0
6.9	0.0	0.0	0.0	0.0	0.0	0.0
8.9	0.0	0.0	0.0	0.0	0.0	0.0
10.9	1.4	0.6	1.0	1.4	1.7	2.2
12.9	6.1	2.8	4.5	6.0	7.5	9.5
14.9	6.7	3.1	5.0	6.7	8.3	10.6
16.9	7.4	3.4	5.6	7.4	9.2	11.7
18.9	20.4	5.7	9.9	13.9	25.4	58.0
20.9	84.0	38.1	63.0	83.8	104.1	132.6
22.9	88.4	40.1	66.2	88.2	109.5	139.5
24.9	89.7	40.7	67.2	89.5	111.1	141.5
26.9	93.4	42.4	69.9	92.9	115.5	147.5
28.9	110.1	49.9	82.4	109.8	136.4	173.6
30.9	112.9	51.2	84.5	112.6	139.9	178.1
32.9	113.6	51.5	85.0	113.3	140.7	179.2
34.9	113.8	51.6	85.2	113.5	141.0	179.6
36.9	114.5	51.9	85.8	114.2	141.9	180.7

Table 3-25b: Estimated Fatalities by Flood Water Elevation for St. Charles Drainage Basin #1 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles 5th	25th	50th	75th	95th
-1.1	0.0	0.0	0.0	0.0	0.0	0.0
0.9	0.0	0.0	0.0	0.0	0.0	0.0
2.9	0.0	0.0	0.0	0.0	0.0	0.0
4.9	0.0	0.0	0.0	0.0	0.0	0.0
6.9	0.0	0.0	0.0	0.0	0.0	0.0
8.9	0.0	0.0	0.0	0.0	0.0	0.0
10.9	1.4	0.6	1.0	1.4	1.7	2.2
12.9	6.1	2.8	4.6	6.1	7.5	9.6
14.9	6.8	3.1	5.1	6.7	8.4	10.6
16.9	7.5	3.4	5.6	7.4	9.2	11.8
18.9	20.6	5.8	10.0	14.0	25.7	58.6
20.9	85.0	38.6	63.7	84.7	105.3	134.1
22.9	89.4	40.6	67.0	89.2	110.8	141.1
24.9	90.8	41.2	67.9	90.5	112.4	143.2
26.9	93.4	42.4	69.9	92.9	115.5	147.5
28.9	110.1	49.9	82.4	109.8	136.4	173.6
30.9	112.9	51.2	84.5	112.6	139.9	178.1
32.9	112.9	51.2	84.5	112.6	139.9	178.1
34.9	113.8	51.6	85.2	113.5	141.0	179.6
36.9	114.5	51.9	85.8	114.2	141.9	180.7

Table 3-26a: Estimated Fatalities by Flood Water Elevation for St. Charles Drainage Basin #2 – Pre-Katrina

Elevation (feet)	Mean	Fatality Uncertainty Distribution Percentiles				
NAV88(2004.65)	Fatalities	*5th*	*25th*	*50th*	*75th*	*95th*
-1	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0
3	0.1	0.0	0.0	0.1	0.1	0.2
5	1.3	0.1	0.5	1.1	1.8	2.9
7	3.1	0.7	1.6	2.7	4.1	6.4
9	10.2	3.0	5.6	8.6	13.0	23.3
11	36.4	15.7	25.9	34.6	44.8	63.3
13	83.0	36.9	60.6	80.5	102.3	137.7
15	152.3	69.6	113.8	150.8	188.2	241.5
17	228.5	103.1	169.2	224.9	282.4	367.0
19	439.8	189.3	314.7	420.6	540.7	764.5
21	919.4	414.7	684.1	908.9	1,137.2	1,465.7
23	1,391.3	628.1	1,036.4	1,376.3	1,722.5	2,215.2
25	2,010.6	914.5	1,505.9	1,998.5	2,487.5	3,175.9
27	2,469.4	1,121.5	1,851.2	2,458.4	3,055.6	3,896.2
29	2,848.0	1,294.0	2,134.6	2,837.4	3,524.7	4,491.7
31	3,181.6	1,444.7	2,383.1	3,170.8	3,938.5	5,017.6
33	3,456.9	1,568.2	2,589.3	3,445.9	4,280.4	5,454.0
35	3,631.6	1,646.7	2,720.1	3,621.3	4,498.9	5,728.0
37	3,740.7	1,695.7	2,801.5	3,730.3	4,633.9	5,900.3

Table 3-25b: Estimated Fatalities by Flood Water Elevation for St. Charles Drainage Basin #2 – Post-Katrina

Elevation (feet) NAV88(2004.65)	Mean Fatalities	Fatality Uncertainty Distribution Percentiles 5th	25th	50th	75th	95th
-1	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0
3	0.1	0.0	0.0	0.1	0.1	0.2
5	1.3	0.1	0.5	1.1	1.8	2.9
7	3.2	0.8	1.6	2.8	4.2	6.5
9	10.4	3.0	5.6	8.7	13.2	23.7
11	36.9	15.9	26.3	35.1	45.4	64.2
13	84.1	37.4	61.4	81.5	103.6	139.6
15	154.8	70.7	115.6	153.3	191.3	245.4
17	232.5	104.8	172.1	228.8	287.3	373.4
19	446.8	192.4	319.8	427.4	549.3	776.4
21	932.4	420.6	693.8	921.9	1,153.4	1,486.4
23	1,410.8	636.9	1,051.0	1,395.5	1,746.6	2,246.2
25	2,040.4	928.1	1,528.2	2,028.2	2,524.4	3,222.9
27	2,469.4	1,121.5	1,851.2	2,458.4	3,055.6	3,896.2
29	2,848.0	1,294.0	2,134.6	2,837.4	3,524.7	4,491.7
31	3,181.6	1,444.7	2,383.1	3,170.8	3,938.5	5,017.6
33	3,182.6	1,445.2	2,383.8	3,171.9	3,939.7	5,019.2
35	3,631.6	1,646.7	2,720.1	3,621.3	4,498.9	5,728.0
37	3,740.7	1,695.7	2,801.5	3,730.3	4,633.9	5,900.3

Appendix 4
Social, Cultural, and Historic Consequences

Section One: Background and Context

I. Introduction and Objective

Hurricane Katrina struck the coasts of Louisiana, Mississippi, and Alabama on 29 August 2005. The hurricane and its aftermath became the costliest natural disaster in U.S. history, resulting in extensive property damage, loss of life, and widespread effects on the lives of local residents. People who once lived, or are attempting to return to live, within the Greater New Orleans area and the affected areas in Plaquemines, Orleans, St. Bernard's, Jefferson and St. Tammany Parishes face pervasive disruption to their homes, families, neighborhoods and communities. For some individuals and communities, the disruptions they experienced are expected to last for decades to come.

The objective of this portion of the larger USACE study is to describe, using quantitative data and qualitative assessments, how Hurricane Katrina and the levee failures affected the social, cultural and historical resources of the people and to project what their lives may be like in coming years. This is a daunting task because of the scope and magnitude of the event and the challenges in securing useful data. The widespread dispersion of the people has created significant barriers to gathering information; likewise, property damage and personnel loss to key offices and agencies undermine traditional ways to gather and analyze data on the disaster's impact. Accordingly, a methodology section addresses how these challenges were met; each section identifies sources used to generate data-driven insights. The overall purpose is to provide an understanding of social, cultural and historic relevance of hurricane protection.

To situate the reader in this section of the report and to provide a flavor of coming sections, a brief overview of the social, historic and cultural consequences for the people of New Orleans is provided first, followed by sections that: (Section II) outline the methodology; (Section III) define terms; (Section IV) review how people experienced the various phases of the disaster; (Section V) overview the historical, cultural and social character of the affected areas; (Section VI) outline regional and national implications; (Section VII) project into the future; and (Section VIII) draw general conclusions. Several appendices then follow with technical information relevant to the study.

II. New Orleans: The History and Culture of New Orleans

Prior to landfall, New Orleans provided residents and visitors with a rich blend of cultural and historic resources derived from its racial and ethnic diversity. New Orleans is a distinctive North American city; there are few, if any other places like it. It has a rich mix of "… handsome architecture, world-famous indigenous music, superb regional cuisine, and a host of urban delights that re peculiar to this special city (Lewis, 2003:171)."

Prior to 1900, inhabitants built communities made distinct through cultural values, languages and social ties. As a geographic region, New Orleans reflected a series of "disconnected suburbs" fostering independent ties to one's neighborhood. Up to Katrina and the flood, those neighborhoods remained distinct and viable as places where people experienced a sense of connection their history and culture. Those areas remained so distinct that New Orleans City Planning formally designed 73 distinct neighborhoods. The National Historic Register lists ten of these neighborhoods as National Historic Districts with the "Uptown Historic District" bearing distinction as the second largest in the U.S. (Leavitt 2000). The "Holy Cross National Register Historic District" with its twin steamboat houses, flood-damaged Holy Cross School, and St. Maurice Church remains as a "target neighborhood" for the local preservationists (Preservation Resource Center 2006). Historic treasures reflect New Orleans' historical diversity with structures as unique as the Greek Revival military architecture of Jackson Barracks, the Classical Revival art and architecture of St. Louis Cemetery #1, and the Art Deco of Booker T. Washington High School and Auditorium (Louisiana National Register of Historic Places 2006).

Social, cultural and historical legacies defined the neighborhoods of New Orleans and fostered "unique cultural innovations: jazz, Creole cuisine, Mardi Gras, above ground burial sites, ("cities of the dead"), cultural rites (including the famous jazz funerals" that survived urbanization and made this city matchless (Leavitt 2000). A hearty mix of cultures built the traditions of jazz, blues, funk and bounce music that reverberate music halls across the city. Legendary jazz musicians built the sounds and ambience of the city, where visitors and locals could "find the houses of Jelly Roll Morton and Buddy Bolden and Papa Jack Laine" or view architecture ranging from the oldest apartment buildings in America to the classic shotgun homes of the Lower Ninth Ward (Piazza 2005).

Inventorying this deep heritage is impossible and, ultimately, would reduce the *esprit* of this city to a mere listing. Capturing the essence of the city is the challenge, noted by local author Tom Piazza (2005, p. xix): "these elements of New Orleans possess an astonishing vitality that has spoken to people around the world and shaped much of the best of what we think of still as American culture. Jazz music, rhythm and blues, and rock and roll, Creole cooking, Mardi Gras, the architecture of the French Quarter, the literary traditions of Williams and Faulkner and Percy and Kate Chopin, the Mardi Gras Indians, whose chanted songs stretch back into the nineteenth century and whose rhythms help form the basis of American popular music…It is not something that you find only in a tourist guide; it is a reality lived by its inhabitants every day." Given the trends of urbanization and mass culture, New Orleans remained an authentic site connecting people to unique, diverse and beloved cultural and historical heritage.

The People. New Orleans is one of the older southern cities in the United States, and like many other aging cities, has experienced a steady decline in population in its central city core.

From 1990-2000, for example, Orleans Parish declined in population by roughly 2.5%, while during the same time period, the state increased in population by 5.9%. Even more striking is the continued decline in population (4.6% in Orleans Parish) from the period 2000-2004 (U.S. Census 2006). Along with the population decline is an increasing concentration of elderly and poor residents. Such quantitative data though, often miss the social dimensions of neighborhoods that make New Orleans a special place to live. Communities like Bywater, the Ninth Ward, Gentilly, Lakeview, and Mid City offered unique locations where residents enjoyed a shared history, a set of social ties, and resources that enable them to survive and even thrive. Residents, as will be seen in data reported later, had often lived in their neighborhood for decades; locals report that homes had been passed down for generations.

The Neighborhoods. That New Orleanians love the Crescent City in a way that outsiders may miss. New Orleanians identify themselves not only by city, but by neighborhood. From the Treme to the Garden District, each neighborhood has a history that is steeped in tradition, celebration, and people. The sense of and attachment to place that many New Orleanians hold about their neighborhood and communities is an important element in understanding the loss this community has suffered. To understand such place affection means learning about the rich heritage of its neighborhoods. The Lower 9th Ward, for example, gave us the music of Fats Domino. Across the Industrial Canal, Homer Plessy challenged racial segregation policy in 1892, resulting in a landmark court case that established a doctrine of "separate but equal" treatment for blacks and whites. More than 100 years later, the neighborhood is still trying for recognition to mark the spot of this watershed event. The Treme is one of the oldest African-American neighborhoods in the country – it has produced musicians, politicians, and scholars. Each neighborhood has a story and life beyond individuals and families.

The Event. Hurricane Katrina and the associated storm surge created breaches in the floodwalls along the 17th Street Canal, the London Street Canal, and the Inner Harbor Navigation Canal. Brackish surge waters from Lake Pontchartrain flowed through the breaches and inundated large areas in New Orleans to depths of up to 20 feet. In addition, water overtopped levees in St. Bernard and Plaquemines Parishes causing catastrophic inundation with extensive damage to infrastructure, lifelines and homes.

Estimates vary on the number of persons within New Orleans that left the area prior to Hurricane Katrina's landfall. What is apparent, however, is that tens of thousands of residents did not or could not evacuate and were trapped by rising floodwaters that remained in the city for weeks. Water trapped residents in their homes, where they waded, took boats or swam to make shift emergency shelters. Within a day, food and water became scarce, and sanitary living conditions worsened at the "shelter of last resort" Superdome, the emergent Convention Center and at bridges, overpasses and other places where survivors gathered. It took emergency rescue service providers over a week to reach the majority of this trapped population. These residents were temporarily relocated out of the hurricane damaged area, often enduring long bus rides or flights with thousands of persons becoming separated from family and friends, disrupting kin and social networks. Many residents not only lost their homes, but also their schools, health care, places of worship, and jobs.

III. The Consequences

The Congressional Research Service (2005) estimates that about half of the all the people displaced by Hurricane Katrina throughout the Gulf Coast lived in New Orleans. Because of the city's social and economic composition prior to the storm, some authors report that the impacts of Hurricane Katrina were felt most heavily among low-income groups and African Americans (Brown 2005). An estimated one-fifth of those displaced by the storm were poor, and 30% had incomes that were 1½ times below the poverty line. Approximately 44% of the storm victims were African American. An estimated 88,000 elderly persons (age 65 and older), many with strong community ties, may have been displaced, along with 183,000 children. Katrina's impact on individuals, families, social institutions and communities will be last for years. In addition to the displacement of the city's residents, over a thousand persons lost their lives, many of who were old, African-American, disabled and poor (Louisiana Department of Health and Hospitals, 2006).

The sense of loss that residents, those that remain in the city as well as those who were relocated to other parts of the country, is enormous and in many ways, immeasurable. Within a city characterized by poverty, crime, substandard schools and housing, the cultural and historical ties were the strengths of the city. As these ties are fragmented, it makes rebuilding the other institutions (economy, schools, and housing) even more difficult. Not only were their homes destroyed, but everything about their daily life was altered. Because of the culture and climate of the city, artists, musicians, photographers, and film makers flocked to the city. One of the strongest components of the city's infrastructure were the musicians who lived and were part of the city's fabric- the Marsellis family, the Neville family, Batiste family to mention a few. The Neville family is an example of how the storm has dispersed musicians and their families. While the Neville's played all over the world, they always came home to closeout the New Orleans Jazz and Heritage Festival. They have not returned—they have raised money for the city and their musicians, but have not come home. Many of the musicians, such as Irma Thomas, lost their homes to the storm which included her music, instruments and a lifetime of work. Photographers and filmmakers lost their entire work in the storm. Galleries lost their collections.

Another important aspect of the culture of the city is the food. As of spring 2006 only of every three restaurants in New Orleans have re-opened. In a city with more than 2000 restaurants, the culinary tradition in New Orleans and the surrounding area was a major aspect of every day live. From the neighborhood restaurant to Brennon family empire, the city celebrated life through food in homes and restaurants.

Pre-Katrina New Orleans was also dominated by extended families that had generations of history in a neighborhood. These strong family ties meant that in the 9th Ward for example, a person might live next door to their sister, with their mother and father in the next block and their grandparents several streets over. These types of community and family ties were shattered by the storm and flood. From accounts, family members tried desperately to get their elderly parents, aunts, and uncles to leave, especially in 9th Ward.

Another important aspect of the communities in New Orleans and the surrounding areas were the congregations. Pre-Katrina, there were more than 800 separate congregations in New Orleans. These congregations were part of the infrastructure of the city. In the lower 9th Ward, some streets had four churches on the same street. On one of the streets stands a congregation, Battleground Baptist Church that exemplifies the story of the storm. The congregation had been there more than 40 years and now its pastor and congregation are scattered throughout the country.

The immediate physical damage made large portions of the city uninhabitable, with thousands of residential, commercial, and public structures destroyed. Basic infrastructure facilities, such as power, water, sewer, and natural gas lines became inoperable and continued to be out of service for months after the event.

The breaching and overtopping of the levees caused a breakdown in New Orleans' social structure, a loss of cultural heritage, and damage to historic structures, dramatically altering the physical, economic, political, social, psychological and social character of the area. These impacts are unprecedented in their social consequence and unparalleled in the modern era of the United States and will remain part of the regional and national social, historic and cultural consciousness for decades.

Section Two: Approach and General Methodology

This section describes the overall approach and methods used in this analysis. Data was derived from a variety of secondary sources as well as some primary observation data collection, specifically related to re-population estimates.

I. Approach and Study Process

An expert panel developed a draft work plan to provide a general direction for the study. This draft work plan focused on neighborhoods (communities inside and outside New Orleans proper) and social institutions serving the residents. After a New Orleans site visit and meeting, the expert panel finalized the work plan. Because of the complexities of the analysis, the panel agreed to become part of the sub-task execution team. The team worked in a "virtual" environment using e-mail and an Internet group site to facilitate their work. Team members gathered data, conducted analyses, shared findings and wrote up the results using a collaborative process to compile the report. All members share in the production of the interim and final report products.

Team members included:

- John Beggs, Optinet Resources (Louisiana State University)
- Susan Cutter, University of South Carolina
- Tom Denes, URS Corporation
- Joan Exnicios, Corps of Engineers, New Orleans District
- Jeanne Hurlbert, Optinet Resources (Louisiana State University)
- Brenda Phillips, Oklahoma State University
- Ed Rossman, Corps of Engineers, Tulsa District
- John Singley, Corps of Engineers, Institute for Water Resources
- Pam Jenkins, University of New Orleans

Many others were involved in data collection and analysis. There input was vital to the completion of the analysis to date.

II. General Methodology

The team identified key units of analysis (i.e., social units) and changes in those units over time using three discrete time periods:

- Pre-Katrina
- Immediate post-Katrina (Sept 2005 – May 2006)
- Post-Katrina period (after June 1, 2006)

The team gathered and analyzed quantitative secondary (existing) data from a variety of sources (e.g., census data) to provide quantitative measures of pre-Katrina conditions and observed changes. To provide a meaningful context for interpreting those data and to supplement them, the team gathered and analyzed qualitative data. To measure the immediate post-Katrina situation, the team developed a strategically-chosen primary data collection task, using both quantitative and qualitative (observation) methods, and also relied upon secondary sources. The team then used existing scientific literature to project beyond the immediate post-Katrina period (after June 1, 2006) in a section that follows the reporting of data by parish and community.

Some of the analyses done in conjunction with this analysis examined scenarios of consequences under vary conditions of levee performance, including conditions with the levees un-breached. Under those scenarios hypothetical floods would have occurred but to far lesser extent than what actually occurred. The study team felt that estimating those hypothetical social consequences would be highly speculative. Social consequences under these hypothetical conditions are not provided in this analysis.

III. Units of Analysis

The primary units of analysis are neighborhoods, communities and parishes. These units of analysis are examined through various social, cultural, and historic indicators that include both qualitative and quantitative measures.

Because of the urban nature of Orleans Parish, the unit of analysis within that parish is the neighborhood in which people reside. The neighborhood is considered to be a meaningful social unit, representing the interactions, social processes and organizations of those living and conducting business within that area.

Outside of Orleans Parish, but within the immediate impact area affected by the levee performance, the units of analysis are the Parish and the larger communities within those Parishes. The classification of units of analysis is not equal across all of the focal areas, so for the analysis, this report uses two primary sub-group indicators: social characteristics and historical/cultural resources (Table 2-1). The units of analysis are outlined in Table 2-1 below, with illustrations of how those units were spatially enumerated.

Table 2-1 Units of Analysis		
Geography	**Unit of Analysis**	**Spatial enumeration**
	Social	
Within Orleans Parish	Population living within neighborhood	Sum of US Census tracts (defined neighborhoods)
	Population living within planning districts	Sum of US Census tracts (defined neighborhoods)
	Institutions (by type)	Location
Outside Orleans Parish	Parish	US Census parish boundary
	Community	Incorporated place
	Institution (by type)	Parish
Region	Gulf Coast Impacted Area	Areas Adjacent to New Orleans Metropolitan Area
Nation	Areas outside the immediate hurricane impacted area	Focus on Areas with Largest Number of Evacuees
	Historical and Cultural Resources	
Within and outside Orleans Parish	Geographic points/locales	Specific point locations (longitude & latitude)
	Neighborhoods	Self-identity, sense of place
	Community	Self-identity, sense of place

IV. Variables

A number of variables were selected to quantitatively represent the social characteristics of the population as well as the social, cultural, and historic conditions of the area in an effort to describe the impacts on each of these measures. The majority of these variables are derived from secondary data sources such as the U.S. Census. The actual date varies by date of observation, depending of availability of the US Census data. This presents methodological problems in measurement and reliability, if, for nothing else, social conditions are not static. However, for the purpose of this analysis and it scope, the data is assumed to be the best representation of the pre-Katrina conditions. The variables, their connections to the units of analysis, their definitions and measurements, the employed data sources and the relevant time frames are listed in Table 2-2. It should be noted that some inconsistency in what is listed in the table and what was final used in the analysis. Those inconsistencies are due to what information was available at the time of the release of this analysis.

Table 2-2
Social, Cultural, and Historical Consequences/Impacts Matrix (Orleans, Jefferson, St. Bernard, St. Charles and Plaquemines Parishes)

Variable	Unit of Analysis	Definition/Measurement	Data Source	Time Frame (actual data date)
Social				
1. Population/ N of Persons	Parish/Community/ (Neighborhood in Orleans Parish)	Population	US Census/Estimate	Pre-Katrina (2000/04)
			Field Observations	Post- June '06
			LA Recovery Authority-LHH /Rand Corporation/Orleans	Post- Long-Term
2. Families	Parish/Community/ (Neighborhood in Orleans Parish)	Number of Families	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment- (local experts/research literature/expert opinion)	Post- June '06 Post-Long
3. Gender Ratio	Parish/Community/ (Neighborhood in Orleans Parish)	Number men/number of women	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment- (ocal experts/research literature/expert opinion)	Post- June '06 Post-Long
4. Women Head Family w/children	Parish/Community/ (Neighborhood in Orleans Parish)	% Female Head Family w/children	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment (local experts/expert opinion)	Post- June '06 Post-Long
5. Children Under 5 years old	Parish/Community/ (Neighborhood in Orleans Parish)	% Under 5 years old	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment (local experts/expert opinion)	Post- June '06 Post-Long
6. Adults Over 65 years old	Parish/Community/ (Neighborhood in Orleans Parish)	% Over 5 years old	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment (local experts/expert opinion)	Post- June '06 Post-Long
7. Race	Parish/Community/ (Neighborhood in Orleans Parish)	% African American	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment (local expert/expert opinion)	Post- June '06 Post-Long
8. Population with Low Income	Parish/Community/ (Neighborhood in Orleans Parish)	%Family Income Below $20k	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment- (local experts/expert opinion)	Post- June '06 Post-Long
9. Population Middle to Upper Income	Parish/Community/ (Neighborhood in Orleans Parish)	% Household Income Below $50k	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment- (local experts/research literature/expert opinion)	Post- June '06 Post-Long
10. Level of Poverty	Parish/Community/ (Neighborhood in Orleans Parish)	% Below Poverty	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment (expert opinion)	Post- June '06 Post-Long

Table 2-2
Social, Cultural, and Historical Consequences/Impacts Matrix (Orleans, Jefferson, St. Bernard, St. Charles and Plaquemines Parishes)

Variable	Unit of Analysis	Definition/Measurement	Data Source	Time Frame (actual data date)
11. Educational Attainment	Parish/Community/ (Neighborhood in Orleans Parish)	%Persons over 25 Education Less than High School	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment (local experts)	Post- June '06 Post- Long Term
13. Population Living Alone	Parish/Community/ (Neighborhood in Orleans Parish)	% Persons in 1 Person Households	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment/ (local experts/research literature/expert opinion)	Post- June '06 Post- Long Term
14. Housing Stock	Parish/Community/ (Neighborhood in Orleans Parish)	Number of Housing Units	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment (local experts/research literature/expert opinion)	Post- June '06 Post- Long Term
15. Number of Renters	Parish/Community/ (Neighborhood in Orleans Parish)	% Housing Unites Renter Occupied	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment (local experts/research literature/expert opinion)	Post- June '06 Post- Long Term
16. Long Term Residency	Parish/Community/ (Neighborhood in Orleans Parish)	% Lived in Same House 1995	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment (local experts/research literature/expert opinion)	Post- June '06 Post- Long Term
17. Households with No personal transportation	Parish/Community/ (Neighborhood in Orleans Parish)	% households with no vehicle	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment	Post- June '06 Post- Long Term
18. Population Change 1990-2000	Parish/Community/ (Neighborhood in Orleans Parish)	% population change 1990-2000	US Census	Pre-Katrina (1990-2000)
19. Population Change	Parish/Community/ (Neighborhood in Orleans Parish)	% population change	US Census	Pre-Katrina (200 to /04)
			(Repopulation Observational data/ Rand Corporation/LRA	Post- June '06 Post- Long Term
20. Disabled persons	Parish/Community/ (Neighborhood in Orleans Parish)	% of persons/ households with disabilities	US Census	Pre-Katrina (2000/04)
			Qualitative Assessment – (local experts/research literature/expert opinion)	Post- June '06 Post- Long Term
21. Health Care	Broad Institutional Level	Number before and after	LA Dept Health and Hospitals	Pre-Katrina (2005)
		(capacity), number in impact zone	LA Dept Health and Hospitals	Post- June '06 Post- Long Term

Table 2-2
Social, Cultural, and Historical Consequences/Impacts Matrix (Orleans, Jefferson, St. Bernard, St. Charles and Plaquemines Parishes)

Variable	Unit of Analysis	Definition/Measurement	Data Source	Time Frame (actual data date)
22. Education	Parish Level/Broad Institutional	Number of Students enrolled	LA Dept of Education	Pre-Katrina (2004)
			Qualitative Assessment (local experts)	Post- June '06 Post-Long Term
23. Political/Goverance	Broad Institutional	Qualitative Descriptions (local experts)	Qualitative Assessment (local experts)	Pre-Katrina (2005)
24. Public Safety	Broad Institutional Level	Qualitative Descriptions /(local experts)	DHH	Pre-Katrina (2005)
			Qualitative Assessment (local experts)	Post- June '06 Post-Long Term
25. Disaster Preparedness Warning/Response	% household w/o vehicle/ Broad Institutional	US Census/ Qualitative Descriptions	Qualitative Assessment (local experts/research literature/expert opinion)	Pre-Katrina (2005)
				Post- June '06 Post-Long Term
26. Socio-Economic (Employment)	Broad Institutional Level	Qualitative Descriptions	Qualitative Assessment (local experts/expert opinion/research) literature)	Pre-Katrina (2005)
				Post- June '06 Post-Long Term
Institutional/Cultural				
27. Community Centers	Parishes, communities	Number of community centers in impact zone	Qualitative Assessment (local experts)	Pre-Katrina (2000/04)
				Post- June '06 Post-Long Term
28. Churches	Broad Institutional Level	Qualitative Descriptors	Qualitative Assessment (local experts/unpublished data bases)	Pre-Katrina (2000/04)
29. Service Organizations/Volunteer	Point	Qualitative Descriptors	Qualitative Assessment (local experts)	Pre-Katrina (2000/04)
				Post- June '06 Post-Long Term
30. Art and Entertainment shows, museums, festivals	Point	Number of advertised events before/after	(Qualitative Assessment) (newspapers)	Pre-Katrina (2005)
				Post- June '06 Post- Long Term
31. Leisure and recreational facilities	Point	Parks, movie theatres, restaurants, libraries	Qualitative Assessment (media accounts) (local experts)	Pre-Katrina (2005)
				Post- June '06 Post-Long Term
32. Landmarks	Point	Parish	Parish Government (websites)	Pre-Katrina (2005)
			(local experts)	Post- June '06 Post-Long Term

Table 2-2 Social, Cultural, and Historical Consequences/Impacts Matrix (Orleans, Jefferson, St. Bernard, St. Charles and Plaquemines Parishes)				
Variable	**Unit of Analysis**	**Definition/Measurement**	**Data Source**	**Time Frame (actual data date)**
		Historical		
33. Historical Buildings	Point	Points, Polygons	Parish Government (local parish websites)	Pre-Katrina (2005)
			(local experts/media accounts)	Post- June '06 Post- Long Term
34. Cemeteries	Point	Cemeteries in impact zone (historic)	Qualitative Assessment (local parish websites)	Pre-Katrina (2005)
			(local experts)	Post- June '06 Post- Long Term

V. Study Area

The study area is defined by scale (local, regional, national) based on the impacts and consequences to populations and institutions. The impacts and consequences are more specific at the local scale and then become more generalized at the regional and national levels. *Local* refers to the immediate hurricane impact area including all Parishes within Greater New Orleans (Jefferson, Orleans, Plaquemine, St. Bernard's, St. Charles, and St. Tammy Parishes). *Regional* scale means those areas adjacent to the metropolitan area as well as the state of Louisiana. *National* includes the rest of the United States**.** Given the national and historic importance of this event, it is important to understand the larger context within which the local and regional impacts and consequences are embedded and the repercussions of levee performance beyond the immediate impact area.

VI. Quantitative Measures of Pre-Katrina Situation in Affected Parishes

As shown in table 2-2, the quantitative analysis relies heavily upon data from the US Bureau of the Census for these measures (US Bureau of Census, 2006). Sources include Summary Files 1 and 3 (SF1 and SF3) of the 2000 Decennial Census and the 2004 American Community Survey (ACS). Many measures come directly from those data; we detail here the calculations for those that did not. We calculated five measures of median value (age, contract rent, housing value, household income, and family income) for the 73 New Orleans neighborhoods. To construct these measures, we aggregated a distribution of these indicators from census data at the tract level. We then used a standard formula for calculating a median from grouped data.[3]

[3] This estimation is calculated as lower real limit of the median class, plus a proportion of the width of the class. This proportion is equal to the distributional position of the median (the number of observations in a distribution divided by two) minus the cumulative frequency of the class below the median class and then this difference is divided by the class frequency.

The sex ratio is calculated as the number of men in a population, divided by the number of women. This ratio is multiplied by 100. The ratio is then interpreted as the number of men per 100 women in a population. At birth, this ratio stands at about 105; generally, for the US population, this figure reaches 100 for groups in their early- to mid-20s and gradually decreases across the later years (because women have longer life expectancies than men).

The economic dependency ratio is a summary measure that evaluates an age distribution. The numerator of this ratio is the number of people who are less than 20 years old plus the number who are 65 years of age or more. The denominator is the number of people 20 to 64 years old. The numerator is considered to be the population that lies outside of their economically active years and the denominator represents the population in their potentially economically active years. This ratio is multiplied by 100 and interpreted as the number in their economically inactive years that needs to be supported by 100 people in their economically active years. The economically inactive population may be separated into a youth component and an elderly component and a ratio can be constructed for each component. These ratios will sum to the overall dependency ratio. The youth component may also be constructed as the number of people less than 16 years old or 18 years old. Because recent work by the Bureau of the Census has used the 20-year old figure, we chose to use that value as the delimiter.

Our indicator of racial diversity is constructed with an index of qualitative variation (IQV). This measure compares the number of observed differences on a characteristic of a population to the number of differences that would be observed if the population was evenly spread across the categories of a characteristic. For example, we used 5 race/ethnicity categories, if the population were evenly spread across the categories, 20% of the population would fall into each race-ethnic group. Thus, the indicator shows the proportion of possible differences in a population that are actually observed. The measure is multiplied by 100 so that it may be interpreted as a percentage. A 0 on this measure indicates that there is no variation in the population on the characteristic (everyone is the same). A score of 100 indicates the population is evenly spread across the categories, diversity is at the maximum.

To measure income inequality, we calculated Gini coefficients for both household and family income. These measures tap the degree to which income is concentrated in one or more segments of a population, as opposed to being spread evenly across a population. Higher values on this measure represent greater inequality. We multiplied the coefficient by 100 to represent an index of income inequality.

Quantitative Impact Measures: Degree of Flooding and Differential Impact. To estimate the degree of flooding in a block group, we began with data on the amount of flooding (minimum, maximum, and mean levels) for blocks in New Orleans. This flood data was from generated by the New Orleans District office in January 2006 which provide depth of flooding by census block. This file did not contain data for the West Bank of New Orleans or the Lake Catherine neighborhood on the eastern edge of New Orleans. There are 984 blocks and 56,782 people in West Bank New Orleans. There are 106 blocks and 1760 people in the Lake Catherine neighborhood. There were 250 other blocks in New Orleans that did not have flooding information. Of these, only 11 had a residential population (5 in Lakewood with 371 people, 4 in Bywater with 81 people, 1 in Pontchartrain Park with a population of 2, and 1 in Village de l'est with a population of 5). The other 239 blocks had no residential population. Thus, although we began with the 10,181 blocks in New Orleans, we used 8841 blocks in the process of estimating flood levels for block groups and neighborhoods. We characterized each neighborhood or block group flood level as the average of the mean level of flooding for each block. We classified flood levels as: no flooding, less than 2 feet of flooding, flooding between 2 and 4 feet, flooding between 4 and 8 feet, and over 8 feet. Available evidence indicated that the extent of flooding was less than 2 feet on the West Bank. When we examined the relationships among income, race, and flooding, we classified the West Bank neighborhoods as having 2 feet or less of water, but we excluded the West Bank and Lake Catherine areas from the sampling frame for the re-occupancy analysis (described below).

To examine the relationship among income, race, and degree of flooding (thus, to assess differential impacts), we began with a distribution of household income by race, at the block group level. We measured race as blacks and whites (thus, we excluded non-black nonwhites from the analysis.) To measure income, we constructed indicators of the number of households with less than $50,000 in income and those with at least $50,000, for each block group. We then constructed separate income distributions, using these categories, for blacks and whites. That allows us to examine the relationships among income, race, and the level of flooding. These data and tables are provided later in the narrative overview.

The 2003 New Orleans Survey. Prior to Katrina's impact, several research teams attempted to estimate the proportion of individuals who would evacuate New Orleans if a severe hurricane approached. One such team, part of the Louisiana State University Center for the Study of the Public Health Impacts of Hurricanes, completed 611 telephone interviews with a random sample of residents of the New Orleans metropolitan area in 2003.[4] Among the ways that these researchers measured likely evacuation behavior was to ask respondents whether, if a Category 4 hurricane threatened New Orleans, they would (a) leave the area, (b) remain in the area but leave their homes, or (c) remain in their homes.[5] We incorporate those data in our discussion of the pre-Katrina situation in Orleans Parish. Next, we describe the measures used in the 2003 New Orleans Survey for the evacuation analysis.

Hurricane-Related Measures. To tap prior evacuation behavior, respondents who were living in the New Orleans/Jefferson Parish area in September, 1998 were asked whether (1) or not (0) they left New Orleans[6] and if they went to the house of a friend or relative. All respondents were asked whether they *had* a friend or relative outside the area to whose house they could have evacuated in Hurricane Georges.

[4] These researchers used random-digit dialing (RDD) to produce a sampling frame. Because the sampling unit was the household and the unit of analysis individuals, the investigators selected randomly among adult residents of sampled households. The sampling frame excluded households that did not have working landline telephones at the time of the survey; excluded households were more likely than those with a probability of inclusion to contain low-income and/or minority residents.

[5] Because no mandatory evacuation order had ever been issued in New Orleans, the scenario did not specify that evacuation was mandatory.

[6] No mandatory evacuation order was issued for Hurricane Georges. However, the serious threat posed by the storm prompted a large-scale of Orleans and surrounding parishes, employing "contraflow" evacuation techniques. Hurricane Georges made a slight, last-minute turn, sparing the New Orleans area and striking the Jackson County, MS area.

The “index of perceived threat” from a severe storm combines a series of indicators of the likelihood of loss and harm if a storm as serious as Hurricane Andrew struck New Orleans. Respondents were asked whether, under that scenario, they thought there would be a serious threat (1), somewhat of a threat (2), not much of a threat (3), or no threat at all (4) that they would (a) lose their lives and (b) be injured if a storm of that magnitude struck New Orleans. Surveyors then asked whether such a storm would be likely to cause severe damage (1), moderate damage (2), little damage (3), or no damage (4) to their property. These items were averaged to construct a threat index. To measure hurricane experience, surveyors asked respondents whether they had ever been through a hurricane, prior to Hurricane Georges. They measured flood threat by combining two dichotomous measures: one that tapped whether (1) or not (0) respondents' houses had flooded previously and one that captured whether (1) or not (0) a respondent perceived that she or he lived in a flood-prone area.

Social Support. To measure perceived adequacy of social support, the researchers asked respondents how much of the time they felt they had enough people to talk to, coding it as a lot of the time (1), some of the time (2), only once in a while (3), or never (4).

*Stress Index***.** The index of stressful life events included measures of whether, in the last year, respondents had experienced the following: death of a close friend or relative, problems at work, problems with family, financial problems, serious illness or injury (to self), or “other” stressful life events. These dichotomous measures were summed.

Additional Individual Characteristics. The team measured age and education of respondents in years. Race contrasted African-American respondents (1) with those who classified themselves as white, Asian, or “other” (0); the survey also measured gender as female (1) and male (0). The dichotomous measure of employment compared part-time employees (1) to all others (0). Marital status contrasted respondents who never married (1) with those who were separated, widowed, divorced, or currently married (0). Researchers included a measure of whether (1) or not (0) respondents had children under 6 living in the household. Vehicle ownership compared respondents who owned an automobile, truck, or motorcycle (1) with those who do not (0). Tenure in the area was measured as the proportion of respondents' lives that they had lived in New Orleans (e.g., number of years lived in the New Orleans metropolitan area/age).

Social Network Characteristics. To measure respondents' network characteristics, these researchers used the standard procedure, the name generator-name interpreter sequence. The first name generator, which modified the name-eliciting question used in the 1985 General Social Survey, tapped routine confidantes of respondents (see Bailey and Marsden 1999; Burt 1985; Marsden 1987) by asking them to name up to five individuals with whom respondents discussed important matters in the six months prior to the interview. To tap the routine associates of respondents, they followed Fischer (1982) and asked them to name up to five individuals with whom they socialized routinely. Both of these name generators tap relatively strong ties—e.g., individuals to whom respondents were emotionally close (Bailey and Marsden 1999; Beggs, Haines, and Hurlbert 1996; Marsden 1987; Munch, McPherson, and Smith-Lovin 1997). To ensure that they measured the prevalence of weaker ties, they included a third name generator that asked respondents to name up to five individuals whom they knew well enough to call up on the phone but did not know well—individuals they would call "acquaintances or friends-of-friends" (see Granovetter 1974). This name generator tends to tap weaker ties than the other two. The networks that we examine include all non-redundant network elicited by these four name generators (maximum possible=20). The measure of network size reports that number.

The name interpreter questions gathered information about the personal characteristics of the named network members. One of the key characteristics they tapped was respondents' reports of whether (1) or not (0) network members left their communities as Hurricane Georges approached. These researchers also asked what network members would be available to help clean up after a storm.

Repopulation Assessment Observations. Although the present study relied primarily upon secondary data sources, some field-based data collection was required to estimate the degree and location of repopulation and to ground the understanding of the process of repopulation. Agencies such as the Louisiana Recovery Authority (with the Louisiana Department of Heath and Hospitals) have provided parish-level estimates of the degree of repopulation on an ongoing basis. However, an important question that those data cannot address is where the highest levels of repopulation are occurring—and what areas remain largely unoccupied. The fieldwork was designed to address that question by estimating the extent of current repopulation and probable reoccupation in selected neighborhoods in New Orleans. These data allow us not only to describe repopulation but also to estimate the size and key characteristics of sampled areas in the New Orleans neighborhoods we studied. For this fieldwork, we used a variety of research techniques, incorporating both qualitative and quantitative methods.

Fieldwork began by categorizing block groups in all 73 neighborhoods in the city, based upon the socioeconomic status of their residents and the level of flooding they experienced in Katrina. When constructing our sample frame, we excluded the West Bank and Lake Catherine neighborhoods because data were not available (see above).To stratify the block groups, we used a five-category schema for levels of flooding and a four-category schema for socioeconomic status, producing 20 different strata or cells.[7]

Each block group, then, was placed in a cell representing its (categorized) level of flooding and socioeconomic status. For example, a given block might be placed in the cell representing the lowest level of flooding and the highest level of socioeconomic status. Within the strata (e.g., among the 20 different cells), we selected randomly among block groups using the following procedure. First, block groups within the strata were assigned a random number and we selected the block group with the lowest number in each for our sample. If that block group contained a significant number of blocks with zero population, we selected the next block group. Second, we ensured that we selected only one block group from each of the 73 New Orleans neighborhoods. Our final sample contained 20 block groups representing 20 different New Orleans neighborhoods.

[7] The measure of flooding is described above. To create the measure of socioeconomic status, we used five measures: median family income, median household income, two measures of median value of owner-occupied homes, and the percentage of college graduates in the block groups. Factor analysis revealed a single underlying dimension for the five measures of socioeconomic status, on which all of these indicators loaded strongly. We then created factor scores for each block group and assigned a socioeconomic status score to each block groups; and then divided the distribution of block groups into quartiles.

Field observation methods were used to estimate the degree of repopulation and rebuilding in sampled block groups. Teams of observers entered the neighborhoods at designated times, recording information for each house in a designated block (see Table C-3a for an overview below and C-2-3b through C-2-5 for detail information Sub-Appendix C). Preliminary observations suggested that rebuilding activity tended to occur more frequently on weekdays in higher-income damaged areas and on weekend days in lower-income damaged areas, the field data collection was scheduled accordingly. Field sampling took place between April 3, 2006 and May 9, 2006.

The coding schema for the field observers was designed to tap variation in levels of re-occupancy. We began by identifying key indicators of re-occupancy. These included the presence of working cars (coded according to whether cars were present and working, present but flooded/nonworking, or absent); indications that waterlines and/or tags had been cleaned (used for neighborhoods that experienced flooding); whether buildings had been gutted, whether repairs had been done or were underway (in neighborhoods with flooding and/or damage); the presence of trash or debris at the curb that had been placed there recently; new signs for political candidates or contractors; people observed working on houses (whether contractors or apparent owners); utility poles for temporary trailers; temporary trailers; lights on in the house at night. Because preliminary observation indicated that rebuilding activity tended to occur more frequently on weekdays in higher-income damaged areas and on weekend days in lower-income damaged areas, we structured the observation schedule accordingly.

Each neighborhood was documented at least once; another team was sent out to verify the exact number of structures a second time, and a selected sample of neighborhoods was selected for a reliability check. For these neighborhoods, one of the original coders went to the neighborhood, along with a faculty member. We chose, for example, to revisit the two Eastern New Orleans neighborhoods from 7:00 am to 11:00 am to verify the original coders' findings. These early morning neighborhood visits illustrated the sparseness of the repopulation of Eastern New Orleans.

Table 2-3 below provides a snapshot of the sampling effort; additional data can be found later in the section on Orleans Parish and in Sub-Appendix C (see Tables C2-3b through C2-5).

Table 2-3 New Orleans Sample Block Groups

Neighborhood	Flooding Category*	Socio-Economic Status Quartile**	Population	Average Level of Flooding
East Riverside	None	1	417	0.00
St. Thomas	None	2	714	0.00
Irish Channel	None	3	1,105	0.00
West Riverside	None	4	768	0.00
St. Claude	0-2 F	1	728	0.63
Leonidas/West C	0-2 Ft	2	626	1.15
Central City/Ma	0-2 Ft	3	884	0.71
Garden District	0-2 Ft	4	527	0.11
Bayou St. John	2-4 Ft	1	1,294	3.99
Fairgrounds/Bro	2-4 Ft	2	879	3.16
Uptown	2-4 Ft	3	773	3.46
Lakeshore/Lake	2-4 Ft	4	682	2.44
Treme'	4-8 Ft	1	736	4.08
Milan	4-8 Ft	2	609	5.68
Plum Orchard/Bo	4-8 Ft	3	1,677	6.32
Edgelake/Little	4-8 Ft	4	1,556	7.54
Lower Ninth War	Over 8	1	934	9.56
St. Anthony	Over 8	2	648	9.61
Gentilly Terrac	Over 8	3	643	8.08
Lakeview	Over 8	4	703	10.60

***Flooding Category** – We used information on the mean level of flooding for each block to construct an average level of flooding for a block group (an average of the mean block levels). We then assigned each block group to a flooding category based upon the average level of flooding for the block group. Flood depth data derived for USACE New Orleans District January estimates of flood depths. Appendix C table 2-3b provides more detailed information.

****Socio-Economic Status Quartile** – To construct this scale we factored three measures of median income in 1999 ((1) Households, (2) Families, and (3) Nonfamily households), 2 measures of median housing value ((1) Owner-occupied and (2) Specified owner-occupied housing units), and a measure of education level (the percent of population 25 and over who are College Graduates). These items all loaded onto one factor with the nonfamily income measure loading at .68 and the other indicators loading between .87 and .92. This factor accounted for 73.3 percent of the variance. The median on the scale was -.282648. We raised the median to zero by adding .282648 to the scale, then divided the block groups into quartiles. The quartile boundaries were -.693, 0.0, and .359. We then assigned Socio-economic Status Quartile scores according to the quartile location of each block group.

Assessment of New Orleans' Congregations. Another important aspect of the post-Katrina assessment is to understand its impact on local institutions—particularly voluntary organizations. To do this, we relied upon a survey conducted by the Urban Institute. Because that survey did not include congregations and because these represent such a vital aspect of not only the nonprofit sector in New Orleans but also the social fabric of the city, we also incorporated an assessment of the extent to which New Orleans congregations that existed pre-Katrina are "up and running." These data were collected by Louisiana State University and University of New Orleans researchers who attempted to contact each congregation (using a list of pre-Katrina congregations). Two phone calls were made to each congregation. Where a congregation could be contacted (e.g., the number was not disconnected and someone answered the phone), they measured whether services were being conducted and collected qualitative information on how Katrina affected that congregation. This study, then, provides both qualitative and quantitative data on this key aspect of the nonprofit sector.

Quantitative Assessment of Recovery in Jefferson Parish. One of our strategic illustrations for the level of recovery relies upon the 2006 Citizen Recovery Survey. Developed to estimate the degree of recovery in Orleans and Jefferson Parishes, this survey was designed as the first wave of an ongoing panel. It focuses on concerns about, and satisfaction with, life in these parishes; health and psychological distress; and current living situation. The Principal Investigators for the project include Susan Howell, University of New Orleans; John Beggs and Jeanne Hurlbert, Louisiana State University; and Valerie Haines, University of Calgary. To collect these data, they conducted a telephone survey with a random sample of Jefferson and Orleans Parish residents, using random-digit dialing (RDD) to construct the sampling frame.[8] Because data collection is complete for Jefferson Parish, we can report preliminary unpublished results. We focus on key aspects of health, distress, and satisfaction. To provide a referent, we compare measures of distress and health to the 2003 baseline data on New Orleans that were collected under the auspices of the Center for the Study of the Public Health Impacts of Hurricanes (see description above). Although those 2003 data were collected only from residents of Orleans Parish, they provide a useful baseline comparison for other parishes in the New Orleans metropolitan area. We focus in this report on key measures of distress, health, and perceived living conditions in the area.

Qualitative Assessments: Sources. The vignettes included in this section come from a series of interviews with a number of local informants in the local parishes. These accounts have been documented since on or about August 29th. They come from conversations in informal settings and formal meetings with a variety of residents of Orleans, Jefferson, Plaquemines, and St. Bernard Parish and local informants ("experts") in community affairs. These vignettes capture, in narrative fashion, the everyday life of individuals and families since Katrina and Rita.

Historical and Cultural Data Sources. Historical and cultural interpretations were derived from a variety of sources. Several team members have lived and worked in New Orleans for decades; their insights and observations proved valuable in understanding not only the local history and culture but how those contexts are and were experienced pre- and post-Katrina. A number of additional sources were consulted including internet sites, agencies, local historical and cultural preservationists and relevant agencies.

VII. Limitations

Due to time limitations, this study relies heavily on data gathered by others. The issues of quality, compatibility, reliability and validity of these data as they relate to the purpose of this analysis are a concern, yet they do provide some measure of the nature and magnitude the consequences on the social system. Despite numerous requests, some agencies and offices were

[8] In Orleans Parish, the RDD sample included only target zip code areas in which a high proportion of landline phone service has been restored.

unable to provide key documents and data, presumably because of the hurricane's impact on their capabilities and personnel. Further, because of the unprecedented nature of the catastrophe, existing models, traditional data collection strategies and previous hurricane impact studies did not readily apply to the events in New Orleans and the Gulf Coast. Finally, this report is not able to capture the full breadth and depth of the impacts because of a variety of situational constraints.

Section Three: Definition of Terms

The purpose of this section is to provide a common set of definitions on the terminology used in the remainder of the report. This section also provides an overview of some of the social science conceptualizations and findings on disasters that equally inform our assessment. Historic and Cultural terminology is defined in Sub-Appendix D.

I. Disasters and Catastrophes

Hazards consequences fall along a general continuum from small-scale emergencies such as a localized landslide affecting a few homes to disasters, a singular event that disrupts daily community functions and promotes closures in schools, businesses, and hospital facilities (Quarantelli 1998; Perry and Quarantelli 2005; Quarantelli 2005). Catastrophes are larger-scale magnitude events that compromise expected organizational and socio-behavioral responses; regional and even national capacities to respond may be significantly undermined depending on the scope and magnitude of the catastrophe (Quarantelli 2006). Katrina and the flood, by any standard, are catastrophic in the magnitude and scope of its physical damage, unprecedented in its social impacts and certainly threatening to cultural and historical resources. Little scientific understanding exists about catastrophes, however, which makes this assessment challenging.

II. Populations at Risk

The total number of people living within a specified hazard area or impact zone is termed the population at risk. Specific populations experience more difficulty in preparing for, responding to and recovering from disasters, a reflection of the structured social vulnerability within a given location. For example, persons with disabilities may experience difficulty in evacuation because support persons are unavailable (Van Willigen, Edwards and Hessee 2002) or because planning did not encompass their needs (Parr 1997). Research indicates that populations experiencing higher risk typically include low-income families, the elderly, children, racial and ethnic minorities, women, persons with disabilities, the non-ambulatory, the non-English speaking, tourists and recent immigrants (NHRAIC 2001; Heinz Center 2002). Persons living at the intersection of multiple vulnerabilities, for example an elderly, low-income woman with health issues, are likely to experience significantly higher risks for injury or death than a younger, healthy woman with financial resources sufficient to prepare, respond and recover from disaster. The affected parishes, particularly Orleans, St. Bernard's and Plaquemines Parish, included high numbers of these populations pre-Katrina.

III. Social Vulnerability

There are characteristics of individuals and groups that make them more or less able to respond to environmental threats and recover from them. These pre-existing conditions result in the creation of socially vulnerable populations and they help to define who is most likely to be affected during a disaster event (Heinz Center 2002). Differential levels of social vulnerability are often a product of social inequalities (not merely based on wealth), and limited access to education, health, public safety, and lifeline resources. When measured quantitatively, using the Social Vulnerability Index (Cutter et al. 2003) changes in the relative levels of social vulnerability can be seen over time. When mapped, disparities between places with higher and lower levels of vulnerability become obvious, such as the case for the Gulf Coast and Hurricane Katrina (Cutter, 2005; Cutter et al. 2006; Cutter and Emrich 2006). The ability to adequately respond to disasters is a function of the social vulnerability of a community, which in turn affects the capacity of that community to recover from disasters.

VI. Institutions

Social institutions are defined as ways of providing a basic societal need (Mills 1959). Efforts to meet those needs are often situated in physical locations. To illustrate, religions vary in how they support parishioners through joyous events such as weddings or provide solace during events such as disasters and funerals. A given culture's ways of meeting key societal needs will take place in physical locations like mosques, churches and temples. As another illustration, urban areas routinely provide trauma centers and helicopter transport, as a way of providing critical medical care often disrupted by disasters. Generally, key social institutions include the family, government/political structures, education, the economy, religion, and health care. This chapter will touch upon these key institutions pre- and post-Katrina and the impact their losses generate for the populations they typically serve(d).

VII. Voluntary and Community-Based Organizations

The non-profit sector in southeast Louisiana represented a critical sector for both the economy and service provision pre-Katrina. We focus on two types of voluntary organizations: membership organizations that physically meet (such as the Knights of Columbus, Kiwanis, PTA, Rotary; this category includes churches) and service-based, non-profit organizations. The focus of our analysis is to estimate the proportion of pre-Katrina voluntary organizations, in these two categories, that exists post-Katrina. We are currently evaluating the scope of this analysis, which will include both an analysis based on data that we collect and reports of data collected through other sources. Figure B 3-1 (see link in Sub-Appendix B) provides one example of the latter by illustrating the number of child care centers that exist post-Katrina in New Orleans and maps their locations. As that map shows, less that 16% of the child care centers that existed in the area before Katrina have reopened and those centers cluster in a small geographic area of the city.

VIII. Community and Neighborhood

The terms community and neighborhood are used as frames of reference for the research in this paper. Yet, these terms are defined in so many ways that the concepts are difficult to measure. For the purposes of this project on the social impacts of the Katrina event and subsequent levee failure, community refers to a group of people who share social interactions and some common ties between themselves and the other members of the group and who share an area for some time. The last factor, area, is used intentionally here to refer to place in a geographical and social sense. We will examine through the concept of community an area's sense of place that arises as these parameters are defined in the Pre-Katrina and Post-Katrina emerging footprints of the parishes. Within communities are specific neighborhoods that represent smaller areas than community with distinctive characteristics, specific people, and a sense of history.

IX. Local Administrative and Governance Units

Louisiana is comprised of 64 parishes (administrative units comparable to counties in other states). Louisiana parish governments tend to be decentralized, with authority vested in numerous local officials. Parish governments take two forms: the police jury and the home rule charter (Police Jury Association of Louisiana 2006). Police juries administer 41 Louisiana parishes and operate similarly to county boards of commissioners in other states. Home rule charters occur in three structures: president-council charters, council-administrative charters (found only in Caddo Parish, since 1983), and city-parish consolidation (within a metropolitan area; in 4 of 8 Louisiana metropolitan areas). Consolidated city-parish governments also exist in East Baton Rouge, Terrebonne, and Lafayette Parishes.

Section Four: Overview and Institutional Impacts

I. Introduction- The Experience of Disasters

As described in the prior section, disasters are normally managed through a set of activities organized into the four phases of comprehensive emergency management: preparedness, response, recovery and mitigation (FEMA IS-1; National Governor's Report 1979). This section provides a brief descriptive overview of how those phases relate to the levee failures. For purposes of presentation, we categorize those phases into Pre-Katrina (preparedness and impact/response) and Post-Katrina (recovery and mitigation). Preparedness includes activities such as writing and exercising plans for warning, transportation and evacuation; its goal is to ready the population and response sectors for an event. Response occurs when warnings are issued and efforts to stem the loss of life begin: transportation, evacuation, search and rescue, medical assistance and sheltering serve as common activities. Recovery can be broken into short-term recovery involving restoration of critical infrastructure and lifelines and typically occurs from weeks to months. Long-term recovery, a process that can take years, restores some degree of normalcy to damaged homes, businesses, community services, the physical environment, general infrastructure, and social institutions. The final phase, mitigation, is addressed in other chapters and is not included here.

II. Pre-Katrina

The People. In 2004, the estimated population of New Orleans was 444,515 people (46% male and 54% female, see U.S. Census 2006). The median age was 34.8 years. About 11.2% of the population was over 65, with another 7.8% under age 5. The city was predominately African American (67.9%), while adjacent Jefferson Parish was just the opposite (67.7% white). Within New Orleans, there were small Asian (2.2%) and Hispanic (3.2%) populations. Twenty-two percent of the households were female-headed with no husband present and there were 9.3% of the households that were 65 years and over. Special needs populations, so designated because they need additional help in evacuations, included those with a disability (15.6%), families below the poverty level (14.5%), female-headed households below the poverty level (29.0%), and those households with no vehicles available (21.2%). Detailed presentation of additional demographic data is included in future sections; tabular presentation of demographic data can be found in Sub-Appendix C.

Preparedness. Preparedness includes a suite of activities designed to protect a population from the adverse impacts of disasters. Preparedness normally occurs well in advance of an event and consists of planning, hypothetical simulations and exercises of the plan, and the coordination between levels of government. New Orleans was in the middle of its planning process when Katrina formed and made landfall. The city had been participating in the Hurricane Pam tabletop exercise along with federal and state officials in 2004, but had not fully developed their plan nor did they have coordination between city, state, and federal responses.

Warning and Response to Immediate Threats. Response consists of warning and the behavioral responses to warning, such as evacuation or sheltering in place. The purpose of a warning is to alert the public that an event is occurring and that immediate, life-saving action must be undertaken. Warnings may be disseminated from a variety of sources and public response may differ upon receipt of the message and its interpretation. The public typically moves through multiple steps upon learning of the message including believing that it is credible, confirming that a threat exists, checking to see how others are reacting, determining if protective action is needed and/or feasible, and determining which action to take (Mileti 1999). Confirmation may depend on the credibility of the communicator as well as prior experience with a similar hazard event (Lindell and Perry 2004). The sequence of warning is provided in Box 1 with a fuller timeline provided in the Appendix.

Figure 4-1
Abbreviated Events Timeline of Hurricane Katrina, Greater New Orleans Area.

Tuesday, August 23, 2005 : The weather system is about 350 miles (560 kilometers) east of Miami. The season's 12th tropical depression has formed over the Bahamas.
Thursday, August 25: Katrina has continued to strengthen and is now a hurricane.
Friday, August 26: Gov. Kathleen Blanco declares State of Emergency in Louisiana. Gulf Coast States officials request troop assistance from the Pentagon
Saturday, August 27: Evacuation of Gulf Coast begins. Hurricane Warning Issued. President Bush declares a Federal Emergency
Sunday, August 28: Storm approaches Gulf Coast; 20-30,000 seek shelter in Superdome. Mayor issues mandatory evacuation order. Late PM water begins to top levees.
Monday, August 29: Hurricane makes landfall early AM. Levees in New Orleans fail.
Tuesday, August 30 through first week in September: Nearly 80 percent New Orleans under waters over 8 feet; Thousands trapped in the city; Massive rescue and relief efforts ensue**.**

Warning Messages. Tropical Storm Katrina prompted numerous messages from the National Hurricane Center (NHC), supported by continually escalating media messages and personal contacts from the NHC Director to parish and federal officials.

- Friday, August 27, 8 pm A TROPICAL STORM WARNING REMAINS IN EFFECT FOR THE FLORIDA KEYSAND FLORIDA BAY FROM KEY LARGO SOUTH AND WESTWARD TO KEY WEST AND THE DRY TORTUGAS.

- Saturday, August 27, 7:00 pm, MAXIMUM SUSTAINED WINDS ARE NEAR 115 MPH...WITH HIGHER GUSTS. KATRINA IS A CATEGORY THREE HURRICANE ON THE SAFFIR-SIMPSONSCALE. STRENGTHENING IS FORECAST DURING THE NEXT 24 HOURS...AND KATRINA COULD BECOME A CATEGORY FOUR HURRICANE LATER TONIGHT OR SUNDAY.

- Sunday, August 28, 7:00 am MAXIMUM SUSTAINED WINDS ARE NEAR 160 MPH...WITH HIGHER GUSTS. KATRINA IS A POTENTIALLY CATASTROPHIC CATEGORY FIVE HURRICANE ONTHE SAFFIR-SIMPSON SCALE.

State and local officials activated the Louisiana emergency evacuation plan on Saturday, August 27 at 9 a.m. starting with the southern most parishes. Contraflow traffic operations began by 4pm on Saturday, continuing until 6 pm on Sunday. By landfall, an unprecedented 1.2 million had evacuated from the area undoubtedly saving many lives.

Evacuation. Evacuation is a protective action response that is ultimately designed to move populations out of harm’s way in advance of hurricanes. There are many challenges in ordering and implementing evacuations along the nation’s hurricane coasts, and the entire process is complicated by the uncertainties in the timing, location, and strength of the landfalling hurricane. One of the most significant aspects of hurricane evacuation is clearance time—or the length of time it takes to clear the transportation network of vehicles prior to tropical force winds reaching the area. The clearance time is a function of the population size in the affected area, its mobility, and the road network and capacity. For New Orleans, the density of population, the lack of individual mobility of some residents (e.g. those without cars), and the low-lying nature of many of the egress routes, meant that the time to effectively clear the area was on the order of days, not hours. In New Orleans Parish, the clearance time estimated by emergency planners was 72 hours, yet the official evacuation order was given a mere 24 hours in advance of Katrina's landfall.

Unpublished data from Louisiana State University 2003 survey data provided for the pre-Katrina Hurricane Pam exercise indicate that approximately 31% of respondents they would leave the area for a Hurricane Pam scenario. Data indicate that the likelihood of evacuation declines as both the level of hurricane experience and the length of residence in New Orleans increase. Consistent with prior literature, those who perceived a greater threat were more likely to indicate that they would evacuate, regardless of whether "threat" entailed threat of injury, property damage, or loss of life. Resources clearly affected the probability of evacuation: Nearly three-quarters of those who owned cars reported that they would leave the area, compared to half of those who did not [employed vs. unemployed]. Persons who reported better health, those who lacked disabilities, and those who reported greater coping skills and higher levels of mastery reported that they were more likely to leave than those in poorer health, the disabled, and those with lower coping skills and mastery. Whites were more likely than African-Americans and women were more likely than men to indicate that they would leave the area. Persons with young children were more likely to leave than those who did not. Data analysis indicates that being employed full-time decreases the likelihood of evacuation but having young children in the household increases the probability. Older persons and individuals who had lived in the New Orleans area longer were less likely than those with shorter tenure to report they would evacuate and vehicle owners were more likely than those who lacked transportation. Individuals reporting having experienced more stressful events in the last year were significantly less likely to evacuate than those with lower stress levels. Persons who reported more adequate levels of routine social support—help from others and emotional help--were more likely to report that they would evacuate than those with less routine support. However, perceiving that social support would be available to deal with a hurricane, after a storm, *decreased* the likelihood of evacuation. Finally, being embedded in a network in which a higher proportion of individuals evacuated for a previous storm indicates the likelihood that the individual will evacuate.

By some standards, the massive evacuation of New Orleans was successful for those who were able to leave or chose to leave. The large numbers of persons that were warned and were able to evacuate was apparently unprecedented in the area's hurricane evacuation history (Laska 2005). However, there are some residents who refuse to evacuate, despite official orders to do so. The reluctance on the part of evacuees to leave is based on a number of factors (as described in the peer-reviewed literature), among them are: perception that the risk is not that severe; assumption that the home is safe; unwillingness to leave pets behind; reluctance to use public shelters; the credibility of warning information; concerns about traffic; and past experience (Dow and Cutter 2001, 2002). Vulnerable populations (defined in the earlier section) often experience considerable difficulty when evacuating. They may lack support systems, transportation, funds for gasoline or hotels, or they simply may not receive an effective warning message. Some reports suggested that persons who were deaf, blind or elderly did not evacuation due to either not receiving an effective warning message. The State of Louisiana has indicated that more than two days are necessary to evacuate the affected population for a future hurricane and that "need a plan and place to relocate the most vulnerable of our population without fail" (State of Louisiana 2006).

III. Post-Katrina Impacts- The People

Cascading Effect of Levee Failure. A wide range of pre-existing conditions came together simultaneously to create catastrophic conditions requiring unprecedented behavioral, organizational, and governmental response. Urban populations unable or unwilling to evacuate, local topography, and the geographical and historical circumstances (Cutter 2005) set up the potential for a long-anticipated event to occur (Laska 2004). Cascading effects occur when a hazard causes a series of domino-like effects from inundation of homes to destruction of critical infrastructure such as utility lines, cellular towers, and more.

Hurricane Rita. Interviews with locals indicate that Hurricane Rita added insult to injury. Evacuees to Baton Rouge, Houston and nearby areas, for example, faced a second evacuation less than two weeks later. Open shelters in Louisiana lost power not long after post-Katrina utility restoration. Those areas that were relatively unaffected by Katrina such as Lake Charles, later experienced heavy damage from Rita. Followed closely by Hurricane Wilma, the "three sisters" as locals describe the three hurricanes, set in motion one of the most organizationally and geographically challenging responses in U.S. history since the 1989 Loma Prieta earthquake that was followed closely by Hurricane Hugo and a typhoon in Guam. Most organizations (voluntary, faith-based, governmental) faced an unprecedented organizational expansion of staff, resources and mission.

Socio-Behavioral Responses: Getting Ready to Leave (if you can). Hurricane Katrina generated one of the largest evacuations of a concentrated, coastal area in history. It is believed that 80% of the residents of Orleans Parish evacuated (10% more than the best estimates for the fictitious Hurricane Pam scenario), suggesting one of the more successful evacuations of an urban area. Considerable numbers of at-risk populations including persons with disabilities, households lacking transportation, nursing home residents, and large families experienced difficulty in mobilizing resources and/or evacuating prior to landfall. Consequently, the flooding that inundated 80% of the city required massive efforts to rescue survivors, provide for immediate survival needs including food, water and medical aid, and offer extended shelter and temporary housing. To understand local pre-impact behavioral response, consider these brief illustrations:

- *First learning of the warning*. This storm came up so quickly that the first warnings were issued without much time for neighbors and family members to 'mull over' the decision to leave. By the time mandatory warnings were issued, many thought they could not leave and so remained, often with multiple vehicles in their driveways and yards.

- *Gathering the family*. Another aspect of pre-Katrina was the constant attempts to convince the extended family to leave. Post-Katrina, many families express regret that they could not convince other members of their families to leave; many of those that stayed died during the event or were subject to days of uncertainty at the emergency shelters.

- *Looking for transportation*. Because of the nature of this event, regular methods of preserving automobile, buses, and trucks were not available. Hundreds of cars were flooded underneath overpasses that historically proved safe areas for vehicles. City buses, school buses, and military transports were also in areas that were very quickly flooded.

- *Mandatory evacuations*. Plaquemines, St. Bernard, Orleans. A mandatory evacuation for a major urban area is a difficult and extraordinary call. Coastal parishes evacuated much quicker, but in this case, many residents were caught in St. Bernard Parish. The mandatory evacuation plan in Orleans left many people in their homes without the time to adequately prepare on many levels to leave. Many people did not want to leave their properties, their pets, or their neighborhood. They thought that they would be safe, and in fact, until the levee breach on Monday, most of the city had survived the hurricane.

- *Shelters of last resort: Superdome*. As part of the city's design, the Superdome was to the shelter of last resort, initially for the medically needy. However, by Monday, estimates ranged (from a variety of personnel in medical, law enforcement and military) from 15,000 to 25,000. By Wednesday, estimates ranged from 30,000 to 50,000 individuals housed in the Superdome. As a shelter of last resort, there was no planning to provide blankets, cots, or clothing. There was planning for food and water for 72 hours. Evacuees were expected to bring medicine, some food, medicine, and other necessities. However, there were two waves of refugees at the Superdome. One wave came from Sunday through Monday, before the water rose. The next group came from Monday evening through Wednesday. The first waves of refugees were dry and able to bring their own supplies. The second wave came in after wading through floodwaters or being rescued from buildings and homes. By Wednesday evening and early Thursday morning, food and water were in short supply.

- *Emergent shelter: Convention Center*. As the Superdome was an intentional shelter of last resort, the Convention center became an emergent shelter. Because of the high numbers of people rescued off rooftops, bridges, overpasses, and other areas, the Convention center quickly became the next public space where people gathered. The conditions at the Convention Center were not set up as any kind of shelter, so the issues of personnel and supplies were even more difficult than the Superdome. At both locations, electricity and water did not function after Monday.

Socio-Behavioral Responses: Survival Strategies. In a disaster situation, altruism emerges as a key value guiding socio-behavioral response (Mileti 1999; Tierney, Lindell and Perry 2001). In most disasters, people often serve as the first individuals to engage in search and rescue and provide critical first-aid. People in crisis conditions tend to remain together, and even in the face of imminent threat people remain committed to each other's survival (Johnson 1988). Usually, less than 20% of those evacuated go to public shelters preferring family, friends and hotels instead (Tierney, Lindell and Perry 2001). Psychological trauma is generally associated with those who directly observe or experience severe injury or death to one's self or a family member. In most disaster research, post-traumatic stress disorder affects a small percentage of those affected. However, much remains to be known about these socio-behavioral responses in a catastrophic context. To understand local socio-behavioral response, consider these brief illustrations.

- *Walking out*. Because of the nature of the catastrophe (80 percent flooded), people were stranded all over the city in their homes, in public buildings, in businesses, and in schools. For more than a week, people would take any measure to find a way out of the city. Many began to walk over a bridge to Jefferson Parish. Although the majority of the evacuees were African American, there were also whites (locals and tourists) in the group that attempted to cross into Greta. They were stopped at the bridge by Gretna Police Department and not allowed to into the Jefferson Parish.

- *Local rescue*. An untold story of the catastrophe was the number of local people who rescued others in any manner they could. People in wheelchairs put elderly people on their laps and someone else pushed them miles to the Superdome, bridges, or I-10 at Causeway. Local individuals had boats or found boats that they used to make numerous rescues of people in their neighborhoods. The NOPD SWAT team was ‘ first boats in the water’ as the waters rose on Monday. Local fire departments estimated that they rescued nearly 15,000 people. Two men in Hollygrove (a small, very poor neighborhood in uptown New Orleans) rescued 60 people themselves between Monday and Friday.

- *Waiting for help: overpasses*. As people were rescued, many were dropped at higher ground. All over the parishes, people were left on overpasses, bridges, levees – any place where the ground was higher. There was every expectation that people would be taken from these emergent staging areas quickly. For a variety of reasons, this was not the case. People remained on these high ground areas (referred to by their residents as islands) for nearly a week in some cases. The largest drop off point besides the Superdome and Convention Center was I-10 at Causeway in Jefferson Parish.

- *Waiting for rescue: rooftops.* As the levees were breached and topped in many locations, local residents were found trapped in their upper floors of their homes and in their attic. The 911 calls that began on Monday morning and calls to help to other family members reflected the desperation of the people throughout the city who were unable to escape. As with all of the events of this catastrophe, the elderly were most vulnerable. Many simply could not get to the roofs and could not physically last through the time it took for help to arrive.

- *Flights to safety: from the airport*. The airport became one and probably the largest triage center for the sick and infirm in this storm. It also became one of the drop-off points for those evacuated from hospitals and nursing homes. Many of these nursing home patients were dropped off without charts or identifying information. Two of the biggest issues for the medical response were treating chronic illness such as diabetes and heart disease as medications became scarce. The other issue was one of dehydration; many patients from hospitals and nursing homes had little food or water for several days, which exasperated their conditions and need for treatment.

- *Process of getting out*. Accounts from evacuees illustrate that getting out of the city was a lengthy and stressful process. Some hired private buses to come into the city to get them. At one hospital, a patient hired a private helicopter to take himself and his wife out of harm's way. Many local residents who stayed borrowed their friend's cars that were on higher ground. Others found buses, trucks, and even bicycles to leave the city. Many who stayed in their own homes literally swam to higher ground (their first stop), then moved on to several other areas (a friend's house, a business), then the Superdome, and eventually evacuated.

- *Arrival at the shelters*. As with their experience staying in the city, the shelter experience for many evacuees was a process. For those at the Superdome, Convention center, and other emergent staging areas (such as I-10 at Causeway), evacuees were placed on buses and often not told where they were going. Or, in several cases, they were told where they were going, but as they got there (arriving in Baton Rouge, for example), the bus did not stop as the destination had been changed arbitrarily. Families were separated from each other; the sick and elderly placed on helicopters alone. When they arrived at their destination, it may have taken two or three placements for them to stay in one shelter for more than a single night. People arriving at these shelters had spent nearly a week, in some cases, in the same clothes, without proper food or water, without the ability to bathe, or receive basic medical treatment.

III. Post-Katrina Impacts- Social Institutions

Social institutions are a central part of the social fabric that holds communities together and allows them to function in an organized fashion. In this section, the report describes the impact Hurricane Katrina had on central social institutions on Orleans Parish for which data were available. Institutional recovery in post-Katrina also includes efforts to restore the critical infrastructure and lifelines that sustain a community: roads, bridges, electricity, water and gas (NHRAIC 2001). Elected officials will begin to enact new codes or ordinances governing the rebuilding process, convene stakeholder groups to envision a recovered community, develop broad visions and plans for rebuilding, educate and involve the public and launch efforts to reconstruct damaged neighborhoods and businesses. Usually, restoration of key infrastructure and lifelines occurs within a few weeks to a month in most disasters (Neal 2004). The catastrophic nature of Hurricane Katrina suggests that such restoration—and the normal short-term nature of this phase of recovery—may be elongated.

Education. One of the key foundations of a community is its educational system. This section looks at issues related to public education (K-12) and Higher Education. Historicallly, public education has faced a series of challenges ranging from deteriorated school buildings to low student achievement. According to the *Bring New Orleans Back Committee*(2006: 6) , the 68 of the 127 New Orleans pre-Katrina schools were deemed "academically unacceptable" while another 44 fell below the State average. Because of the devotion that many residents feel toward their neighborhoods, however, efforts had been underway in some areas to improve the situation. Katrina and the levee failure undermined those efforts.

Table 4-1 displays the public school enrollment pre- and post-Katrina. Hurricane Katrina greatly impacted enrollment in Orleans Parish, and to a lesser but still significant degree in

St. Bernard Parish. Jefferson and Plaquemine Parishes are around 60% of their pre-Katrina enrollment, and St. Charles and St. Tammy Parishes are close to their pre-Katrina enrollment. A number of interrelated issues will determine how slowly or quickly the educational system recovers. These issues include, for example, rebuilding the infrastructure and housing (for teachers, administrators, staff, and students' families), protecting the area from future hurricane and flood hazards, repair and restoration of structural elements as well as furniture, books and other teaching resources, and retention of teachers and administrators.

Table 4-1
Public School Enrollment Variable

	Pre-Katrina	Post-Katrina	
		March-June 06 LDE (4/06)	Long Term Projected
Schools-Enrollment	Jefferson 51,666 Orleans 65,349 Plaquemine 5,034 St. Bernard 8,872 St. Charles 9,797 St. Tammany 36,169	Jefferson 42,777 Orleans 9,278 Plaquemine 3,068 St. Bernard 2,268 St. Charles 9,775 St. Tammany 35,021	Uncertain

Source: Louisiana State Department of Education, 2006.

In addition, for a wide range of historical reasons, many parents have used private schools as an alternative to public education for their children. These private schools also were damaged by the hurricane. However, a large number of these private schools were parochial and institutionally linked to other schools that were undamaged. Many of those students were able to transfer easily to other schools. In short, although also impacted by Hurricane Katrina, it appears that private schools along with their students, administration, teachers and staff did suffer the degree of overall impact as the public school system. As a result, they may be recovering more quickly. Overall, given the pre-Katrina state of the educational system, the scattering of students and faculty along with damage to schools made an undesirable condition worse. The rebuilding of the schools and the re-enrollment of students will be one of the key dynamics in the overall repopulation of the city.

Recent reports from State education officials show that statewide test scores reflect the impact of Katrina and the flood. For example, Plaquemines Parish eighth-graders gained on basic math skills while tenth-grade English scores dropped. It appears that the decline in numbers of students, many of whom were from "lower-performing systems" may have statistically increased test scores (Ritea 2006). Test scores from other school systems support this finding. For example, Texas administers a statewide test as well. Fewer "Katrina" students passed this test than did Texans. Among fifth graders, 45% of "Katrina" students passed the math test compared to 81% of Texas students. Impacts on enrollment in the Texas school system can be viewed at http://www.tea.state.tx.us/hcane/KatEvaMap.pdf.

New Orleans is also a center of higher education with a number of private and public universities and colleges including Dillard, Loyola, Tulane, University of New Orleans, and Xavier. These universities have historically played a number of vital roles in the community and continue to do so during the hurricane response and recovery. Most of these universities cancelled most if not all of their fall classes. Dillard, UNO and Xavier faced up to 50% decrease in enrollment from a year ago. Both Tulane and Loyola have between 10-20% less enrollment for Spring 2006 enrollment (Brookings 2006). Dillard, a historically black institution, is in danger of closing, with students currently housed in a local hotel. The University of New Orleans, a seminal urban university dedicated to the city through public service of its faculty, has lost numerous faculty through relocation or retirement. During the spring semester, UNO had to request emergency assistance from the community to house students when FEMA trailers did not arrive. As with other institutions, faculty members are now retooling to offer courses via distance education technologies. UNO, facing widespread problems with building mold that is preventing faculty from returning to research facilities, has declared financial exigency. Tulane University, similar to other institutions, has had to make difficult choices about which journals their library can afford to renew. Similar to the situation with the public schools, the more quickly the infrastructure and housing are brought back on line, coupled with protecting the city from future hurricanes or flooding, the more quickly the local universities and colleges can return to their pre-Katrina status.

Health Care. Health care is a key institution in any community. A central component of health care is hospitals. Prior to Hurricane Katrina, many of these facilities served New Orleans as major medical clinical and research centers. Hurricane Katrina forced the closure of many of the hospitals in the area. For months following the hurricane, the closure of these hospitals inhibited and even prohibited 9-1-1 medical response. Table 4-2 displays the number of hospitals open before and after Hurricane Katrina.

Table 4-2
Hospital Count

	Pre-Katrina Louisiana Hospital Association	Post-Katrina	
		March-June 06 Count	Long Term Projected
Hospitals-Number	Jefferson 14 Orleans 22 Plaquemine - St. Bernard St. Charles 13 St. Tammany 12	Jefferson 13 Orleans 7 Plaquemine - St. Bernard (2 remained closed) St. Charles 12 St. Tammany 12	Uncertain

Source: Brookings 2006

Post-Katrina New Orleans has less than a third of the hospitals functioning. With one large hospital totally destroyed by flood waters and other major hospitals seriously damaged, the return of the level of health care provided in New Orleans before the hurricane may be years away.

Religion. New Orleans is often portrayed as a place in which the “good times roll,” where tourists can come and act in a fashion that it is not permitted in their own communities. Yet, one of the strongest and historically significant institutions in Orleans Parish is the religious community; that importance is reflected in the myriad of congregations that dot the landscape. Pre-Katrina, the religious institutions were some of the strongest advocates for their communities in Orleans Parish. According to the pre-Katrina Operation Brothers’ Keeper data base, more than 800 separate congregations existed in Orleans Parish.

Although a few "mega-churches" existed in Orleans Parish pre-Katrina, more common are the smaller congregations of 150 to 200 that serve their neighborhoods. These congregations often fulfilled more than the religious needs of their members—they served their communities. In addition to spiritual guidance, such churches served as formal or informal meeting places for socializing, political action, weddings, funerals and other similar activities. In short, these neighborhood churches were the heart of the community.

Post-Katrina finds each congregation struggling to find its members, to restore the buildings, and to renew their service components. A recent survey by Operation Brother's Keeper provides a glimpse of these struggles. We report these data with caution, because reaching individuals and organizations by a land phone in New Orleans remains difficult. However, it is clear that the majority of the congregations are not currently up and running. They appear to face similar problems of the other congregations. Their parishioners have not returned, their parishioners have no place to live (or jobs to hold), lifelines are not yet or only just now available in their neighborhoods, and/or their place of worship has not yet been repaired or replaced. The rebuilding of the congregations appears, from the available data, to follow the same pattern as other structures. On the Westbank and Uptown, many of the congregations are up and running. Some of these congregations have changed their outreach mission, so that they now provide basic services--including food and clothing--across the city. Other congregations are slower to come back. Some re-opening in January, while others are anticipating opening later this summer.

Certainly the congregations need to be restored. They remain a source of employment, leadership, and community to each of the neighborhoods and could be part of the future planning for the city. They constitute an integral component of the social capital of New Orleans and their vitality will affect not only the vitality of the community but also the relocation decisions of New Orleans residents. However, with the legal precedent of Jefferson's notion of separation of church and state and the establishment clause, these places of worship will have to rely strictly upon the help of others and not government for much of their rebuilding efforts.

Non-Profit Organizations. The nonprofit sector encompasses two types of organizations: membership organizations that physically meet (such as the Knights of Columbus, Kiwanis, PTA, Rotary) and service-based, non-profit organizations. Katrina severely affected both types. Non-profits played a key role in assisting with many social needs in the hurricane impacted area. For example, In September 2005, the Urban Institute assessed the overall state of the nonprofit sector in Louisiana, highlighting the status of agencies in the New Orleans metropolitan area. They noted that nearly half of the $8.7 billion in Louisiana charity expenditures in 2003[9] and the $13.8 billion in assets lay in New Orleans, which housed 900 charities at that time. Of those charities, the 83 direct providers of health services in New Orleans accounted for about $2.6 billion in expenditures annually. Another 385 New Orleans organizations focused on "human services and community improvement programs to New Orleans residents (The Urban Institute 2005). The reported noted that, "[b]efore Katrina, New Orleans was depending on its charitable sector to deliver many services to residents and their communities. While charitable human service and community improvement expenditures were $256 per resident statewide, the expenditures per resident in New Orleans were $291 (The Urban Institute 2006). Their data, which come from information reported by charitable nonprofits to the Internal Revenue Service, exclude (a) congregations and (b) any charitable organizations operating in Louisiana but whose headquarters lie in other states. The 2003 data were the most recent data that were available in 2005.

The Urban Institute summarized their findings on nonprofits in the following manner:

> *[n]early all nonprofits have been affected by Hurricane Katrina or Rita. About 95 percent of the 262 survey respondents indicated that they were affected by the storms. Some, particularly those in the Baton Rouge and Lafayette metropolitan areas, work in undamaged buildings but are serving significantly more clients due to the influx of evacuees. Others are experiencing increased demand but have sustained damage that prevents them from operating at their previous capacity. Still others, including charities in New Orleans and the southwestern parish of Calcasieu [the parish in which Lake Charles lies] have been physically destroyed (The Urban Institute 2006).*

As a result of the damage and destruction of Hurricane Katrina, a wide range of services provided by non-profits cannot be met. These include, for example, housing and community development issues, day care, health care, mental health, and family services. (The Urban Institute 2006:5). As one illustration, those providing support for local victims of domestic violence lost all shelter locations due to the storm and flood. These providers convened in February to identify alternative strategies to "rebuild the safety net" in the aftermath of several homicides.

In short, similar to the other institutions we have reviewed, the non-profit base will require an "immense" effort from the private and public sectors. The non-profits will need funds for the restoration of their physical space, their staff, and most of all to meet the needs of their clients.

Politics. Akin to most major cities in the United States, the City of New Orleans has a colorful political history. The impact of Hurricane Katrina has certainly magnified key political issues in the city, while also creating some hardships. Probably the most major political impact, which is still in progress, is the mayoral elections. First, the impacts of the hurricane, including the evacuation of thousands of residents both out of the city and out of the State, lead to the postponement of city elections. When the initial round of the mayoral and city elections were held in April 2006, many registered New Orleans voters had not yet returned to the city. Mayoral candidates had to travel to cities as far as Houston and Atlanta to reach their constituents. Voters had to find satellite sites, travel to New Orleans to polling locations, or send in absentee ballots in advance of the initial election in order to exercise their right to self-determination. Thus, the delay in the mayoral elections and the potential unintentional disenfranchisement of (absentee) voters has perhaps delayed the recovery process.

Public Services. A key component of local government is to provide public services. This section offers glimpses at different institutions, utilities and public services. Qualitative assessments within the Orleans Parish section that follows describe the daily lived experience of these realities.

Criminal/civil legal system. Every aspect of the criminal/civil legal system in Orleans Parish was impacted by the displacement of personnel and by damage to their structures. Much of the physical damage is under repair and estimates of the time to repair vary greatly. As residents of the city return, the rates of victimization and of participation in the courts are slowly changing. Reports, from all aspects of the criminal/civil legal system, show that a reduced number of personnel are now dealing with a combination of old and new cases. As the city re-populates, the number of new cases is gradually increasing. The last crime statistics reported that the rate of most interpersonal violent crime is down, but rates of others crimes, including reports of new gang infiltrations, have increased.

All aspects of this complex system have had to make significant physical and personnel adjustments. The District Attorney's office has been one of the agencies seriously impacted by the storm. Much of the support staff including the victim support division and investigators were laid off immediately after the storm. The Criminal District Court was operating during the storm at Hunt Correctional Institute in St. Gabriel, and then, the House of Detention, the oldest building of the Orleans Parish Prison. In December 2005, Municipal Court was housed at the House of Detention in Orleans Parish Prison. The Civil District Court temporarily relocated to Gonzales.

Disaster Management. The City of New Orleans is in the process of revamping is Emergency Operating Plans following Hurricane Katrina. A key social component being focused on as hurricane season draws near is evacuation. Rather than rely upon a "shelter of last resort," various options such as evacuation by train or plane and earlier evacuation orders should alter evacuation efforts in the future (City of New Orleans Emergency Management, 2006). However, those most vulnerable to disaster risks such as the elderly, those with disabilities, single parents with children and the infirm must be the direct focus of heightened efforts to reduce their risk for death, injury and property losses.

Fire Protection. Before Hurricane Katrina, the New Orleans Fire Department had 35 Fire Stations (City of New Orleans Emergency Management, 2006). The Hurricane damaged or destroyed many of the fire stations. For example, in mid-November 2005, the city was operating with only nine stations and had established six other staging areas. In addition, the hurricane damaged or destroyed equipment and supplies (Neal and Webb 2005). As the area rebuilds, officials must insure that fire houses, fire equipment, and properly trained personnel are brought online to meet the needs of the public. Doing so requires that a holistic approach be adopted that recognizes the losses of these key first responders. The trauma associated with being unable to rescue the dying, retrieve the dead and remain in a destroyed city must be addressed. Support for rebuilding destroyed homes must be provided. Rebuilding lost resources must take place.

Police. The New Orleans Police Department is now operating in many temporary structures. At present, the command staff is occupying trailers in Mid-City. Orleans Parish Prison temporarily located in the Greyhound Bus Station in the aftermath of the storm, but has now returned to a few of the structures that could be easily repaired including the House of Detention. As with much of the community, the loss of the structures was difficult, but also every aspect of the criminal/civil legal system also lost equipment (law enforcement lost cars, uniforms, radios, computers), and, in many cases, a number of records were lost or damaged.

Garbage Pick-up. Hurricane Katrina left an immense amount of debris that needed to be cleared from the devastated area. In addition, as people's lives started to show some degree of normalcy, people needed their daily garbage pick-up. Residents had to learn to sort potentially hazardous debris, to identify recyclables and to transport those items to specific places, and to deal with newly-feral animals tearing through garbage.

Utilities. Slow progress continued with water and gas utilities (Brookings 2006). The number of electric customers increased from 50% in March to 60% in April, based on the total number of users prior to Katrina and the flood. Gas customers have been slower to return, with only 41% of the original customer base having been restored.

Employment. Before Hurricane Katrina the New Orleans Metro area's unemployment rate was at 7.4 %. Despite spikes of unemployment rates between 16.5% to 17.5% for the three months just following the hurricane, by the end of April 2006 it fell back to 7.9%. Clearly, the massive reconstruction efforts have mitigated some employment issues following the Hurricane. Many of these workers appear to be from outside the New Orleans metro area. However, a more telling set of unemployment figures focuses upon returning evacuees. While unemployment rates varied between 20.7 % through 27.8% between November 2005 and February 2006, the most recent measure (March 2006) indicates the unemployment rate among this group at 34.7% (Brookings 2006: 20-11).

Tourism. The hotel and restaurant sectors reflect one of the larger segments of the New Orleans area economy (i.e., tourism). About two months following the Hurricane, 38% of the hotels in the New Orleans Metro area were open. By the end of April 2006, this number had moved to only 60%. Only 31% of the metro area restaurants were open two months after Hurricane Katrina. By the end of April 2006, only an additional 10% of restaurants had opened (Brookings 2006: 10-11).

Mortgages and Foreclosures (Economic Institutions). Loans past due and foreclosures also indicate social and economic impacts. Although the State of Louisiana has rates above the United States' average, the State's rates dramatically increased following Hurricane Katrina. For example, for the first quarter of 2005 Louisiana had a 13.7% rate of loans up to 90 days past due and foreclosures while the nation's rate was 9.5%. For the fourth quarter of 2005 (i.e., following the Hurricane's impact), Louisiana had a 33.9% past due and foreclosure rate while the nation reflected an 11.6% rate (Brookings 2006: 30-32).

Housing Permits. Data are just becoming available on building permits. For the City of New Orleans, the one month total of permits issued for January 2006 was 6,250. About 16,000 permits were by the city for February 2006 (Brookings 2006: 53). More specific details are available on housing permits. Just before Hurricane Katrina (August 2006), the New Orleans metro area gave 668 housing permits. With one exception, for September through January 2006, the number of permits stayed per month stayed below 100. February saw a dramatic increase to 378 permits whereas March had 547 permits (Brookings 2006: 7). Although these rates are still quite below the pre-Katrina numbers, the do reflect that some reconstruction is underway. In comparison, Orleans Parish numbers have increased as well but only slightly.

Home Sales. Perhaps the most telling data regarding the repopulation of New Orleans comes from home sales. The Brookings Institution May 2006 report indicated that home sales were up, reaching a high of 3400, up from 2800 the previous month.

Summary of Institutional Impacts. Hurricane Katrina impacted greatly social institutions key to the successful functioning of both small neighborhoods and the larger society. In addition, with a wide range of social institutions being impacted, the outcomes have been more severe though not enough to foster a complete standstill. Put another way, in other smaller disasters, perhaps a few social institutions may be impacted, but not severely enough to create a social standstill. However, with Hurricane Katrina impacting all the noted social institutions, a synergistic effect resulted that created a form of inertia. For example, with the economic base devastated, tax revenues were not available to rebuild and maintain the schools. Without schools, people with children were reluctant to move back to the area. In addition, with the housing stock devastated, few if any residences were available for families or members of the school system or to return to work. Visitors to New Orleans, for example, find that some restaurants have a 1-2 hour waiting period simply because there are not enough staff to work. The famous restaurants – a key part of the economic and cultural character of the region- faced re-opening challenges when nearly half of his staff lost their homes.

These data suggest that the Hurricane Katrina devastated an already struggling economy for the area. Although these data may suggest that some sectors are rebounding from the hurricane's impact (e.g., employment, personal income), other indicators (e.g., tourism) show that longer term problems will continue to plague the area. Key tourist events such as Mardi Gras and the Jazz Festival have assisted in rebuilding the economy. The Brookings Institution (2006: 5.) recently summarized these trends in May 2006 in the following fashion, "Yet, the well-being of the hundreds of thousands of people still displaced by Katrina continues to be in doubt and cannot be forgotten. Among the troubling findings, nearly one in three of the working age adults still displaced by Katrina are out of a job."

Residents affected by the flood and storm face a vicious cycle influenced by a prolonged recovery. Without housing, residents cannot return. Without residents, businesses cannot become re-established. Without business and tax revenue, schools cannot be maintained. Without schools, children and their families cannot return. The reiterative pattern exemplifies the social conundrum where locals remain in limbo.

VI. Post Katrina: Long-Term Recovery (post June 1)

The pattern of long-term recovery and reconstruction in New Orleans will take decades. In one of the few comparative studies of reconstruction after disasters, Kates and colleagues proposed a model of the recovery process. In this model, there are four phases (the emergency period, followed by restoration, reconstruction 1 and reconstruction 2) (Kates and Pijawka 1977). Based on their assessment of a number of large disasters, they suggest that each phase is ten times greater than the one before it. When the model is applied to New Orleans with an emergency period of six weeks (a conservative estimate), then the restoration period would be sixty weeks (more than a year), with complete reconstruction taking more than eleven years (600 weeks). Given the slow recovery up to this point, the timing of longer-term recovery will undoubtedly lengthen. Further longitudinal analysis of the recovery period was not possible due to the deadline for this report.

Section Five: Parish Level of Analysis

This section is divided into five subsections, with one subsection for each parishes under consideration. As noted, Orleans Parish is addressed at both the parish and neighborhood resolutions. Each section examines the cultural/historic and social consequences for pre-Katrina and post-Katrina conditions.

I. Section 5.1: Orleans Parish

5.1.1 Introduction. For many, New Orleans served as the symbolic epicenter for the social, cultural and historic consequences of Hurricane Katrina and the related levee failures. Although people throughout the Gulf Coast and Parishes surrounding Orleans parish suffered property loss, injury, death, and disruption to social ties, the density and characteristics of the population along with the magnitude of the damages resulted in catastrophic consequences of unprecedented dimensions. The demographic and social characteristics of the neighborhoods vary considerably in the Orleans Parish, as did the degree of damage. For these reasons, the pre-Katrina conditions and post-Katrina consequences are address at the parish and at the neighborhood level. To contextualize loss consequences, this report first situates Orleans Parish historically and culturally.

5.1.2 Pre-Katrina

Historic and Cultural Context. As noted in the introduction to this section of the report and briefly expanded upon in this section, Louisiana and New Orleans has a long and rich history. Various Indian tribes lived in the area, using the rivers and bayous to travel between the rich ecosystems offered by Lake Pontchartrain and the Gulf of Mexico. As is typical of many human settlement patterns worldwide, early Native American communities clustered along sedimentary buildup deposited by the waterways. The French founded their communities along these crescent-shaped banks of the Mississippi which gave the area one of its nicknames, the "Crescent City." Colonists received land grants along the natural levee of the Mississippi River, in a settlement pattern that would later give rise to the important port of New Orleans. Bayou communities including the Bayou Gentilly, Bayou Sauvage, Bayou Metairie and Bayou St. John began to expand in support of immigrant groups.

The population of greater New Orleans is comprised of many ethnic groups originating from its earliest days. These populations include the original Native American including Muskogeeans, which included Chitimacha, Houma, Choctaw, Attakapa and numerous other groups. Some of the earliest colonists included French settlers from France and Canada, African slaves from Africa or the West Indies and German settlers seeking farmland. Many of these German families moved above New Orleans in St. Charles and St. John the Baptist Parish along what became known as the Cote des Allemands or German coast as it is still referred to even today. African slaves were brought into the colony increasing African-American population until it outnumbered the white population, a pattern that continued until Hurricane Katrina and the levee failures. A free black society (gens de couleur libres)of Greater New Orleans developed; many bought homes in Plaquemines and Orleans Parishes and made substantial contributions to the cultural and historic legacy of the area.

Orleans Parish is rich in historic structures and places with over 130 sites on the National, State and local registries of historically significant properties and places (See Figure B-2, Sub-Appendix B). The reader is referred back to the opening section of this part of the report for additional historic and cultural context.

Social Context. This sub-section begins with a qualitative overview of pre-Katrina life in New Orleans. The next section examines quantitative data followed by a demographic review of neighborhoods by flood levels. Qualitative descriptions are based on local informants and study team observations over the years of research activity in the region. Quantitative data were derived from a combination of census data and drive-through observations as described in the methods section of this re port. Flood depth was derived from a data file developed by U. S. Army Corps of Engineers New Orleans District Office listing the depth of flooding, as estimated in January 2006, by census block. In the latter neighborhood-by-neighborhood section, the following areas are used:

- *No reported flooding*:
  - East Riverside
  - St. Thomas
  - Irish Channel
  - West Riverside.
- *Less than 2 feet*:
  - St. Claude
  - Leonidas
  - Central City
  - Garden District.
- *2-4 feet*:
  - Bayou St. John
  - Fairgrounds
  - Uptown
  - Lakeshore.
- *4-8 feet*:
  - Tremé
  - Milan
  - Plum Orchard
  - Edgelake.
- *More than 8 feet*:
  - Lower Ninth Ward
  - St. Anthony
  - Gentilly Terrace
  - Lakeview.

Pre-Katrina Life. Most residents of New Orleans before Katrina could give visitors a litany of what they perceived to be wrong with city. Crime is always up. Public schools are bad. There are lots of poor people. People lack faith in some politicians. Houses are falling down. For a majority African-American city, racism still remains. Residents drive carefully down some streets because they were worried about the huge potholes. The economy is flat. The city is sinking. One day the big one (hurricane) will come, the city will become a bowl and the water filled with all matter of sludge will drown us all.

Many of these statements have some elements of truth. While crime had not yet reached the high of the early 1990's, the rate was gradually increasing, especially the rate of interpersonal violence. The controversy of the public schools Pre-Katrina seemed to reach a crisis point as the state had begun the process of taking over consistently failing schools. While New Orleans did not have the highest poverty rate in the country, the overall poverty rate of 27.9 % masked some neighborhoods where people lived two levels below the poverty threshold.

Abandoned and substandard housing was a political issue Pre-Katrina with city officials trying to find a way to legally tear down such structures. The population of New Orleans had been gradually declining and the economy was not growing very fast. The city was sinking and residents all lived with the fear that the big one would finally make shore. Hurricane Ivan, and Tropical Storms Isadore and Lilly all pointed out the vulnerabilities of the city.

It was never easy to live in the city that care forgot. People who lived here Pre-Katrina attempted to make the best of these social conditions. They struggled to find the best education for their children. Parents would wait in lines over night so their children might have a spot in one of the better New Orleans' public schools. They found ways to make themselves safe in a city that was dangerous. People continued to buy houses in marginal neighborhoods and work to bring them back.

Yet, in the midst of the struggle to live in this city, there remained a sense that New Orleans was a place like no other. Certainly, there are few places in the United States that have such a unique history of people, place, and culture. New Orleans, Pre-Katrina, had not been completely swamped by urbanization and mass culture. For much of its history, New Orleans was a series of scattered sites along the natural ridges. As the city developed into drained areas and came to see itself as a city, the unique character and loyalty of neighborhoods remained.

What arose from its history is a city's culture reflected in music, food, religion, and architecture. These cultural aspects worked together in each neighborhood and in the city as a whole to create a sense of place that, to a degree, ameliorated the social conditions. For many residents, it was not just that there is great music and food; it was that there is great music and food just down the street from where you lived. In some neighborhoods, it was possible to walk to a neighborhood place to eat and then go hear music. Parts of the city were a new urbanist's dream- a walkable community.

One of the most unknown characteristics of New Orleans is the tremendous number of congregations that were active in the city. At last count before the storm, there were more than 600 separate congregations. These congregations varied in size from the thousands to twenty. The congregations were one of the cores of the city – there were Protestant congregations, a strong Catholic base, and a historical and very active Jewish community. There were also Muslims in New Orleans as well as a number of obscure and off-beat religious affiliations that found New Orleans welcoming. People worshiped in New Orleans and this faith was a major part of every day life.

Another part of New Orleans that created a sense of community came from an extensive and dedicated number of community organizations. With so many specific neighborhoods (approximately 73), many of these neighborhoods had one or more organizations. Also, many neighborhoods had some community centers and business associations that were attempting to bring their neighborhoods back. A drive through Central City, for example, shows the efforts of the last several decades of activities focusing on rebuilding the sense of neighborhood and place. The Bywater, Marigny and St. Roch neighborhoods were all experiencing a sense of renewal before the storm.

Pre-Katrina, there was a sense that if that there was only, at best, one degree of separation from each other—people knew each other. Part of this is explained by the number of family members who lived near each other or with each other. The sense of family and its connection was a mainstay of life pre-Katrina in New Orleans. This sense of knowing each other expanded beyond the family. As in a small town, a local conversation would eventually turn to how each person knew the same people.

These conversations not only determined how you might be related, they also gave life to the culture. Locals would joke that before Katrina, it would take hours to decide where to go out to eat. Word-of-mouth information about new restaurants could bring success or failure to new establishments. Information about music followed the same path – people talked to each other about music on a day-to-day basis. Jazz, blues, rock and roll, rap, soul, bounce, funk, zydeco, Cajun, and even country western could all be found in some club in New Orleans. Also, the celebrations of the city had both local and tourist dimensions. The local dimensions of Mardi Gras and Jazz Fest were part of the rhythms of the year. Not to mention, the celebration of both St. Joseph's and St. Patrick's Day that followed soon on the heels of Mardi Gras. For locals, Mardi Gras was not the wild revelry reported on national television—it was a cultural event with parades where, over years, families sat in traditional places along the parade route, shared food and visited with each other. Museums opened special exhibits and balls celebrated the season.

This is not to diminish the difficult life for the most vulnerable in New Orleans. For poor people, especially families with children, this was not an easy life. Young black men were the most vulnerable to threats and temptations of the street life pre-Katrina. The high rate of incarceration both in local jails and state prisons reflects local crime. As well, the effects of racism, both on individual and institutional levels, cannot be dismissed, especially as it was manifested in the debate on the public schools.

Yet, in the midst, this city was a rich place to live, providing an immeasurable culture that seemed to go on forever and sustain the city. Whether the musicians, the chefs, the architects, the ministers, the artists, and their audience will come back is unclear. To use a term from the local music community, many remain in "exile."

Pre-Katrina-Demographic Description. The US Census Bureau (2006) provides demographic characteristics of Orleans Parish. A detailed enumeration of characteristics can be found in Sub-Appendix C. In 2000, the total population of Orleans Parish was 484,674. Nearly 88% (87.5%) of housing units were occupied; of these, less than 47% (46.5%) were owner-occupied. Approximately one-third (33.2%) of housing units were occupied by only one individual. The median contract rent was $378 and the median value of owner-occupied housing units was $88,100.

Among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 88.5. Approximately 12% (11.7%) of residents were over 65 years of age. The economic dependency ratio stood at 71.7 and the median age in the parish was 33.1. The pre-Katrina population of Orleans Parish was about two-thirds (66.7%) black and about one-quarter (26.6%) white. Hispanics comprised just over 3% (3.1%), Asians made up 2.3%, and the remaining 1.4% consisted of other races. The index of qualitative variation (IQV) for race stood at 59.3%, reflecting the racial mix of the parish, pre-Katrina. This report notes that the IQV measures for Jefferson and Orleans Parishes are nearly identical, but the proportions of blacks and whites comprising them are reversed: Orleans was approximately two-thirds black, pre-Katrina, and the population of Jefferson was nearly two-thirds white.

Over 77% (77.4%) of Orleans Parish's residents in 2000 were born in Louisiana. Over 56% (56.8%) resided in the same house that they did in 1995; over one-quarter (28.6%) lived in a different house but in the same county as 1995. Taken together, then, these measures show that 85.4% of residents had lived in Orleans Parish for at least 5 years.

Over one-quarter (25.3%) of residents reported that they had not completed high school and one-quarter (25.7%) indicated that they had graduated from college. The employment-related indicators show that 23.2% of residents reported a limiting disability and 1.7% were linguistically isolated. Over 42% of residents (42.2%) were not in the labor force. Of those in the civilian labor force, 9.5% were unemployed.

Median income of households in this parish stood at $27,133 in 2000; median family income was $32,338. The poverty rate stood at 27.9%. The level of income inequality in the parish, as measured by the Gini index, was 54.6 for household income and 53 for family income. Notably, over 27% (27.3%) of households had no vehicle in 2000 and 4.4% lacked a land-line telephone.

Pre-Katrina Neighborhoods of New Orleans. The Greater New Orleans Community Data Center (GNOCDC 2006) developed a strategy to analyze the city of New Orleans based on social, cultural and historic similarities. Using U. S. Census tract designations and City of New Orleans Planning Department information, the GNOCDC identifies 73 neighborhoods in the city. Because time limitations prohibit detailed descriptions of all 73 neighborhoods, this report profiles the 20 neighborhoods that were sampled for the repopulation analysis. The sampling procedure insured that the report captures the city's neighborhood diversity through examining 20 areas spread out across the various levels of flooding. The statistical profiles for the other 53 New Orleans neighborhoods appear in Sub-Appendix C as table C-5-1. Figure B-5-1 in Sub-Appendix B links and orients the reader to a map of the neighborhoods.

Neighborhoods with No Flooding. Neighborhoods described here can be found on the bend of the river, along one of the natural ridges in the city. These neighborhoods, in many ways, represent the diversity of the population pre-Katrina and the issues facing the Post-Katrina housing. The non-flooded four neighborhoods described here range from some of the poorest residents of New Orleans (East Riverside) to the solidly middle class incomes represented in West Riverside. As suggested earlier, two of these neighborhoods were in transition pre-Katrina. The historic Irish Channel has undergone several significant population shifts and may go through those again. Pre-Katrina, much of St. Thomas housing development was closed and residents had moved throughout the city. An accompanying challenge to the presentation of these data is that these internal migration patterns had changed population demographics, changing the accuracy of the 2000 Census. The future of this area without water, post-Katrina, will bear watching. This report next presents an overview of these neighborhoods, with the exception of St. Thomas, pre- Katrina.

East Riverside. In 2000, the total population of East Riverside was 3,220. Eighty-five percent of the housing units were occupied; of these, just under 43% (42.9%) were owner-occupied. Over 39% (39.1%) of housing units were occupied by only one individual. The median contract rent was $357 and the median value of owner-occupied housing units was $91,349.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 88.5. Ten percent of residents were over 65 years of age. The economic dependency ratio stood at 58.9 and the median age in the neighborhood was 33.5. These residents included a relatively high percentage of African-Americans: Slightly more than 64% (64.3%) reported this racial category and about one-third (33.1%) classified themselves as white. Less than 4% (3.6%) were Hispanic and the percentages of Asian and other races were extremely low (.3% and .7%, respectively). The index of qualitative variation for race stood at 60.2%, reflecting the mix of blacks and whites, pre-Katrina.

Over 77% (77.9%) of the East Riverside residents in 2000 were born in Louisiana. Fifty-three percent resided in the same house that they did in 1995; nearly one-third (32.7%) lived in a different house but in the same county as 1995. Taken together, then, these measures show that 85.7% of residents had lived in Orleans Parish for at least 5 years.

Just over 23% (23.4%) of residents had not completed high school; 21.3% indicated that they had graduated from college. The employment-related indicators show 25.1% of residents reported a limiting disability and 40.1% were not in the labor force. Of those in the civilian labor force, 11.5% were unemployed.

The median income of households in this neighborhood stood at $21,292 in 2000; median family income was $26,327. The poverty rate stood at 36.9%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 53.25 for household income and 49.1 for family income. In 2000, 31.5% of households lacked vehicles and 6.1% lacked phones.

St. Thomas. In 2000, the total population of the St. Thomas neighborhood stood at 6,116. Nearly 83% (82.6%) percent of housing units were occupied; of these, 24.8% were owner-occupied. Fifty-seven percent of housing units were occupied by only one individual. The median contract rent was $482 and the median value of owner-occupied housing units was $161,713.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 113.2, one of the highest among the sampled neighborhoods. Approximately 10% (10.6%) of residents were over 65 years of age. The economic dependency ratio stood at 39.2 and the median age in the neighborhood was 33.4. A majority of residents were white in 2000: the percentage reporting this racial category was 59.6, with 34.4% classifying themselves as black. Hispanics constituted 6.6% and the percentages of Asian and other races were low (1.5% and 1.7%, respectively). The index of qualitative variation for race stood at 65.3, reflecting the high level of racial diversity in this neighborhood.

Over half (55.2%) of St. Thomas residents in 2000 were born in Louisiana. Over 45% (45.1%) resided in the same house that they did in 1995; 26.8% lived in a different house but in the same county as 1995. Taken together, then, these measures show that 71.9% of residents had lived in Orleans Parish for at least 5 years.

Nearly 18% (17.8%) of residents had not completed high school but 41.9% (10.5%) had graduated from college. The employment-related indicators show that approximately 23% (23.2%) of residents reported a limiting disability and nearly one-third (32.6%) were not in the labor force. Of those in the civilian labor force, 6.9% were unemployed.

The median income of households in this neighborhood stood at $29,576 in 2000; median family income was $33,521. The poverty rate stood at 28.5%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 57.5 for household income and 60.5 for family income. In 2000, 26.8% of households had no vehicle and 4.5% had no phone.

Irish Channel. In 2000, the total population of the Irish Channel was 4,270. Over 85% (85.8%) of the housing units were occupied; of these, 37.4% were owner-occupied. Over 36% (36.5%) of housing units were occupied by only one individual. The median contract rent was $336 and the median value of owner-occupied housing units was $75,915.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 96.3. Approximately 8% (8.4%) of the residents were over 65 years of age. The economic dependency ratio stood at 64.9 and the median age in the neighborhood was 29.6. The majority of residents were African American in 2000: sixty-eight point eight percent reported this racial category and less than 27.6% classified themselves as white. Hispanics constituted 3.9% and the percentages of Asian and other races were extremely low (.2% and 1.1%, respectively). The index of qualitative variation for race stood at 56.9, reflecting the mix of blacks and whites in this neighborhood.

Nearly 76% (75.8%) of Irish Channel residents in 2000 were born in Louisiana. The percent who resided in the same house that they did in 1995 was 47.9; over 38% (38.9%) lived in a different house but in the same county as 1995. Taken together, then, these measures show that 86.8% of residents had lived in Orleans Parish for at least 5 years.

Nearly 30% (29.3%) of residents had not completed high school; only 23.3% indicated that they had graduated from college. The employment-related indicators show that over 21% (21.5%) of residents reported a limiting disability and just over 39% (39.1%) were not in the labor force. Of those in the civilian labor force, 12.4% were unemployed.

The median income of households in this neighborhood stood at $20,996 in 2000; median family income was $20,523. The poverty rate stood at 41.1%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 53.4 for household income and 55.2 for family income. In 2000, 36.1% of households had no vehicle and 4.5% had no phone.

West Riverside. In 2000, the total population of the West Riverside neighborhood was 5,232. Nearly 90% (89.3%) percent of housing units were occupied; of these, 40.8% were owner-occupied. Forty-six percent of housing units were occupied by only one individual. The median contract rent was $404 and the median value of owner-occupied housing units was $129,910.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 94.3. Just over 13% (13.3%) of residents were over 65 years of age. The economic dependency ratio stood at 47.8 and the median age in the neighborhood was 35.6. A majority of residents were white in 2000: The percentage reporting this racial category was 59.4, with 36.5% classifying themselves as black. Hispanics constituted 4.2% and the percentages of Asian and other races were low (.7 % and 1%, respectively). The index of qualitative variation for race stood at 64.3, reflecting the mix of black and white residents in this neighborhood.

Approximately 63% (63.7%) of West Riverside residents in 2000 were born in Louisiana. Approximately half (51.2%) resided in the same house that they did in 1995; 29.8% lived in a different house but in the same county as 1995. Taken together, then, these measures show that 81.0% of residents had lived in Orleans Parish for at least 5 years.

Eighteen percent of residents had not completed high school and 37.8% had graduated from college. The employment-related indicators show that twenty-one percent of residents reported a limiting disability and slightly more than one-third (34.9%) were not in the labor force. Of those in the civilian labor force, 6.9% were unemployed.

The median income of households in this neighborhood stood at $30,568 in 2000; median family income was $38,417. The poverty rate stood at 18.1%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 53.4 for household income and 52.9 for family income. In 2000, 22% of households had no vehicle and 2.5% had no phone.

Neighborhoods with Less than Two Feet of Flooding. The neighborhoods with less than two feet of flooding represent an even more diverse picture of the pre-Katrina city. St. Claude, Leonidas, Central City, and the Garden District are all neighborhoods that were in different states of development and occupancy before the storm. Three of the neighborhoods--St. Claude, Leonidas and Central City--had an average family income within a few thousand dollars of each other, all below 23,000 dollars. The Garden District has historically been home to wealthy white families. Central City and Leonidas block groups are situated in neighborhoods that have great diversity of wealth, income, and race. For example, there are four distinct areas in Leonidas, but the census tract described here is one of the poorest in the neighborhood. The St. Claude neighborhood, on the other hand, is located in an area that stretches into the Lower Ninth Ward and is not bounded by diversity of upper and middle income housing.

Yet, both Central City and St. Claude have been sites of community organizing in the last several decades. Annie E. Casey chose Central City as one its Making Families, Making Connection pilot sites, plus there has been a revitalization of the main thoroughfare of the area, Oretha Castle Haley. St. Claude, through the efforts of the St. Claude Business Association, the Renaissance Project, the Frederick Douglas Community Coalition, and other groups was undergoing renewed community activity pre-Katrina.

St. Claude. In 2000, the total population of the St. Claude neighborhood was 11,721. Over 84% (84.1%) percent of housing units were occupied; of these, 44.9% were owner-occupied. Twenty-six percent of housing units were occupied by only one individual. The median contract rent was $345 and the median value of owner-occupied housing units was $57,858.

Turning to the composition of the population, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 81.7. Just under 10% (9.9%) of residents were over 65 years of age. The economic dependency ratio was 83.5 and the median age in the neighborhood was 30.5. A majority of residents were African American in 2000: the percentage reporting this racial category was 91.2, with only about 7% (7.3%) classifying themselves as white. Hispanics constituted 1.7% and the percentages of Asian and other races were extremely low (.2% and .5%, respectively). The index of qualitative variation for race stood at 21.7, reflecting the level of racial diversity in this neighborhood.

Over 87% (87.5%) of St. Claude residents in 2000 were born in Louisiana. Sixty-one percent resided in the same house that they did in 1995; 33.4% lived in a different house but in the same county as 1995. Taken together, then, these measures show that 94.4% of residents had lived in Orleans Parish for at least 5 years.

More than 35% (35.3%) of residents had not completed high school; only about 10% (10.5%) had graduated from college. The employment-related indicators show that over 25% (25.9%) of residents reported a limiting disability and nearly half (49.4%) were not in the labor force. Of those in the civilian labor force, 13.8% were unemployed.

The median income of households in this neighborhood stood at $19,836 in 2000; median family income was $21,193. The poverty rate stood at 39%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 50.8 for household income and 47 for family income. In 2000, 36.6% of households had no vehicle and 5.7% had no phone.

Leonidas. In 2000, the total population of the Leonidas neighborhood was 8,953. Eighty-eight percent of housing units were occupied; of these, 41.8% were owner-occupied. Thirty-five percent of housing units were occupied by only one individual. The median contract rent was $354 and the median value of owner-occupied housing units was $80,416.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 87.3. Approximately 12%

(11.9%) of residents were over 65 years of age. The economic dependency ratio stood at 69.9 and the median age in the neighborhood was 32.8. The majority of residents were African American in 2000: The percentage reporting this racial category was 75.9 and 21.6% classified themselves as white. Hispanics constituted 2.2% and the percentages of Asian and other races were extremely low (.5% and .8%, respectively). The index of qualitative variation for race stood at 48, reflecting the mix of blacks and whites in this neighborhood.

Over 78% (78.6%) of Leonidas residents in 2000 were born in Louisiana. Fifty-six percent resided in the same house that they did in 1995; 30.4% lived in a different house but in the same county as 1995. Taken together, then, these measures show that 86.4% of residents had lived in Orleans Parish for at least 5 years.

Over 29% (29.3%) of residents had not completed high school; 22.8% indicated that they had graduated from college. The employment-related indicators show that over 27% (27.4%) of residents reported a limiting disability and just over 41% (41.6%) were not in the labor force. Of those in the civilian labor force, over 10% (10.5%) were unemployed.

The median income of households in this neighborhood stood at $21,951 in 2000; median family income was $26,819. The poverty rate stood at 31.5%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 50.7 for household income and 49.6 for family income. In 2000, 29.5% of households had no vehicle and 3.9% had no phone.

Central City. In 2000, the total population of Central City was 19,072. Nearly 79% (78.8%) of housing units were occupied; of these, only 16.3% were owner-occupied. Over 40% (44.1%) of housing units were occupied by only one individual. The median contract rent was $280 and the median value of owner-occupied housing units was $65,303.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 85. Less than 12.5% of residents were over 65 years of age. The economic dependency ratio stood at 83, one of the highest of the 20 sampled neighborhoods. The median age in the neighborhood was 31.4. These residents included a high percentage of African-Americans: Slightly more than 87% (87.5%) reported this racial category and only about 10% (10.5%) classified themselves as white. Less than 2% (1.6%) were Hispanic and the percentages of Asian and other races were extremely low (.6% and .4%, respectively). The index of qualitative variation for race stood at 29%, reflecting the fact that this neighborhood had a relatively low level of racial diversity, pre-Katrina.

Over 80% (84.3%) of the Central City residents in 2000 were born in Louisiana. Over 60% (60.2%) resided in the same house that they did in 1995; slightly more than 30% (30.8%) lived in a different house but in the same county as 1995. Taken together, then, these measures show that 91% of residents had lived in Orleans Parish for at least 5 years.

The percentage of residents who reported that they had not completed high school was strikingly high (43.7%); only 12.6% indicated that they had graduated from college. The employment-related indicators show that fully 31.1% of residents reported a limiting disability and just over half of residents (53.1%) were not in the labor force. Of those in the civilian labor force, over 20% (20.4%) were unemployed.

Given the educational and work-related indicators, it is not surprising to see that the median income of households in this neighborhood stood at $13,030; median family income was $14,391. The poverty rate stood at 49.8%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 57 for household income and 56.9 for family income. In 2000, over half—56.5%--of households had no vehicle and 13.7% had no phone.

Garden District. In 2000, the total population of the Garden District was 1,970. Over 88% (88.5%) of housing units were occupied; of these, 49.2% were owner-occupied. Over 50% (50.1%) of housing units were occupied by only one individual. The median contract rent was $588 and the median value of owner-occupied housing units was $320,263.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 102.1—one of the highest among our sampled neighborhoods. Approximately 16% (16.1%) of residents were over 65 years of age. The economic dependency ratio stood at 39 and the median age in the neighborhood was 41.8. These residents were disproportionately white: Ninety-three percent reported this racial category and less than 3% (2.9%) classified themselves as African American. Slightly more than 5% (5.1%) were Hispanic and the percentages of Asian and other races were extremely low (.9% and 1%, respectively). The index of qualitative variation for race stood at 16.4, reflecting the low level of racial diversity in this predominantly white neighborhood.

Less than 45% (44.7%) of Garden District residents in 2000 were born in Louisiana. Forty-nine percent resided in the same house that they did in 1995; over 20% (20.6%) lived in a different house but in the same county as 1995. Taken together, then, these measures show that 69.6% of residents had lived in Orleans Parish for at least 5 years.

Less than 5% (4.7%) of residents had not completed high school; fully 73.4% indicated that they had graduated from college. The employment-related indicators show that less than 10% (9.5%) of residents reported a limiting disability and just over 36% (36.1%) were not in the labor force. Of those in the civilian labor force, only 2.4% were unemployed.

The median income of households in this neighborhood stood at $45,894 in 2000; median family income was $102,385. The poverty rate stood at 11.3%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 53.4 for household income and 39.3 for family income. In 2000, only 7.3% of households had no vehicle and 1.2% lacked a phone.

Neighborhoods with 2-4 Feet of Flooding. The next four neighborhoods represent the differential impact of flooding in relation to re-occupancy. The first two neighborhoods have the potential for returning and, as the discussion that follows will show, many individuals have returned. In the next two neighborhoods, although they have received less than four feet of water, the rate of return is not as clear. Bayou St. John, Fairgrounds, and Uptown are all still part of the historic architecture of New Orleans, while Lakeshore is the first suburban neighborhood to be discussed. Bayou St. John and Fairgrounds are both part of the larger Mid-City area with its bungalows, cottages, and other historic structures interspersed with business, schools, cemeteries and parks, including the racetrack. The Uptown neighborhood is part of the larger Uptown area of New Orleans, yet remains unique as with many neighborhoods in composition of structures, population and history. Lakeshore is part of the broader area that was created from the reclamation of Lake Pontchartrain.

Bayou St. John. In 2000, the total population of Bayou St. John was 4,861. Nearly 90% (89.8%) of housing units were occupied; of these, 35% were owner-occupied. Slightly less than 40% (39.7%) of housing units were occupied by only one individual. The median contract rent was $348 and the median value of owner-occupied housing units was $94,414.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 85.9%. Less than 9% (8.8%) of residents were over 65 years of age. The economic dependency ratio stood at 62.3, one of the lowest of the 20 sampled neighborhoods. The median age in the neighborhood was 32.8. Thus, the population of this neighborhood is composed heavily of working-age individuals. These residents included a high percentage of African-Americans: Slightly more than 68% (68.4%) reported this racial category and just under 30% (27.7%) classified themselves as white. Only 3.2% were Hispanic and the percentages of Asian and other races were extremely low (.9% and 1.3%, respectively). The index of qualitative variation for race stood at 57.8%, reflecting the racial diversity of the neighborhood, pre-Katrina.

Over 80% of Bayou St. John's residents in 2000 had been born in Louisiana. Just over half (53%) resided in the same house that they did in 1995; slightly more than one-third (34.8%) lived in a different house but in the same county as 1995. Taken together, then, these measures show that 87.8% of residents had lived in Orleans Parish for at least 5 years.

Just over 28% (28.1%) of residents reported that they had not completed high school and 23.1% indicated that they had graduated from college. The employment-related indicators show that 24.1% of residents reported a limiting disability and just over one-third of residents (34.1%) were not in the labor force. Of those in the civilian labor force, 9.3% were unemployed.

Median income of households in this neighborhood stood at $24,047 in 2000; median family income was $24,893. The poverty rate stood at 32%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 53.2 for household income and 54.1 for family income. Over 28% (28.9%) of households had no vehicle in 2000 and 4.1% lacked a phone.

Fairgrounds. In 2000, the total population of Fairgrounds was 6,575. Ninety percent of housing units were occupied; of these, 43.6% were owner-occupied. Over 42% (42.1%) of housing units were occupied by only one individual. The median contract rent was $427 and the median value of owner-occupied housing units was $76,116.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 82.5. Nearly 17% (16.6%) of residents were over 65 years of age. The economic dependency ratio stood at 70.6 and the median age in the neighborhood was 38.2. These residents included a high percentage of African-Americans: Nearly 70% (69.8%) reported this racial category, and nearly 28% (27.5%) classified themselves as white. Less than 4% (3.3%) were Hispanic and the percentages of Asian and other races were extremely low (.2% and 1.3%, respectively). The index of qualitative variation for race stood at 55.7%, reflecting the relatively high racial diversity in this predominantly African American neighborhood.

Eighty-one percent of the Fairgrounds residents in 2000 were born in Louisiana. Nearly 62% (61.9%) resided in the same house that they did in 1995; over 27% (27.8%) lived in a different house but in the same county as 1995. Taken together, then, these measures show that 89.7% of residents had lived in Orleans Parish for at least 5 years.

Over 23% (23.2%) of residents had not completed high school; 20.4% indicated that they had graduated from college. The employment-related indicators show that over one-quarter (25.5%) of residents reported a limiting disability and nearly 42% (41.7%) were not in the labor force. Of those in the civilian labor force, 7.1% were unemployed.

The median income of households in this neighborhood stood at $27,189 in 2000; median family income was $31,262. The poverty rate stood at 16.9%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 45.4 for household income and 42.6 for family income. In 2000, 26.1% of households had no vehicle and 1.4% had no phone.

Uptown. In 2000, the total population of the Uptown neighborhood was 6,681. Nearly 90% (89.8%) percent of housing units were occupied; of these, 43.4% were owner-occupied. Forty-two percent of housing units were occupied by only one individual. The median contract rent was $454 and the median value of owner-occupied housing units was $191,301.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 100.3. Just over 11% (11.3%) of residents were over 65 years of age. The economic dependency ratio stood at 44.3 and the median age in the neighborhood was 34.3. A majority of residents were white in 2000: The percentage reporting this racial category was 59.9, with 36.3% classifying themselves as black. Hispanics constituted 3.5% and the percentages of Asian and other races were low (1.1% and 1%, respectively). The index of qualitative variation for race stood at 63.7, reflecting the mix of black and white residents in this neighborhood.

Sixty-three percent of Uptown residents in 2000 were born in Louisiana. Approximately half (50.9%) resided in the same house that they did in 1995; 24.9% lived in a different house but in the same county as 1995. Taken together, then, these measures show that 75.8% of residents had lived in Orleans Parish for at least 5 years.

Approximately 13% (13.1%) of residents had not completed high school and 53% had graduated from college. The employment-related indicators show that approximately 18% (17.5%) of residents reported a limiting disability and slightly more than one-third (34.9%) were not in the labor force. Of those in the civilian labor force, 6.1% were unemployed.

The median income of households in this neighborhood stood at $32,259 in 2000; median family income was $48,952. The poverty rate stood at 23.9%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 56.4 for household income and 52.6 for family income. In 2000, 18.5% of households had no vehicle and 2.4% had no phone.

Lakeshore. In 2000, the total population of the Lakeshore neighborhood was 3,615. Ninety-four percent of housing units were occupied; of these, 85.7% were owner-occupied. Twenty-eight percent of housing units were occupied by only one individual. The median contract rent was $645 and the median value of owner-occupied housing units was $259,800.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 94.7. Approximately 25% (25.4%) of residents were over 65 years of age. The economic dependency ratio stood at 101.4 and the median age in the neighborhood was 45.6. The majority of residents were white in 2000: The percentage reporting this racial category was 96.1; less than 1% (.7%) classified themselves as black. Hispanics constituted 2.7% and the percentages of Asian and other races were extremely low (2.1% and .1%, respectively). The index of qualitative variation for race stood at 9.4, reflecting the strikingly low racial diversity in this majority-white neighborhood.

Over 69% (69.4%) of Lakeshore residents in 2000 were born in Louisiana. The percent who resided in the same house that they did in 1995 was 67.1; 25% lived in a different house but in the same county as 1995. Taken together, then, these measures show that 92.1% of residents had lived in Orleans Parish for at least 5 years.

Less than 5% (4.8%) of residents had not completed high school; fully 61.4% indicated that they had graduated from college. The employment-related indicators show that over 15% (15.6%) of residents reported a limiting disability and just over 45% (45.1%) were not in the labor force. Of those in the civilian labor force, only 1.3% were unemployed.

The median income of households in this neighborhood stood at $72,064 in 2000; median family income was $89,972. The poverty rate stood at 2.7%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 45.3 for household income and 41 for family income. In 2000, 4.1% of households had no vehicle and 0% lacked a phone.

Neighborhoods with 4-8 Feet of Flooding. The next four neighborhoods demonstrate the diversity of the African-American community in New Orleans. Yet, within these neighborhoods, significant differences exist. For example, the Tremé, one of the oldest African American neighborhoods in the country, is also one of the poorest neighborhoods in the city. Milan is a typical New Orleans neighborhood, with low-income to working-class families living in small houses. Plum Orchard and Edgelake/Little Woods represent the African-American population's move to the East, as development in that area increased. How these four neighborhoods rebuild are the key to the return to major portions of the African-American community.

Tremé. In 2000, the total population of the Tremé neighborhood was 8,853. Nearly 81% (80.6%) percent of housing units were occupied; of these, 21.8% were owner-occupied. Slightly more than one-third (33.7%) of housing units were occupied by only one individual. The median contract rent was $263 and the median value of owner-occupied housing units was $70,347.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 71.3. Just under 10% (9.6%) of residents were over 65 years of age. The economic dependency ratio stood at 88.1 and the median age in the neighborhood was 28.5. A majority of residents were black in 2000: The percentage reporting this racial category was 93.1, with only 5.3% classifying themselves as white. Hispanics constituted 1.5% and the percentages of Asian and other races were low (.1% and .6%, respectively). The index of qualitative variation for race stood at 17.9, reflecting the low level of racial diversity in this neighborhood.

Over 91% (91.3%) of Tremé residents in 2000 were born in Louisiana. Over 60% (60.5%) resided in the same house that they did in 1995; 33% lived in a different house but in the same county as 1995. Taken together, then, these measures show that over 93% of residents had lived in Orleans Parish for at least 5 years.

Over 39% (39.1%) of residents had not completed high school and only 8.5% had graduated from college. The employment-related indicators show that nearly 30% (29.5%) of residents reported a limiting disability and over half (52.4%) were not in the labor force. Of those in the civilian labor force, 21.4% were unemployed.

The median income of households in this neighborhood stood at $12,179 in 2000; median family income was $12,532. The poverty rate stood at 56.9%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 53.5 for household income and 54.8 for family income. In 2000, over half—55.5%--of households had no vehicle and nearly 10% (9.7%) lacked a phone.

Milan. In 2000, the total population of the Lower Ninth Ward neighborhood was 7,480. Over 83% (83.4%) of housing units were occupied; of these, one-third (33%) were owner-occupied. Just over 36% (36.3%) of housing units were occupied by only one individual. The median contract rent was $380 and the median value of owner-occupied housing units was $87,411.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 89.7. Just over 12% (12.6%) of residents were over 65 years of age. The economic dependency ratio stood at 65.9 and the median age in the neighborhood was 32.7. The majority of residents were African American in 2000: The percentage reporting this racial category was 74.2 and 22.6% classified themselves as white. Hispanics constituted 2.5% and the percentages of Asian and other races were extremely low (1.1% and .9%, respectively). The index of qualitative variation for race stood at 50.4, reflecting the mix of blacks and whites in this neighborhood.

Over 73% (73.7%) of Milan residents in 2000 were born in Louisiana. Slightly more than half (50.2%) resided in the same house that they did in 1995; 33.9% lived in a different house but in the same county as 1995. Taken together, then, these measures show that 84.1% of residents had lived in Orleans Parish for at least 5 years.

Nearly 28% (27.9%) of residents had not completed high school; but over one-quarter (26.8%) indicated that they had graduated from college. The employment-related indicators show that over 27% (27.1%) of residents reported a limiting disability and over 41% (41.4%) were not in the labor force. Of those in the civilian labor force, 9.3% were unemployed.

The median income of households in this neighborhood stood at $23,193 in 2000; median family income was $28,718. The poverty rate stood at 28.6%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 55.1 for household income and 54.2 for family income. In 2000, over one-third (34.4%) of households had no vehicle and 7.1% had no phone.

Plum Orchard. In 2000, the total population of the Plum Orchard neighborhood was 7,005. Ninety-one percent of housing units were occupied; of these, 57.4 were owner-occupied. Only 23.9% of housing units were occupied by only one individual. The median contract rent was $332 and the median value of owner-occupied housing units was $69,252.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 76.6. Just over 12% (12.4%) of residents were over 65 years of age. The economic dependency ratio stood at 81.9 and the median age in the neighborhood was 34. The majority of residents were African American in 2000: The percentage reporting this racial category was 93.7 and only 4.6% classified themselves as white. Hispanics constituted 1.3% and the percentages of Asian and other races were extremely low (.1% and .5%, respectively). The index of qualitative variation for race stood at 16.6, reflecting the low level of racial diversity in this African-American neighborhood.

Over 89% (89.1%) of Plum Orchard residents in 2000 were born in Louisiana. Seventy-three percent resided in the same house that they did in 1995; 24.1% lived in a different house but in the same county as 1995. Taken together, then, these measures show that 97.1% of residents had lived in Orleans Parish for at least 5 years.

Over one-quarter% (25.5%) of residents had not completed high school; 16.1% indicated that they had graduated from college. The employment-related indicators show that over 31% (31.1%) of residents reported a limiting disability and over 46% (46.8%) were not in the labor force. Of those in the civilian labor force, 8.5% were unemployed.

The median income of households in this neighborhood stood at $24,474 in 2000; median family income was $27,486. The poverty rate stood at 33.2%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 47.9 for household income and 45.2 for family income. In 2000, 24.3% of households had no vehicle and 4.8% had no phone.

Edgelake. In 2000, the total population of Edgelake was 44,311. Over 96% (96.1%) of housing units were occupied; of these, over half (51.4%) were owner-occupied. Over 23% (23.4%) of housing units were occupied by only one individual. The median contract rent was $435 and the median value of owner-occupied housing units was $90,632.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 76.2. Just over 7% (7.2%) of residents were over 65 years of age. The economic dependency ratio stood at 70.4 and the median age in the neighborhood was 30. These residents included a high percentage of African-Americans: Nearly 87% (86.8%) reported this racial category and only about 10% (10.2%) classified themselves as white. Less than 2% (1.6%) were Hispanic and the percentages of Asian and other races were extremely low (.9% and .6%, respectively). The index of qualitative variation for race stood at 30.7%, reflecting the relatively low racial diversity in this predominantly African American neighborhood.

Over 85% (85.1%) of the East Riverside residents in 2000 were born in Louisiana. Over 57% (57.6) resided in the same house that they did in 1995; over one-third (35.1%) lived in a different house but in the same county as 1995. Taken together, then, these measures show that 92.7% of residents had lived in Orleans Parish for at least 5 years.

Nearly 17% (16.9%) of residents had not completed high school; 23.9% indicated that they had graduated from college. The employment-related indicators show 18.2% of residents reported a limiting disability and 32.3% were not in the labor force. Of those in the civilian labor force, 7.6% were unemployed.

The median income of households in this neighborhood stood at $34,538 in 2000; median family income was $40,177. The poverty rate stood at 17.4%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 44.4 for household income and 41.2 for family income. In 2000, 15.8% of households had no vehicle and 1.9% had no phone.

Neighborhoods with Eight Feet of Flooding. Two of these last four neighborhoods, Lakeview and the Lower Ninth Ward, are often depicted as the icons of the Katrina devastation. And, in many ways, the destruction and damage to these two neighborhoods was the most severe. The contrast between Lakeview and the Lower Ninth could not be greater: Lakeview's residents were nearly all white, the Lower Ninth almost all African-American. Median family income in Lakeview was $63,940 and for the Lower Ninth, 22,130. The levee failure here blasted solid brick homes off their foundations and across the street, or drove pouring, violent streams of water through one's living room. Driving through Lakeview now, one views the remains of once sturdy, multi-story brick homes; for months after the flood it was unusual to see anyone in or near the devastation. In the Lower Ninth, what remains is the debris of wood and slab houses that have either collapsed or have cascaded into one other. In the blocks nearest the levee, only the front steps and broken sidewalks remain along with a few items remindful of former neighborhoods: a child's toy, someone's china, or a single necklace. The landscape is similar to the scouring effects of an F5 tornado. FEMA trailers did not arrive here until May 2006, and even then lacked some utilities. How Lakeview and the Lower Ninth come back will be part of a major and very public controversy. Yet, it is the story of the other two neighborhoods, St. Anthony and Gentilly, that may be more telling. Both of these neighborhoods were more racially integrated than most of the city and, although they did not have the history of the other neighborhoods, they were areas of the city in which whites and blacks had chosen to live next door to each other. Both of these neighborhoods housed working- to middle-income homeowners.

The Lower Ninth Ward. In 2000, the total population of the Lower Ninth Ward neighborhood was 14,008. Over 86% (86.1%) of housing units were occupied; of these, 59% were owner-occupied. Just over 25% (25.6%) of housing units were occupied by only one individual. The median contract rent was $289 and the median value of owner-occupied housing units was $52,114.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 82. Fourteen percent of residents were over 65 years of age. The economic dependency ratio stood at 91.9 and the median age in the neighborhood was 32.4. The majority of residents were African American in

2000: The percentage reporting this racial category was 98.6 and less than 1% (.5%) classified themselves as white. Hispanics constituted .5% and the percentages of Asian and other races were extremely low (0% and .2%, respectively). The index of qualitative variation for race stood at 4.2, reflecting the extremely low level of racial diversity in this African-American neighborhood.

Nearly 92% (91.9%) of Lower Ninth Ward residents in 2000 were born in Louisiana. Over 73% (73.5%) resided in the same house that they did in 1995; 23.5% lived in a different house but in the same county as 1995. Taken together, then, these measures show that 96.0% of residents had lived in Orleans Parish for at least 5 years.

Over 40% (40.3%) of residents had not completed high school; only 6.9% indicated that they had graduated from college. The employment-related indicators show that nearly 31% (30.9%) of residents reported a limiting disability and just over half (52.1%) were not in the labor force. Of those in the civilian labor force, over 13% (13.5%) were unemployed.

The median income of households in this neighborhood stood at $19,281 in 2000; median family income was $22,130. The poverty rate stood at 36.4%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 48 for household income and 44.8 for family income. In 2000, nearly one-third (32.4%) of households lacked a vehicle and 6.4% had no phone.

St. Anthony. In 2000, the total population of the St. Anthony neighborhood was 5,318. Over 86% (86.8%) percent of housing units were occupied; of these, 57.5% were owner-occupied. Over 30% (30.9%) of housing units were occupied by only one individual. The median contract rent was $408 and the median value of owner-occupied housing units was $74,144.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 88. Just under 14% (13.7%) of residents were over 65 years of age. The economic dependency ratio stood at 65.6 and the median age in the neighborhood was 34. A majority of residents were African American in 2000: The percentage reporting this racial category was 58.6 but one-third (33%) classified themselves as white. Hispanics constituted 5.6% and the percentages of Asian and other races were higher than in many other sampled neighborhoods (4.1% and 2.1%, respectively). The index of qualitative variation for race stood at 68.7, reflecting the high level of racial diversity in this neighborhood.

Over 79% (79.4%) of St. Anthony residents in 2000 were born in Louisiana. Approximately 59% (59.1%) resided in the same house that they did in 1995; 25.1% lived in a different house but in the same county as 1995. Taken together, then, these measures show that 84.2% of residents had lived in Orleans Parish for at least 5 years.

Approximately 18% (18.1%) of residents had not completed high school; 23% indicated that they had graduated from college. The employment-related indicators show that over 20% (20.7%) of residents reported a limiting disability and slightly less than one-third (32.3%) were not in the labor force. Of those in the civilian labor force, 7.1% were unemployed.

The median income of households in this neighborhood stood at $29,697 in 2000; median family income was $35,041. The poverty rate stood at 20.6%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 44.2 for household income and 40.7 for family income. In 2000, 16.9% of households had no vehicle and 1.9% lacked a telephone.

Gentilly Terrace. In 2000, the total population of the Gentilly Terrace was 10,542. Over 93% (93.3%) of housing units were occupied; of these, 68.7% were owner-occupied. Approximately 30% (30.3%) of housing units were occupied by only one individual. The median contract rent was $398 and the median value of owner-occupied housing units was $85,798.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 80.1. Approximately 12% (12.2%) of residents were over 65 years of age. The economic dependency ratio stood at 70 and the median age in the neighborhood was 36.3. The majority of residents were African American in 2000: Seventy point two percent reported this racial category and less than 26.5% classified themselves as white. Three percent were Hispanic and the percentages of Asian and other races were extremely low (.5% and 1.1%, respectively). The index of qualitative variation for race stood at 55.3, reflecting the mix of blacks and whites in this neighborhood.

Over 86% (86.5%) of Gentilly Terrace residents in 2000 were born in Louisiana. The percent who resided in the same house that they did in 1995 was 64.3; over 28% (28.7%) lived in a different house but in the same county as 1995. Taken together, then, these measures show that 93% of residents had lived in Orleans Parish for at least 5 years.

Approximately 16% (16.3%) of residents had not completed high school; only 27.2% indicated that they had graduated from college. The employment-related indicators show that over 20% (20.8%) of residents reported a limiting disability and just over 36% (36.2%) were not in the labor force. Of those in the civilian labor force, 5.7% were unemployed.

The median income of households in this neighborhood stood at $33,137 in 2000; median family income was $39,866. The poverty rate stood at 16.1%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 44.1 for household income and 42 for family income. In 2000, 15.8% of households had no vehicle and 2% lacked a telephone.

Lakeview. In 2000, the total population of the Lakeview neighborhood was 9,875. Over 94% (94.2%) of housing units were occupied; of these, 69.5% were owner-occupied. Over 35% (35.1%) of housing units were occupied by only one individual. The median contract rent was $627 and the median value of owner-occupied housing units was $168,863.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 87.9. Nineteen percent of residents were over 65 years of age. The economic dependency ratio stood at 69.2 and the median age in the neighborhood was 39.5. The majority of residents were white in 2000: The percentage reporting this racial category was 96.9 and less than 1% (.7%) classified themselves as black. Hispanics constituted 3.7% and the percentages of Asian and other races were extremely low (.8% and .6%, respectively). The index of qualitative variation for race stood at 7.4, reflecting the strikingly low racial diversity in this majority-white neighborhood.

Over 75% (75.3%) of Lakeview residents in 2000 were born in Louisiana. The percent who resided in the same house that they did in 1995 was 57.4; 23.2% lived in a different house but in the same county as 1995. Taken together, then, these measures show that 80.6% of residents had lived in Orleans Parish for at least 5 years.

Only about 7% (7.2%) of residents had not completed high school; 49.9% indicated that they had graduated from college. The employment-related indicators show that over 17% (17.4%) of residents reported a limiting disability and just over 34% (34.1%) were not in the labor force. Of those in the civilian labor force, only 2% were unemployed.

The median income of households in this neighborhood stood at $50,173 in 2000; median family income was $63,940. The poverty rate stood at 4.9%. The level of income inequality in the neighborhood, as measured by the Gini coefficient, was 43.3 for household income and 37.3 for family income. In 2000, 8.5% of households lacked vehicles and less than 1% (.7%) had no telephone.

5.1.3 Post Katrina. This sub-section reports on life post-Katrina within Orleans Parish. To do so, it provides a qualitative overview of what daily life is like for someone living in or attempting to return to their neighborhood as written by a team member who is a resident of New Orleans and experienced nearly four feet of water in her home. Subsequent sections then provide quantitative demographic profiles using the same flooded areas as in the pre-Katrina section.

A Day in the Post-Disaster Life of Residents. What is difficult for people not living in New Orleans to understand is the unremitting difficulty of everyday life. It began with the evacuation and the de-population and continues to the present nearly nine months later. It is the near constant struggle to get institutions and services to respond. While major conferences were held in New Orleans in the fall of 2005 to develop plans for the future of the city, the average citizen was interested in short-term issues such as electricity, FEMA monies, insurance reimbursement, and hooked-up FEMA travel trailers. Negotiating these systems amounted to full–time jobs. The following examples illustrate the daily trials and tribulations of residents:

- *Insurance*: there was a felt disparity in the insurance companies' responses to individuals and families in neighborhoods, for those fortunate enough to have insurance. The story many heard was that if you lived in Lakeview, had a particular insurance company, the adjustors did not even come out to view your property--they just wrote a check which many received in October. Other residents had to provide detail for their companies about loss of contents that proved almost impossible given the state of their homes or the effort required to return to the flooded areas. The average wait for reimbursement was 8 to 10 weeks after the independent adjustors filed the paperwork. During this time, residents expressed uncertainty about what they would actually receive from their insurance claims. Many reportedly waited nearly six months for their checks before they could begin to work on their homes. Even after the initial award, some homeowners found it necessary to file appeals with their insurance companies which took additional time, resources, and effort. The insurance struggle is one example of the negotiations with bureaucratic systems that individuals confront every day among the complex interactions of recovery in post-Katrina.

- *Making decisions*: once the flood checks came, there was little consistent information in deciding what to do with them. Residents now had money, but they had to make decisions that would affect themselves and their property with little or no support. Should you pay off your mortgage and get an SBA loan? Should you keep the check in escrow with your bank? Some homeowners felt pressure to pay off their mortgage. To be eligible for an SBA loan after the mortgage was paid your lending institution had to sign a form that said they required the borrower to pay off the loan. Some lending institutions did not have that policy (requiring the borrower to pay off the mortgage) and after the homeowner paid off the mortgage, they were no longer eligible for SBA funding. Homeowners had to make difficult choices. Some still have their money in escrow, but are not working on restoring their homes. Some immediately paid off their homes and are working their way through cumbersome SBA processes to rebuild their homes or purchase another home, often at a significant distance from the offices they need to access to do so.

- *Getting your FEMA trailer*: for many people, this process will remain in residents' memories as the most difficult, surreal, and irrational part of the recovery. Many residents signed up for FEMA trailers early in October, and were told that would arrive in three to four weeks. They didn't. Or, if they did, there were no hook-ups for electricity. Or, there was electricity, but no trailer. Or, there was a trailer, electricity, but no sewer hook up. And in many cases, there was everything in place, but it took a month to get the keys to the trailer delivered. People traded information and phone numbers about who to contact. They moved electrical poles themselves so that they were in the right place. People broke into their own trailers and hooked up generators when they could not get electricity. The only successful, nearly immediate recourse appeared to be to contact one of the local television stations and make your case. If the television station thought that it was a good story, it appeared on the news and, more importantly, the television station contacted FEMA and the contractors. This strategy seemed to work. Another strategy was to paint your struggle on your trailer. One couple, on a major boulevard painted, "we need electricity," on the side of their trailer. The next day, they did. Another strategy was to spend your days calling every FEMA and contractor number available. This strategy sometimes worked over a period of time, but it could take weeks or months. The other part to this strategy was that there were few land telephone lines, so for this strategy, a person would use up their cell phone minutes very quickly. Now, some citizens are finding out that the gas lines were not checked and many of the trailers may, in fact, be dangerous. The subtext of all of this is that there appeared to be no recourse--people left message after message with FEMA or with the contractors—but to no avail. Nearly nine months after the storm, residents are still waiting on trailers, hook-ups, and keys. The amount of time and energy it took to actually get a trailer cannot be measured.

- *Feeling vulnerable*: the trailer in the yard or in one of the few trailer parks in the area poses additional concerns, especially during the traditional spring storms and hurricane season. When there is a thunderstorm, there is fear among trailer residents about what they will do when the weather reports warn, "Do not stay in your trailer, go outside and lie on the ground and cover your head." The 60,000+ trailer residents in Louisiana are living in dangerous situations with very little help or information.

- *Living with devastation:* is another aspect of daily life for people in New Orleans. In a city that was eighty percent flooded, there are few places that do not have a physical reminder of the event. In some neighborhoods, there are few remnants of the storm. Everyone is back and you have to look closely to see the reminders of the storm such as the water line or the law enforcement markings. People who are back do not necessarily have the same everyday life. Some residents are able to go home to all their possessions just as they left them August 29, 2005. But others go home to their FEMA trailer (usually 8 ft by 30ft) or a strange apartment with unfamiliar furniture.

- *Vulnerability*: for most of the neighborhoods, the devastation is very close. In some blocks, there may be one trailer with the lights on surrounded by only empty houses. Or, one-half of a street may be occupied, but the other half stands empty. At night, the wind blows the doors shut in empty houses, windows bang, and the ever present debris blows down the street. Some houses have been gutted with the debris on the curb; other houses are still full of flood-damaged contents. Neighbors report they have delayed their return because of the isolation of their trailer in their neighborhood; women in particular report feeling vulnerable in areas that lack land line telephones and where cell phones did not and still do not always function properly as late as May 2006.

- *Visible reminders*: another constant of everyday life is the debris and the trash. Residents have learned that there are different kind of debris – the white debris (old refrigerators, washers, dryers, dishwashers) and the other debris (sheetrock, plaster, floor slats, and insulation). This debris can be on the curb for a long time, until it gets on the list to be picked up. Early in the storm, trash was picked up by subcontractors with the federal government. While this was slow and frustrating, the trash eventually was removed. Now the city's subcontractor, Waste Management, is picking up the trash. This means some delay – the trash often sits in the heat for days adding to the unsafe unsanitary conditions.

- *Physical losses*: part of the devastation is what is no longer there. Driving through the Lower 9th Ward, it is apparent that whole blocks were literally washed away. What remains are the stoops and the foundation. Residents come back to their homes and lovingly place a statue of the Virgin Mary, a few urns, or other memorabilia to commemorate their homes. In many neighborhoods, there are many community places that are not open. The buildings are still there, but these businesses, churches, and community centers are still not open. Everyday residents drive by their favorite restaurants or coffee shops that remain closed.

- *Social losses*: It is just not the physical loss; it is also the loss of part of each community. In every neighborhood, people have moved away. People who have lived next door to each other for decades are no longer there. In a city, where families often live next to each other, they are separated, sometimes by hundreds of miles. Whole neighborhoods are missing and the cultural and history that defines them is gone as well.

- *Daily survival*: everything takes longer and, much of everyday life seems altered. To go to the grocery store, you often have to drive to unfamiliar neighborhoods to shop in stores where you don't know where anything is which always takes longer than before Katrina. To get gas, you might have to drive to Metairie from the city itself or all the way

Uptown. To find a land phone, fax machine, or copy machine, you have stand in line in Metairie or Uptown. Because so many lost their homes, they also no longer have a washer and dryer. The few laundromats that are open are over-crowded. To change your oil, you must rise early to get in line before 7 a.m. Some days, daily survival means having to choose between going to work or getting food, gas, or clean clothes.

- *June 1 is coming*: finally, each day the residents of New Orleans are aware that the next hurricane season is fast approaching. As they hurry to work on their homes, they wonder if they have made the right decision. Will the levees hold?

Historical and Cultural Consequences. Much of the information on historical and cultural consequences was unavailable for this report despite requests to appropriate agencies and officials. Anecdotal evidence can be found from Internet media searches, such as these excerpted overviews from the *New York Times* and the New Orleans *Times Picayune: (as cited in* (http://www.heritagepreservation.org/PROGRAMS/KatrinaLA.HTM, accessed May 15, 2006)

- March 19 *New York Times* article: Music Landmark Caught in Tug of Priorities After Storm NEW ORLEANS, March 16 — The doors of the deserted Milne Boys Home flap open in the wind, and anyone who cares to brave the dank interior here in the heart of the drowned Gentilly neighborhood can find crumbling logbooks noting who visited in the early 1900's and yellowing sheet music in the attic. Many wonder if the Milne Boys Home, which was damaged by floodwaters after Hurricane Katrina, will have a place in the new New Orleans. A bronze plaque on the weather-beaten facade announces that Milne is "A Landmark of American Music," but it hardly looks the part, taking its place among the city's once-grand buildings ruined by floodwater after Hurricane Katrina. Nonetheless, what happens to this 11-acre campus of wide lawns and oak trees is of more than casual interest to many people here because of its ties to Louis Armstrong, arguably this city's most famous native son.

- March 15 *Times-Picayune* article: Ain't That a Shame. State museum officials trying to save musical treasures from the flooded home of rock 'n' roll pioneer Fats Domino. Fats Domino's Katrina-flooded house sat gutted and full of treasures Tuesday as a crew from the Louisiana State Museum arrived in the Lower 9th Ward to salvage the beloved musician's two Steinway grand pianos and a smaller electric Wurlitzer piano that sat at the foot of his big bed, next to a huge jar of pickled pigs feet. The museum is negotiating with the Domino family to save the pianos from further deterioration and include them in a planned national touring exhibit about the August hurricane and subsequent flooding, said Greg Lambousy, director of collections for the museum. Domino was rescued by boat Aug. 29 as the floodwaters rose in his neighborhood.

Social Context. Orleans Parish had a 1980 population of 557,927, over one hundred thousand persons more than the number of people 2004. In conjunction with the hurricane event, the historic population dynamics are likely to be extenuated. Poverty has been a long term condition for many areas of New Orleans, with 27.9 percent (23.4 percent in 2004) of the population living in poverty in 2004. This is much higher compared to the 12.4 percent national figure and the state of Louisiana's 19.4 percent. Flood waters inundated eight of the ten poorest neighborhoods in New Orleans, along with a sizable portion of the metropolitan area. Flood water disproportionately hit poor areas, with 21 percent of the households in damaged areas being below poverty level as compared to 15 percent of the population of area living in non-flooded areas. Income and race variables intersect as the two conditions do in many communities in the United States. Being African-American increases one's chance of being poor. In New Orleans, the median income for white households was $61,000 a year in 2000. Comparatively, the median of income for African-American was $25,000. There are a number of dynamics that could be involved in income. Influxes of low wage labor may result in a new set of unskilled working class groups staying in the city. Those experiencing property damage and storm related job loss may also confront financial burden and increasing their chances to being or becoming poor.

Though decreasing in population since 1980, the poverty rate had decreased over all in the metropolitan area, an indication that there an upwardly mobility of African-Americans in the metropolitan area. Many of the predominantly African American neighborhoods that were flooded provided an affordable residential place which fosters upward mobility for this segment of the population. With these places flooded, the areas where upward mobility occurs in the African-American community no longer exist. Many of the evacuees who remain outside the city are African-American.

Housing has been a long standing issue in the New Orleans community, with high concentrations of poor and African Americans in specific locations in the city. Much of that concentration is related to public housing. Flooded public housing neighborhoods were predominantly composed of African Americans. Housing units in neighborhoods such as Iberville, St. Bernard Area, and Florida Projects were over 90 percent occupied by renters. All of these areas experienced extensive flood damage after the Hurricane and were evacuated. Overall, a high percentage of the flooded housing units were rental property which reduces the likelihood that resident were insured or have been offered alternate housing within the city. It is not clear if or when the areas within the neighborhoods will be rebuilt within the next few years. The future of affordable housing is also uncertain.

In comparison to the population under 65 years of age, older populations have a more difficult time with evacuations, response and evacuations, as well as dealing with recovery issues. While the overall age of the population of Orleans Parish is not substantially different than other parishes, some areas of the parishes hit heavily by flooding had over a quarter of their population over the age of 65. Disabled populations are also vulnerable the events related to disasters. As might be expected, neighborhoods with higher percentages of older persons also have higher number of disabled persons. There are many anecdotal accounts in the media about problems of evacuating the elderly and disabled. Mortality data of Katrina victims clearly indicates that being elderly increases the likelihood being killed by the event. Initial analysis of 300 deaths accounted for by the State coroner indicated Katrina victims were on average over 70 years old. The abilities of the elderly and person with disabilities to return are unknown; it is expected that the lower incomes among these groups will compromise their ability to return. For the elderly, who may have lived in their homes for a lifetime, the loss will be keenly experienced.

Repopulation figures for Orleans Parish vary. Estimates made by the Rand Corporation indicated that the population of the parish was, as of December 2005, approximately 91,000. These estimates indicated that the parish population was 155,000 in March 2006, as basic repairs and stabilization of housing are completed, public services and infrastructure are restored, and schools and universities reopen. The Louisiana Redevelopment Authority estimated the March 2006 population of Orleans Parish to be 181,000 persons. Subsequently, repopulation starts to slow: One year Post Katrina, in September 2006, Rand estimates a population of about 198,000. Three years after the storm, the estimated New Orleans population is about 272,000— or about 56 percent of the pre-Katrina population. Normally, most rebuilding has been completed in most communities hit by disaster; the catastrophic effects of this flood suggest dramatic and permanent change for the people, culture and history of New Orleans.

Observations of the Repopulation of New Orleans. The observational analysis conducted for this study provides detail information for each sampled neighborhood. Following the structure of our discussion of pre-Katrina neighborhoods, we organize this according to the level of flooding that neighborhoods experienced.

Neighborhoods with No Reported Flooding. The description of these neighborhoods clearly points to a high level of re-occupancy, regardless of the pre-Katrina income level of the neighborhood.[10] West Riverside, which enjoyed the highest reported median income and the highest value of occupied hosing, also demonstrates the highest rate of occupancy.

East Riverside. The sampled block group for the East Riverside neighborhood experienced an average level of flooding (across blocks) of 0 feet, placing it the lowest category of flooding; it lies in the lowest quartile of socioeconomic status. The results from our fieldwork show that 73.7% of the structures in this neighborhood are currently occupied, with another 2.9% having people living in trailers on the site. In less than 1% of cases (0.7%) did we see trailers without signs of occupancy. In 9.5% of the structures, no trailer exists but some initial repair has been done. Just over 13.1% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 22% and the median year in which houses were built was 1939.

St. Thomas. The sampled block group for the St. Thomas neighborhood experienced an average level of flooding (across blocks) of 0 feet, placing it the lowest category of flooding; it lies in the second quartile of socioeconomic status (thus, above the mean). The results from our fieldwork show that 85.1% of the structures in this neighborhood are currently occupied, with another 2.3% having people living in trailers on the site. In 0% of cases, we saw trailers without signs of occupancy. In 4.6% of the structures, no trailer exists but some initial repair has been done. Another 8% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 15.9% and the median year in which houses were built was 1939. However, the relocation of the public housing units were not taken into consideration for this discussion. It should be noted that although the St. Thomas neighborhood did not include the St. Thomas project itself, but the Census figures for the entire neighborhood are no longer accurate.

Irish Channel. The sampled block group for the Irish Channel neighborhood experienced an average level of flooding (across blocks) of 0 feet, placing it the lowest category of flooding; it lies in the third quartile of socioeconomic status (thus, above the mean). The results from our fieldwork show that 86.3% of the structures in this neighborhood are currently occupied, with another 0.4% having people living in trailers on the site. In 0.4% of cases, we saw trailers without signs of occupancy. In 4.7% of the structures, no trailer exists but some initial repair has been done. Another 8.3% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 13.1% and the median year in which houses were built was 1939.

West Riverside. The sampled block group for the West Riverside neighborhood experienced an average level of flooding (across blocks) of 0 feet, placing it the lowest category of flooding; it lies in the highest quartile of socioeconomic status (thus, above the mean). The results from the fieldwork show that 94.8% of the structures in this neighborhood are currently occupied, with another 0% having people living in trailers on the site. In 0% of cases, the team saw trailers without signs of occupancy. In 0.6% of the structures, no trailer exists but some initial repair has been done. Another 4.5% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 10.2% and the median year in which houses were built was 1939.

Neighborhoods with Less Than Two Feet of Flooding. Again, in these neighborhoods, there is a high rate of occupancy. As with West Riverside, the Garden District, which reported the highest income and occupied housing values pre-Katrina, also has the highest rate of occupancy (with nearly all structures occupied). St. Claude, with less than two feet of water, does not appear at first glance to have returned at the same rate as the other neighborhoods in this stratum. This was a very poor neighborhood pre-Katrina and had almost a nearly-23% vacancy rate. This particular neighborhood, near Poland Ave and the Industrial Canal, seems to be returning more slowly.

St. Claude. The sampled block group for the St. Claude neighborhood experienced an average level of flooding (across blocks) of 0.6 feet, placing it the second category of flooding; it lies in the lowest quartile of socioeconomic status. The results from the fieldwork show that 45.2% of the structures in this neighborhood are currently occupied, with another 2.7% having people living in trailers on the site. In 1.1% of cases, researchers saw trailers without signs of occupancy. In 7.5% of the structures, no trailer exists but some initial repair has been done. Another 43.5% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 22.8% and the median year in which houses were built was 1941.

Leonidas. The sampled block group for the Leonidas neighborhood experienced an average level of flooding (across blocks) of 1.2 feet, placing it the second category of flooding; it lies in the second quartile of socioeconomic status. The results from the fieldwork show that 87.9% of the structures in this neighborhood are currently occupied, with another 6.0% having people living in trailers on the site. In 0% of cases, researchers saw trailers without signs of occupancy. In 2% of the structures, no trailer exists but some initial repair has been done. Another 4% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 13.7% and the median year in which houses were built was 1939.

Central City. The sampled block group for the Central City neighborhood experienced an average level of flooding (across blocks) of 0.7 feet, placing it the category of > 0 and less than 2 feet of flooding (the second flooding stratum) and the third quartile of socioeconomic status (thus, above the median for socioeconomic status). The results from the fieldwork show that 76% of the structures in this neighborhood are currently occupied, with another 3.4% having people living in trailers on the site. In less than 1% of cases (0,6%) did researchers see trailers without signs of occupancy. In 1.1% of the structures, no trailer exists but some initial repair has been done. More than one-quarter (28%) show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 20% and the median year in which houses were built was 1939.

Garden District. The sampled block group for the Garden District neighborhood experienced an average level of flooding (across blocks) of 0.1 feet, placing it the second of the five categories of flooding; it lies in the highest quartile of socioeconomic status. The results from the fieldwork show that 99.4% of the structures in this neighborhood are currently occupied, with 0% having people living in trailers on the site. In no case did researchers see trailers without signs of occupancy. In 0% of the structures, no trailer exists but some initial repair has been done. Just under 1% (0.6%) of the structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 12.8% and the median year in which houses were built was 1945.

Neighborhoods with Two to Four Feet of Flooding. These neighborhoods tell a different story than the previous two groups. They are "coming back," but more slowly than the previous two groups. From initial observations to the review of these neighborhoods, it is suggested that these neighborhoods should be watched closely for further development. The analysis suggests that they have the potential to return completely.

Bayou St. John. The sampled block group for the Bayou St. John neighborhood experienced an average level of flooding (across blocks) of 4 feet, placing it the category of 2-4 feet of flooding; it lies in the lowest socioeconomic status stratum. The results from the fieldwork show that 57.9% of the structures in this neighborhood are currently occupied, with another 3.2% having people living in trailers on the site. In no case did researchers see trailers without signs of occupancy. In 10.9% of the structures, no trailer exists but some initial repair has been done. More than one-quarter (28%) show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units in this block group was 10.2% and the median year in which houses were built was 1942.

Fairgrounds. The sampled block group for the Fairgrounds neighborhood experienced an average level of flooding (across blocks) of 3.2 feet, placing it the third of the five categories of flooding; it lies in the second quartile of socioeconomic status. The results from the fieldwork show that 60.4% of the structures in this neighborhood are currently occupied, with another 7.4% having people living in trailers on the site. In 1.3% of cases, researchers saw trailers without signs of occupancy. In 19.6% of the structures, no trailer exists but some initial repair has been done. Just over 11.3% of structures show no signs of either re-occupancy or repair—

thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 12% and the median year in which houses were built was 1945.

Uptown. The sampled block group for the Uptown neighborhood experienced an average level of flooding (across blocks) of 3.5 feet, placing it the third category of flooding; it lies in the third quartile of socioeconomic status (thus, above the mean). The results from the fieldwork show that 68.9% of the structures in this neighborhood are currently occupied, with another 3.3% having people living in trailers on the site. In 1.1% of cases, researchers saw trailers without signs of occupancy. In 8.2% of the structures, no trailer exists but some initial repair has been done. Another 18.6% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 10.2% and the median year in which houses were built was 1941.

Lakeshore. The sampled block group for the Lakeshore neighborhood experienced an average level of flooding (across blocks) of 2.4 feet, placing it the third category of flooding; it lies in the highest quartile of socioeconomic status. The results from the fieldwork show that 86% of the structures in this neighborhood are currently occupied, with 0% having people living in trailers on the site. In 6% of cases, researchers saw trailers without signs of occupancy. In 4.7 % of the structures, no trailer exists but some initial repair has been done. Another 3.4% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 8.5% and the median year in which houses were built was 1960.

Neighborhoods with Four to Eight Feet of Flooding. These neighborhoods are returning at an uneven rate. As noted above, they represent the diversity of the African-American community. The neighborhoods in this section that have the lowest rate of return are the neighborhoods with the higher incomes (Plum Orchard and Edgelake). In these neighborhoods which are much more spread out than either Tremé or Milan, the distance between occupancy appears greater.

Tremé. The sampled block group for the Tremé neighborhood experienced an average level of flooding (across blocks) of 4.1 feet, placing it the third category of flooding; it lies in the lowest quartile of socioeconomic status. The results from the fieldwork show that 17.3% of the structures in this neighborhood are currently occupied, with another 1% having people living in trailers on the site. In 2.1% of cases, researchers saw trailers without signs of occupancy. In 11% of the structures, no trailer exists but some initial repair has been done. Another 68.6% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 30.2% and the median year in which houses were built was 1939.

Milan. The sampled block group for the Milan neighborhood experienced an average level of flooding (across blocks) of 5.7 feet, placing it the fourth category of flooding; it lies in the second quartile of socioeconomic status. The results from the fieldwork show that 9.1% of the structures in this neighborhood are currently occupied, with another 5.2% having people living in trailers on the site. In 3.2% of cases, researchers saw trailers without signs of occupancy. In 50.6% of the structures, no trailer exists but some initial repair has been done. Another 31.8% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 10.5% and the median year in which houses were built was 1939.

Plum Orchard. The sampled block group for the Plum Orchard neighborhood experienced an average level of flooding (across blocks) of 6.3 feet, placing it the third category of flooding; it lies in the third quartile of socioeconomic status (thus, above the mean). The results from the fieldwork show that 1.5% of the structures in this neighborhood are currently occupied, with another 5.4% having people living in trailers on the site. In 8.9% of cases, researchers saw trailers without signs of occupancy. In 47% of the structures, no trailer exists but some initial repair has been done. Another 37.1% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 7.8% and the median year in which houses were built was 1966.

Edgelake. The sampled block group for the Edgelake neighborhood experienced an average level of flooding (across blocks) of 7.5 feet, placing it the fourth of the five categories of flooding; it lies in the highest quartile of socioeconomic status. The results from the fieldwork show that 4.5% of the structures in this neighborhood are currently occupied, with another 11.6% having people living in trailers on the site. In 7.9% of cases, researchers saw trailers without signs of occupancy. In 57.6% of the structures, no trailer exists but some initial repair has been done. Just over 18.4% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 2.2% and the median year in which houses were built was 1976.

Neighborhoods with More than Eight Feet of Flooding. These neighborhoods are the most devastated; not surprisingly, they demonstrate the lowest rate of occupancy. The Lower Ninth Ward remains distinct, in that less gutting and salvaging has been done here than in any other sampled neighborhood. The sampled block group of the Lower Ninth was one that was almost completely destroyed by the over-topping of the levees and the subsequent storm surge. From other observations, we know that gutting has occurred in some parts of the Lower Ninth. And, from observation and other reports, some residents, at very serious risk to themselves have returned to live in the neighborhood.

Lower Ninth. The sampled block group for the Lower Ninth Ward neighborhood experienced an average level of flooding (across blocks) of 9.6 feet, placing it the highest category of flooding; it lies in the lowest quartile of socioeconomic status. The results from the fieldwork show that 0% of the structures in this neighborhood are currently occupied, with another 0% having people living in trailers on the site. In no cases did researchers see trailers with signs of occupancy. Researchers observed no structures at which no trailer existed but some initial repair has been done. Thus, 100% of structures have no signs of either re-occupancy or repair—they appear to be abandoned at this point. Field workers were unable to drive through some streets in the sampled block group; they were closed due to the continued presence of debris. According to 2000 census figures, the vacancy rate for housing units was 10.7% and the median year in which houses were built was 1952.

St. Anthony. The sampled block group for the St. Anthony neighborhood experienced an average level of flooding (across blocks) of 9.6 feet, placing it the highest category of flooding; it lies in the second quartile of socioeconomic status (thus, above the mean). The results from the fieldwork show that 0% of the structures in this neighborhood are currently occupied, with another 0.4% having people living in trailers on the site. In 13.9% of cases, researchers saw trailers with signs of occupancy. In 38.5% of the structures, no trailer exists but some initial repair has been done. Another 47.1% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 4.3% and the median year in which houses were built was 1954.

Gentilly Terrace. The sampled block group for the Gentilly Terrace neighborhood experienced an average level of flooding (across blocks) of 8.1 feet, placing it the highest of the five categories of flooding; it lies in the third quartile of socioeconomic status (thus, it lies above the mean). The results from the fieldwork show that 0% of the structures in this neighborhood are currently occupied, with 2.9% having people living in trailers on the site. In 14.1% of cases, researchers saw trailers with signs of occupancy. In 41.5% of the structures, no trailer exists but some initial repair has been done. Another 41.5% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 3.6% and the median year in which houses were built was 1951.

Lakeview. The sampled block group for the Lakeview neighborhood experienced an average level of flooding (across blocks) of 10.6 feet, placing it the highest category of flooding; it lies in the highest quartile of socioeconomic status. The results from the fieldwork show that 0% of the structures in this neighborhood are currently occupied, with 3.6% having people living in trailers on the site. In 0.4% of cases, researchers saw trailers with signs of occupancy. In 48.4% of the structures, no trailer exists but some initial repair has been done. Another 47.6% of structures show no signs of either re-occupancy or repair—thus, appear to be abandoned at this point. According to 2000 census figures, the vacancy rate for housing units was 4.9% and the median year in which houses were built was 1956.

Observational Analysis of the 20 Sampled Neighborhoods. Several key findings and implications emerge from our observational analysis of repopulation. First, it underscores the degree to which the repopulation picture remains extremely fluid: in the five-week period during which the team made observations, the picture shifted slightly within some neighborhoods. Clearly, neighborhood residents continue to make re-occupancy decisions. Findings and a preliminary discussion of their implications are presented next. Observations have limitations due to their static nature, that is, they capture a moment in time. Different time sampling may have produced potentially different results.

Key Preliminary Findings

1. In general, neighborhoods that received little or no flooding—regardless of socioeconomic status--have returned to near-pre-Katrina levels of occupancy. Yet, the two neighborhoods with the highest level of income and lower flooding evidence the highest rate of occupancy. East Riverside exemplifies a neighborhood that housed relatively low-income residents pre-Katrina, but in which occupancy levels approach pre-Katrina levels.

2. Among neighborhoods in which flooding occurred, the occupancy rate varies widely. Within a given census tract, some blocks exhibit a great deal of activity (e.g., salvage/

gutting, repair work, trailers), while other blocks—often adjacent--demonstrate no sign of occupancy.

3. Within neighborhoods--especially those that experienced significant flooding--occupancy levels also fluctuate widely across blocks. For example, in the two sampled neighborhoods in East New Orleans, the occupancy rate remains very low. One household might have returned to its trailer or house, but the residents find themselves isolated because nearby houses stand in varying stages of repair or remain completely abandoned.

4. The presence of temporary trailers does not necessarily mean that people are living there. Especially in devastated neighborhoods, many trailers remain disconnected to electricity or stand unused.

5. Even within census blocks that experienced significant flooding, the level of building repair proves surprisingly uneven. Some buildings have been gutted and appear to be under repair; others have been gutted with no apparent renovation, and still others remain virtually untouched, eight months after Katrina.

Preliminary Implications

1. There appears to be no uniform timetable for rebuilding in any of the sampled neighborhoods. For example, in some blocks, one might find the following array: some houses have completed repair and residents have returned; occupied trailers stand on other sites, connected to electricity and sewage; other trailers stand on sites with no electrical hook-up; some houses have been gutted but no other repair has been done; and several abandoned properties have been neither gutted nor salvaged. This lack of consistency contributes to the sense of isolation and feelings of vulnerability for residents. It also makes planning difficult for residents and for local officials.

2. The prevalence of abandoned houses throughout certain neighborhoods highlights the slow pace of recovery. In those neighborhoods, repairs will not be completed before hurricane season begins; if severe weather inflicts further damage, the rate of recovery will slow even further.

3. Despite predictions to the contrary, some neighborhoods that housed predominantly low-income, African-American residents demonstrate high rates of occupancy. These include East Riverside, Irish Channel, Central City, and Fairgrounds. We cannot assume that African-Americans are the only people returning to these neighborhoods, but it is a certainly an area for future research and planning.

4. Many neighborhoods in which significant numbers of middle-income African-Americans resided before Katrina appear to be among the most de-populated in the city. Even neighborhoods (such as Gentilly Terrace) that lie on the west side of the Industrial Canal—where they may be protected by the repaired levee—demonstrate extremely low occupancy rates.

5. In the most devastated neighborhoods, the occupants who have returned face enormous obstacles in remaining there. Because of the unevenness of re-occupancy within and across blocks, many of these residents are very vulnerable. Because only a few people have returned, neighbors report feeling vulnerable to possible criminal activity.

6. In many parts of the city, basic retail services remain unavailable, eight months after Katrina: few convenience stores, banks, and grocery stores have re-opened in those areas. For residents, this exacerbates the difficulty of living in damaged locales.

7. 7) Some neighborhoods appear to stand at a turning point, at which they might either experience repopulation or be abandoned completely. These neighborhoods, which lie between those with high occupancy rates (such as East Riverside or the Irish Channel) and those that remain devastated (such as the lower 9th Ward), include Bayou St. John, Fairgrounds, Uptown and Lakeshore. Other neighborhoods that bear close scrutiny include the range of African-American neighborhoods, such as Tremé, Milan, Plum Orchard and Edgelake/Little Woods. The future of these neighborhoods may serve as an important indicator of the city's future.

II. Section 5.2: Jefferson Parish

5.2.1 Introduction. Jefferson Parish is the second largest parish in the New Orleans metropolitan area. Levee breaches and overtopping, along with inoperable storm water pumps, resulted in massive flooding especially in the areas of near the center of the New Orleans parish.

5.2.2 Pre-Katrina.

Cultural and Historic Context. Named after Thomas Jefferson, president when Louisiana was purchased from France, Jefferson Parish was originally part of Orleans Parish, and not created as a separate political entity until February 11, 1825. Indigenous people populated the area for thousands of years prior to European settlement. The earliest European settlement in the parish was along the banks of the Mississippi River and along the old Bayou Metairie ridge which runs from New Orleans into the parish. Large sugar cane plantations were along the Metairie ridge while beyond this area small farms produced vegetable crops. Metairie once had the largest unincorporated areas in the state. During the 1950s as New Orleans' population increased, new residential subdivisions in the parish were built. Other development followed the main transportation corridors: Causeway Boulevard, Airline Highway, and the Veterans Memorial Highway (Lewis, 2003; The Parish of Jefferson 2006).

Beginning in the 1920's much of Jefferson parish was transformed from farm lands to residential neighborhoods and towns. Large towns and neighborhoods include Shrewsbury, River Ridge, Harahan, and Kenner. The largest incorporated area of Jefferson Parish is Kenner. Several communities were founded on the west bank of the river at Harvey, Gretna, Bridge City, Westwego, Avondale, Waggaman, and Marrero. Communities in Jefferson Parish are also home to a large number of descendants of coastal fishermen and trappers that had lived along the Gulf coast at Chenier Caminada near Grand Isle. In 1893, the community at Chenier Caminada was devastated by a severe hurricane that wiped out the community and killed large numbers of the people. Many of the survivors moved to Westwego where they were safer and closer to schools and other services.

The area of Jefferson Parish on the west bank of the river between the Mississippi River and the Gulf of Mexico was known as Barataria. Barataria was a vast expanse of marsh and swamp lands where Jean Lafitte and other privateers lived and smuggled contraband into the City of New Orleans in the early 1800's. Lafitte, one of the towns in the Barataria Basin, is named after the famous privateer. The people of Lafitte were predominantly fishermen and trappers until recently when many people began to settle in the area and build large residential homes along Bayou Barataria. Grand Isle was predominantly a fishing village in the 1800's and has remained a seafood center. The area has both summer and year round camps lining the Gulf shore. It is a mecca for recreational and commercial fishermen. The only road access to the island is by state Highway.

Jefferson Parish has numerous archaeological and historic properties. Like the other metropolitan parishes of New Orleans the number of National Register of Historic Places properties does not reflect the significant sites that exist in the parish. The Louisiana Division of Historic Preservation database contains only 18 listings for properties on the Register. The Division of Archaeology has listed archaeological sites recorded in its site files. Many more archaeological sites probably exist in the parish but have not been recorded or are deeply buried by subsidence or alluvium.

Social Context. US Census (2006) provides a wide variety demographic characteristic of Jefferson Parish. A detailed enumeration of characteristics can be found in Sub-Appendix C. Jefferson Parish is located upriver from New Orleans on both sides of the Mississippi River. The parish is long and linear and stretches over 60 miles from Lake Pontchartrain to the Gulf of Mexico. The diverse population reflects those living and working and living in a metropolitan and those residing and conducting business in smaller communities. There are many long term residents mixed with new residents moving to the areas of the parish closest to the metropolitan center of New Orleans.

In 2000, the total population of Jefferson Parish was 455,466. Nearly 94% (93.8%) of housing units were occupied; of these, 63.9% were owner-occupied. Slightly less than 27% (26.7%) of housing units were occupied by only one individual. The median contract rent was $455 and the median value of owner-occupied housing units was $102,800.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 92.9. Approximately 12% (11.9%) of residents were over 65 years of age. The economic dependency ratio stood at 66.2 and the median age in the parish was 35.9. The pre-Katrina population of Jefferson was about two-thirds (65.4%) white and nearly one-quarter (22.7%) black. Hispanics comprised just over 7% (7.1%), Asians made up 3.1%, and the remaining 1.7% consisted of other races. The index of qualitative variation (IQV) for race stood at 56.9%, reflecting the pre-Katrina racial mix of the parish. We note that the IQV measures for Jefferson and Orleans Parishes are nearly identical, but the proportions of blacks and whites comprising them are reversed: Orleans was approximately two-thirds black, pre-Katrina, and the population of Jefferson was nearly two-thirds white.

Nearly 76% (75.9%) of Jefferson Parish's residents in 2000 were born in Louisiana. Slightly more than 60% (61.4%) resided in the same house that they did in 1995, while nearly one-quarter (23.7%) lived in a different house but in the same county as 1995. Taken together, these measures show the stability of the parish, where 85.1% of residents have for at least 5 years.

Just over 20% (20.7%) of residents reported that they had not completed high school and 21.5% indicated that they had graduated from college. The employment-related indicators show that 21% of residents reported a limiting disability and 2.6% were linguistically isolated. Just over 36% of residents (36.1%) were not in the labor force. Of those in the civilian labor force, only 5.6% were unemployed.

Median income of households in this parish stood at $38,435 in 2000; median family income was $45,834. The poverty rate stood at 13.7%. The level of income inequality in the parish, as measured by the Gini index, was 45.9 for household income and 43.2 for family income. Slightly more than 9% (9.3%) of households had no vehicle in 2000 and 1.9% lacked a telephone.

5.2.3 Post Katrina.

Cultural and Historic Context. Impacts to cultural and historic features and culture have yet to be determined.

Social Context. The Louisiana Department of Health and Hospitals (2006) estimates placed the post-Katrina population of Jefferson Parish at 368,435 as of March, 2006. This represents a 20 percent decrease from the pre-Katrina population. However, local officials perceive that the population of the parish has increased. They note a positive business climate in the parish, post-Katrina. Before Katrina, occupational license data indicated that 28,982 businesses operated in the parish. Three hundred seventy businesses had closed as of 30 March, 2006, representing 1.28% of the pre-Katrina business population. However, the occupational license data showed that 31,146 businesses were open, overall, at that time, representing a 7.5% increase. Labor represents a difficult issue for these businesses, however, as demand appears by far to exceed supply. An economic development official in the parish characterized the labor supply as the "second biggest problem" that the parish currently faces, with the first—availability of housing—integrally connected to it. Many houses remain under repair in the parish and the lack of housing constrains the availability of labor and new migrants.

All of the public schools in the parish were opened by mid-November 2005. Only half of the public libraries are now open. Nearly 75% of the child care centers are operable, while all but one major hospital is now operating (Brookings 2006).

III. Section 5.3: Plaquemines Parish

5.3.1 Introduction. Plaquemines Parish located below New Orleans is the southernmost parish in the state. Many areas in the parish were unprotected by levees, making them highly susceptible to tidal surge during hurricane events. Areas of the Parish near the New Orleans metropolitan area have experienced growth as residential suburbs have developed over the past twenty years. Many of the traditional resource related activities –fishing, citric farming and oil exploration- provide economic base of many communities in the parish. The hurricane event damage and destroyed many of the resources upon which these economic activities depend.

Local residents who tried to ride out the storm report a 30 foot tidal surge sweeping across the parish. Waters became trapped inside the levees, creating a washing-machine like effect that sloshed houses, large boats, horses and cars from levee to levee. Plaquemines Parish and most of its infrastructure sustained catastrophic damage. Persons that ventured into the parish after impact experienced stagnant conditions with festering piles of sewage and animal carcasses and rotting debris piles. Those who stayed often fought for their lives, with some survivors reporting that they leaped from their rooftops into the waters. Residents report that they have lost everything, with many no longer knowing where their homes went. FEMA trailers arrived months after impact, with many residents attempting to stay in nearby parishes, often in an effort to return to work in order to feed their families. The numerous fishing villages, many populated by Native American and Vietnamese American fishermen, face possible permanent relocation.

Section 5.3.2 Pre-Katrina.

Historic and Cultural Context. The parish name is derived from an Indian word corrupted by the French which means persimmons. Near the present day town of Venice, the French explorer, LaSalle claimed the Mississippi River and adjacent lands for the French crown (1682). The parish's strategic location at the mouth of the river meant that the country that controlled the mouth of the river could control Mississippi River Valley commerce. For this reason, several bends in the river served as sites for military fortifications; the changing currents of the Mississippi River destroyed many. Only Fort St. Philip and Fort Jackson existed pre-Katrina. The French encountered indigenous peoples from the Chawasha and Washa tribes living near English Turn. In the 1720's, French settlers who were given grants of land began to settle in the area and clear the land for cultivation. Soon concessions lined both banks of the Mississippi River. These settlers built small plantation houses and cleared the land to farm indigo and later sugar cane. The lower elevation of the area proved to be good for rice cultivation as well. By the early 1800's many large prosperous plantations existed in the parish. (Plaquemine Parish 2006).

Following the Louisiana Purchase Plaquemines Parish was later officially organized on March 31, 1807. The plantation owners in the parish prospered from the rich alluvial soils and their proximity to New Orleans In the mid to late 1800's large numbers of Yugoslavians arrived in the parish and established oyster processing villages along the river such as Ostrica and Olga. Some of these new immigrants began to cultivate citrus crops and the Plaquemines Parish Fair and Orange Festival became a major event in the parish celebrating that heritage. Pre-Katrina, it was common to purchase citrus along the fruit stands stretching along the highway between the levees.

Many people worked in the large oil, petrochemical and sulphur industries that lined the river. The town of Venice, located near the Head of Passes, serves as a support area for the oil rigs offshore including helicopter services and fishing charter companies. The levees on the east bank end just below Pointe a la Hache, which is the parish seat, has a ferry landing connecting both parish banks. Across from Pointe a la Hache is West Pointe a la Hache. Previously plantations, other communities include Belair, Boothville, Bratihwaite, Carlisle, Davant, Empire, Ironton, Ostrica, Port Sulphur, Potash, Port Eads, South Pass, Buras, and Triumph. Pilottown is another community located on the east bank of the river which serves as the staging area for ships picking up river pilots to guide them upriver. The largest community in the parish was Belle Chase located at the northern most part of the parish closer to New Orleans. The population of this community has increased over the years due to the movement of people from the lower parish into the area and people from New Orleans moving to new subdivisions established in the area.

Plaquemines has numerous archaeological and historic properties. The number of National Register of Historic Places properties likely reflects the number of culturally significant sites that exist in the parish. The Louisiana Division of Historic Preservation database contains only 8 listing for properties on the Register. The Division of Archaeology also lists archaeological sites recorded throughout the parish. Many more archaeological sites probably exist in the parish but have not been recorded or are deeply buried by subsidence or alleviation. A major Native American mound complex is known to exist near Grand Bayou. This site has not been nominated to the National Register of Historic Places but would surely qualify. A community, known as Grand Bayou, that lives near the mound complex outside the hurricane protection levee and trace their ancestry to this mound site and the Atakapa Indians. Plaquemines Parish

Social Context. The population of the parish is scattered throughout the parish in small, unincorporated communities. Many of the residents are long-term residents of the state, often employed by local businesses such as off shore petroleum exploration, outdoor recreation and agriculture. Commercial fishing, much of which is conducted by small business owners residing in the area is also a major economic activity in the Parish.

Perhaps the small fishing village of Grand Bayou, Louisiana exemplifies the marginal but stoic situation of many low-income residents prior to landfall. This unincorporated community is located in coastal wetlands south of New Orleans and lies one mile west outside the protection of the Mississippi levee. This community has experienced repetitive losses due to repeated natural disasters, coastal erosion, and economic challenges, as well as threats to cultural heritage and social networks. Situated along a bayou that stretched to the Gulf, and accessible only by water, this intercultural Native American (Atakapa, Houma) and Cajun community of 125 relied on traditional extractive activities such as shrimping, oystering, and trapping to provide for their families. Due to coastal erosion, import of non-local shrimp, and pollution, local economic options had declined dramatically. Local residents relied on trapping of nutria and other animals during the winter months and had recently secured some funding to assess their options for home elevations. Grants had been awarded from the Heifer Project to provide minnow fishing as an employment opportunity for teenagers. Despite the threats to their existence, locals relied on strong attachments to the land, to their faith, to each other and to the nearby Native American burial mounds they claimed as part of their ancestry. Residents saw themselves as stewards of dwindling environmental resources and sought means to save the bayou and its people prior to Katrina.

Driving along Plaquemines Parish it is clear that, pre-Katrina, some parts had become bedroom communities for the Greater New Orleans area, with increasing numbers of fairly new brick home subdivisions. Smaller communities offered stick-built homes in small enclaves where neighbors walked easily across the road to visit each other.

In 2000, the total population of the parish was 26,757. Over 86% (86.1%) of housing units were occupied; of these, nearly 79% (78.9%) were owner-occupied. Approximately 19% (18.6%) of housing units were occupied by only one individual. The median contract rent was $401 and the median value of owner-occupied housing units was $68,900.

Among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 101.3, the highest of the 6 parishes profiled here. Approximately 10% (9.8%) of residents were over 65 years of age. The economic dependency ratio stood at 72.1 and the median age in the parish was 33.7. The pre-Katrina population of Plaquemines Parish was about two-thirds (68.8%) white and about one-quarter (23.3%) African American. Hispanics comprised just over 1% (1.6%), Asians made up 2.6%, and the remaining 3.7% consisted of other races. The index of qualitative variation (IQV) for race stood at 57, reflecting the racial mix of the parish, pre-Katrina.

Over 80% (80.8%) of Plaquemines Parish's residents in 2000 had been born in Louisiana. Over 65% (65.5%) resided in the same house that they did in 1995; just over 16% (16.4%) lived in a different house but in the same county as 1995. Taken together, then, these measures show that 81.9% of residents had lived in Plaquemines Parish for at least 5 years.

Nearly one-third (31.3%) of residents reported that they had not completed high school and only about 10% (10.8%) indicated that they had graduated from college. The employment-related indicators show that 19.1% of residents reported a limiting disability and 2% were linguistically isolated. Nearly 45% of residents (44.6%) were not in the labor force. Of those in the civilian labor force, 6.7% were unemployed.

Median income of households in this parish stood at $38,173 in 2000; median family income was $42,610. The poverty rate stood at 18%. The level of income inequality in the parish, as measured by the Gini index, was 46.6 for household income and 43.4 for family income. Approximately 10% (9.6%) of households had no vehicle in 2000 and 5.2% lacked a phone.

Section 5.3.3 Post-Katrina.

Cultural and Historic Context. Impacts to Cultural and Historic features have yet to be determined. However, the tidal surge did extensive nature of damage to lands and properties and likely damaged both historical and cultural resources of the eras of both the pre- and post-European contact.

Social Context. Plaquemines Parish experienced extensive flooding in Hurricane Katrina. Flooding was a result of both levee breaches and overtopping as well as tidal surges in areas not having hurricane protection. The Louisiana Redevelopment Authority (2006) estimates the current population of the parish to be 17,567 (as of March, 2006), about 34 percent fewer residence than in 2000. Local officials expect that number to increase after children of displaced residents complete the school year. Aiding the return of these families is the fact that modular schools will be erected in Port Sulphur in August, providing educational facilities for residents in lower Plaquemines. Three schools (Belle Chase Primary, Middle, and High Schools) already serve upper Plaquemines. Electricity has been restored parish-wide along main highways. Officials estimate that most residents in the parish have electricity, potable water, and electricity; gas restoration moves more slowly. Sewage connections exist in every area except small parts of Buras and Empire. Most residents live in trailers, on boats or travel into the area to retrieve what little remained after the storm. Some residents (an unknown number) reportedly live in nearby parishes in order to work, often with other families in overcrowded conditions.

Long-term social consequences for Plaquemines Parish include significant disruptions to daily life and long-term consequences for family, religious, ethnic, educational and employment opportunities. In an article posted May 15, 2006 by the New Orleans Times Picayune (2006), those living in the "Village" near Venice are probably typical of some smaller communities of people. Residents have reportedly lived in the area for over 40 years but were forced to relocate when fences were erected around their bayou. Residents now live, scattered, in travel trailers but hope to return home. Much of lower Plaquemines Parish residents are now living in travel trailers. For many of the smaller unincorporated areas, certain families have been able to remain near their boats, while others have been dislocated to higher grounds in the Parish or to other areas.

Local officials indicate that the post-Katrina population mirrors the pre-Katrina population in composition. Unlike St. Bernard, Plaquemines Parish does not perceive that older individuals are returning at a lower rate, though younger individuals and families (e.g, those in their 20s and 30s) generally chose to resettle in the Belle Chase area, rather than lower Plaquemines. Parish officials indicate the re-establishment of a recreation program that will provide softball and baseball times for children during the summer. They are also heartened by the reestablishment of businesses throughout the parish, including restaurants and convenience stores, and the announcement that Cypress Cove Marina will reopen. The storm did inflict heavy damage on the citrus industry, decimating citrus groves. It is unlikely that Plaquemines Parish will return to anything resembling pre-Katrina conditions anytime soon.

IV. Section 5.4: St. Charles Parish

5.4.1 Introduction. St. Charles Parish is bordered by the banks of Lake Pontchartrain and on the west side of the parishes included in this study. Much of the parish population evacuated in advance of Katrina, however damage was not as substantial as other Katrina hit areas. Because of the relatively low level of damage, many evacuees sought out temporary housing and services in the parish.

Section 5.4.2 Pre-Katrina.

Cultural and Historic Context. In 1805, Louisiana only consisted of the current land west of the Mississippi River and the Isle of Orleans (the land on the east bank of the Mississippi River and south of Bayou Manchac). St. Charles Parish, one of the original 19 parishes of the territory of Orleans, was created in 1807 from the county of the German Coast which begins 25 miles above the city of New Orleans and extends along both sides of the Mississippi River for 40 miles toward Baton Rouge. Today, this incorporates all or part of St. Charles and St. John the Baptist Parishes. German Coast County included the Catholic Church parishes of St. Charles Borromeo and St. John the Baptist, commonly called the first and second German Coasts. On March 31, 1807 the Legislative Council of the Territory of Orleans re-divided the original twelve counties into nineteen parishes, based on the ecclesiastical boundaries of the period of Spanish government. At this point German Coast county was divided into St. Charles Parish and St. John the Baptist Parish. The courthouse was established on the west bank near Hahnville. The Territory of Orleans along with the West Florida Republic became the state of Louisiana in 1812. By 1861 the current boundaries of St. Charles Parish were in place.

Social Context. US Census (2006) provides a wide variety demographic characteristic of St. Charles Parish. A detailed enumeration of characteristics can be found in Sub-Appendix C. In 2000, the total population of St. Charles Parish was 48,072. Over 94% (94.2%) of housing units were occupied; of these, nearly 82% (81.4%) were owner-occupied. Approximately 17% (16.7%) of housing units were occupied by only one individual. The median contract rent was $390 and the median value of owner-occupied housing units was $96,300.

Turning to the composition of the population, we find that, among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 93.2. Nine percent of residents were over 65 years of age. The economic dependency ratio stood at 72.6 and the median age in the parish was 34.2. The pre-Katrina population of St. Charles Parish was over 70% (70.5%) white and about one-quarter (25.1%) black. Hispanics comprised 2.8%, Asians made up .6%, and the remaining 1.1% consisted of other races. The index of qualitative variation (IQV) for race stood at 51.5, reflecting the mix of blacks and whites in the parish.

Over 81% (81.9%) of St. Charles Parish's residents in 2000 had been born in Louisiana. Over 66% (66.5%) resided in the same house that they did in 1995; more than 15% (15.5%) lived in a different house but in the same county as 1995. Taken together, then, these measures show that 82% of residents had lived in St. Charles Parish for at least 5 years.

Twenty percent of residents reported that they had not completed high school and about 18% (17.5%) indicated that they had graduated from college. The employment-related indicators show that 17.1% of residents reported a limiting disability and 1.1% were linguistically isolated. Over 35% of residents (35.4%) were not in the labor force. Of those in the civilian labor force, only 5.2% were unemployed.

Median income of households in this parish stood at $45,139 in 2000; median family income was $50,562. The poverty rate stood at 11.4%. The level of income inequality in the parish, as measured by the Gini index, was 42.7 for household income and 39.8 for family income. Approximately 6% (6.4%) of households had no vehicle in 2000 and 2.5% lacked a phone.

Section 5.4.3 Post-Katrina.

Historic and Cultural Context. Impacts to Cultural and Historic features and culture have yet to be determined.

Social Context. According to the Louisiana Department of Health and Hospitals (2006), St. Charles Parish gained population as result of flood victims of Orleans Parish and recovery workers seeking housing. An estimated 51,314 persons resided in the parish in March 2006. As with other Parishes, though unconfirmed, the increase in population is likely to put some pressure on existing demand for goods and services in the parish. Time and funding limitations precluded further data collection and analysis.

V. Section 5.5: St. Bernard Parish

5.5.1 Introduction. Flooding is an integral part of the parish's history, including that events associated of the dynamiting levees in the Mississippi River flood of 1927 in order to save urban areas within New Orleans. During Hurricane Katrina, the direct forces of the wind and rain and tidal surge sent flood waters throughout the parish. The breaches of the Industrial Canal, immediately to the east, added to the already intense flooding in the parish. The parish was the closest of all the parishes in this study to the path of the hurricane's eye. Consequently, the cumulative flooding and winds damaged nearly every residence and business in the parish. Damage was catastrophic.

Section 5.5.2 Pre-Katrina.

Historic and Cultural Context. St. Bernard Parish, which is located downriver from New Orleans, was created on March 31, 1807. The first Europeans to settle in the parish were French settlers that established concessions (plantations) along the Mississippi River. During the Spanish colonial period settlers from the Canary Islands were granted tracts of land along the banks of the bayou. These settlers, known as Islenos were predominantly farmers who also herded cattle and supplied the markets of New Orleans with fresh produce and meats such as garlic, onions, beans, potatoes and poultry. St. Bernard was originally part of the territory of Orleans following the Louisiana Purchase in 1803. The parish received its name for the patron saint of one of Louisiana's most noted Spanish governors, Bernardo de Galvez. Governor Galvez was well known for his capture of the British settlements of Baton Rouge, Mobile and Pensacola during the American Revolution. Prior to the Louisiana the area was known as Terre aux Boeufs for the wild oxen that roamed the area. Bayou Terre aux Boeuf, one of the major bayous of the parish and an abandoned channel of the Mississippi River also derived its name from the wild oxen that roamed along its natural levees. As the population grew people moved from the banks of the Mississippi River and Bayou Terre aux Boeuf into several small settlements along other bayous such as Bayou La Loutre and along the shore of Lake Borgne. In 1779 the hamlet of St. Bernard was settled. Some of the Islenos settlers worked on sugar plantation harvesting sugar and cypress, which was valued for construction. By 1840's the railroad had penetrated the Terre aux Boeufs section of eastern St. Bernard and by 1850 a railroad track was built to old shell beach on Lake Borgne. The bulk of sugar cane, produce, and wild game harvested in St. Bernard were shipped to N.O. using the railroad. The homes of the early settlers along Bayou Road were similar to the houses of small farmers residing above and below N.O. along the river. The typical house consisted of four rooms with porches in the front and rear. Two small storage rooms flanked either side of the rear porch. The roofs were usually steeply pitched gabled roofs. Kitchens were detached to avoid fires which were common with open hearth cooking.

The social life of the people focused on family and Roman Catholicism which was the religion of both the French and succeeding Spanish colony. People lived in extended family units. A church was established in 1785 and became the first permanent church below New Orleans. Several settlements were established in St. Bernard. Chalmette the largest community in St. Bernard with a population today of over 32,000 is well known as the site where General Andrew Jackson defeated the British at the Battle of New Orleans in January 1815. A National Historical Park and National Military Cemetery was established on a portion of the battlefield.

Some of the other larger communities of the parish include the towns of Arabi, Meraux, Poydras, Reggio and Violet. Arabi, considered a suburb of New Orleans has a population of around 8,000. The community received its name after the Sheik of Arabi who tried to free his people from of British rule. Meraux a community named after well known sheriff of the parish had a population of around 10,000 according to the 2000 census. Poydras, with a population of 3,800 was named after Julien Poydras philanthropist and one of Louisiana's first poets. The town of Reggio was established in the 1780 and named after a plantation owner Auguste Reggio. Violet located along the canal of the same name developed out of the Livaudais plantation and had a population of over 8500 in the 2000 Census. Two other communities Toca and Verrett are communities that grew when roads were improved in the parish starting in the 1920's.

Several small fishing villages were founded in the late 1700's and 1800's and still exist today. These include Delacroix, Yscloskey, Shell Beach, and Hopedale, The Delacroix village was established well before the Civil War as a fishing community. Yscloskey and Shell Beach near Lake Borgne were thriving communities inhabited primarily by Islenos commercial fishermen. Many of the people in these communities would trap and hunt not only to sustain their households but, to supply the markets in New Orleans and around the country. Many made a living harvesting, cleaning and shipping oysters and other seafood. In the 1940's and 1950's large industrial facilities were established along the Mississippi River in the parish.

St. Bernard is an old parish that has numerous archaeological and historic properties. Unfortunately only 7 properties are listed on the National Register of Historic Places. The Division of Archaeology has listed archaeological sites in its site files. Many more sites probably exist in the parish but have not been recorded or are deeply buried by subsidence or alleviation. Several major military sites that protected entrance to various waterways leading to New Orleans have not been nominated to the National Register of Historic Places. These include Battery Bienvenue, and Martello Castel Tower Dupre. (St. Benard Parish 2006)

Social Context. St. Bernard Parish is immediately to the east of Orleans Parish and bounded at the south by the Mississippi River. The parish is characterized by both residential and heavy industry areas. St. Bernard Parish can be characterized by its working class neighborhoods. The parish's population size has remained steady over the past thirty years. A vast majority of people living in the parish have been in residence for more than 5 years.

US Census (2006) provides a wide variety demographic characteristic of St. Bernard Parish. A detailed enumeration of characteristics can be found in Sub-Appendix C. In 2000, the total population of St. Bernard Parish was 67,229. Nearly 94% (93.8%) of housing units were occupied; of these, nearly 75% (74.6%) were owner-occupied. Approximately 23% (22.9%) of housing units were occupied by only one individual. The median contract rent was $374 and the median value of owner-occupied housing units was $82,900. Among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 95.8. Approximately 14% (13.8%) of residents were over 65 years of age. The economic dependency ratio stood at 72.1 and the median age in the parish was 36.6. The pre-Katrina population of St. Bernard Parish was nearly 85% (84.4%) white and only about 8% (7.6%) black. Hispanics comprised just over 5% (5.1%), Asians made up 1.3%, and the remaining 1.7% consisted of other races. The index of qualitative variation (IQV) for race stood at 26.4, the lowest of the parishes profiled here.

Over 86% (86.1%) of St. Bernard Parish's residents in 2000 had been born in Louisiana. Over 65% (65.1%) resided in the same house that they did in 1995; more than 23% (23.6%) lived in a different house but in the same county as 1995. Taken together, then, these measures show that 88.7% of residents had lived in St. Bernard Parish for at least 5 years.

More than one-quarter (26.9%) of residents reported that they had not completed high school and only about 9% (8.9%) indicated that they had graduated from college. The employment-related indicators show that 23.4% of residents reported a limiting disability and 1.4% were linguistically isolated. Over 40% of residents (40.3%) were not in the labor force. Of those in the civilian labor force, 5.8% were unemployed.

Median income of households in this parish stood at $35,939 in 2000; median family income was $42,785. The poverty rate stood at 13.1%. The level of income inequality in the parish, as measured by the Gini index, was 43 for household income and 38.5 for family income. Approximately 10% (10.3%) of households had no vehicle in 2000 and 2.6% lacked a phone.

Section 5.4.3 Post Katrina.

Cultural and Historic Context. Impacts to Cultural and Historic features of Saint Bernard Parish have yet to be determined. Historic sites such as the Chalmette Battlefield and cemetery (site of the Battle of New Orleans War of 1812) were flooded and have remained closed through the spring 2006.

Social Context. St. Bernard Parish experienced extensive flooding in Hurricane Katrina. The Parish experienced flooding from many sources, including levee breaches and tidal surges. Although the Louisiana Development of Health and Hospitals Authority places the current population of the parish at 14,015, a recently-completed survey conducted for the government of the parish, estimates that 20,000 residents have returned. Parish officials anticipate that the population will grow to 40,000 residents within the next two years. A local official indicated that the current population mirrors the pre-Katrina composition in all respects except one: older residents have returned at a much lower rate than younger.

The Murphy oil spill has complicated the issue of return. Many of the issues surrounding Murphy oil are contested. For example, there is disagreement about the boundaries of the spill. Moreover, some of the residents affected by the spill have settled with Murphy Oil and are fixing their houses. Others have become part of lawsuits and have left their homes as they were after the flood. Further complicating this issue is that Murphy Oil is an employer in the parish and many of those affected also have jobs or relatives with jobs with the company.

In terms of infrastructure, debris removal has been completed throughout the parish so that all streets are passable. Local officials estimate that 80% of the electricity has been restored as well as 90% of the potable water; however only about 30% of the gas is in service. As with southern Plaquemines Parish, much of southern St. Bernard Parish is populated by travel trailers. Yet, the greatest current need, according to local officials, was temporary trailers to house residents.

VI. Section 5.6: St. Tammany Parish.

5.6.1 Introduction. St. Tammany Parish is on the north shore of Lake Pontchartrain. Hurricane Katrina brought heavy rains and winds to the parish. The eye of the hurricane passed within a few miles of Slidell. The community is adjacent to Lake Pontchartrain. Tidal surge from the lake caused substantial damage to parts of the community. However, the extent of damage is less than that found in Orleans, St. Bernard or Plaquemine parishes. A consequence associated with the hurricane is the influx of evacuees from the harder hit areas in the New Orleans metropolitan area.

5.6.2 Pre-Katrina.

Historic and Cultural Context. According to the Tammany Parish government, the first French explorers intruded into the parish region during the late 1600s, the nations of Muskegon peoples were firmly established in the area. Consequently, tribes began to migrate west in search of new lands. Among the tribes that eventually migrated to, or through, St. Tammany were the Biloxi, Koasati, and Choctaw. Early European settlers came to the area for its resources. The area was under Spanish rule as part of what was known as West Florida. After an uprising in 1804, the United States annexed the territory. Both British and U. S. troops used the area during the War of 1812. Much of St. Tammany consisted of dense woods, wetlands and marshes and served as a hiding ground for slaves escaping from surrounding plantations and industrial sites. After the civil war, the area remained relatively poor and undeveloped. Old fishing camps, dating back to before the early 20th century, had ties to both recreational and commercial fishing activities on Lake Pontchartrain. With the growth of New Orleans and access of highway systems in the mid to late 20th century the area experienced considerable residential and industrial development.

Social Context. US Census (2006) provides a wide variety demographic characteristic of St. Tammany Parish. A detailed enumeration of characteristics can be found in Sub-Appendix C. In 2000, the total population of St. Tammany Parish was 191,268. Over 90% (91.9%) of housing units were occupied; of these, 80.5% were owner-occupied. Approximately 20% (19.7%) of housing units were occupied by only one individual. The median contract rent was $493 and the median value of owner-occupied housing units was $116,000.

Among individuals 20-64 years of age, the sex ratio (the number of males per 100 females) stood at 95.1. Ten percent of residents were over 65 years of age. The economic dependency ratio stood at 69.7 and the median age in the parish was 36.3. The pre-Katrina population of St. Tammany Parish was over 85% (85.3%) white and about 10% (9.8%) black. Hispanics comprised 2.5%, Asians made up .7%, and the remaining 1.7% consisted of other races. The index of qualitative variation (IQV) for race stood at 29.1, reflecting the low level of racial diversity in the parish.

Over 67% (67.7%) of St. Tammany Parish's residents in 2000 had been born in Louisiana. Approximately 55% (54.7%) resided in the same house that they did in 1995; more than 20% (20.2%) lived in a different house but in the same county as 1995. Taken together, then, these measures show that 74.9% of residents had lived in St. Tammany Parish for at least 5 years.

Over 16% (16.1%) of residents reported that they had not completed high school and about 28% (28.4%) indicated that they had graduated from college. The employment-related indicators show that 17.6% of residents reported a limiting disability and .5% were linguistically isolated. Over 35% of residents (35.4%) were not in the labor force. Of those in the civilian labor force, only 3.8% were unemployed.

Median income of households in this parish stood at $47,883 in 2000; median family income was $55,346. The poverty rate stood at 9.7%. The level of income inequality in the parish, as measured by the Gini index, was 45.3 for household income and 41.8 for family income. Approximately 4% (4.4%) of households had no vehicle in 2000 and 2.2% lacked a phone.

5.6.3 Post Katrina.

Cultural and Historic Context. The full impacts to cultural and historic features and culture have yet to be determined. The Old Town and lakefront areas of the city of Slidell were hit especially hard with many buildings as a result of water from the storm surge. The storm surge completely leveled many of the houses in the large and historic Oak Harbor and Eden Isles subdivisions. Most of the old fishing camps that lined the lakefront north and south of I-10 were all but erased, with only the wood pylons remaining.

Social Context. The Louisiana Department of Health and Hospitals (DHH) estimated the population of St. Tammany Parish, post-Katrina, at 206,204 as of March, 2006. Thus, St. Tammany has experienced an increase in population since Katrina. Local officials describe the influx as a population "explosion"; their estimates of current populations exceed, by far, the DHH estimates, running as high as 275,000 to 300,000. The explanation for the discrepancy may lie in the data sources employed for the DHH estimates as they rely heavily on school enrollment data. When asked about the effect on schools, a local official indicated that the schools had experienced only a relatively small increase in enrollment. Apparently, a relatively low proportion of the new residents are young families with children and many are "empty nesters" and elderly individuals. If local perceptions are correct, then the DHH estimates may, indeed, understate significantly the rate of population increase in St. Tammany Parish post-Katrina. This scenario would predict an increase in the proportion of the St. Tammany Parish population that is over 65 and a corresponding increase in the economic dependency ratio in the parish.

Slidell suffered damage from the effects of the hurricane surge. In various parts of the town, damage was significant. The eye of the storm passed within 20 miles from the city causing wind and rain damage to property. Storm surge also caused substantial damage properties near the lake front.

The greatest effect of this increased population appears to be the marked increase in traffic and congestion in the parish, with feeder roads and interstate highways consistently "jammed." Sewer, water, and electric services have been restored throughout the parish. Local officials indicate that the increased population has brought a positive business climate and a near-doubling in sales tax revenues. The parish is currently selling bonds to fund road improvements. A local 2% sales tax is dedicated exclusively to roads.

Section Six: Broader Impacts: Regional and National Perspectives

I. Introduction

The social and cultural impacts of the hurricane event and levee breeches extend well beyond the study area. Besides the flooding in New Orleans, Hurricane Katrina caused damage and disruption to the lives of more than a million people living along the Gulf Coast. The impacts of the levee breeches in New Orleans have both regional (Gulf Coast states) and national consequences.

The regional and national impacts are still occurring but it is still too premature to assess the both the direct and indirect consequences of the New Orleans levee breeches and Hurricane Katrina. For example, there is little data on the consequences and costs of evacuation (a short-term situation) versus migration and relocation (the social and economic costs of setting up a new life in a new location). The number of fatalities and acute injuries are still in flux with some people still listed as missing, bodies that remain unidentified, health concerns from mold in water-damaged homes posing problems for returning residents, and the overall mental stress from living in damaged homes. We know from the literature, for example, that the longer-term mental health consequences may be significant (Norris et al. 2002a, b) under these catastrophic conditions where the social fabric of a community has been torn apart. Families in stress could lead to increased divorce rates, domestic abuse, child abuse, and even substance abuse, all of which could occur in both the short term and longer term, requiring response from both a regional and national array of social and public agencies. There are undoubtedly many longitudinal studies that are currently underway to assess both the national and regional impacts of this disaster on the residents and communities in Greater New Orleans. We provide only a brief synopsis of some of the more important considerations.

II. Regional Impacts

The impacts described here include those associated with the mass out-migration of evacuees into the communities immediately adjacent to the Greater New Orleans metropolitan area, as well communities within Louisiana and in the neighboring states of Alabama, and Mississippi. While the overall number of internally displaced persons is unknown at this time, there are estimates of the registrants for individual assistance from FEMA. Table 6-1 shows the breakdown of the over 700,000 applications for FEMA assistance in the region adjacent to the Greater New Orleans Metropolitan Area as of March 2006. FEMA does not disaggregate application data from Rita and Katrina victims. However, the number do reflect the cumulative impacts of the areas as result of the storms. The greatest number of individual assistance claims (in May 2006) in the three-state impact area is in the New Orleans metro area (382,000), followed by Baton Rouge (186,000), Gulfport-Biloxi (100,000), and Mobile (84,5000) (FEMA 2006).

Table 6-1
Number of Applicants for FEMA Assistance
By State within the Region Adjacent to the Greater New Orleans Metropolitan Area

State	FEMA Applicants
Alabama	106,292
Louisiana (Outside Greater New Orleans)	395,229
Mississippi (Outside Gulf Port-Biloxi)	204,299
Total	705,820

Source: FEMA 2006. Not included on the list are applicants who gave current addresses outside a US Census designated metropolitan area.

In the short-term, individuals, state and local governments, voluntary groups, and faith based organizations all attempted to meet the needs of the populations living within the affected parishes and counties. According to the Louisiana State Hurricane Center, approximately 89 of the state's 126 emergency room hospitals and 59 of the 84 non-critical service hospitals were impacted by Katrina (LSU 2005). The Red Cross opened 264 shelters in Louisiana (for 142,494 people), 55 in Alabama (for 5,493 people), 229 in Mississippi (42,774 people), and 358 in Texas serving 231,572. In all the Red Cross opened 1,095 shelters throughout the nation, providing temporary assistance to nearly half a million evacuees (Brookings 2006). Shelters remained open into late October, with tens of thousands of hotel rooms being used as well through February 2006. Unofficial shelters opened as well, in city convention centers, places of worship, local schools, and private homes. Citizens took entire families of strangers into their homes, with communities raising funds to provide rental units, furniture, clothing and food. The effort to provide shelter for those displaced by the flood was unprecedented.

Government and non-governmental agencies established evacuation centers and provided interim housing for those whose homes were damaged by flooding. The Louisiana Recovery Authority (LRA) estimates that temporary relief services cost state and local governments $15 to 20 billion. At the same time the LRA (2005) estimates that government revenue losses were $8 to 10 billion.

The performance of the levees and the aftermath also indirectly impacted the region as evacuees sought out areas of safety. Cities such as Baton Rouge, Lafayette, Alexandria, Lake Charles and Monroe in Louisiana and Jackson and Hattiesburg in Mississippi experienced large influxes of evacuees in a short period following the hurricane causing some communities to nearly double in population. Researchers at LSU indicated that approximately 50% of households in Baton Rouge sheltered evacuees from Hurricane Katrina. Not surprisingly, the majority of those sheltered were friends or relatives; only about 5% were reported to be strangers (Shihadeh, Berthelot, Weil, and Lee 2006).

In these host communities, there was an increased demand for housing, already in short supply in some areas, local infrastructure (such as schools, health care, public safety) as well as services (child care, elderly care, domestic violence prevention). Oftentimes immeasurable in economic terms, the short and long term disruptions in host communities caused by the rapid population influx can be significant.

Since the much of the hurricane damage to residences and business in Greater New Orleans has not yet been repaired, many of evacuees remain in temporary housing, either in travel trailers or mobile homes (50,376 in Louisiana in May 2006,(Brookings Institution 2006). FEMA estimates that 944,000 households are receiving some form of housing assistance. The influx of population and length of stay has put heavy demands on host community public services such as schools, hospitals, and public safety.

The impact on regional schools has been large. For example the Louisiana State Department of Education reported that as of March 2006 there were in 111,493 displaced students as a result of the Hurricane with 30,624 attending school in different parishes than prior to the event. School districts throughout the state have had to accommodate to the needs of the new students, putting demands on an educational system already facing challenges prior to the event.

The loss of a sense of place and the cultural amenities therein is one of the more intangible consequences of Hurricane Katrina and its aftermath. The social ties and networks that developed for generations have been drastically altered, and it is unclear whether the spirit of New Orleans can or will return.

While the demographics of the region have been altered, it is unclear at this time whether the local and regional demographic changes will be temporary or reflect more permanent out migration from the region. Post-disaster demographic change is expected, but most of the literature indicates this is a short-lived phenomena (months to a few years) and not discernible from one decennial census to another (Wright et al. 1979; Smith and McCarthy 1996; Peacock et al. 1997).

National Impact of Hurricane Katrina. Hurricane Katrina displaced over a million people making it the largest mass migration of people since the Civil War. By early October 2006, displaced individuals were located in nearly every state of the nation, with thousands clustered in large Southern cities like Houston, Atlanta, and Memphis. Many others were scattered in large coastal cities or small rural communities. As of March 2006, the Federal Emergency Management Administration reported over 369 cities in the United Sates serving as hosts to evacuees, with 76 of the cities hosting over 1,000 evacuees. It is not yet known how many people relocated because of the initial hurricane or because of the subsequent levee breaches. The overall impact of the diaspora of New Orleans residents on some communities throughout the United States may be similar to rapid population "booms" associated with rapid community growth (Finsterbusch and Fruedenburg 2002).

The American Red Cross opened 1,095 shelters for evacuees with over 831 shelters in states outside of Louisiana (Brookings 2006; see also previous section of this part of the report that overviews events and examines institutional impact). Other government, voluntary organizations and private individual provided shelter as well, and many states established shelter for evacuee that never arrived, often costing state and local communities large amounts of money and personnel time. Ultimately, though the numbers of evacuees using shelters will never be known fully.

However the magnitude of those displaced from the Greater New Orleans area is reflected in the number of persons who applied for Federal assistance because of the Hurricane Rita and Katrina (Figure 6-1). Again, the numbers reflects the cumulative impacts of the two events. It appears that nearly every state in the nation was affected in some way from the event.

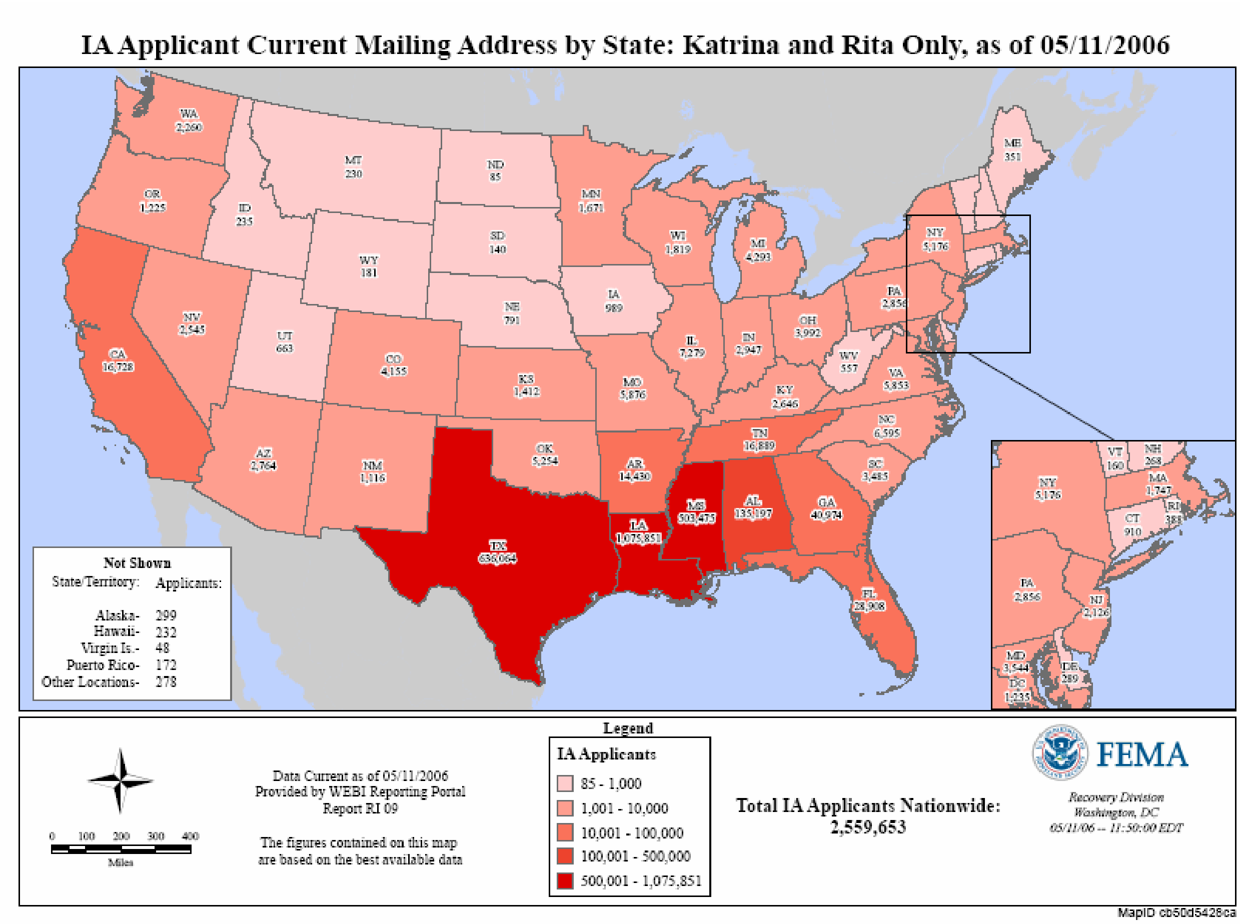

Figure 6-1: Location of FEMA Applicants by State. Source: FEMA, as cited on Greater New Orleans Data Center (2006)
http://www.fema.gov/pdf/hazards/hurricane/2005Katrina/locations_applicants_combine_map.pdf

Nearly 320,000 people found Houston to be a safe haven from Katrina and its aftermath. This caused a five percent increase in Houston's population in less than a month. The influx of people over a very short period put stress on existing social and public services as well as the rental/housing market. For example, Harris County Hospital District, the agency that runs the public hospitals and health clinics in Houston and surrounding Harris County, treated 15,000 evacuees in two weeks at the Astrodome and other evacuee centers (Baylor College of Medicine, 2005). The initial few weeks after the event, the number of evacuees was not overwhelming and was not delaying care for Houston residents. However, treating refugees has substantial cost in terms of dollars and human resources.

The evacuees have also impacted local school systems. By the end of November 2005, FEMA reported 42,000 students who were from displaced families. Some 21,000 students from

Louisiana now attend southeastern Texas schools, including approximately 6,000 in Houston (Texas Department of Education, 2005). Across the state, Louisiana children scored considerably lower than Texas youngsters on a state exam and thousands could be held back, imposing even higher costs on overburdened school districts.

New Orleans was a major center for higher education, and thousands of university students faced the fall semester with closed schools. Universities throughout the United States, such as those located in the Houston/College Station areas, took these displaced college students during the fall semester typically under free tuition offers; many offered stipends for books and housing. It is not known at this time how many will return to New Orleans for the Fall 2006 semester.

On a national level, response and recovery costs have affected federal spending and will continue to do so. But the national consequences are more than that. The United States does not have recent experience with a sudden, mass migration of this magnitude. Studies of the responses to disasters have tended to focus on moving resources to the immediate area of the disaster rather than the migration of hundreds of thousands of people to new locations on a semi-permanent basis. In addition, the research literature does not provide clear insight of the social, historical consequences of this mass movement of people on the national character.

Perhaps the Mississippi River flood of 1927 provides the most recent insight into the effects of mass migration. That flood became part of the national folklore and displaced 700,000 people, many of whom were poor African Americans. Many of the African Americans eventually migrated to U.S. cities in the north. The treatment of flood victims varied by race and income; consequently, many questioned and permanently changed their political affiliations. The migration also caused an exchange of culture between groups in the northern and southern parts of the United States. Though there are differences in the circumstances and the era in relation to Hurricane Katrina and the Mississippi Flood of 1927, both can be characterized as having a lasting effect on the political and cultural character of the Nation.

Section Seven: The Post Katrina Future/Projections- Beyond June 1

I. Greater New Orleans

One of the consequences of the hurricane event will be a national, regional and local dialogue about the availability and commitment of resources to rebuild the area. Along with rebuilding the areas damaged by the hurricane, there is a dialogue about the level and type of flood protection to be provided to the City of New Orleans and the surrounding areas. The dialogue is tied into individual and institutionalized visions and perceptions regarding the future of New Orleans and the Gulf Coast. The visions and perceptions of New Orleans is particularly ambiguous because of the status of levee system that protect the city and the geophysical condition of the city being surrounded by sources of potential flooding: the Gulf of Mexico, the Mississippi and the low areas of the city that can be flooded by rainfall within the city itself.

It should be noted that impacts to smaller nearby communities, though not a large in scale, are substantial and in some ways proved unique issues beyond the scope of this analysis. This particularly the case in the southern portions of Plaquemine Parish, where villages and clusters of homes were essential destroyed. The long term impacts to these areas are unknown.

Damage to residences appears to be the most significant obstacle to repopulation of New Orleans. The financial and human resources required to repair or reconstruct flood-damaged dwellings is lacking in many areas of the city. Throughout the greater New Orleans there are substantial differences in housing habitability and the time required to return damaged dwellings to a habitable state according to the flooding damage and dwelling characteristics. Other factors likely to shape the repopulation of New Orleans include the provision of basic services and infrastructure, employment, schools and colleges, and social networks.

As noted by Freudenburg and Gramling (1992), the social processes of such dialogues can impacts in and of itself. In discussing social impact of construction of large projects such as dams, they not that discussion of the locations, the size and economic and social outputs of a project may impact a community months or even year prior to initiation of any construction. During deliberations about a project, associated land speculation, polarization of the community over disagreements about project benefits, labor markets shift and uncertainty of relocation of residences and businesses all can have a lasting impact on a community. In a similar fashion the discussion and planning for the future of New Orleans well likely have a lasting impact. It is with that in mind that any estimate of re-population of the city has to be done with caution.

The Rand Corporation (2006) developed some repopulation estimates for New Orleans. The estimates are not based on observational information. According to the Rand analysis, housing is likely to be the main impediment to the rapid return of former residents who want to move back to the city. Based on the degree of damage to housing throughout New Orleans, the extensive demolition, repairs, and reconstruction is likely slow pace of repopulation. Temporary housing, such as trailers, may provide an interim solution for some people, but will not adequately address for the overall housing problem that New Orleans confronts. The analysis also notes the severe damage to infrastructure and the associated loss public services. Though many infrastructure is being repaired and services are being made available again, the pace is slow and there considerable uncertainty about their recovery. The main driver of the Rand estimates is housing habitability, which was based on assumption that greater depth of flooding equates to longer time period for repair. Given that many of the owners of flooded residents were poor and uninsured along with the extent of damage, some residential structures are assumed not be rebuilt within the three year estimate timeframe. Table x summarized the estimated relationship between depth of flooding and re-population of areas of the city.

Table 7-1
New Orleans Population Estimates Based on Depth of Flooding of Residential Structures

Mean Depth of Flooding	Repopulation Rate (percent) March 06	September 06	September 08
No Flooding	100	110	110
Less than 2 feet	32	75	100
2 to 4 Feet	15	25	45
More than 4 Feet	5	10	30

Source: Rand Corporation 2006, Table 3.3.

Based on these assumptions, maps of the depth flooding and pre-Katrina population information by area of the city, the Rand Corporation study estimates that the population of New Orleans in 155,000 by March 2006. Subsequently, repopulation starts to slow: In September 2006, the study estimates a population of about 198,000. Three years post-Katrina, the estimate of the New Orleans population is 272,000—about 56 percent of the pre-Katrina population. Though not included it the estimate calculation, the Rand study notes that the costs of rebuilding could sharply driving up the costs of rental properties, as well as the ability of poor residents to find transportation back to the city. Higher costs for flood insurance, labor, and rebuilding are likely to push down employment. Businesses that don't need a presence in New Orleans may leave, while higher costs will be passed on to consumers, not only in the form of rent, but in goods and services.

The Rand estimates are not based on empirical data other than the pre-Katrina conditions. The study provides a sensitivity analysis, based on changing assumption rather than statistical probabilities. Varying the degree of damage at a given depth and occupancy rates, the study estimated the September 2008 population of New Orleans to be as high as 320,000, still considerably smaller than the pre-Katrina population of the city.

The City of New Orleans (2006) estimate 181,400 persons (+/- 20,900 persons) residing in the city at the end of January 2006. The city's estimate is based household survey conducted beginning in November 2005. The city cautions that the estimates are "rough" and intended for planning purposes only.

The city estimates of population are higher than that provided by the Rand analysis. The two estimates overlap if one takes into account the confidence interval in the city's analysis and the sensitivity analysis of the Rand numbers. Though not statistical comparison, the two sets of numbers provide a general range of population numbers. The City does not provide any estimates beyond June 2006. However, the numbers could be interpreted as supporting the higher numbers presented in the Rand sensitivity based estimates, beyond the early summer 2006 timeframe.

Some insight into longer term re-population may be gained from the observational data collected for this analysis. Table 7-2 summarizes the analysis of re-population of selected new Orleans block groups conducted as part of this study in March 2006. The table displays the level of flooding by neighborhood and population estimates of pre- and post- Katrina. It also provides information about the ethic and socioeconomic character of the neighborhood. Looking first at block groups in neighborhoods that experienced no flooding, the sampled block groups are fully repopulated, according to the adjusted estimates, with 98-105% of the 2000 population. Turning to block groups in neighborhoods with less than two feet of flooding, these block groups—with the exception of St. Claude, which lies in the lowest socioeconomic stratum—are also fully repopulated. St. Claude, one of the poorest sampled neighborhoods, evidenced a 23% vacancy rate prior to Katrina. In neighborhoods that experienced two to four feet of flooding, Bayou St. John (which was in the lowest socioeconomic stratum and the highest level of flooding in this group of neighborhoods) shows an estimated adjusted repopulation rate that is 68% of the pre-Katrina population. Lakeshore, on the other hand—which lay in the highest socioeconomic stratum and experienced the lowest level of flooding in this group—has an adjusted occupancy rate that stands at 94% of the pre-Katrina population. Moving to the group of neighborhoods that experienced more than 4 feet and less than 8 feet of flooding, the occupancy rates decline precipitously. Plum Orchard and Edgelake, with the highest pre-Katrina socioeconomic status in this group of neighborhoods, only evidence adjusted repopulation rates of 7.5% and 16.4%, respectively. These neighborhoods housed largely middle-class, African-American residents before Katrina. The individuals who have returned in these neighborhoods face isolation and a lack of services. Finally, among the block groups that experienced more than 8 feet of flooding, virtually no one has returned. In Lakeview, for example, our adjusted population estimate suggests that 27 people are living in Lakeview and 19 in Gentilly.

Table 7-2
Re-population Estimates of Selected New Orleans Block Groups

Neighborhood	Flood Depth (ft)	2000 Census	Re-population Estimate	% of 2000	Socio-Economic Quartile	% African American
East Riverside	0.0	417	409	98%	1	86.6
St. Thomas	0.0	714	738	100% +	2	79.6
Irish Channel	0.0	1,105	1,101	100% +	3	69.0
West Riverside	0.0	768	809	100% +	4	5.7
St. Claude	0.6	728	450	28%	1	88.3
Leonidas	1.2	626	680	100% +	2	79.7
Central City	0.7	884	878	98%	3	67.0
Garden District	0.1	527	598	100% +	4	3.0
Bayou St. John	4.0	1,294	879	28%	1	94.5
Fairgrounds	3.2	879	676	24%	2	88.9
Uptown	3.5	773	618	20%	3	80.7
Lakeshore	2.4	682	641	96%	4	.7
Treme'	4.1	736	192	26%	1	97.8
Milan	5.7	609	97	14%	2	82.6
Plum Orchard	6.3	1,677	126	13%	3	97.0
Edgelake	7.5	1,556	255	16%	4	90.7
Lower Ninth Ward	9.6	934	0	0%	1	97.1
St. Anthony	9.6	648	3	<1%	2	46.3
Gentilly Terrace	8.1	643	19	3%	3	63.6
Lakeview	10.6	703	27	4%	4 .1	

Re-population of neighborhoods is linked to depth of flooding. However this table tempers the notional rates of repopulation estimate by the Rand Corporation, as reflected in table 7-1. The re-population figures may be in the upper rank of the Rand's sensitivity analysis. There is a large number of factors related re-population. Individual decisions about economic and financial opportunities in the post-Katrina New Orleans, public and private agencies ability to return basic services, the planning and regulatory decisions, the perception of threat of future storms, views of credibility of public agencies to provide flood control, and reformation of neighborhood based social networks are just some of the constellation of variables in the future of the metropolitan area. Specific projections regarding the future social and demographic characteristics are beyond the scope of this analysis. However, given the number of people that evacuated, the dramatic disruption of social networks and the wide-scale destruction neighborhoods, the character of the metropolitan area will change. As research has shown that preparedness and evacuation is contingent upon the characteristics population, private and government officials will have to account for both the size and the changing character of the population.

A review of the U.S. Bureau of Census data for neighborhoods in New Orleans shows that African-Americans (56.36%) are about 23% more likely to have experienced heavy flooding (greater than 4 feet) than Whites (33.41%) -see table C-C2, Sub-Appendix C. This difference is statistically significant ($p < .0001$). Households with incomes less than $50,000 are about 2% (48.42% - 46.47%) more likely to have experienced flooding over 4 feet. Although this difference is statistically significant, it is substantively small. Although 40.83% of Whites have household incomes of $50,000 or more, only 17.5% of African-American households have this level of income. This difference of 23.33% is statistically significant ($p < .0001$). The analysis indicate there is little relationship between household income and level of flooding but a strong relationship between race and both level of flooding and household income.

There is a strong relationship between race and level of flooding taking into account household income level. Among households with less than $50,000 income, African-Americans are about 20% more likely to have experienced heavy flooding. As noted the difference between levels of flooding between blacks and whites was 23% with out taking income into account. However, for African-American households with an income of $50,000 or more, this difference has increased to 34%. Almost 2 in 3 (66.21%) higher-income African American households experienced more than 4 feet of flooding. About 32% of white households experienced that level of flooding. Both of these differences are statistically significant ($p < .0001$).

Among white households, lower-income households are 2.44% (34.41% – 31.97%) more likely to have experienced heavy flooding than higher-income households were. Within the African-American community, this pattern reverses: Higher-income African Americans households are almost 12% (66.21% - 54.27%) more likely to have experienced heavy flooding than lower-income households were.

We are seeing the effect of the differential impact of flooding in the observations conducted in New Orleans neighborhoods. Middle- and upper-middle-class African American areas that experienced heavy flooding have had few residents return to their homes. Middle- and upper-middle-class neighborhoods—such as Edgelake/Little Woods, Gentilly Terrace, and Plum Orchard--have 75% to 80% of their homes gutted and empty, or the houses simply stand empty and boarded-up. Almost 2 in 3 (66.21%) of higher-income African American households experienced flooding of greater than 4 feet. Although some hardy souls are struggling to recover in these empty and isolated neighborhoods, most have not come back in the 8 months since Katrina.

Section Eight: Discussion and Conclusions

I. Introduction

While this report presents both original and secondary research findings and the implications for the social, cultural and historic consequences of Hurricane Katrina and the levee failures, much remains to be explored and understood. Standard ways to reach disaster victims and to learn about the context of their response and recovery proved challenging. For example, obtaining information from personnel and victims displaced from their homes and offices proved difficult. Secondary sources at times proved contradictory or incomplete. Observational techniques, while illuminating, represent a cross-sectional slice in time. Cultural and historical inventories of damages proved difficult to secure. Discussion and conclusions, therefore, should be understood in the context of these limitations.

Another part of the context for this section of the report is the uniqueness of the event under consideration. As noted in the section that overviews the initial days after Katrina, disaster events fall along a continuum from mass emergencies (i.e., a localized flood) to disasters (that inundate wide areas) to catastrophes (with regional and national impact along a massive scale and magnitude). While Katrina fits into the latter category of catastrophe, most disasters and related research fit into the categories of disasters and mass emergencies. Thus, a challenge exists to extrapolate from existing research to the present contexts experienced in Orleans, St. Bernard, Plaquemines and other affected parishes. In short, Katrina and the levee performance represent a unique event of magnitude and scope not yet examined by researchers within the United States. However, a wide number and type of studies are presently underway that should eventually provide additional insight into the social, cultural and historic consequences of these events.

One of the obvious questions about the Katrina event is what would have happened if the levees had held contained a majority of the flood walls. No doubt that flood would have occurred, as the storm brought heavy rainfall and the tidal surge was higher in places than the height of the levee. The exact nature of the social consequences in that scenario is difficult to assess. The hypothetical flood would have inundated homes and businesses, force relocation of people and disrupted public services and social networks. The level of consequences of such a hypothetical event would have been similar to recent disaster events in region. Response and recovery would have followed by a relatively quick community readjustment. Vulnerable populations would take longer than others to recover. However, social consequences of Katrina were catastrophic and lasting. The magnitude of difference between what happened and a hypothetical is not measure quantitatively. There is not a linear relationship between the real and the hypothetical.

A related challenge stems from the lack of longitudinal research on the recovery period. During the 1990s, a group of 100 experts examined disaster studies from the past two decades resulting in a seminal volume titled *Disasters by Design* (Mileti 1999) and published by the Joseph Henry Press of the National Academies. That effort, known as the “Second Assessment” demonstrated the paucity of studies on recovery in particular. Thus, any effort to project into the future given the uniqueness of the context and gap in the literature is difficult.

Further complicating discussion, the three parishes hardest hit (Orleans, St. Bernard and Plaquemines) have experienced slow, attenuated recovery processes. In most communities hit by disaster, rebuilding is underway within months and it is not unusual to see most rebuilding completed within 2-3 years. This will not be the case for the majority of the homes and many of the businesses, schools, health care facilities and organizations in the most damaged parishes. As one indicator, FEMA normally provides up to eighteen months of Individual Assistance. As of this writing, the halfway point in that timeline has nearly been reached, yet neighborhoods remain visibly under-populated as suggested by the data in the section on Orleans Parish. The Lower Ninth Ward, for example, is expected received its first FEMA trailers in May 2006. The general uncertainty and difficulty surrounding rebuilding at this point in time indicates that previous empirically-generated timelines of long-term recovery will not apply.

II. Social, Cultural and Historic Consequences

To conclude this report, this section briefly addresses some key examples of the flood consequences. The comments are perhaps best conceptualized within a traditional social science term of "life chances" defined as the probabilities that one will benefit from what society has to offer. As described in earlier sections, those probabilities have been considerably affected for those still living in the damaged areas and are likely to remain compromised for some time. As just one example, only one in five schools have re-opened in Orleans Parish and those in lower Plaquemines will not open until August. Students that have relocated to Texas have experienced higher failure rates than their non-Katrina counterparts. Historically in the U.S., educational opportunities represent a chance to better one's social and economic situation. It appears that, at present, this indicator of "life chances" has been undermined.

It is also appropriate, though to observe that relocated persons may have seen an improvement in their life chances. Discussions with colleagues studying Katrina report that some families have relocated successfully and permanently away from the damaged areas, often with the financial support and general assistance of faith-based groups, the federal, state and local governments, and the broader communities in which they have landed. However, it is equally viable to point out that the economic impact of their losses back home have not yet been calculated or reported on, including material and financial losses and the potential for social psychological trauma.

Discussion Points

- *Levee Performance*. The performance of the levees protecting New Orleans is key to its social, cultural, and historic conditions. The immediate physical damage made large portions of the city uninhabitable, with thousands of residential, commercial, and public structures destroyed. Basic infrastructure facilities, such as power, water, sewer, and natural gas lines were made inoperable and continued to be out of service for months after the event. Many victims not only lost their homes, but also their schools, health care, places of worship, places of trade, and jobs. The forced relocations disrupted family and friend networks. As a result the event not only had an immediate impact on the well-being of the population of those living and working in the metropolitan area, but also resulted in basic aspects in the social organization of that population.

- *The "Diaspora."* Studies of the responses to disasters have tended to focus on moving resources to the immediate area of the disaster rather than the migration of hundreds of thousands of people to new locations on a semi-permanent basis. The United States does not have recent experience with a sudden, mass migration of the magnitude seen with Katrina and the flood. In addition, the research literature does not provide clear insight of the social, historical consequences of this mass movement of people on the national character.

- *Rebuilding Uncertainty.* Local residents are struggling to rebuild their neighborhoods, but under great uncertainty about who will come back. As noted by Freudenburg and Gramling (1992) in their discussion of the social impacts of large natural resource based projects, the social processes of planning can have impacts itself. Groups within a community respond in a variety of ways to planned futures, even before physical construction begins. This results in a variety of consequences ranging from real estate speculation to various stakeholders maintaining lasting distrust of each other.

- *Income, Race and Ethnicity.* As noted by the Brookings Institution, New Orleans has some of the most concentrated poverty neighborhoods in the nation. Given the racial and social stratification of the city which intersects at time with income, the rebuilding process has the potential to shape future interactions of the various racial, ethnic and economic groups that make up the community. Middle class African American repopulation in the East of the city has been uneven and slow to occur.

- *Age and Disability.* Early projections suggest that persons over 65 and those with disabilities may have permanently relocated out of New Orleans metro into other areas. This demographic shift has potential to shape inter-generational and familial relationships and social interaction patterns. This may be experienced particularly in families for which such inter-generational affinity is particularly important.

- *Vulnerable Populations*. Though some reports suggest that the evacuation numbers represented the largest and potentially the most successful numerical evacuation of the area, it is also true that those who remained and those who died came from predictable populations. Recent reports at the National Hurricane Conference, for example, indicate that as many as 70% of the 1300+ who died were over 65 years of age. Further demographic analysis of the deaths, injuries and transportation challenges of the elderly and other historically vulnerable populations must be coupled with vulnerability planning.

- *Faith in the System.* The issues of competency and legitimacy of governments to respond to the large scale disasters as well as the allocation of resources for recovery will likely be part of the social and political future of the city. Repopulation, recovery and investment will be contingent on the faith people put into their community's ability to provide a safe place to live.

- *Demographic Transitions and Response.* With a number of groups coming to the city to assist in rebuilding, the recovery process itself has changed the nature of the city even if only temporarily. There has been anecdotal evidence of Spanish speaking workers becoming a manual labor source associated with recovery work. Less than five percent of the pre-Katrina population was of Hispanic origins. In-migration of Hispanics could have a lasting impact on the racial composition of the city

- *Social Institutions Remain Damaged.* The education system and health care institutions in New Orleans are critical elements of the city's future. A significant factor in the historic out-migration from the city can be attributed to the performance of the public school system. The flood resulted in the shut down of all schools and a relatively slow recovery, as indicated by school enrollment figures. The flood was a major blow to already troubled system. The New Orleans had some of the best hospitals in region and in some instance the nation. As an institution, hospitals had an essential role in the community as providing health care, public health education and employment. The loss of many of the hospitals and the uncertainty of rebuilding will have a long term multi-dimensional social consequences.

- *Community Organizations.* Key support agencies particularly non-profit and grass roots organizations that provided valuable services to neighborhoods have seen their facilities destroyed, have lost the homes of their staff and volunteers, and have found it necessary to reconstitute their services or to close their doors. Faith-based sectors have lost much of their congregations essentially undermining their social functions and their financial viability.

- *Disaster Preparedness*. No matter what level of protection future levee will provide, disaster preparedness will be a factor in individual, business and groups decision about moving back to the city. Protection of human populations from risks such as hurricanes is based on multiple systems, both physical structures and social organization. Each has its own probability of failure. Planning and preparing for future hurricanes and system failures will influence whether or not another catastrophic event like Hurricane Katrina can be minimized. The success of that preparedness, too, is contingent upon involvement of all segments of the community.

- *Public Safety*. Domestic violence shelters, police stations, fire houses and other resources to enhance public safety have all been affected from loss of personnel to damaged facilities to loss of key resources.

- *History Repeating Itself?* Perhaps the Mississippi River flood of 1927 provides the most recent insight into the effects of mass migration. That flood became part of the national folklore and displaced 700,000 people many of whom were poor African Americans. Many eventually migrated to U.S. cities in the North. The treatment of flood victims varied by race and income and caused many people to question the existing social and political institutions. The migration also caused an exchange of culture between groups in the northern and southern parts of the United States. Though there are differences in the circumstances and the era in relation to Hurricane Katrina and the Mississippi Flood of 1927, both can be characterized as having a lasting effect on the political and cultural character of the Nation, region, cities and neighborhoods.

III Conclusion

It is clear that Katrina and the flood represent catastrophic physical damages with potentially vast social, cultural and historic consequences. At all levels of social interaction it is possible to observe the potential for trauma. A few examples demonstrate this. At the interpersonal level, families and social networks have been disrupted perhaps permanently. The linking mechanisms between households and organizations, social support services, schools, health care and more have been severed in many cases and have been slow to repair. Faith in the system that was depended on for life-saving rescue has probably been undermined. Connections to large-scale institutions such as the school sector, the political process and the economic system have been dramatically altered.

Thus, at all levels it is possible to observe profound alterations. Perhaps what is most poignant comes from the neighborhood level though, where neighbors and organizations had labored valiantly to transform their areas and to enable Greater New Orleans to rise from its beleaguered social problems pre-Katrina. Those social processes and grass-roots efforts to improve local life chances have been abbreviated and perhaps irrevocably taken away.

To understand disasters, it is necessary to examine the intersection between the built environment (e.g., levees, homes, business districts), the physical environment (wetlands, meteorological conditions, elevations) and the socio-cultural environment (the people). Disasters result from a misfit between these three key systems (Mileti 1999). To provide for an appropriate level of protection for the people, then, discussion must take into consideration the other two systems. Ultimately, what determines the line between acceptable and unacceptable risk reflects social, political and even economic contexts and realities. Any decision about levels of protection reflects these realities; what is key to understand from the perspective of this chapter is that the socio-cultural dimension is a critical component that cannot be divorced from engineered solutions.

Appendix 4
Sub-Appendices

A/ References

B/ Figures

C/ Data Tables

D/ Cultural and Historic Terminology

Appendix 4
Sub-Appendix A. References

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Appendix 4
Sub-Appendix B. Figures

Appendix B: List of Figures

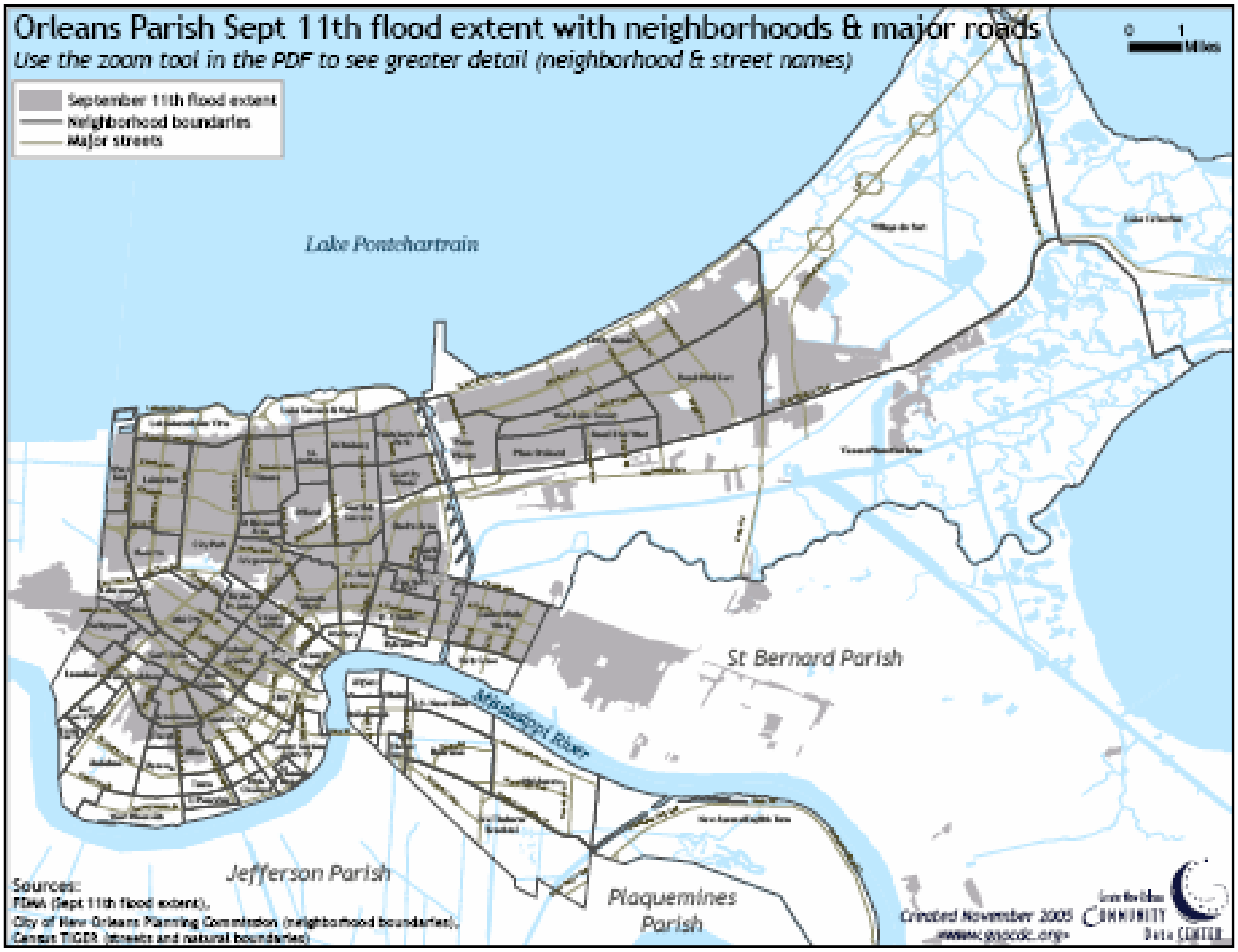

Figure B-2 (for interactive map, see webl ink: *www.gnocdc.org/maps/PDFs/flood_extent.pdf*) Source: Greater New Orleans Community Data Center 2006

Appendix 4
Sub-Appendix C. Data Tables

List of tables

(Note: "Table C-.." notion in the list indicates table is located in sub-appendix C)

Table 7-2: Re-Population Estimates of Selected New Orleans Block Groups (see text of narrative)

Table C-C1 Detailed Demographic Overview of Parishes in Study

Table C-C2 T-Test Analysis of Household's Race, Income, and Flooding

Table C 2-3b: Flood Data for Block groups in New Orleans Drive Sample

Neighborhood	Block Group ID	Flooding Level	Socio-Economic Status Quartile	Population	Average Block Flood Level	Maximum Average Block Flood Level	Minimum Average Block Flood Level	Flood,, Mean 0,	Flood Mean GT 0 and LE 2	Flood Mean GT 2 and LE 4	Flood Mean GT 4 and LE 8	Flood Mean GT 8
East Riverside	220710096003	None	1	417	0.0	0.0	0.0	10	0	0	0	0
St. Thomas	220710083002	None	2	714	0.0	0.0	0.0	11	0	0	0	0
Irish Channel	220710088002	None	3	1105	0.0	0.0	0.0	13	0	0	0	0
West Riverside	220710114001	None	4	768	0.0	0.0	0.0	18	0	0	0	0
St. Claude	220710013013	0-2 Ft	1	728	0.6	2.0	0.0	1	11	0	0	0
Leonidas/West C	220710130003	0-2 Ft	2	626	1.2	1.8	0.7	0	12	0	0	0
Central City/Ma	220710091001	0-2 Ft	3	884	0.7	1.8	0.2	0	15	0	0	0
Garden District	220710090001	0-2 Ft	4	527	0.1	0.3	0.0	3	10	0	0	0
Bayou St. John	220710045002	2-4 Ft	1	1294	4.0	7.7	2.4	0	0	13	9	0
Fairgrounds/Bro	220710037024	2-4 Ft	2	879	3.2	4.6	2.0	0	1	12	3	0
Uptown	220710109001	2-4 Ft	3	773	3.5	4.4	1.9	0	1	12	3	0
Lakeshore/Lake	220710133014	2-4 Ft	4	682	2.4	6.6	0.4	0	12	2	4	0
Treme'	220710044013	4-8 Ft	1	736	4.1	4.6	3.2	0	0	5	10	0
Milan	220710102004	4-8 Ft	2	609	5.7	6.0	5.3	0	0	0	9	0
Plum Orchard/Bo	220710017225	4-8 Ft	3	1677	6.3	9.2	1.7	0	1	0	11	5
Edgelake/Little	220710017391	4-8 Ft	4	1556	7.5	9.8	6.0	0	0	0	9	5
Lower Ninth War	220710007012	Over 8	1	934	9.6	10.5	8.1	0	0	0	0	16
St. Anthony	220710033033	Over 8	2	648	9.6	10.6	7.1	0	0	0	1	8
Gentilly Terrac	220710025031	Over 8	3	643	8.1	9.1	7.2	0	0	0	7	9
Lakeview	220710056021	Over 8	4	703	10.6	11.2	9.5	0	0	0	0	14

Source: US Bureau of Census 2000 Census of Population and Housing; Flood Data derived from New Orleans District estimates of flood depth by census blocks, January 2006.

Table C-2-5: Base Demographic Data for Block Groups in New Orleans Drive Sample

Neighborhood	Block Group ID	Flooding Level	Socio-Economic Status Quartile	Population	Median, Household Income	Median Family Income	Median NonFamily Income	% College Graduate	Median Year Built Housing	Median Year Householder Moved In	Median Value Specified Owner Occupied Units	Median Value Owner Occupied Units
East Riverside	220710096003	None	1	417	16053,	19821	9632	2.1	1939	1991	86000	83500
St. Thomas	220710083002	None	2	714	18542,	15625	26765	21.1	1939	1991	73100	73600
Irish Channel	220710088002	None	3	1105	19018,	19167	18750	24.4	1939	1998	109600	116700
West Riverside	220710114001	None	4	768	33719,	56250	30450	52.0	1939	1997	152500	158900
St. Claude	220710013013	0-2 Ft	1	728	18889,	19155	11750	11.0	1941	1989	38800	56800
Leonidas/West C	220710130003	0-2 Ft	2	626	19500,	20917	13583	16.9	1939	1995	95000	94700
Central City/Ma	220710091001	0-2 Ft	3	884	22600,	23026	20769	32.3	1939	1997	82300	105400
Garden District	220710090001	0-2 Ft	4	527	64417,	132335	34286	77.4	1945	1996	327300	314100
Bayou St. John	220710045002	2-4 Ft	1	1294	15083,	16167	11492	4.7	1942	1996	64400	61900
Fairgrounds/Bro	220710037024	2-4 Ft	2	879	25739,	24375	19464	7.6	1945	1993	60800	60500
Uptown	220710109001	2-4 Ft	3	773	14803,	10750	18702	25.7	1941	1993	138300	129000
Lakeshore/Lake	220710133014	2-4 Ft	4	682	66607,	79222	58750	63.2	1960	1993	233500	236300
Treme'	220710044013	4-8 Ft	1	736	6709,	5893	7321	6.5	1939	1991	64800	62000
Milan	220710102004	4-8 Ft	2	609	15000,	30329	11573	17.0	1939	1990	43300	61400
Plum Orchard/Bo	220710017225	4-8 Ft	3	1677	28056,	31386	11063	25.3	1966	1977	88800	89600
Edgelake/Little	220710017391	4-8 Ft	4	1556	56332,	61471	21375	41.1	1976	1992	122400	121400
Lower Ninth War	220710007012	Over 8	1	934	20809,	31375	8750	6.0	1952	1979	51800	54700
St. Anthony	220710033033	Over 8	2	648	26200,	35347	12946	17.6	1954	1990,	66400	67200
Gentilly Terrac	220710025031	Over 8	3	643	27841,	48542	23529	22.2	1951	1992	103700	101600
Lakeview	220710056021	Over 8	4	703	61765,	66250	37344	42.0	1956	1994	172400	167600

Source: US Bureau of Census 2000 Census of Population and Housing; Flood Data derived from New Orleans District estimates of
Flood Depth by census blocks, January 2006.

Table C-2-4: Base Demographic Data for Block Groups in New Orleans Drive Sample (continued)

Neighborhood	Block Group ID	Flooding Level	Socio-Economic Status Quartile	Population	Number of Blocks in Area	Number of Zero Population Blocks	% Vacant Households	Born in LA	% Population African American	% Owner Occupied	% Persons Live Alone	% Persons in Group Quarters	% Persons Institution Group Quarters
East Riverside	220710096003	None	1	417	10	0	22.2	90.4	86.6	37.4	16.6	0.2	0.0
St. Thomas	220710083002	None	2	714	11	2	15.9	82.9	79.6	41.8	11.5	0.0	0.0
Irish Channel	220710088002	None	3	1105	13	0	13.1	79.2	69.0	37.6	12.1	1.9	1.9
West Riverside	220710114001	None	4	768	18	2	10.2	61.7	5.7	38.4	31.0	0.0	0.0
St. Claude	220710013013	0-2 Ft	1	728	12	3	22.8	92.0	88.3	38.8	7.7	0.0	0.0
Leonidas/West C	220710130003	0-2 Ft	2	626	12	3	13.7	76.5	79.7	45.7	16.1	0.0	0.0
Central City/Ma	220710091001	0-2 Ft	3	884	15	3	20.0	62.5	67.0	30.4	24.4	7.5	0.0
Garden District	220710090001	0-2 Ft	4	527	13	1	12.8	40.5	3.4	60.2	30.7	0.0	0.0
Bayou St. John	220710045002	2-4 Ft	1	1294	22	4	10.2	94.5	94.5	26.1	10.0	0.0	0.0
Fairgrounds/Bro	220710037024	2-4 Ft	2	879	16	1	12.0	89.6	88.9	40.7	15.0	0.0	0.0
Uptown	220710109001	2-4 Ft	3	773	16	5	10.2	80.2	82.1	39.9	14.2	0.0	0.0
Lakeshore/Lake	220710133014	2-4 Ft	4	682	18	6	8.5	70.3	0.7	65.6	18.2	0.0	0.0
Treme'	220710044013	4-8 Ft	1	736	15	3	30.2	91.9	97.8	23.5	16.8	0.0	0.0
Milan	220710102004	4-8 Ft	2	609	9	0	10.5	79.7	82.6	43.1	11.7	0.0	0.0
Plum Orchard/Bo	220710017225	4-8 Ft	3	1677	17	0	7.8	86.6	97.0	63.4	8.0	5.4	0.0
Edgelake/Little	220710017391	4-8 Ft	4	1556	14	5	2.2	85.0	90.7	68.7	3.4	0.0	0.0
Lower Ninth War	220710007012	Over 8	1	934	16	0	10.7	90.5	97.1	56.0	9.6	0.0	0.0
St. Anthony	220710033033	Over 8	2	648	9	2	4.3	84.0	46.3	74.8	11.9	0.0	0.0
Gentilly Terrac	220710025031	Over 8	3	643	16	2	3.6	81.7	63.6	77.5	13.8	0.0	0.0
Lakeview	220710056021	Over 8	4	703	14	0	4.9	80.0	0.1	69.6	16.6	0.0	0.0

Source: US Bureau of Census 2000 Census of Population and Housing; Flood Data derived from New Orleans District estimates of Flood Depth by Census Blocks, January 2006.

Table C-4-1
LSU 2003 Survey Data- T-Test Comparison of Group Means, Evacuation Decision

Variables	Would Not Leave Area	Would Leave Area	Difference[11]
Age[12]	46.053	44.544	1.509**
Black	0.498	0.394	0.103
Female	0.662	0.603	0.059
Education[13]	14.790	15.228	-0.438
Employed Fulltime	0.547	0.517	0.031
Employed Part-time	0.076	0.084	-0.009
Never Married	0.277	0.193	0.084*
Children Under Age 6	0.113	0.160	-0.048#
Lived in Area[14]	76.049	62.224	13.825***
Vehicle Owner	0.648	0.837	-0.189***
Stress Index	0.298	0.233	0.065***
Perceived Support Adequacy[15]	2.135	2.375	-0.240***
Felt Neighborhood Unsafe	0.068	-0.034	0.102
Network Size	3.409	3.804	-0.396*
Alter Evacuees for Georges[16]	0.096	0.193	-0.097***
Alter Hurricane Support[17]	0.321	0.262	0.060*
Evacuees for Georges	0.071	0.240	-0.170***
Threat Index[18]	3.051	3.544	-0.493***
Hurricane Experience	1.277	1.122	0.155*
Flood Threat	0.586	0.588	-0.003
Would evacuate to a House	0.042	0.514	-0.472***
Had Place to Evacuate	0.778	0.752	0.026
N = 581-606[19]			

[11] Source: Unpublished LSU survey conducted in 2003 as part of the Joint Hurricane Pam Exercise. *p ≤.05 **p ≤ .01 ***p ≤ 001; two-tailed tests. #p ≤.05; one-tailed test.
[12] Reported in years.
[13] Reported in years completed.
[14] Proportion of life lived in New Orleans.
[15] Refers to instrumental support.
[16] Proportion of respondent's network members who evacuated New Orleans for Hurricane Georges.
[17] Proportion of network members respondent perceived would provide assistance during a hurricane.
[18] Perceived threat of life, injury, and property damage in the event of a Category 4 hurricane.
[19] There was a single exception: Perceived Neighborhood threat had an N = 501 due to missing values.

Table C-4-2 Coefficients for Logistic Regression Models of the Log Odds of Leaving New Orleans

Variable	Model				
	A	B	C	D	E
Intercept	1.578**	1.314#	1.377#	1.401#	-2.452**
Age	-0.011	-0.005	-0.006	-0.006	-0.011
Black	-0.460*	0.053	0.126	0.127	0.028
Female	-0.250	-0.149	-0.200	-0.200	-0.205
Education	0.008	-0.030	-0.028	-0.030	-0.022
Employed Fulltime	-0.247	-0.370#	-0.477	-0.511*	-0.493*
Never Married	-0.653**	-0.371	-0.300	-0.284	-0.146
Children Under Age 6	0.430	0.546#	0.542#	0.561#	0.973**
Lived in Area		-0.010***		-0.012***	-0.011***
Vehicle Owner		1.015***	0.892***	0.836***	0.810**
Stress Index		-1.065**	-1.357**	-1.201**	-1.715***
Perceived Support Adequacy		0.231*	0.238*	0.208#	0.244*
Network Size			0.055	0.055	0.060
Alter Evacuees for Georges			1.941***	1.598***	1.401**
Alter Hurricane Support			-0.886**	-0.848**	-0.890**
Evacuated for Georges				1.044***	0.823**
Threat Index					1.185***
R^2	0.04	0.11	0.16	0.17	0.25
Max-Rescaled R^2	0.05	0.15	0.21	0.24	0.35
Model chi-square	21.3274**	64.0271***	95.694***	107.036***	163.733***
Degrees of Freedom	7	11	14	15	16

Source: Unpublished LSU survey conducted in 2003 as part of the Joint Hurricane Pam Exercise.
*p ≤.05 **p ≤ .01 ***p ≤ 001; two-tailed tests. #p ≤.05; one-tailed test

Table C-5-1 Demographic Overview of New Orleans Parish Neighborhoods

Neighborhood	Number Housing Units	Number Occupied Housing Units	Percent Vacant Housing Units	Percent Occupied Housing Units	Percent Owner Occupied	Percent Renter Occupied	% Population in Owner Occupied	Percent 1 Person Houising Units
New Orleans Cit	215091	188251	12.5	87.5	46.5	53.5	48.8	33.2
Algiers Point	1408	1145	18.7	81.3	48.0	52.0	50.0	41.1
Audubon/Univers	6176	5700	7.7	92.3	54.3	45.7	60.2	35.6
B.W. Cooper Pro	1647	1421	13.7	86.3	3.9	96.1	3.0	18.7
Bayou St. John	2352	2113	10.2	89.8	35.0	65.0	34.7	39.7
Behrman	4184	3568	14.7	85.3	47.1	52.9	46.5	23.8
Black Pearl	1111	967	13.0	87.0	38.1	61.9	40.9	50.1
Broadmoor	3222	2915	9.5	90.5	48.1	51.9	47.7	30.6
Bywater	2725	2263	17.0	83.1	38.1	61.9	38.3	40.0
Central Busines	1173	921	21.5	78.5	23.2	76.8	26.9	70.9
Central City/Ma	10344	8147	21.2	78.8	16.3	83.7	17.7	44.1
City Park	1697	1565	7.8	92.2	42.0	58.0	47.2	50.3
Desire Area	1610	1398	13.2	86.8	48.1	51.9	52.4	28.0
Desire Project	426	189	55.6	44.4	13.2	86.8	7.9	13.2
Dillard	2750	2609	5.1	94.9	57.9	42.1	60.3	34.3
Dixon	747	668	10.6	89.4	42.1	57.9	43.3	30.4
Donna Villa/Cam	2048	1963	4.2	95.9	85.1	14.9	89.9	24.3
East Carrollton	2366	2182	7.8	92.2	39.2	60.8	44.2	41.9
East Riverside	1631	1386	15.0	85.0	42.9	57.1	42.7	39.1
Edgelake/Little	16402	15761	3.9	96.1	51.4	48.6	55.3	23.4
Fairgrounds/Bro	3315	2983	10.0	90.0	43.6	56.4	47.3	42.1
Fillmore	2886	2757	4.5	95.5	85.6	14.4	87.2	27.2
Fischer Project	704	506	28.1	71.9	12.1	87.9	8.3	15.6
Florida Area	1442	1189	17.6	82.5	58.5	41.6	58.0	26.6
Florida Project	649	399	38.5	61.5	3.3	96.7	2.6	11.5
Freret	1085	902	16.9	83.1	35.4	64.6	36.2	33.6
Garden District	1262	1117	11.5	88.5	49.2	50.9	58.4	50.1
Gentilly Terrac	4564	4258	6.7	93.3	68.7	31.3	70.1	30.3
Gentilly Woods	1596	1480	7.3	92.7	75.7	24.3	74.7	20.2
Gerrtown/Zion C	1876	1541	17.9	82.1	24.2	75.8	25.9	38.6
Hollygrove	2981	2655	10.9	89.1	54.2	45.8	54.1	28.8
Holy Cross	2340	1982	15.3	84.7	41.8	58.2	43.5	30.5
Iberville Proje	915	830	9.3	90.7	0.5	99.5	0.6	15.2
Irish Channel	2039	1750	14.2	85.8	37.4	62.6	38.1	36.5
Lake Catherine/	1187	788	33.6	66.4	90.2	9.8	90.6	27.3
Lake Forest Eas	3986	3578	10.2	89.8	23.8	76.2	26.3	28.1
Lake Kenilworth	1833	1699	7.3	92.7	63.5	36.5	61.1	18.3
Lake Terrace/ L	713	689	3.4	96.6	95.1	4.9	95.5	21.3
Lakeshore/Lake	1642	1543	6.0	94.0	85.7	14.3	88.8	28.0
Lakeview	4805	4524	5.9	94.2	69.5	30.5	73.5	35.1
Lakewood	795	780	1.9	98.1	91.7	8.3	91.9	21.3
Lakewood/West E	2755	2472	10.3	89.7	60.7	39.3	62.3	45.1
Leonidas/West C	4129	3633	12.0	88.0	41.8	58.2	41.7	35.0
Lower Ninth War	5601	4820	13.9	86.1	59.0	41.0	57.0	25.6
Marigny	2349	1960	16.6	83.4	32.9	67.1	34.8	59.3
Marlyville/Font	3106	2845	8.4	91.6	52.0	48.1	55.9	37.8
McDonogh	1410	1055	25.2	74.8	47.9	52.1	46.4	32.5
Mid-City	6728	5830	13.4	86.7	27.9	72.1	28.5	40.3
Milan	3807	3175	16.6	83.4	33.0	67.0	35.2	36.3
Milneburg	2362	2194	7.1	92.9	71.2	28.8	72.7	27.7
Navarre	1551	1470	5.2	94.8	55.9	44.2	58.2	41.4
New Aurora/Engl	1828	1712	6.4	93.7	72.8	27.2	72.8	13.6
Old Aurora	6409	5926	7.5	92.5	73.7	26.3	76.2	24.3
Plum Orchard/Bo	2695	2453	9.0	91.0	57.4	42.6	56.7	23.9
Pontchartrain P	1046	1009	3.5	96.5	92.1	7.9	90.5	25.3
Seventh Ward	7745	6489	16.2	83.8	33.2	66.8	33.5	34.5
Sherwood Forest	2939	2841	3.3	96.7	88.6	11.4	93.1	21.1
St. Anthony	2574	2233	13.3	86.8	57.5	42.5	59.7	30.9
St. Bernard Are	2249	2020	10.2	89.8	17.0	83.0	13.2	20.2
St. Claude	4894	4114	15.9	84.1	44.9	55.1	43.7	26.0
St. Roch	5200	4336	16.6	83.4	42.2	57.8	41.1	29.2
St. Thomas	4036	3332	17.4	82.6	24.8	75.2	28.3	57.0
St. Thomas Proj	1429	834	41.6	58.4	10.3	89.7	8.8	24.7
Tall Timbers/Br	5548	5007	9.8	90.3	35.4	64.6	43.9	35.0

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods - Housing Structure

Neighborhood	Number Housing Units	Number Occupied Housing Units	Percent Vacant Housing Units	Percent Occupied Housing Units	Percent Owner Occupied	Percent Renter Occupied	% Population in Owner Occupied	Percent 1 Person Houising Units
Touro	1888	1672	11.4	88.6	32.3	67.7	41.1	57.0
Treme'	4254	3429	19.4	80.6	21.8	78.2	21.5	33.7
Tulane/Gravier	1934	1583	18.2	81.9	19.3	80.7	19.8	39.0
U.S. Naval Base	992	893	10.0	90.0	50.5	49.5	47.2	21.1
Uptown	3600	3233	10.2	89.8	43.4	56.6	47.9	42.0
Viavant/Venetia	772	617	20.1	79.9	27.6	72.5	28.6	35.7
Vieux Carre	4642	2908	37.4	62.7	24.6	75.4	28.7	67.1
Village de l'es	3999	3817	4.6	95.5	47.1	52.9	52.3	16.2
West Riverside	2952	2635	10.7	89.3	40.8	59.2	43.8	46.0
Whitney	1034	873	15.6	84.4	50.4	49.6	48.0	23.1

-Age Structure 1

Neighborhood	Total Dependency Ratio	Youth Dependency Ratio	Elderly Dependency Ratio	Average Household Size	% Population Under 20 Years	% Population 20 to 64 Years	% Population 65 or More Years
New Orleans Cit	71.7	51.6	20.1	2.5	30.1	58.2	11.7
Algiers Point	43.4	29.0	14.5	2.1	20.2	69.7	10.1
Audubon/Univers	60.0	41.8	18.1	2.2	26.2	62.5	11.3
B.W. Cooper Pro	132.2	120.4	11.7	3.1	51.9	43.1	5.0
Bayou St. John	62.3	48.0	14.3	2.3	29.6	61.6	8.8
Behrman	80.7	66.3	14.4	2.9	36.7	55.3	8.0
Black Pearl	54.2	26.3	27.9	1.8	17.0	64.8	18.1
Broadmoor	67.3	44.9	22.3	2.5	26.9	59.8	13.4
Bywater	56.6	40.4	16.2	2.2	25.8	63.9	10.4
Central Busines	28.4	7.1	21.3	1.4	5.5	77.9	16.6
Central City/Ma	83.0	60.1	22.9	2.3	32.8	54.6	12.5
City Park	36.7	21.0	15.7	1.8	15.4	73.2	11.5
Desire Area	78.0	57.0	20.9	2.7	32.0	56.2	11.8
Desire Project	110.2	92.4	17.8	3.5	43.9	47.6	8.5
Dillard	80.5	47.5	33.0	2.3	26.3	55.4	18.3
Dixon	81.2	56.9	24.3	2.6	31.4	55.2	13.4
Donna Villa/Cam	80.7	57.7	23.0	2.8	31.9	55.3	12.7
East Carrollton	41.4	27.9	13.5	2.0	19.7	70.7	9.6
East Riverside	58.9	43.1	15.8	2.3	27.1	62.9	10.0
Edgelake/Little	70.4	58.1	12.3	2.8	34.1	58.7	7.2
Fairgrounds/Bro	70.6	42.3	28.3	2.2	24.8	58.6	16.6
Fillmore	77.1	43.2	34.0	2.5	24.4	56.5	19.2
Fischer Project	173.8	161.1	12.7	4.0	58.8	36.5	4.6
Florida Area	87.0	55.6	31.4	2.7	29.7	53.5	16.8
Florida Project	170.0	166.8	3.2	4.0	61.8	37.0	1.2
Freret	70.0	49.1	20.8	2.5	28.9	58.8	12.3
Garden District	39.0	16.6	22.4	1.8	11.9	71.9	16.1
Gentilly Terrac	70.0	49.3	20.7	2.5	29.0	58.8	12.2

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

	-Age Structure 1						
Neighborhood	Total Dependency Ratio	Youth Dependency Ratio	Elderly Dependency Ratio	Average Household Size	% Population Under 20 Years	% Population 20 to 64 Years	% Population 65 or More Years
Gentilly Woods	65.5	47.7	17.9	2.9	28.8	60.4	10.8
Gerrtown/Zion C	110.3	88.1	22.1	2.3	41.9	47.6	10.5
Hollygrove	82.5	54.2	28.3	2.6	29.7	54.8	15.5
Holy Cross	88.7	67.4	21.3	2.7	35.7	53.0	11.3
Iberville Proje	135.6	130.2	5.4	3.0	55.3	42.4	2.3
Irish Channel	64.9	51.1	13.9	2.4	31.0	60.6	8.4
Lake Catherine/	53.7	24.1	29.6	2.2	15.7	65.1	19.3
Lake Forest Eas	71.1	63.4	7.7	2.6	37.1	58.4	4.5
Lake Kenilworth	78.7	64.2	14.4	3.0	36.0	56.0	8.1
Lake Terrace/ L	98.5	53.3	45.3	2.5	26.8	50.4	22.8
Lakeshore/Lake	101.4	50.3	51.1	2.3	25.0	49.7	25.4
Lakeview	69.2	37.0	32.2	2.2	21.8	59.1	19.0
Lakewood	94.3	51.2	43.1	2.5	26.4	51.5	22.2
Lakewood/West E	59.8	27.1	32.7	1.9	16.9	62.6	20.5
Leonidas/West C	69.9	49.7	20.1	2.5	29.3	58.9	11.9
Lower Ninth War	91.9	65.0	26.9	2.9	33.9	52.1	14.0
Marigny	30.1	11.6	18.4	1.6	8.9	76.9	14.2
Marlyville/Font	57.6	32.5	25.1	2.2	20.6	63.5	15.9
McDonogh	86.3	63.4	22.9	2.6	34.0	53.7	12.3
Mid-City	40.5	29.8	10.8	2.3	21.2	71.2	7.7
Milan	65.9	45.0	20.9	2.3	27.1	60.3	12.6
Milneburg	75.9	49.9	26.0	2.6	28.4	56.8	14.8
Navarre	52.1	28.4	23.7	2.0	18.7	65.7	15.6
New Aurora/Engl	77.0	63.1	13.9	3.3	35.7	56.5	7.8
Old Aurora	78.6	51.1	27.5	2.6	28.6	56.0	15.4
Plum Orchard/Bo	81.9	59.3	22.6	2.8	32.6	55.0	12.4
Pontchartrain P	120.3	50.7	69.6	2.6	23.0	45.4	31.6
Seventh Ward	90.4	63.8	26.6	2.6	33.5	52.5	14.0
Sherwood Forest	72.9	53.4	19.4	2.9	30.9	57.9	11.3
St. Anthony	65.6	43.0	22.6	2.4	25.9	60.4	13.7
St. Bernard Are	121.4	104.5	16.8	3.1	47.2	45.2	7.6
St. Claude	83.5	65.3	18.2	2.8	35.6	54.5	9.9
St. Roch	83.4	63.5	19.9	2.7	34.6	54.5	10.8
St. Thomas	39.2	24.4	14.7	1.8	17.5	71.9	10.6
St. Thomas Proj	116.9	106.0	10.9	3.4	48.9	46.1	5.0
Tall Timbers/Br	67.0	51.0	16.0	2.4	30.5	59.9	9.6

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

-Age Structure 1

Neighborhood	Total Dependency Ratio	Youth Dependency Ratio	Elderly Dependency Ratio	Average Household Size	% Population Under 20 Years	% Population 20 to 64 Years	% Population 65 or More Years
Touro	41.2	12.8	28.4	1.6	9.1	70.8	20.1
Treme'	88.1	70.0	18.1	2.5	37.2	53.2	9.6
Tulane/Gravier	66.3	48.2	18.1	2.4	29.0	60.1	10.9
U.S. Naval Base	78.5	60.9	17.6	3.0	34.1	56.0	9.9
Uptown	44.3	28.0	16.3	2.1	19.4	69.3	11.3
Viavant/Venetia	103.6	60.1	43.5	2.5	29.5	49.1	21.3
Vieux Carre	24.0	4.5	19.4	1.4	3.7	80.7	15.7
Village de l'es	85.4	74.6	10.9	3.4	40.2	53.9	5.9
West Riverside	47.8	28.1	19.7	1.9	19.0	67.7	13.3
Whitney	88.4	71.1	17.3	2.9	37.8	53.1	9.2

-Age Structure 2

Neighborhood	Average Household Size	% Population Under 20 Years	% Male	Median Age	Median Age Males	Median Age Females	Gini Index Age
New Orleans City	2.5	30.1	46.9	32.6	31.0	34.1	40.0
Algiers Point	2.1	20.2	48.0	37.0	36.7	37.4	34.1
Audubon/University	2.2	26.2	47.0	28.5	29.0	28.0	36.8
B.W. Cooper Projec	3.1	51.9	39.6	18.4	12.5	23.5	50.0
Bayou St. John	2.3	29.6	46.8	32.8	31.9	33.6	38.9
Behrman	2.9	36.7	46.1	28.1	25.9	29.9	42.8
Black Pearl	1.8	17.0	45.5	34.3	32.8	36.0	35.6
Broadmoor	2.5	26.9	44.6	34.7	32.0	37.0	38.4
Bywater	2.2	25.8	50.8	34.9	35.4	34.4	36.6
Central Business D	1.4	5.5	58.4	42.7	43.6	40.5	27.2
Central City/Magno	2.3	32.8	45.7	31.4	30.4	32.3	42.0
City Park	1.8	15.4	47.5	37.4	36.4	38.4	31.7
Desire Area	2.7	32.0	46.1	31.1	28.0	34.0	41.4
Desire Project	3.5	43.9	43.2	23.6	16.9	32.4	44.7
Dillard	2.3	26.3	41.6	37.6	35.1	39.4	38.0
Dixon	2.6	31.4	43.9	32.9	28.3	35.9	41.1
Donna Villa/Camelo	2.8	31.9	45.1	36.0	33.1	38.2	39.7
East Carrollton	2.0	19.7	48.5	29.7	28.8	30.9	35.5
East Riverside	2.3	27.1	47.5	33.5	32.7	34.3	37.3
Edgelake/Little Wo	2.8	34.1	45.5	30.0	27.8	31.7	40.8
Fairgrounds/Broad	2.2	24.8	44.1	38.2	34.9	40.7	37.5
Fillmore	2.5	24.4	44.6	41.8	39.0	43.8	36.6
Fischer Project	4.0	58.8	40.5	15.7	12.8	18.8	49.6
Florida Area	2.7	29.7	46.8	37.5	35.3	39.5	39.3
Florida Project	4.0	61.8	39.7	14.5	11.7	18.2	48.4
Freret	2.5	28.9	46.0	35.1	32.5	37.2	38.8
Garden District	1.8	11.9	49.6	41.8	40.3	43.8	30.7
Gentilly Terrace	2.5	29.0	45.2	36.3	33.8	38.0	38.5
Gentilly Woods	2.9	28.8	48.7	34.5	32.0	36.8	38.9
Gerrtown/Zion City	2.3	41.9	39.3	21.1	25.7	20.2	41.2
Hollygrove	2.6	29.7	44.2	36.2	33.1	38.5	39.9
Holy Cross	2.7	35.7	44.3	30.6	27.6	32.9	42.7
Iberville Project	3.0	55.3	38.5	15.8	10.6	22.0	51.0
Irish Channel	2.4	31.0	48.0	29.6	29.3	29.9	39.9
Lake Catherine/For	2.2	15.7	52.1	48.2	48.4	48.0	29.1
Lake Forest East	2.6	37.1	44.9	25.6	23.6	27.2	42.3
Lake Kenilworth/Ge	3.0	36.0	45.2	30.6	26.8	33.7	41.1
Lake Terrace/ Lake	2.5	26.8	45.6	39.4	40.2	38.5	37.1

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Age Structure 2

Neighborhood	Average Household Size	% Population Under 20 Years	% Male	Median Age	Median Age Males	Median Age Females	Gini Index Age
Lakeshore/Lake Vis	2.3	25.0	48.1	45.6	44.5	46.6	35.6
Lakeview	2.2	21.8	45.7	39.5	37.5	41.3	36.4
Lakewood	2.5	26.4	46.9	44.6	44.0	45.0	36.7
Lakewood/West End	1.9	16.9	46.5	41.3	39.7	42.6	33.7
Leonidas/West Carr	2.5	29.3	45.7	32.8	31.2	34.5	39.7
Lower Ninth Ward	2.9	33.9	46.3	32.4	29.7	34.6	42.5
Marigny	1.6	8.9	59.7	41.8	41.2	43.1	27.2
Marlyville/Fontain	2.2	20.6	47.9	34.5	31.8	37.8	36.5
McDonogh	2.6	34.0	46.7	31.7	30.3	32.8	42.1
Mid-City	2.3	21.2	61.4	32.4	31.1	34.9	33.5
Milan	2.3	27.1	46.6	32.7	30.7	34.6	38.8
Milneburg	2.6	28.4	45.9	36.5	33.5	38.9	39.2
Navarre	2.0	18.7	46.4	36.4	34.7	38.0	35.1
New Aurora/English	3.3	35.7	46.5	32.0	30.9	32.8	41.3
Old Aurora	2.6	28.6	47.0	36.5	35.1	37.8	39.4
Plum Orchard/Bonit	2.8	32.6	45.2	34.0	30.7	36.2	40.7
Pontchartrain Park	2.6	23.0	46.5	45.5	42.5	48.0	35.7
Seventh Ward	2.6	33.5	46.9	32.7	30.0	34.9	42.3
Sherwood Forest/la	2.9	30.9	46.8	37.5	35.3	39.0	38.4
St. Anthony	2.4	25.9	46.8	33.9	31.0	36.6	38.6
St. Bernard Area/P	3.1	47.2	42.2	21.3	15.5	25.7	49.0
St. Claude	2.8	35.6	46.3	30.5	28.7	31.9	42.1
St. Roch	2.7	34.6	46.4	31.3	28.5	33.6	41.9
St. Thomas	1.8	17.5	51.1	33.4	33.6	33.1	33.9
St. Thomas Project	3.4	48.9	46.2	20.1	17.1	24.2	46.0
Tall Timbers/Brech	2.4	30.5	46.1	30.3	29.4	31.0	41.0

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Age Structure 2

Neighborhood	Average Household Size	% Population Under 20 Years	% Male	Median Age	Median Age Males	Median Age Females	Gini Index Age
Touro	1.6	9.1	46.9	39.5	36.0	42.5	30.9
Treme'	2.5	37.2	44.0	28.5	26.3	29.6	44.0
Tulane/Gravier	2.4	29.0	45.7	28.9	30.3	28.1	40.2
U.S. Naval Base	3.0	34.1	50.0	29.5	29.3	29.8	41.9
Uptown	2.1	19.4	48.6	34.3	33.5	35.3	34.8
Viavant/Venetian I	2.5	29.5	44.0	35.8	32.2	38.4	42.0
Vieux Carre	1.4	3.7	60.7	45.5	44.0	48.3	23.7
Village de l'est	3.4	40.2	47.8	25.5	24.3	26.4	43.6
West Riverside	1.9	19.0	46.5	35.6	34.0	37.2	34.7
Whitney	2.9	37.8	45.5	28.6	25.6	30.8	43.5

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Sex Structure

Neighborhood	Total Population	% Male	Sex Ratio	Sex Ratio, 0 to 5 Years Old	Sex Ratio, 5 to 14 Years Old	Sex Ratio, 15 to 19 Years Old	Sex Ratio, 20 to 64 Years Old	Sex Ratio, 65 or More Years Old
New Orleans Cit	484674	46.9	88.2	104.4	103.6	92.9	88.5	60.8
Algiers Point	2381	48.0	92.2	92.3	114.8	98.0	94.8	58.9
Audubon/Univers	14898	47.0	88.8	112.5	108.6	65.3	94.8	69.6
B.W. Cooper Pro	4339	39.6	65.5	110.3	105.6	89.2	39.3	26.6
Bayou St. John	4861	46.8	88.0	99.5	110.3	95.4	85.9	58.7
Behrman	10430	46.1	85.5	105.3	102.6	95.6	78.4	69.9
Black Pearl	1772	45.5	83.6	79.6	117.5	80.0	90.9	55.1
Broadmoor	7232	44.6	80.3	96.4	107.3	84.2	78.2	59.9
Bywater	5096	50.8	103.3	103.3	87.8	111.2	113.1	67.6
Central Busines	1794	58.4	140.5	95.2	68.8	106.7	150.4	119.1
Central City/Ma	19072	45.7	84.0	99.7	101.4	78.7	85.0	56.6
City Park	2813	47.5	90.5	96.8	89.5	129.3	96.4	52.4
Desire Area	3791	46.1	85.7	113.9	101.0	103.3	84.7	51.2
Desire Project	660	43.2	76.0	116.7	132.8	156.3	50.2	30.2
Dillard	6471	41.6	71.2	91.4	94.2	55.1	73.7	56.8
Dixon	1772	43.9	78.3	80.6	115.9	73.4	75.0	57.6
Donna Villa/Cam	5564	45.1	82.3	90.1	104.3	103.3	78.9	58.0
East Carrollton	4438	48.5	94.1	116.1	96.2	121.0	96.2	60.6
East Riverside	3220	47.5	90.6	131.6	101.4	96.2	88.5	69.8
Edgelake/Little	44311	45.5	83.4	105.3	104.5	94.6	76.2	65.5
Fairgrounds/Bro	6575	44.1	79.0	92.1	102.0	100.5	82.5	46.7
Fillmore	6983	44.6	80.5	111.0	103.1	86.0	80.8	60.2
Fischer Project	2034	40.5	68.0	108.4	97.0	70.3	40.7	51.6
Florida Area	3171	46.8	87.9	136.6	100.0	80.7	85.6	76.7
Florida Project	1604	39.7	65.9	91.1	100.0	89.9	32.9	35.7
Freret	2446	46.0	85.0	118.8	100.0	93.2	87.1	48.5
Garden District	1970	49.6	98.6	145.5	121.2	57.1	102.1	81.7
Gentilly Terrac	10542	45.2	82.4	109.5	104.7	100.7	80.1	52.1
Gentilly Woods	4387	48.7	95.0	99.3	121.8	126.4	91.3	67.5
Gerrtown/Zion C	4748	39.3	64.7	126.7	105.4	34.4	71.5	65.0
Hollygrove	6919	44.2	79.2	105.3	94.7	92.7	78.0	56.3
Holy Cross	5507	44.3	79.6	96.5	97.6	89.1	76.7	52.8
Iberville Proje	2540	38.5	62.5	111.9	93.6	84.8	32.4	45.0
Irish Channel	4270	48.0	92.3	104.1	92.8	78.0	96.3	71.0
Lake Catherine/	1760	52.1	108.8	81.8	95.3	122.0	106.7	124.5
Lake Forest Eas	9596	44.9	81.4	113.2	105.3	93.7	70.7	62.3
Lake Kenilworth	5092	45.2	82.4	116.7	98.0	109.7	72.4	69.8
Lake Terrace/ L	2162	45.6	83.8	86.2	92.1	52.3	99.1	75.4
Lakeshore/Lake	3615	48.1	92.7	97.8	116.2	127.0	94.7	71.9
Lakeview	9875	45.7	84.2	102.9	111.7	117.4	87.9	53.3
Lakewood	1962	46.9	88.3	114.0	90.5	109.3	87.0	79.0
Lakewood/West E	4724	46.5	86.9	118.8	89.6	139.7	91.0	63.0
Leonidas/West C	8953	45.7	84.2	97.1	90.2	88.6	87.3	56.7
Lower Ninth War	14008	46.3	86.2	100.4	103.0	114.4	82.0	63.9
Marigny	3145	59.7	148.2	70.6	108.2	84.6	181.5	70.9
Marlyville/Font	6740	47.9	91.9	106.0	108.4	121.0	102.6	44.2
McDonogh	2815	46.7	87.5	105.5	107.2	100.8	85.9	56.6
Mid-City	19909	61.4	159.1	98.3	105.4	186.6	191.3	59.3
Milan	7480	46.6	87.2	94.5	108.7	96.9	89.7	53.1
Milneburg	5640	45.9	84.8	125.9	97.6	101.0	83.4	60.0
Navarre	2908	46.4	86.5	107.5	113.3	110.9	92.2	47.6
New Aurora/Engl	5672	46.5	87.1	95.9	102.0	101.2	80.0	83.1
Old Aurora	15807	47.0	88.7	107.0	103.1	93.9	90.0	64.7
Plum Orchard/Bo	7005	45.2	82.4	124.4	104.4	87.9	76.6	62.4
Pontchartrain P	2630	46.5	86.9	108.3	136.2	106.9	82.3	73.8
Seventh Ward	16955	46.9	88.3	108.9	110.4	93.6	88.1	57.4
Sherwood Forest	8240	46.8	87.9	115.4	102.1	118.5	83.3	63.5
St. Anthony	5318	46.8	88.0	112.2	94.9	110.1	88.0	65.6
St. Bernard Are	6427	42.2	72.9	100.8	115.9	96.7	51.7	42.2
St. Claude	11721	46.3	86.1	106.9	99.6	90.8	81.7	69.6
St. Roch	11975	46.4	86.5	108.5	102.4	103.6	81.1	65.9
St. Thomas	6116	51.1	104.4	107.4	112.1	91.9	113.2	58.8
St. Thomas Proj	2957	46.2	85.7	143.1	112.8	105.3	65.8	47.5
Tall Timbers/Br	12177	46.1	85.5	97.2	101.9	94.5	86.4	48.8

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Sex Structure

Neighborhood	Total Population	% Male	Sex Ratio	Sex Ratio, 0 to 5 Years Old	Sex Ratio, 5 to 14 Years Old	Sex Ratio, 15 to 19 Years Old	Sex Ratio, 20 to 64 Years Old	Sex Ratio, 65 or More Years Old
Touro	3242	46.9	88.3	95.2	109.8	136.1	101.4	47.0
Treme'	8853	44.0	78.6	98.1	106.0	81.9	71.3	55.9
Tulane/Gravier	4234	45.7	84.2	86.5	106.9	82.7	81.1	74.6
U.S. Naval Base	2902	50.0	99.9	92.4	103.2	96.6	107.7	67.3
Uptown	6681	48.6	94.5	85.7	103.6	108.3	100.3	59.2
Viavant/Venetia	1883	44.0	78.7	86.1	102.8	85.9	96.8	34.9
Vieux Carre	4176	60.7	154.6	118.8	113.3	92.9	174.7	92.6
Village de l'es	12912	47.8	91.5	102.3	102.3	102.2	85.0	83.1
West Riverside	5232	46.5	86.9	107.1	105.4	83.1	94.2	45.3
Whitney	2564	45.5	83.4	102.7	106.0	100.0	76.1	56.7

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Race Structure

Neighborhood	Total Population	Percent White	Percent Black	Percent Asian	Percent Native American	Percent 2 or More Races	Percent Other Races	Percent Hispanic
New Orleans Cit	484674	28.1	67.3	2.3	0.2	1.3	1.0	3.1
Algiers Point	2381	70.6	25.2	0.9	0.5	1.5	1.3	4.7
Audubon/Univers	14898	89.3	5.1	2.5	0.2	1.9	1.0	4.4
B.W. Cooper Pro	4339	0.3	99.0	0.0	0.0	0.6	0.1	0.9
Bayou St. John	4861	27.7	68.4	0.9	0.5	1.2	1.3	3.2
Behrman	10430	15.0	78.1	1.6	0.3	1.9	3.1	6.6
Black Pearl	1772	58.1	37.3	2.7	0.1	1.1	0.7	4.2
Broadmoor	7232	27.8	68.9	0.6	0.2	1.7	0.8	3.7
Bywater	5096	34.8	62.2	0.6	0.3	1.1	1.0	4.8
Central Busines	1794	57.0	33.4	5.9	0.3	2.2	1.2	3.2
Central City/Ma	19072	10.5	87.5	0.6	0.2	0.9	0.4	1.6
City Park	2813	85.5	9.6	1.4	0.2	2.1	1.2	5.3
Desire Area	3791	3.8	94.6	0.2	0.1	0.7	0.6	1.4
Desire Project	660	0.0	98.3	0.8	0.0	0.9	0.0	0.2
Dillard	6471	7.8	88.9	0.3	0.1	2.0	0.9	2.1
Dixon	1772	3.4	95.4	0.1	0.0	0.7	0.5	1.5
Donna Villa/Cam	5564	17.1	80.7	0.8	0.2	0.6	0.6	2.4
East Carrollton	4438	63.8	31.6	1.6	0.3	1.6	1.1	4.5
East Riverside	3220	33.1	64.3	0.3	0.4	1.1	0.7	3.6
Edgelake/Little	44311	10.2	86.8	0.9	0.1	1.3	0.6	1.6
Fairgrounds/Bro	6575	27.5	69.8	0.2	0.2	1.1	1.3	3.3
Fillmore	6983	38.2	57.7	1.6	0.0	1.7	0.8	3.8
Fischer Project	2034	0.5	99.2	0.0	0.0	0.2	0.0	0.1
Florida Area	3171	0.4	99.0	0.0	0.0	0.4	0.1	0.8
Florida Project	1604	0.2	98.9	0.0	0.2	0.6	0.0	0.9
Freret	2446	13.7	83.0	0.4	0.4	1.3	1.2	1.8
Garden District	1970	93.0	2.9	0.9	0.4	1.9	1.0	5.1
Gentilly Terrac	10542	26.5	70.2	0.5	0.2	1.4	1.1	3.0
Gentilly Woods	4387	25.8	69.1	2.7	0.3	1.0	1.0	2.4
Gerrtown/Zion C	4748	3.2	94.9	0.5	0.0	0.9	0.4	1.3
Hollygrove	6919	3.0	95.3	0.1	0.0	1.0	0.5	1.5
Holy Cross	5507	9.9	88.0	0.2	0.5	1.0	0.4	1.4
Iberville Proje	2540	0.9	98.6	0.0	0.0	0.5	0.0	0.8
Irish Channel	4270	27.6	68.8	0.2	0.3	1.9	1.1	3.9
Lake Catherine/	1760	95.2	2.0	2.2	0.0	0.4	0.2	1.0
Lake Forest Eas	9596	2.1	96.2	0.4	0.2	0.9	0.2	1.3
Lake Kenilworth	5092	10.0	87.8	0.3	0.4	1.0	0.5	1.0
Lake Terrace/ L	2162	75.1	19.0	3.8	0.1	1.3	0.6	3.7
Lakeshore/Lake	3615	96.1	0.7	2.1	0.1	0.9	0.1	2.7
Lakeview	9875	96.9	0.7	0.8	0.1	0.9	0.6	3.7
Lakewood	1962	96.1	1.7	1.2	0.3	0.8	0.0	2.3
Lakewood/West E	4724	94.4	1.7	1.7	0.1	1.1	1.0	5.1
Leonidas/West C	8953	21.6	75.9	0.5	0.1	1.0	0.8	2.2
Lower Ninth War	14008	0.5	98.6	0.0	0.0	0.6	0.2	0.5
Marigny	3145	76.2	18.0	1.0	0.7	2.3	1.8	6.0
Marlyville/Font	6740	65.3	28.1	3.5	0.2	1.4	1.5	4.2
McDonogh	2815	10.1	87.9	0.6	0.2	0.9	0.4	1.3
Mid-City	19909	27.7	65.0	1.3	0.4	1.9	3.7	10.0
Milan	7480	22.6	74.2	1.1	0.2	1.1	0.9	2.5
Milneburg	5640	20.1	76.0	0.7	0.1	1.9	1.2	4.2
Navarre	2908	92.3	3.6	0.7	0.1	2.0	1.3	5.3
New Aurora/Engl	5672	17.3	68.5	13.0	0.1	0.6	0.5	1.3
Old Aurora	15807	62.7	31.2	2.7	0.5	1.6	1.3	4.8
Plum Orchard/Bo	7005	4.6	93.7	0.1	0.0	1.1	0.5	1.3
Pontchartrain P	2630	0.9	97.0	0.1	0.3	0.8	0.8	0.8
Seventh Ward	16955	3.3	94.5	0.1	0.2	1.2	0.8	1.9
Sherwood Forest	8240	17.1	73.7	6.9	0.4	1.5	0.5	1.4
St. Anthony	5318	33.0	58.6	4.1	0.3	1.8	2.1	5.6
St. Bernard Are	6427	1.2	98.2	0.0	0.0	0.5	0.0	0.8
St. Claude	11721	7.3	91.2	0.2	0.1	0.8	0.5	1.7
St. Roch	11975	4.9	92.7	0.2	0.2	1.2	0.8	3.2
St. Thomas	6116	59.6	34.4	1.5	0.2	2.6	1.7	6.6
St. Thomas Proj	2957	4.7	93.7	0.1	0.2	0.6	0.7	2.0
Tall Timbers/Br	12177	38.3	54.8	3.7	0.3	1.5	1.4	4.3

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Race Structure

Neighborhood	Total Population	Percent White	Percent Black	Percent Asian	Percent Native American	Percent 2 or More Races	Percent Other Races	Percent Hispanic
Touro	3242	77.3	18.6	1.6	0.2	1.1	1.3	4.7
Treme'	8853	5.3	93.1	0.1	0.3	0.6	0.6	1.5
Tulane/Gravier	4234	14.3	78.8	5.0	0.3	0.7	1.0	2.6
U.S. Naval Base	2902	32.3	64.0	0.8	0.1	1.7	1.2	4.2
Uptown	6681	59.9	36.3	1.1	0.3	1.5	1.0	3.5
Viavant/Venetia	1883	15.6	77.3	3.3	0.1	1.2	2.4	4.4
Vieux Carre	4176	91.9	4.3	1.2	0.5	1.5	0.6	2.6
Village de l'es	12912	3.9	56.6	37.2	0.1	1.7	0.5	2.4
West Riverside	5232	59.4	36.5	0.7	0.5	1.9	1.0	4.2
Whitney	2564	11.7	85.5	0.5	0.2	1.1	0.9	2.3

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Race/Ethnic Diversity

Neighborhood	Total Population	Percent NonHisp White	Percent NonHisp Black	Percent NonHisp Asian	Percent Hispanic	Percent NonHisp Other	IQV - Race Ethnic Diversity
New Orleans Cit	484674	26.6	66.7	2.3	3.1	1.4	59.3
Algiers Point	2381	67.4	25.1	0.8	4.7	2.0	54.5
Audubon/Univers	14898	86.1	5.1	2.4	4.4	2.0	24.6
B.W. Cooper Pro	4339	0.2	98.4	0.0	0.9	0.6	4.0
Bayou St. John	4861	26.7	67.8	0.9	3.2	1.4	57.8
Behrman	10430	12.8	77.4	1.6	6.6	1.6	46.7
Black Pearl	1772	55.1	36.7	2.7	4.2	1.4	65.6
Broadmoor	7232	25.8	68.2	0.6	3.7	1.7	57.0
Bywater	5096	32.4	61.1	0.6	4.8	1.2	62.9
Central Busines	1794	55.2	32.9	5.9	3.2	2.7	70.2
Central City/Ma	19072	9.9	87.0	0.6	1.6	0.9	29.0
City Park	2813	81.9	9.4	1.4	5.3	2.0	32.1
Desire Area	3791	3.5	94.1	0.2	1.4	0.8	14.1
Desire Project	660	0.0	98.2	0.8	0.2	0.9	4.4
Dillard	6471	6.9	88.4	0.3	2.1	2.4	26.4
Dixon	1772	3.2	94.9	0.1	1.5	0.3	12.3
Donna Villa/Cam	5564	16.2	79.9	0.8	2.4	0.8	41.5
East Carrollton	4438	60.8	31.5	1.6	4.5	1.7	61.4
East Riverside	3220	30.9	63.8	0.3	3.6	1.3	60.2
Edgelake/Little	44311	9.8	86.2	0.9	1.6	1.5	30.7
Fairgrounds/Bro	6575	26.0	69.1	0.2	3.3	1.4	55.7
Fillmore	6983	36.4	56.9	1.6	3.8	1.4	66.1
Fischer Project	2034	0.5	99.1	0.0	0.1	0.3	2.2
Florida Area	3171	0.4	98.3	0.0	0.8	0.4	4.2
Florida Project	1604	0.2	98.0	0.0	0.9	0.9	4.9
Freret	2446	13.5	82.7	0.4	1.8	1.7	37.1
Garden District	1970	89.2	2.7	0.9	5.1	2.1	16.4
Gentilly Terrac	10542	24.9	69.7	0.5	3.0	1.9	55.3
Gentilly Woods	4387	24.8	68.5	2.7	2.4	1.7	57.8
Gerrtown/Zion C	4748	2.9	94.5	0.5	1.3	0.8	13.2
Hollygrove	6919	2.6	94.7	0.1	1.5	1.1	12.7
Holy Cross	5507	9.4	87.3	0.2	1.4	1.6	28.5
Iberville Proje	2540	0.7	98.0	0.0	0.8	0.5	4.9
Irish Channel	4270	26.0	68.3	0.2	3.9	1.5	56.9
Lake Catherine/	1760	94.3	2.0	2.2	1.0	0.5	11.6
Lake Forest Eas	9596	2.0	95.4	0.4	1.3	1.0	11.1
Lake Kenilworth	5092	9.7	87.5	0.3	1.0	1.5	28.0
Lake Terrace/ L	2162	72.4	18.9	3.8	3.7	1.2	49.7
Lakeshore/Lake	3615	93.7	0.6	2.1	2.7	0.9	9.4
Lakeview	9875	93.9	0.7	0.7	3.7	1.0	7.4
Lakewood	1962	94.0	1.7	1.2	2.3	0.8	9.4
Lakewood/West E	4724	90.5	1.7	1.6	5.1	1.0	13.2
Leonidas/West C	8953	20.6	75.4	0.5	2.2	1.2	48.0
Lower Ninth War	14008	0.5	98.3	0.0	0.5	0.7	4.2
Marigny	3145	72.6	17.7	1.0	6.0	2.7	47.9
Marlyville/Font	6740	62.6	27.9	3.5	4.2	1.8	61.6
McDonogh	2815	9.3	87.7	0.6	1.3	1.2	27.5
Mid-City	19909	23.2	64.3	1.2	10.0	1.3	62.4
Milan	7480	21.6	73.8	1.0	2.5	1.1	50.4
Milneburg	5640	17.7	75.4	0.7	4.2	2.0	48.6
Navarre	2908	89.0	3.2	0.6	5.3	1.9	18.0
New Aurora/Engl	5672	16.9	68.1	13.0	1.3	0.7	61.1
Old Aurora	15807	60.0	30.9	2.7	4.8	1.6	63.5
Plum Orchard/Bo	7005	4.4	93.0	0.1	1.3	1.2	16.6
Pontchartrain P	2630	0.6	96.7	0.1	0.8	1.7	8.1
Seventh Ward	16955	3.0	93.6	0.1	1.9	1.4	15.3
Sherwood Forest	8240	16.6	73.3	6.8	1.4	2.0	53.5
St. Anthony	5318	29.8	58.0	4.0	5.6	2.6	68.7
St. Bernard Are	6427	1.1	97.7	0.0	0.8	0.3	5.7
St. Claude	11721	6.9	90.6	0.2	1.7	0.7	21.7
St. Roch	11975	3.9	91.5	0.2	3.2	1.2	19.9
St. Thomas	6116	55.4	34.2	1.5	6.6	2.3	65.3
St. Thomas Proj	2957	4.2	93.1	0.1	2.0	0.6	16.3
Tall Timbers/Br	12177	35.8	54.6	3.7	4.3	1.6	69.0

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Race/Ethnic Diversity

Neighborhood	Total Population	Percent NonHisp White	Percent NonHisp Black	Percent NonHisp Asian	Percent Hispanic	Percent NonHisp Other	IQV - Race Ethnic Diversity
Touro	3242	74.0	18.4	1.6	4.7	1.3	45.7
Treme'	8853	4.9	92.4	0.1	1.5	1.1	17.9
Tulane/Gravier	4234	13.5	78.2	5.0	2.6	0.7	45.6
U.S. Naval Base	2902	30.2	63.1	0.7	4.2	1.7	61.9
Uptown	6681	57.8	36.0	1.1	3.5	1.7	63.7
Viavant/Venetia	1883	14.3	76.6	3.3	4.4	1.4	48.2
Vieux Carre	4176	89.8	4.3	1.2	2.6	2.1	19.0
Village de l'es	12912	3.6	55.4	37.1	2.4	1.5	69.1
West Riverside	5232	56.9	36.1	0.7	4.2	2.2	64.3
Whitney	2564	11.1	84.9	0.5	2.3	1.2	33.1

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Geo-Mobility

Neighborhood Name	Planning District Code	% Born in Louisiana	% Foreign Born	% Lived Same House 1995	%Different House-Same County	% Different County-Same State	% Different State 1995
New Orleans City	.	77.4	4.2	56.8	28.6	6.0	7.1
Algiers Point	12	56.7	5.3	36.6	32.5	11.7	17.3
Audubon/Universi	3	49.4	6.0	40.2	20.7	7.1	28.3
B.W. Cooper Proj	4	90.8	0.3	71.7	24.4	2.6	0.6
Bayou St. John	4	80.0	3.8	53.0	34.8	5.2	6.4
Behrman	12	80.9	6.0	55.2	30.1	7.1	5.5
Black Pearl	3	63.3	3.9	43.9	30.5	7.7	16.5
Broadmoor	3	78.3	3.7	60.6	28.9	4.2	4.9
Bywater	7	73.3	3.6	58.9	28.8	2.7	7.5
Central Business	1	49.6	10.6	32.6	19.6	13.7	29.8
Central City/Mag	2	84.3	2.4	60.2	30.8	3.3	3.9
City Park	5	59.5	7.1	43.6	34.9	10.1	9.2
Desire Area	7	83.7	2.0	65.5	30.5	0.9	3.0
Desire Project	7	96.8	0.0	87.6	11.3	0.0	1.1
Dillard	6	83.3	2.0	63.1	24.5	3.9	8.1
Dixon	3	89.4	0.4	61.4	30.1	5.8	2.8
Donna Villa/Came	9	86.2	2.7	65.5	29.9	1.6	2.6
East Carrollton	3	52.6	6.3	45.4	23.4	6.4	22.4
East Riverside	2	77.9	2.8	53.0	32.7	5.8	7.9
Edgelake/Little	9	85.1	2.5	57.6	35.1	3.4	3.2
Fairgrounds/Broa	4	81.0	4.0	61.9	27.8	6.4	3.8
Fillmore	6	75.7	4.9	69.0	21.3	3.6	5.4
Fischer Project	12	96.8	0.0	84.9	13.6	1.5	0.0
Florida Area	7	89.3	0.2	70.1	27.4	0.1	1.5
Florida Project	7	97.9	0.0	62.0	36.5	1.0	0.0
Freret	3	83.3	1.6	59.1	31.5	2.7	5.8
Garden District	2	44.7	7.4	49.0	20.6	6.3	19.2
Gentilly Terrace	6	86.5	2.9	64.3	28.7	3.1	3.0
Gentilly Woods	6	72.6	6.4	61.0	20.4	1.9	12.6
Gerrtown/Zion Ci	4	67.5	3.3	35.5	30.1	14.4	17.2
Hollygrove	3	86.7	0.4	68.5	25.6	3.7	1.9
Holy Cross	8	88.2	1.9	65.4	29.3	3.5	1.5
Iberville Projec	4	98.6	0.3	73.7	24.0	0.9	0.4
Irish Channel	2	75.8	3.5	47.9	38.9	3.8	7.6
Lake Catherine/F	11	80.7	2.4	65.4	8.7	24.4	0.6
Lake Forest East	9	88.1	1.4	34.6	54.5	3.9	5.7
Lake Kenilworth/	9	89.1	1.3	65.5	31.1	1.9	1.5
Lake Terrace/ La	6	67.0	10.1	57.6	12.3	14.6	12.1
Lakeshore/Lake V	5	69.4	4.2	67.1	25.0	4.4	3.5
Lakeview	5	75.3	4.0	57.4	23.2	11.4	7.8
Lakewood	5	71.7	3.5	72.4	15.9	7.4	3.6
Lakewood/West En	5	70.0	7.1	49.4	24.3	17.1	6.0
Leonidas/West Ca	3	78.6	2.5	56.0	30.4	5.7	6.8
Lower Ninth Ward	8	91.9	0.5	73.5	23.5	1.2	1.4
Marigny	7	52.8	7.6	53.3	26.9	6.7	12.5
Marlyville/Fonta	3	62.9	6.9	50.5	22.2	7.5	14.9
McDonogh	12	87.4	1.1	53.9	32.5	6.4	7.0
Mid-City	4	67.6	6.6	40.5	23.6	24.8	9.6
Milan	2	73.7	3.1	50.2	33.9	4.0	9.8
Milneburg	6	84.8	6.3	64.7	29.0	3.3	2.3
Navarre	5	74.1	3.0	49.1	24.4	18.8	6.8
New Aurora/Engli	13	77.3	9.4	67.0	22.4	4.5	5.0
Old Aurora	12	66.7	6.3	56.9	23.6	10.4	8.1
Plum Orchard/Bon	9	89.1	1.0	73.0	24.1	0.9	1.1
Pontchartrain Pa	6	87.8	0.0	73.6	22.9	1.6	1.9
Seventh Ward	4	89.7	1.5	58.7	34.9	2.9	2.1
Sherwood Forest/	9	79.4	5.2	68.8	28.1	1.6	1.3
St. Anthony	6	79.4	9.0	59.1	25.1	6.1	5.8
St. Bernard Area	4	95.6	0.4	72.0	24.7	1.4	0.9
St. Claude	7	87.5	1.2	61.0	33.4	2.3	3.1
St. Roch	7	88.1	2.4	61.5	31.4	4.0	2.1
St. Thomas	2	55.2	7.9	45.1	26.8	5.8	18.7
St. Thomas Proje	2	91.6	1.1	76.7	18.5	2.4	0.3
Tall Timbers/Bre	12	61.4	6.2	37.3	32.0	11.5	16.2

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Geographic Mobility

Neighborhood Name	Planning District Code	% Born in Louisiana	% Foreign Born	% Lived Same House 1995	%Different House-Same County	% Different County-Same State	% Different State 1995
Touro	2	53.2	6.6	40.7	26.2	11.0	20.2
Treme'	4	91.3	0.3	60.5	33.0	1.6	3.6
Tulane/Gravier	4	81.2	7.1	45.6	34.3	10.5	6.3
U.S. Naval Base	12	57.4	2.8	47.1	14.0	4.1	30.2
Uptown	3	63.0	5.2	50.9	24.9	8.8	13.1
Viavant/Venetian	11	76.7	3.8	42.6	42.8	12.3	1.7
Vieux Carre	1	38.7	5.8	46.3	20.4	7.3	24.0
Village de l'est	10	65.0	24.2	57.7	32.9	3.8	4.2
West Riverside	3	63.7	4.4	51.2	29.8	5.0	13.1
Whitney	12	87.1	2.7	72.9	15.7	6.2	3.5

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Education

Neighborhood Name	Planning District Code	% Less Than High School	% High School Graduate	% Some College	% Associate Degree	% College Graduate	% Advanced Degree
New Orleans City	.	25.3	23.4	21.9	3.6	15.0	10.7
Algiers Point	12	11.7	22.8	28.9	4.8	17.9	13.9
Audubon/University	3	5.6	7.2	13.1	2.7	34.6	36.8
B.W. Cooper Project	4	52.9	28.5	15.7	2.4	0.4	0.0
Bayou St. John	4	28.1	22.8	22.1	4.0	13.8	9.3
Behrman	12	31.2	32.2	21.7	4.8	7.6	2.4
Black Pearl	3	15.0	14.8	20.0	6.2	25.7	18.3
Broadmoor	3	25.4	24.5	22.0	2.4	14.7	11.0
Bywater	7	35.8	24.9	17.3	2.1	13.4	6.5
Central Business Dis	1	22.4	19.0	14.6	3.7	23.2	17.1
Central City/Magnoli	2	43.7	26.3	15.5	1.9	7.1	5.5
City Park	5	6.1	14.8	20.4	4.3	30.3	24.1
Desire Area	7	44.4	23.7	20.1	3.2	4.7	4.0
Desire Project	7	48.6	36.1	15.3	0.0	0.0	0.0
Dillard	6	23.5	28.2	21.7	4.0	13.6	9.0
Dixon	3	40.1	29.9	13.4	3.9	9.2	3.6
Donna Villa/Camelot	9	19.6	29.4	27.1	4.9	12.8	6.3
East Carrollton	3	12.9	12.5	21.0	1.3	32.6	19.7
East Riverside	2	23.4	33.1	19.1	3.0	12.1	9.2
Edgelake/Little Wood	9	16.9	24.6	30.0	4.6	15.9	8.0
Fairgrounds/Broad	4	23.2	25.8	24.7	5.8	13.3	7.1
Fillmore	6	11.5	21.7	22.4	4.3	19.5	20.5
Fischer Project	12	61.5	28.0	5.7	0.4	2.5	1.8
Florida Area	7	48.7	26.5	19.4	0.7	3.5	1.2
Florida Project	7	63.5	29.0	7.4	0.0	0.0	0.0
Freret	3	31.3	29.8	18.5	5.0	6.3	9.1
Garden District	2	4.7	5.4	14.1	2.4	41.5	31.9
Gentilly Terrace	6	16.3	25.0	25.8	5.7	17.5	9.7
Gentilly Woods	6	19.4	24.0	26.1	2.6	16.8	11.1
Gerrtown/Zion City	4	43.1	25.2	15.3	2.6	6.7	7.0
Hollygrove	3	34.9	29.5	21.5	2.8	6.7	4.5
Holy Cross	8	37.8	25.6	24.1	3.6	5.9	3.1
Iberville Project	4	57.0	33.6	9.4	0.0	0.0	0.0
Irish Channel	2	29.3	22.4	21.3	3.7	14.3	9.0
Lake Catherine/Fort	11	26.5	35.5	22.6	1.9	10.8	2.7
Lake Forest East	9	17.9	28.6	29.0	6.3	13.4	4.9
Lake Kenilworth/Geor	9	22.7	27.9	31.4	4.4	8.0	5.6
Lake Terrace/ Lake O	6	5.7	10.7	21.3	2.2	26.9	33.2
Lakeshore/Lake Vista	5	4.8	10.8	21.4	1.6	34.3	27.1
Lakeview	5	7.2	16.1	22.9	4.0	29.1	20.8
Lakewood	5	1.9	7.8	20.1	0.8	30.7	38.7
Lakewood/West End	5	11.2	19.0	24.7	4.2	21.9	18.9
Leonidas/West Carrol	3	29.3	23.0	21.7	3.2	12.8	10.0
Lower Ninth Ward	8	40.3	28.7	21.4	2.8	5.4	1.5
Marigny	7	16.3	15.4	30.7	4.0	19.2	14.3
Marlyville/Fontainbl	3	13.6	11.1	17.0	2.4	26.3	29.7
McDonogh	12	38.9	27.4	18.3	3.8	9.5	2.0
Mid-City	4	45.6	19.8	18.6	2.3	8.3	5.3
Milan	2	27.9	18.9	22.6	3.8	13.9	12.9
Milneburg	6	22.9	30.2	24.4	3.8	12.2	6.4
Navarre	5	12.0	13.9	24.3	4.5	26.1	19.2
New Aurora/English T	13	27.5	28.0	22.4	2.3	10.1	9.8
Old Aurora	12	10.8	21.6	24.3	6.2	23.8	13.3
Plum Orchard/Bonita	9	25.5	32.1	22.2	4.2	10.8	5.3
Pontchartrain Park	6	22.3	16.3	25.5	4.4	19.8	11.6
Seventh Ward	4	40.4	31.9	17.3	3.0	5.6	1.8
Sherwood Forest/lake	9	17.1	23.3	23.3	7.2	19.6	9.5
St. Anthony	6	18.1	27.4	28.2	3.3	15.5	7.5
St. Bernard Area/Pro	4	44.7	30.4	17.2	2.8	2.5	2.4
St. Claude	7	35.3	30.2	22.0	2.0	7.8	2.7
St. Roch	7	37.8	29.0	20.6	2.7	6.8	3.0
St. Thomas	2	17.8	15.6	20.6	4.1	23.9	18.0
St. Thomas Project	2	48.1	38.5	9.4	0.0	3.5	0.5
Tall Timbers/Brechte	12	13.2	21.3	26.9	5.2	18.0	15.4

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Education

Neighborhood Name	Planning District Code	% Less Than High School	% High School Graduate	% Some College	% Associate Degree	% College Graduate	% Advanced Degree
Touro	2	14.4	13.2	16.4	2.9	27.6	25.5
Treme'	4	39.1	32.3	18.3	1.9	5.9	2.6
Tulane/Gravier	4	43.2	24.4	18.3	0.5	6.5	7.2
U.S. Naval Base	12	19.7	31.1	26.9	4.7	9.8	7.8
Uptown	3	13.1	11.4	19.9	2.7	24.2	28.8
Viavant/Venetian Isl	11	40.6	31.5	8.8	2.9	9.7	6.5
Vieux Carre	1	5.9	13.3	22.0	5.3	30.0	23.5
Village de l'est	10	36.8	22.2	21.6	4.2	10.7	4.6
West Riverside	3	18.0	21.9	18.9	3.4	20.9	16.9
Whitney	12	30.6	30.9	22.4	4.9	7.0	4.3

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Work Issues

Neighborhood Name	Planning District Code	% with a Disability	% Households linguistically Isolated	% Not In the Labor Force	Civilian Labor Force Unemployed	Work in County of Residence	Work in Different State
New Orleans City	.	23.2	1.7	42.2	9.5	78.2	0.9
Algiers Point	12	21.1	1.7	23.5	3.7	74.2	1.7
Audubon/University	3	10.2	1.4	40.2	3.9	81.1	1.6
B.W. Cooper Project	4	39.3	0.7	53.1	27.7	89.3	1.1
Bayou St. John	4	24.1	1.7	34.1	9.3	77.3	0.9
Behrman	12	22.8	1.8	40.5	10.1	64.4	0.6
Black Pearl	3	22.5	1.1	39.9	8.4	80.8	0.0
Broadmoor	3	27.4	1.0	42.8	9.6	78.6	1.4
Bywater	7	26.8	0.9	44.4	9.7	81.9	0.8
Central Business Dis	1	20.7	4.4	46.3	12.5	73.9	4.4
Central City/Magnoli	2	31.1	1.3	53.1	20.4	85.0	0.5
City Park	5	13.0	3.5	23.4	6.7	74.1	1.1
Desire Area	7	37.2	1.1	52.7	9.1	83.2	0.5
Desire Project	7	34.4	0.0	56.0	28.8	84.4	0.0
Dillard	6	26.4	1.4	45.9	10.2	79.0	0.6
Dixon	3	26.9	1.6	41.7	15.0	73.3	0.0
Donna Villa/Camelot	9	23.4	1.1	38.5	6.3	83.5	2.0
East Carrollton	3	17.0	2.4	40.3	4.8	80.8	1.3
East Riverside	2	25.1	1.0	40.1	11.5	80.8	2.4
Edgelake/Little Wood	9	18.2	0.8	32.3	7.6	80.9	0.8
Fairgrounds/Broad	4	25.5	2.0	41.7	7.1	77.5	0.9
Fillmore	6	22.7	0.7	41.7	6.5	74.3	1.9
Fischer Project	12	21.5	0.0	64.8	24.7	67.9	0.0
Florida Area	7	28.1	0.0	58.2	15.0	83.3	0.0
Florida Project	7	22.5	0.0	64.4	53.2	82.0	0.0
Freret	3	37.8	1.9	51.7	20.6	78.1	0.0
Garden District	2	9.5	2.7	36.1	2.4	87.2	1.6
Gentilly Terrace	6	20.8	1.2	36.2	5.7	78.6	0.4
Gentilly Woods	6	18.0	3.4	35.4	9.0	75.7	0.7
Gerrtown/Zion City	4	24.0	1.0	40.8	42.5	74.1	0.8
Hollygrove	3	29.5	0.1	45.8	9.7	67.6	0.2
Holy Cross	8	28.6	1.0	48.1	13.9	74.6	0.5
Iberville Project	4	19.6	0.0	59.1	44.9	86.1	0.0
Irish Channel	2	21.5	0.9	39.1	12.4	83.0	0.4
Lake Catherine/Fort	11	26.5	0.6	48.1	1.4	70.4	0.6
Lake Forest East	9	21.5	1.0	32.1	11.1	85.4	0.0
Lake Kenilworth/Geor	9	18.8	0.4	33.5	9.7	78.3	0.6
Lake Terrace/ Lake O	6	13.3	0.0	35.9	5.5	84.1	0.0
Lakeshore/Lake Vista	5	15.6	0.0	45.1	1.3	68.6	1.8
Lakeview	5	17.4	2.0	34.1	2.0	66.6	0.6
Lakewood	5	13.3	0.0	41.6	0.0	67.9	1.8
Lakewood/West End	5	21.3	2.4	36.4	1.9	65.0	0.8
Leonidas/West Carrol	3	27.4	1.4	41.6	10.5	77.3	0.8
Lower Ninth Ward	8	30.9	0.0	52.1	13.5	78.2	0.7
Marigny	7	26.2	2.3	31.1	7.9	88.9	0.6
Marlyville/Fontainbl	3	16.9	1.0	35.6	4.7	78.5	1.2
McDonogh	12	36.0	1.2	52.6	16.3	71.1	1.9
Mid-City	4	25.8	5.1	63.0	9.5	81.0	0.6
Milan	2	27.1	0.8	41.4	9.3	83.4	0.5
Milneburg	6	24.5	0.9	35.8	6.6	81.9	0.9
Navarre	5	16.9	0.3	32.0	4.4	68.3	0.0
New Aurora/English T	13	24.3	5.0	44.0	10.8	66.3	0.7
Old Aurora	12	16.5	1.8	35.7	5.0	63.1	0.8
Plum Orchard/Bonita	9	31.1	0.0	46.8	8.5	78.7	1.4
Pontchartrain Park	6	26.7	0.0	53.7	6.6	86.1	1.7
Seventh Ward	4	30.2	0.8	49.4	13.8	86.1	0.6
Sherwood Forest/lake	9	19.1	2.2	38.8	4.0	79.0	0.9
St. Anthony	6	20.7	3.2	32.3	7.1	81.2	0.6
St. Bernard Area/Pro	4	25.7	0.0	53.2	20.8	82.4	0.0
St. Claude	7	25.9	1.4	49.4	13.8	86.2	0.0
St. Roch	7	27.3	1.1	48.2	14.4	83.7	0.3
St. Thomas	2	23.2	3.4	32.6	6.9	88.0	1.4
St. Thomas Project	2	31.2	0.0	61.9	24.2	90.0	0.0
Tall Timbers/Brechte	12	18.9	2.8	34.1	6.9	63.2	1.4

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Work Issues

Neighborhood Name	Planning District Code	% with a Disability	% Households linguistically Isolated	% Not In the Labor Force	Civilian Labor Force Unemployed	Work in County of Residence	Work in Different State
Touro	2	15.9	1.0	37.4	1.8	81.7	1.0
Treme'	4	29.5	0.0	52.4	21.4	84.8	0.0
Tulane/Gravier	4	25.0	4.5	56.6	16.0	82.3	0.0
U.S. Naval Base	12	21.7	1.4	39.2	7.7	67.4	1.8
Uptown	3	17.5	1.5	34.9	6.1	85.4	1.1
Viavant/Venetian Isl	11	28.0	3.5	59.2	10.3	80.0	0.0
Vieux Carre	1	14.6	4.3	23.5	4.8	87.1	0.4
Village de l'est	10	19.9	11.1	40.6	10.6	76.9	2.1
West Riverside	3	21.0	3.0	34.9	6.9	78.0	2.1
Whitney	12	29.6	3.3	51.2	14.7	75.7	0.0

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Household Income

Neighborhood Name	Planning District Code	Household Income Less than 20000	Household Income 20000-50000	Household Income 50000-100000	Household Income 100,000 or more
New Orleans City	.	38.9	35.0	18.3	7.8
Algiers Point	12	23.4	41.6	25.3	9.7
Audubon/University	3	22.5	23.6	22.4	31.5
B.W. Cooper Project	4	82.8	15.1	0.5	1.6
Bayou St. John	4	44.5	35.7	15.4	4.5
Behrman	12	41.0	42.9	13.7	2.5
Black Pearl	3	38.2	29.4	22.2	10.1
Broadmoor	3	40.4	34.6	19.1	5.9
Bywater	7	49.6	34.6	12.5	3.2
Central Business Dis	1	40.9	22.8	21.6	14.7
Central City/Magnoli	2	62.8	27.4	7.1	2.7
City Park	5	27.7	37.8	25.6	8.8
Desire Area	7	56.9	26.8	14.5	1.8
Desire Project	7	77.7	19.9	2.4	0.0
Dillard	6	36.3	39.7	19.6	4.3
Dixon	3	53.8	29.8	14.9	1.5
Donna Villa/Camelot	9	22.9	40.4	31.6	5.1
East Carrollton	3	36.9	32.8	15.5	14.8
East Riverside	2	47.1	33.5	15.9	3.5
Edgelake/Little Wood	9	27.7	41.1	25.1	6.1
Fairgrounds/Broad	4	34.0	46.8	16.4	2.8
Fillmore	6	20.8	28.5	37.7	13.0
Fischer Project	12	85.4	13.3	0.0	1.2
Florida Area	7	50.4	40.5	7.0	2.1
Florida Project	7	88.2	11.8	0.0	0.0
Freret	3	55.4	27.3	12.4	4.9
Garden District	2	21.1	32.2	21.1	25.5
Gentilly Terrace	6	28.9	41.8	23.5	5.8
Gentilly Woods	6	20.4	49.4	26.6	3.6
Gerrtown/Zion City	4	59.8	30.0	7.7	2.5
Hollygrove	3	47.2	37.8	12.6	2.4
Holy Cross	8	48.0	36.5	12.4	3.2
Iberville Project	4	89.0	11.0	0.0	0.0
Irish Channel	2	47.8	32.7	16.6	2.9
Lake Catherine/Fort	11	27.0	35.2	28.4	9.4
Lake Forest East	9	41.1	40.2	16.3	2.4
Lake Kenilworth/Geor	9	25.1	43.4	29.3	2.3
Lake Terrace/ Lake O	6	7.3	20.6	25.2	46.9
Lakeshore/Lake Vista	5	8.7	25.9	28.3	37.1
Lakeview	5	16.2	33.2	33.5	17.1
Lakewood	5	6.0	15.4	22.0	56.7
Lakewood/West End	5	18.9	38.7	26.5	15.9
Leonidas/West Carrol	3	46.6	32.7	16.8	4.0
Lower Ninth Ward	8	50.5	37.1	10.9	1.6
Marigny	7	39.7	39.3	14.8	6.2
Marlyville/Fontainbl	3	23.7	30.6	29.7	16.0
McDonogh	12	58.5	31.4	8.3	1.8
Mid-City	4	45.6	39.5	11.9	3.0
Milan	2	46.0	33.3	15.9	4.8
Milneburg	6	30.4	42.9	22.9	3.8
Navarre	5	25.2	32.6	28.4	13.9
New Aurora/English T	13	35.9	34.9	13.6	15.6
Old Aurora	12	17.9	33.3	37.0	11.9
Plum Orchard/Bonita	9	38.3	41.0	16.5	4.2
Pontchartrain Park	6	21.4	47.2	23.0	8.4
Seventh Ward	4	57.5	33.7	7.5	1.4
Sherwood Forest/lake	9	19.6	33.7	34.2	12.6
St. Anthony	6	33.4	46.2	18.1	2.4
St. Bernard Area/Pro	4	71.6	19.7	6.8	1.9
St. Claude	7	49.4	38.2	10.1	2.2
St. Roch	7	51.1	35.5	11.3	2.1
St. Thomas	2	35.4	38.9	13.7	12.1
St. Thomas Project	2	72.3	23.2	0.6	3.9
Tall Timbers/Brechte	12	31.5	32.5	20.8	15.3

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Household Income

Neighborhood Name	Planning District Code	Household Income Less than 20000	Household Income 20000-50000	Household Income 50000-100000	Household Income 100,000 or more
Touro	2	30.9	38.7	20.5	9.9
Treme'	4	63.6	28.6	7.0	0.9
Tulane/Gravier	4	74.2	21.6	2.8	1.5
U.S. Naval Base	12	30.7	43.3	21.4	4.7
Uptown	3	33.4	31.1	21.6	13.8
Viavant/Venetian Isl	11	62.6	28.7	7.6	1.2
Vieux Carre	1	28.2	37.8	20.6	13.4
Village de l'est	10	35.7	42.4	17.4	4.5
West Riverside	3	34.3	38.7	17.4	9.7
Whitney	12	46.0	32.8	18.7	

Source: US Bureau of Census. Note: New Orleans Neighborhoods are listed by associate Census Tract and Planning District below:

Census Tract Number	Tract Population 2000	Neighborhood Code	Neighborhood Name	Planning District Code	City Planning District
22071000100	2381	1	Algiers Point	12	Algiers
22071000400	2564	2	Whitney	12	Algiers
22071000601	2034	3	Fischer Project	12	Algiers
22071000200	1347	4	McDonogh	12	Algiers
22071000300	1468	4	McDonogh	12	Algiers
22071000605	2902	5	U.S. Naval Base	12	Algiers
22071000606	4400	6	Old Aurora	12	Algiers
22071000607	3746	6	Old Aurora	12	Algiers
22071000608	7661	6	Old Aurora	12	Algiers
22071000602	2957	7	Behrman	12	Algiers
22071000603	2342	7	Behrman	12	Algiers
22071000604	5131	7	Behrman	12	Algiers
22071000611	4525	8	New Aurora/English Turn	13	English Turn
22071000612	1147	8	New Aurora/English Turn	13	English Turn
22071000613	4630	9	Tall Timbers/Brechtel	12	Algiers
22071000614	7547	9	Tall Timbers/Brechtel	12	Algiers
22071012500	1772	10	Black Pearl	3	Uptown and Carrollton
22071012600	1929	11	East Carrollton	3	Uptown and Carrollton
22071012700	2509	11	East Carrollton	3	Uptown and Carrollton
22071007501	3100	12	Hollygrove	3	Uptown and Carrollton
22071007502	3819	12	Hollygrove	3	Uptown and Carrollton
22071012900	1572	13	Leonidas/West Carrollton	3	Uptown and Carrollton
22071013000	1993	13	Leonidas/West Carrollton	3	Uptown and Carrollton
22071013100	2156	13	Leonidas/West Carrollton	3	Uptown and Carrollton
22071013200	3232	13	Leonidas/West Carrollton	3	Uptown and Carrollton
22071002700	2510	14	Seventh Ward	4	Mid-City
22071002800	2085	14	Seventh Ward	4	Mid-City
22071002900	2309	14	Seventh Ward	4	Mid-City
22071003000	1972	14	Seventh Ward	4	Mid-City
22071003100	1936	14	Seventh Ward	4	Mid-City
22071003400	2008	14	Seventh Ward	4	Mid-City
22071003500	1861	14	Seventh Ward	4	Mid-City
22071003600	2274	14	Seventh Ward	4	Mid-City
22071001703	3739	15	Desire Area	7	Marigny, Bywater, St. Claude, St. Roch
22071001706	52	15	Desire Area	7	Marigny, Bywater, St. Claude, St. Roch
22071001714	660	16	Desire Project	7	Marigny, Bywater, St. Claude, St. Roch
22071001401	3171	17	Florida Area	7	Marigny, Bywater, St. Claude, St. Roch
22071001600	1604	18	Florida Project	7	Marigny, Bywater, St. Claude, St. Roch
22071001100	2892	19	Bywater	7	Marigny, Bywater, St. Claude, St. Roch
22071001200	2204	19	Bywater	7	Marigny, Bywater, St. Claude, St. Roch
22071000702	2976	20	Holy Cross	8	Lower Ninth Ward/Holy Cross
22071000800	2531	20	Holy Cross	8	Lower Ninth Ward/Holy Cross
22071001800	1519	21	Marigny	7	Marigny, Bywater, St. Claude, St. Roch
22071002600	1626	21	Marigny	7	Marigny, Bywater, St. Claude, St. Roch
22071000701	3278	22	Lower Ninth Ward	8	Lower Ninth Ward/Holy Cross
22071000901	2737	22	Lower Ninth Ward	8	Lower Ninth Ward/Holy Cross
22071000902	2943	22	Lower Ninth Ward	8	Lower Ninth Ward/Holy Cross
22071000903	2640	22	Lower Ninth Ward	8	Lower Ninth Ward/Holy Cross
22071000904	2410	22	Lower Ninth Ward	8	Lower Ninth Ward/Holy Cross
22071001301	3022	23	St. Claude	7	Marigny, Bywater, St. Claude, St. Roch
22071001302	1969	23	St. Claude	7	Marigny, Bywater, St. Claude, St. Roch
22071001303	781	23	St. Claude	7	Marigny, Bywater, St. Claude, St. Roch
22071001304	721	23	St. Claude	7	Marigny, Bywater, St. Claude, St. Roch
22071001402	3202	23	St. Claude	7	Marigny, Bywater, St. Claude, St. Roch
22071001500	2026	23	St. Claude	7	Marigny, Bywater, St. Claude, St. Roch

Table C5-1 Note (cont)

Census Tract Number	Tract Population 2000	Neighborhood Code	Neighborhood Name	Planning District Code	City Planning District
22071001900	2524	24	St. Roch	7	Marigny, Bywater, St. Claude, St. Roch
22071002000	2155	24	St. Roch	7	Marigny, Bywater, St. Claude, St. Roch
22071002100	1522	24	St. Roch	7	Marigny, Bywater, St. Claude, St. Roch
22071002200	2049	24	St. Roch	7	Marigny, Bywater, St. Claude, St. Roch
22071002300	3725	24	St. Roch	7	Marigny, Bywater, St. Claude, St. Roch
22071003701	2151	25	Fairgrounds/Broad	4	Mid-City
22071003702	4424	25	Fairgrounds/Broad	4	Mid-City
22071003305	1173	26	St. Bernard Area/Project	4	Mid-City
22071003306	5254	26	St. Bernard Area/Project	4	Mid-City
22071003307	1689	27	Dillard	6	Gentilly
22071003308	4782	27	Dillard	6	Gentilly
22071002401	2175	28	Gentilly Terrace	6	Gentilly
22071002402	3707	28	Gentilly Terrace	6	Gentilly
22071002503	2035	28	Gentilly Terrace	6	Gentilly
22071002504	2625	28	Gentilly Terrace	6	Gentilly
22071001702	4387	29	Gentilly Woods	6	Gentilly
22071002501	2541	30	Milneburg	6	Gentilly
22071002502	3099	30	Milneburg	6	Gentilly
22071001701	2630	31	Pontchartrain Park	6	Gentilly
22071003303	2514	32	St. Anthony	6	Gentilly
22071003304	2804	32	St. Anthony	6	Gentilly
22071003301	2818	33	Fillmore	6	Gentilly
22071003302	4165	33	Fillmore	6	Gentilly
22071013302	2162	34	Lake Terrace/ Lake Oaks	6	Gentilly
22071013301	3615	35	Lakeshore/Lake Vista	5	Lakeview
22071007605	1772	36	Dixon	3	Uptown and Carrollton
22071005601	2926	37	Lakeview	5	Lakeview
22071005602	3160	37	Lakeview	5	Lakeview
22071005603	1843	37	Lakeview	5	Lakeview
22071005604	1946	37	Lakeview	5	Lakeview
22071007604	1962	38	Lakewood	5	Lakeview
22071007603	4724	39	Lakewood/West End	5	Lakeview
22071005500	2908	40	Navarre	5	Lakeview
22071004800	2540	41	Iberville Project	4	Mid-City
22071003900	1447	42	Treme'	4	Mid-City
22071004000	2582	42	Treme'	4	Mid-City
22071004401	2320	42	Treme'	4	Mid-City
22071004402	2504	42	Treme'	4	Mid-City
22071004100	1720	43	Bayou St. John	4	Mid-City
22071004500	3141	43	Bayou St. John	4	Mid-City
22071004600	2813	44	City Park	5	Lakeview
22071005000	1666	45	Mid-City	4	Mid-City
22071005400	1636	45	Mid-City	4	Mid-City
22071006300	2494	45	Mid-City	4	Mid-City
22071006400	3193	45	Mid-City	4	Mid-City
22071006500	3312	45	Mid-City	4	Mid-City
22071007100	7608	45	Mid-City	4	Mid-City
22071004900	2968	46	Tulane/Gravier	4	Mid-City
22071006000	1266	46	Tulane/Gravier	4	Mid-City
22071005700	510	47	Central Business District	1	Vieux Carre, CBD, Warehouse District
22071005800	487	47	Central Business District	1	Vieux Carre, CBD, Warehouse District
22071005900	797	47	Central Business District	1	Vieux Carre, CBD, Warehouse District
22071003800	1726	48	Vieux Carre	1	Vieux Carre, CBD, Warehouse District
22071004200	2055	48	Vieux Carre	1	Vieux Carre, CBD, Warehouse District
22071004700	395	48	Vieux Carre	1	Vieux Carre, CBD, Warehouse District
22071001724	5642	49	Edgelake/Little Woods	9	New Orleans East
22071001725	7773	49	Edgelake/Little Woods	9	New Orleans East
22071001726	74	49	Edgelake/Little Woods	9	New Orleans East
22071001728	8269	49	Edgelake/Little Woods	9	New Orleans East
22071001737	4099	49	Edgelake/Little Woods	9	New Orleans East
22071001738	9931	49	Edgelake/Little Woods	9	New Orleans East
22071001739	3232	49	Edgelake/Little Woods	9	New Orleans East
22071001740	5291	49	Edgelake/Little Woods	9	New Orleans East
22071001720	5092	50	Lake Kenilworth/Georgetown/Pines	9	New Orleans East
22071001722	7005	51	Plum Orchard/Bonita Park	9	New Orleans East
22071001732	8240	52	Sherwood Forest/lake Forest/Eastover	9	New Orleans East
22071001723	5564	53	Donna Villa/Camelot	9	New Orleans East
22071001733	1883	54	Viavant/Venetian Isles	11	New Orleans East
22071001735	5338	55	Lake Forest East	9	New Orleans East
22071001736	4258	55	Lake Forest East	9	New Orleans East
22071001730	2213	56	Village de l'est	10	New Orleans East
22071001741	1711	56	Village de l'est	10	New Orleans East
22071001742	8988	56	Village de l'est	10	New Orleans East
22071011500	1692	57	Audubon/University	3	Uptown and Carrollton
22071011600	1529	57	Audubon/University	3	Uptown and Carrollton
22071011700	3019	57	Audubon/University	3	Uptown and Carrollton
22071011900	1764	57	Audubon/University	3	Uptown and Carrollton

Table C5-1 Note (cont)

Census Tract Number	Tract Population 2000	Neighborhood Code	Neighborhood Name	Planning District Code	City Planning District
22071012000	1351	57	Audubon/University	3	Uptown and Carrollton
22071012101	2233	57	Audubon/University	3	Uptown and Carrollton
22071012102	3310	57	Audubon/University	3	Uptown and Carrollton
22071012200	2191	58	Marlyville/Fontainbleau	3	Uptown and Carrollton
22071012400	1873	58	Marlyville/Fontainbleau	3	Uptown and Carrollton
22071012800	2676	58	Marlyville/Fontainbleau	3	Uptown and Carrollton
22071008101	2551	59	St. Thomas Project	2	Central City/Garden District
22071008102	406	59	St. Thomas Project	2	Central City/Garden District
22071006900	4339	60	B.W. Cooper Project	4	Mid-City
22071006700	643	61	Central City/Magnolia	2	Central City/Garden District
22071006800	1938	61	Central City/Magnolia	2	Central City/Garden District
22071007900	847	61	Central City/Magnolia	2	Central City/Garden District
22071008000	870	61	Central City/Magnolia	2	Central City/Garden District
22071008400	1239	61	Central City/Magnolia	2	Central City/Garden District
22071008500	1778	61	Central City/Magnolia	2	Central City/Garden District
22071008600	1599	61	Central City/Magnolia	2	Central City/Garden District
22071009100	2569	61	Central City/Magnolia	2	Central City/Garden District
22071009200	1950	61	Central City/Magnolia	2	Central City/Garden District
22071009301	1190	61	Central City/Magnolia	2	Central City/Garden District
22071009302	2259	61	Central City/Magnolia	2	Central City/Garden District
22071009400	2190	61	Central City/Magnolia	2	Central City/Garden District
22071007000	2172	62	Gerrtown/Zion City	4	Mid-City
22071007200	2576	62	Gerrtown/Zion City	4	Mid-City
22071010300	3423	63	Broadmoor	3	Uptown and Carrollton
22071011200	1534	63	Broadmoor	3	Uptown and Carrollton
22071012300	2275	63	Broadmoor	3	Uptown and Carrollton
22071011100	2446	64	Freret	3	Uptown and Carrollton
22071009000	1970	65	Garden District	2	Central City/Garden District
22071010000	2355	66	Milan	2	Central City/Garden District
22071010100	2429	66	Milan	2	Central City/Garden District
22071010200	2696	66	Milan	2	Central City/Garden District
22071009900	3242	67	Touro	2	Central City/Garden District
22071010700	1849	68	Uptown	3	Uptown and Carrollton
22071010800	1449	68	Uptown	3	Uptown and Carrollton
22071010900	3383	68	Uptown	3	Uptown and Carrollton
22071009600	1610	69	East Riverside	2	Central City/Garden District
22071009700	1610	69	East Riverside	2	Central City/Garden District
22071008700	768	70	Irish Channel	2	Central City/Garden District
22071008800	1967	70	Irish Channel	2	Central City/Garden District
22071008900	1535	70	Irish Channel	2	Central City/Garden District
22071007700	1628	71	St. Thomas	2	Central City/Garden District
22071007800	1186	71	St. Thomas	2	Central City/Garden District
22071008200	1886	71	St. Thomas	2	Central City/Garden District
22071008300	1416	71	St. Thomas	2	Central City/Garden District
22071010400	395	72	West Riverside	3	Uptown and Carrollton
22071010500	1421	72	West Riverside	3	Uptown and Carrollton
22071010600	1574	72	West Riverside	3	Uptown and Carrollton
22071011400	1842	72	West Riverside	3	Uptown and Carrollton
22071001734	1760	73	Lake Catherine/Fort Pike	11	New Orleans East

Table C-C1 Detailed Demographic Overview of Parishes in Study

	Jefferson Parish	Orleans Parish	Plaquemines Parish	St. Bernard Parish	St. Charles Parish	St. Tammany Parish
Total Population	455466	484674	26757	67229	48072	191268
Sex Ratio, 20 to 64 Years Old	92.9	88.5	101.3	95.8	93.2	95.1
Median Age	35.9	33.1	33.7	36.6	34.2	36.3
% of Population 65 or More Years	11.9	11.7	9.8	13.8	9.0	10.0
Total Dependency Ratio	66.2	71.7	72.1	72.1	72.6	69.7
Average Household Size	2.6	2.5	2.9	2.6	2.9	2.7
% Non-Hispanic White	65.4	26.6	68.8	84.4	70.5	85.3
% Non-Hispanic Black	22.7	66.7	23.3	7.6	25.1	9.8
% Non-Hispanic Asian	3.1	2.3	2.6	1.3	0.6	0.7
% Hispanic	7.1	3.1	1.6	5.1	2.8	2.5
% Non-Hispanic Other	1.7	1.4	3.7	1.7	1.1	1.7
Race/Ethnic Diversity(IQV)	56.9	59.3	57.0	26.4	51.5	29.1
Number of Housing Units	187907	215091	10481	26790	17430	75398
Number of Occupied Housing Units	176234	188251	9021	25123	16422	69253
% Occupied Housing Units	93.8	87.5	86.1	93.8	94.2	91.9
% Owner Occupied Housing Units	63.9	46.5	78.9	74.6	81.4	80.5
% 1 Person Housing Units	26.7	33.2	18.6	22.9	16.7	19.7
Household Income:						
1999:						
Median	38435	27133	38173	35939	45139	47883
Gini Index	45.9	54.6	46.6	43.0	42.7	45.3
2003:						
Median	38018	27408	38329	36156	45423	51175
Family Income 1999:						
Median	45834	32338	42610	42785	50562	55346
Gini Index	43.2	53.0	43.4	38.5	39.8	41.8
Non-Family Income 1999:						
Median	24594	19453	17490	17525	21482	23520
Per Capita Income	19953	17258	15937	16718	19054	22514
% Persons Below Poverty:						
1999	13.7	27.9	18.0	13.1	11.4	9.7
2003	15.7	22.5	15.3	14.2	12.5	10.5
Median Contract Rent	455	378	401	374	390	493
Median Value Owner Occupied Homes	102800	88100	68900	82900	96300	116000
Civilian Labor Force Unemployed	5.6	9.5	6.7	5.8	5.2	3.8
% Not In Labor Force	36.1	42.2	44.6	40.3	35.4	35.4
% Less Than High School	20.7	25.3	31.3	26.9	20.0	16.1
% College Graduate	21.5	25.7	10.8	8.9	17.5	28.4
% With a Disability	21.0	23.2	19.1	23.4	17.1	17.6
% Households Linguistically Isolated	2.6	1.7	2.	1.4	1.1	0.5
% Born in Louisiana	75.9	77.4	80.8	86.1	81.9	67.7
% Lived Same House 1995	61.4	56.8	65.5	65.1	66.5	54.7
% Different House-Same County	23.7	28.6	16.4	23.6	15.5	20.2
% Lived in Orleans 1995	85.1	85.4	81.9	88.7	82.0	74.9
% Households - No Vehicle	9.3	27.3	9.6	10.3	6.4	4.4
% Households - No Phone	1.9	4.4	5.2	2.6	2.5	2.2

Source: US Bureau of Census, 2000 Census of the Population and Housing STF 3 Files.

Table C-C-2 T-Test Analysis of Race, Income and Level of Flooding.

Households - Race, Income, and Level of Flooding

	0 – 4 Feet	Over 4 Feet	N
Total	52.1%	47.9%	179543
Panel A			
Black	43.6%	56.4%	113428
White	66.6%	33.4%	66115
Panel B			
0 to $49,999	51.6%	48.4%	132663
$50,000 or More	53.5%	46.5%	46880
Panel C1: Income 0 to $49,999			
Black	45.7%	54.3%	93571
White	65.6%	34.4%	39092
Panel C2: Income $50,000 or More			
Black	33.8%	66.2%	19857
White	68.0%	32.0%	27023
Panel D1: Black			
0 to $49,999	45.7%	54.3%	93571
$50,000 or More	33.8%	66.2%	19857
Panel D2: White			
0 to $49,999	65.6%	34.4%	39092
$50,000 or More	68.0%	32.0%	27023

Household Income by Race of Householder

	0 to $49,999	$50,000 or More	N
Total	73.8%	26.2%	180380
Panel E			
Black	82.5%	17.5%	113437
White	59.2%	40.8%	66943

Note: A review of the U.S. Bureau of Census data for neighborhoods in New Orleans shows that African-Americans (56.36%) are about 23% more likely to have experienced heavy flooding (greater than 4 feet) than Whites (33.41%). This difference is statistically significant ($p < .0001$). Households with incomes less than $50,000 are about 2% (48.42% - 46.47%) more likely to have experienced flooding over 4 feet. Although this difference is statistically significant, it is substantively small. Although 40.83% of Whites have household incomes of $50,000 or more, only 17.5% of African-American households have this level of income. This difference of

23.33% is statistically significant (p < .0001). The analysis indicate there is little relationship between household income and level of flooding but a strong relationship between race and both level of flooding and household income.

There is a strong relationship between race and level of flooding taking into account household income level. Among households with less than $50,000 income, African-Americans are about 20% more likely to have experienced heavy flooding. As noted the difference between levels of flooding between blacks and whites was 23% with out taking income into account. However, for African-American households with an income of $50,000 or more, this difference has increased to 34%. Almost 2 in 3 (66.21%) higher-income African American households experienced more than 4 feet of flooding. About 32% of white households experienced that level of flooding. Both of these differences are statistically significant (p < .0001).

Among white households, lower-income households are 2.44% (34.41% – 31.97%) more likely to have experienced heavy flooding than higher-income households were. Within the African-American community, this pattern reverses: Higher-income African Americans households are almost 12% (66.21% - 54.27%) more likely to have experienced heavy flooding than lower-income households were.

We are seeing the effect of the differential impact of flooding in the observations conducted in New Orleans neighborhoods. Middle- and upper-middle-class African American areas that experienced heavy flooding have had few residents return to their homes. Middle- and upper-middle-class neighborhoods—such as Edgelake/Little Woods, Gentilly Terrace, and Plum Orchard--have 75% to 80% of their homes gutted and empty, or the houses simply stand empty and boarded-up. Almost 2 in 3 (66.21%) of higher-income African American households experienced flooding of greater than 4 feet. Although some hardy souls are struggling to recover in these empty and isolated neighborhoods, most have not come back in the 8 months since Katrina.

Appendix 4
Sub-Appendix D. Cultural and Historic Terminology

Local Cultural Terms. A variety of terms are used to describe New Orleans physical features and social groups, and cultural features (Lewis 2003). "Bayou" is a Choctaw term for a small stream with a slow current. "Cajun" describes descendents of the Acadian immigrants from Nova Scotia. "Creole" describes native Orleanians with French Canadian or Spanish ancestry. "Faubourgs" represents the neighborhoods of New Orleans, formerly representing small island enclaves prior to incorporation. "Islenos" are Spanish settlers from the Canary Islands living mostly in St. Bernard's Parish today.

Historical Terms (Obtained from http://www.cr.nps.gov). Comprehensive Historic Preservation Planning describes the organization of preservation information into a logical sequence pertaining to identification, evaluation, registration and treatment of historic properties, and then setting priorities for accomplishing preservation activities.

The following historic terms are used in this report:

- Historic Context. A unit created for planning purposes, which categorizes information about historic properties based on a shared theme, specific time period and geographical area.

- Historic Property. A district, site, building, structure or object significant in American history, architecture, engineering, archeology or culture at the national, State, or local level.

- Integrity. The authenticity of a property's historic identity, as evidenced by the survival of physical characteristics of the property, which existed during the property's historic or prehistoric period.

- Intensive Survey. A systematic, detailed examination of an area designed to gather information about historic properties sufficient to evaluate them against predetermined criteria of significance within specific historic contexts.

- Inventory. A list of historic properties determined to meet specified criteria of significance.

- National Register Criteria. Established criteria that are used in evaluating the eligibility of properties for inclusion into the National Register of Historic Places.

- Preservation (treatment). The act or process of applying measures to sustain the existing form, integrity and material of a building or structure, and the existing form and vegetative cover of a site. It may include initial stabilization work, where necessary, as well as ongoing maintenance of the historic building materials. [Current definition of this treatment standard, as revised in The Secretary of the Interior's Standards for the Treatment of Historic Properties, 1995: Preservation is defined as the act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property. Work, including preliminary measures to protect and stabilize the property, generally focuses upon the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. New exterior additions are not within the scope of this treatment; however, the limited and sensitive upgrading of mechanical, electrical, and plumbing systems and other code-required work to make properties functional is appropriate within a preservation project.

- Property Type. A grouping of individual properties based on a set of shared physical or associative characteristics.

- Protection (treatment). The act or process of applying measures designed to affect the physical condition of a property by defending or guarding it from deterioration, loss or attack, or to cover or shield the property from danger or injury. In the case of buildings and structures, such treatment is generally of a temporary nature and anticipates future historic preservation treatment; in the case of archeological sites, the protective measure may be temporary or permanent. This treatment standard and definition was deleted in The Secretary of the Interior's Standards for the Treatment of Historic Properties, 1995.

- Reconnaissance Survey. An examination of all or part of an area, that is accomplished in sufficient detail to make generalizations about the types and distributions of historic properties that may be present.

- Reconstruction (treatment). The act or process of reproducing by new construction the exact form and detail of a vanished building, structure, or object, or any part thereof, as it appeared at a specific period of time. Current definition of this treatment standard, as revised in The Secretary of the Interior's Standards for the Treatment of Historic Properties, 1995: Reconstruction is defined as the act or process of depicting, by means of new construction, the form, features, and detailing of a non-surviving site, landscape, building, structure, or object for the purpose of replicating its appearance at a specific period of time and in its historic location.

- Rehabilitation (treatment). The act or process of returning a property to a state of utility through repair or alteration which makes possible an efficient contemporary use while preserving those portions or features of the property which are significant to its historical, architectural and cultural values. The current definition of this treatment standard, as revised in The Secretary of the Interior's Standards for the Treatment of Historic Properties, 1995, is "Rehabilitation is defined as the act or process of making possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features which convey its historical, cultural, or architectural values."

- Restoration [treatment]. The act or process of accurately recovering the form and details of a property and its setting as it appeared at a particular period of time by means of the removal of later work or by the replacement of missing earlier work. The current definition of this treatment standard, as revised in The Secretary of the Interior's Standards for the Treatment of Historic Properties, 1995: "Restoration is defined as the act or process of accurately depicting the form, features, and character of a property as it appeared at a particular period of time by means of the removal of features from other periods in its history and reconstruction of missing features from the restoration period. The limited and sensitive upgrading of mechanical, electrical, and plumbing systems and other code-required work to make properties functional is appropriate within a restoration project."

- Sample Survey. A survey of a representative sample of lands within a given area, in order to generate or test predictions about the types and distributions of historic properties in the entire area.

- Stabilization (treatment). The act or process of applying measures designed to reestablish a weather resistant enclosure and the structural stability of an unsafe or deteriorated property while maintaining the essential form as it exists at present. This treatment standard and its definition was deleted in The Secretary of the Interior's Standards for the Treatment of Historic Properties, 1995.

Appendix 5A
Chemical Indicators of Contamination

Water and Sediment Data for Chemical Indicators of Contamination

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Executive Summary

The Engineer Research and Development Center Environmental Laboratory (ERDC-EL) was tasked with collection and condensation of available chemical concentration data in floodwaters and sediments related to the flooding and dewatering events in New Orleans, LA. The investigation focused on available sources of this data, including peer-reviewed scientific journal articles, documents from private organizations, and Federal and State Government agency projects. By far, the largest single source of data was the US Environmental Protection Agency's STORET database which housed thousands of data points collected in the weeks and months following the flooding and dewatering of the city. In addition to this data, however, 'snapshots' of the floodwaters and sediments were obtained from two journal articles published by University researchers that document the floodwaters and deposited sediments immediately after the flooding event. Historical data for some analytes of interest were also found in the published literature and were used to establish analyte concentrations prior to the flooding event. Furthermore, the ERDC-EL made two expeditionary sampling trips to New Orleans during December 2005 and March 2006 to secure additional, site-specific, samples to provide data on discharge of potential contaminants into surrounding ecosystems, specifically, the Violet Marsh. The compilation of these data gathering and collection efforts are discussed in the following report.

Introduction

In this subtask of the Interagency Performance Evaluation Team (IPET) Task 9 project, we focused on data mining and compilation for chemical results in four Louisiana parishes affected by flooding from Hurricanes Katrina and Rita – Orleans, Plaquemines, St. Bernard and St. Charles. The compounds of interest are arsenic, lead, benzo[a]pyrene (BaP) and 1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene (DDE), selected by consensus as likely candidates because of availability of data following the flooding events (Hurricanes Katrina and Rita) and chemical variability between them. Arsenic and lead, although both inorganic analytes, would behave differently based on soil:solution chemistry, with lead sorbing to soil as a traditional cation, whereas arsenic speciation [As(III) or (V)] would yield little sorption in reduced environments as As(III), compared to increased sorption in the case of As(V) being favored in oxidizing environments. Benzo[a]pyrene is an organic polycyclic aromatic hydrocarbon which could be used to trace petroleum impacted floodwaters. The pesticide DDE was selected because of it's presence at superfund sites in the New Orleans area and historical production and usage in the area.

Three distinct time frames are of interest for this work: 1) Pre-Katrina, roughly defined as prior to 28 August 2005; 2) Immediately after the flooding events, roughly 1-2 weeks after Hurricanes Katrina and Rita affected the area; and 3) The post dewatering of New Orleans time period. Possible data sources for this information were ultimately narrowed down primarily to two Federal Government Agencies and two journal articles authored by University Researchers, as described below. Investigations of the US Geological Survey National Water Information System (NWIS) database provided only simple water quality parameters, such as pH, Total Suspended Solids, Dissolved Oxygen, etc., and not specific analytes of interest found in the US Environmental Protection Agency (USEPA) and US Army Corps of Engineers (USACE) studies.

The USEPA provided the most temporally and spatially useful data. The USEPA began an extensive sediment and water sampling plan within days of the flooding event, providing thousands of data points in the on-line STORET (STOrage and RETrieval System) database. The US Army Corps of Engineers Environmental Laboratory (ERDC EL) made sampling trips to New Orleans in December 2005 and again in March 2006 to collect additional data from pump locations where floodwaters were discharged into marshes surrounding the urban areas. These data were considered 'perishable' because of the limited sampling by other agencies and the time since the floodwaters were discharged. The data published by the Principle University Researchers at Louisiana State University and Texas Technical University provide intimate temporal and spatial data in the weeks immediately after the flood event while the city was being dewatered.

Pre-Katrina Data

Using the EPA's STORET data warehouse http://oaspub.epa.gov/stormodb/DW_resultcriteria_geo , no results were found for the period January 1, 2001 through August 24, 2005 for the parishes of interest. A search of the Legacy STORET data warehouse provided some results from the early 1990s, but none of the data was usable for this study. Dave Walters with the US Geological Survey New Orleans Office was able to locate four water quality data samples from the NWIS database (http://waterdata.usgs.gov/nwis) from 2001 and 2002. None of the four compounds of interest were included in the analyses of these four samples. A search of the Louisiana Department of Environmental Quality database (http://www.deq.louisiana.gov/portal/) also turned up no results for our study period and analytes of interest. In general, most of the data available from these sources for the Pre-Katrina time period consists of simple water quality parameters, and not specific analytes of interest.

A review of the peer-reviewed scientific literature yields two articles of interest (Mielke *et al*., 2001; Mielke *et al*., 2004) which report concentrations of PAH and metals in New Orleans inner-city and suburban soils. Benzo[a]pyrene concentrations reported for New Orleans soils ranged from 0.091-6.859 mg/kg, whereas sediment concentrations for spillways and bayous ranged from nondetects to 4.044 mg/kg. Lead concentrations in city soils ranged from 32-4298 mg/kg, whereas bayou sediment concentrations were in the 4-1587 mg/kg range (Mielke *et al*., 2001). In a more recent article, Mielke *et al.* (2004) used census tract information to partition off sections of the city for more detailed spatial analysis of analytes of interest. In addition, site descriptions were used to isolate sources of contamination, i.e. busy streets, residential streets, open areas, etc. The results reported indicate that for most metals and PAHs, 'busy streets' had a higher median concentration than did less impacted areas, such as 'open areas' (Mielke *et al*., 2004).

Immediately After Flooding

Although some data was found in the EPA STORET database for the first weeks after the flooding, perhaps the most detailed data is obtained from the two publications in the Journal *Environmental Science and Technology*. The articles, authored by Pardue *et al.,* (2005*)* and Presley *et al.,* (2006), ["LSU" and "TX Tech" articles, respectively] contain water chemistry data parameters for three of the four analytes of interest, Benzo[a]pyrene, arsenic, and lead. Statements are made in the LSU article about the water quality of the floodwater to the effect: "…Katrina floodwater is similar to normal stormwater runoff but with elevated [lead] and [volatile organic compound] concentrations", yet no specific references or data are given in the article to support this conclusion (Pardue *et al.,* 2005*)*.

Concentrations were not reported in the LSU and TX Tech articles for DDE, although sediment concentrations of Benzo[a]pyrene were reported by TX Tech (Presley *et al.,* 2006). Dissolved metal concentrations were also reported, and ranged from 17-54 μg/L for arsenic and 1-72 μg/L for lead. Sediment samples reported in the TX Tech article list arsenic and lead concentrations as 6-24 and 340-640 mg/kg, respectively, in close agreement to the pre-Katrina values reported by the Mielke *et al*. (2001) study. In fact, the 2001 study found its highest lead concentration in soil to be an order of magnitude higher than the highest value reported by TX Tech (Mielke *et al*., 2001; Pardue *et al*., 2005; Presley *et al*., 2006) The benzo[a]pyrene concentrations reported by TX Tech ranged from 0.01-1.26 mg/kg, also in close agreement to the available Pre-Katrina data.

Post-Katrina Data

Using the EPA's STORET Katrina Central Warehouse, http://oaspub.epa.gov/storetkp/DW_resultcriteria_geo, for the same four Louisiana parishes provided a much different data set for the Post-Katrina and Rita period. The period from August 28, 2005 through February 13, 2006 produced 4729 results for the four parishes and compounds of interest with the exception being St. Charles parish. No samples were taken in St. Charles parish, post-Katrina, according to the STORET Katrina Central Warehouse.

Concentrations for arsenic and lead in soil ranged from 5-12 and 20-117 mg/kg, respectively, in close agreement to those previously reported and discussed for pre-Katrina and immediately after the flooding event timeframes. The organic compounds of interest also showed similar levels as reported prior to the flooding event, with Benzo[a]pyrene ranging from 0.01-0.5 mg/kg and DDE ranging from 0.007-0.013 mg/kg. The one outlying point would be the maximum concentrations of Benzo[a]pyrene reported by Mielke *et al*., (2001) of over 6.5 mg/kg. Water concentrations for arsenic, lead, Benzo[a]pyrene, and DDE in the EPA database ranged from 1-5, 1-100, nondetect-2 and nondetect-1 μg/L, respectively, which also agree closely with the limited pre-Katrina values available.

Water samples were not collected for analysis on the two ERDC-EL sampling trips in the New Orleans and Violet Marsh areas in December 2005 and March 2006. Of the sediment samples collected, arsenic and lead concentrations found ranged from 3-13 and 27-181 mg/kg, respectively. The DDE concentrations found ranged from 0.003-0.015 mg/kg. These values are in close agreement with the limited Pre-Katrina data available, as well as the USEPA data reported after the flooding events.

General Analyte Trends and Observations

The Louisiana Department of Environmental Quality (LDEQ) Risk Evaluation/Corrective Action Program (RECAP) standards for residential soil and water were used to qualify the EPA STORET data. LDEQ developed RECAP to address risks to human health and the environment posed by the release of chemical constituents to the environment. The LDEQ RECAP Table can be found at the following URL: http://www.deq.louisiana.gov/portal/Portals/0/technology/recap/2003/RECAP%202003%20Text%20Table%201.pdf.

Orleans Parish

Figure 1 (Arsenic in Sediment > LDEQ RECAP)

Of the samples tested for arsenic, 36% had a level greater than or equal to the LDEQ RECAP level of 12 mg/kg. The average arsenic level in sediment for Orleans Parish was 11.8 mg/kg (Table 1). In the Mid-City district, at the intersection of Euphrosine and S. Lopez St, a sample with an arsenic level of 78 mg/kg was taken. This was the maximum level found in a sediment sample in Orleans Parish and is the red square with yellow center on the map shown in Figure 1. All other locations that had an arsenic detection greater than the RECAP level are also shown in Figure 1. In New Orleans, elevated metals levels, including arsenic and lead, may result in large part from the incorporation of the pre-hurricane local urban soil (Mielke *et al*., 2001; Plumlee, *et al*, 2006). Arsenic may also be so widespread in the New Orleans area because of past use of arsenic based pesticides, trash incineration, leakage from industrial sites and the use of building materials pressure-treated with chromium-copper arsenate (Solomon, et al, 2006).

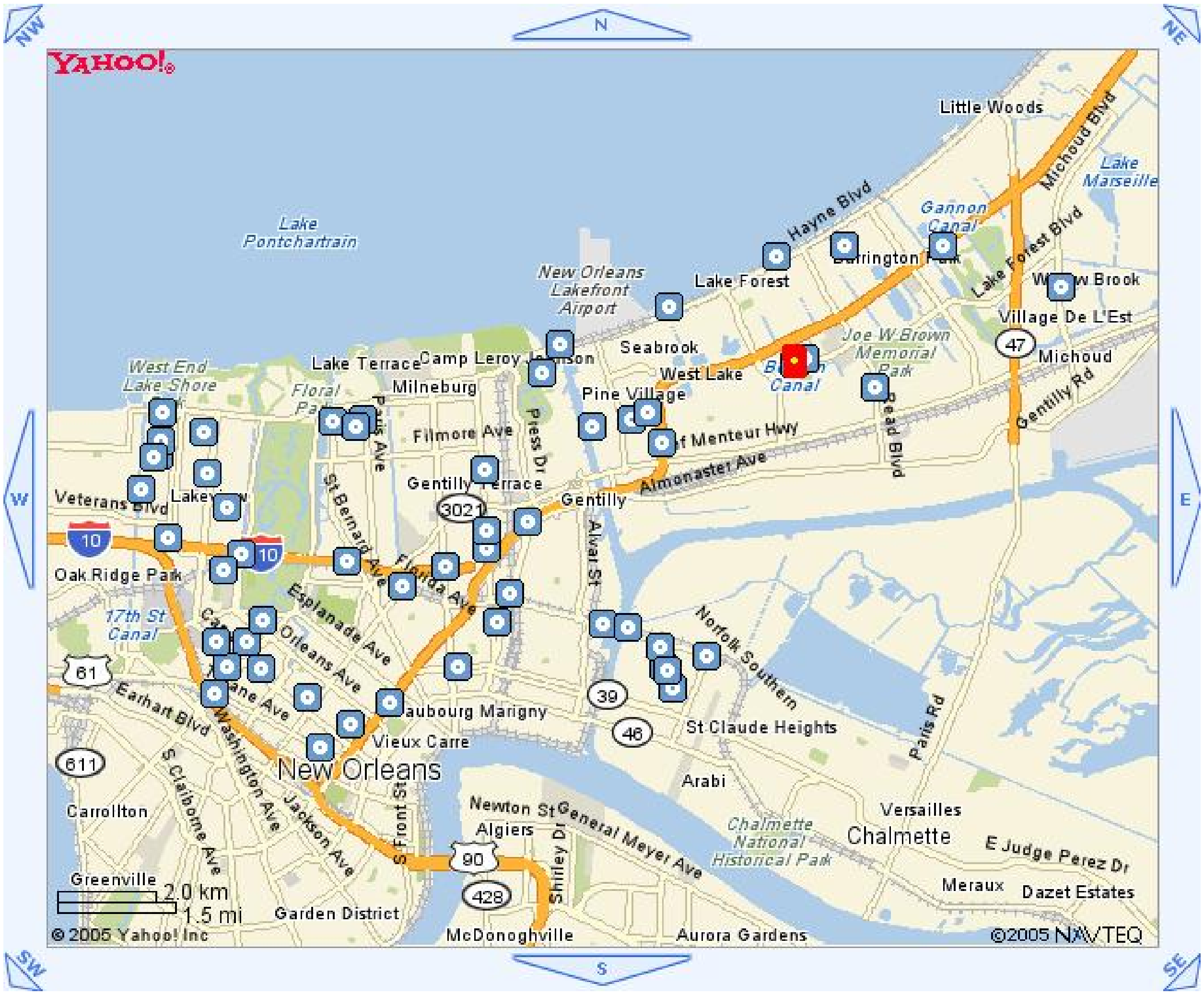

Figure 2. (Arsenic in Water > LDEQ RECAP)

The LDEQ RECAP level for arsenic in groundwater is 0.01 mg/L. Figure 2 shows locations of all samples that exceeded the RECAP level with the maximum level location shown in red with yellow center. Thirteen percent of the floodwater samples taken in Orleans Parish had an arsenic level of 0.01 mg/L or greater. In East Gentilly, a sample taken at the intersection of Lake Forest Blvd and Glouster Rd had an arsenic level of 0.357 mg/L. This was the highest level of arsenic found in Orleans Parish. Three other samples taken along Lake Forest Blvd had levels between 0.05 and 0.27 mg/L.

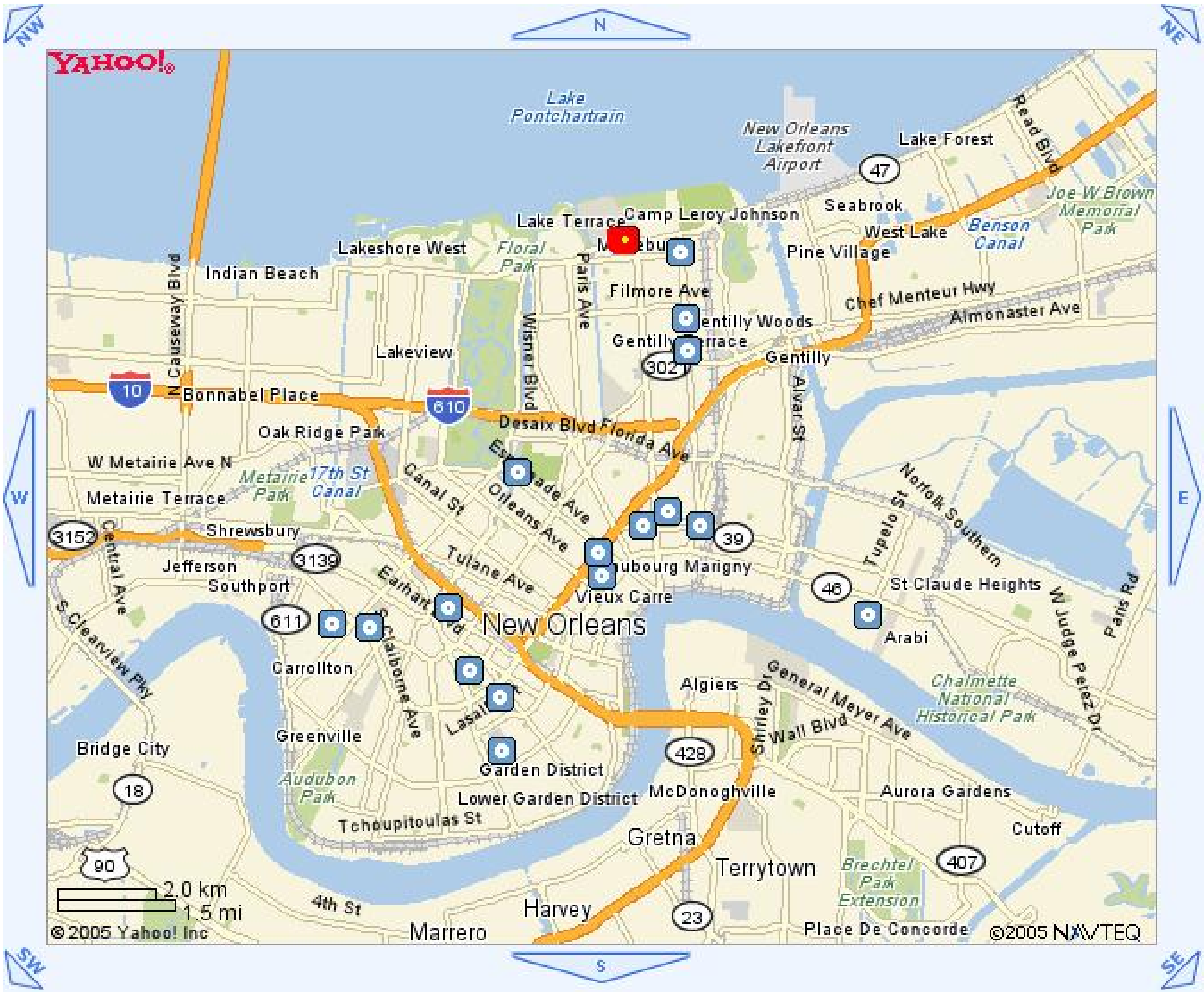

Figure 3. (Lead in Sediment > LDEQ RECAP)

For Lead, the sediment RECAP level is 400 mg/kg. Only 7% of the samples (shown in Figure 3) had a level above the RECAP level. The highest level of lead, 1160 mg/kg, was found on the south side of the University of New Orleans Campus at the intersection of Leon C. Simon Dr and Milneburg Rd. The high levels of lead found in the Orleans' sediments are likely due to past use of lead in paint and gasoline, or from leakage from industrial sites in and around New Orleans (Solomon, et al, 2006).

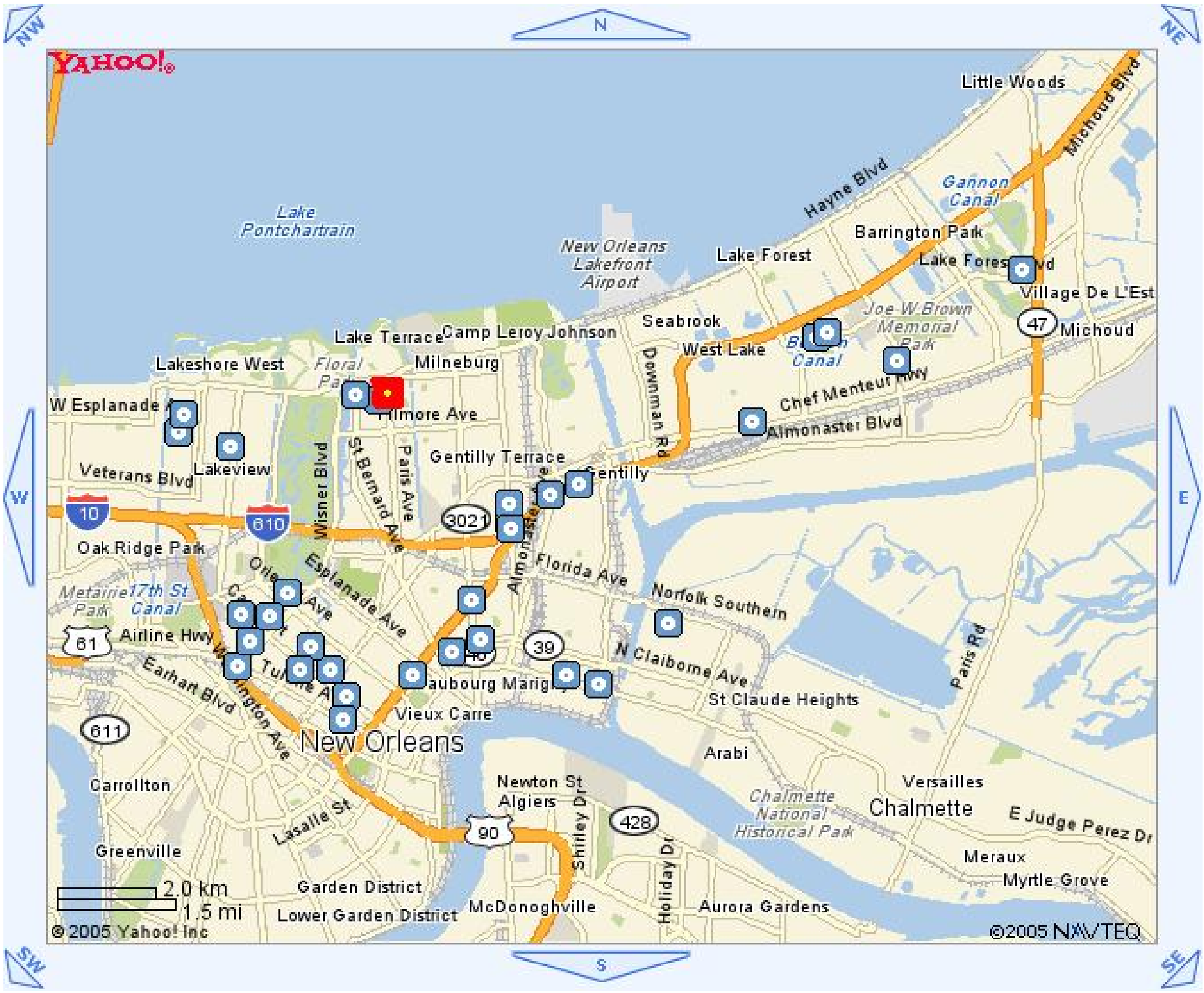

Figure 4. (Lead in Water > LDEQ RECAP)

Lead concentrations in water greater than or equal to the LDEQ RECAP level of 0.15 mg/L was found in 11% of the samples in Orleans parish. (See Figure 4) The highest level of lead in water, 1.34 mg/L, was found in the northwest part of the Gentilly district near the intersection of Paris Ave. and Burbank Dr. In the Bywater district, seven samples with lead levels above the RECAP level were found ranging from 0.846 mg/L near the I-10 exit 236 and 0.026 mg/L at the intersection of Marais and Poland Ave.

In Orleans Parish, fifteen of the metals analytes were found in all 265 sediment samples – Al, Ba, Be, Ca, Cr, Co, Fe, Pb, Mg, Mn, Ni, Na, K, V, and Zn. Another four analytes, Cu, As, Cd, Hg, were detected on at least 90% of the 265 sediment samples taken. Since Cadmium and Mercury are known to be especially toxic to humans, we compared these results to the LDEQ RECAP levels of 3.9 and 2.3 mg/kg respectively. Only one sample exceeded the Mercury RECAP level. Seventeen percent of the Cadmium concentrations found were higher than the RECAP level, with the maximum level of 45.3 mg/kg found at the same location (the intersection of Euphrosine and S. Lopez St) as the maximum level of arsenic.

For comparison, only three metals analytes, Ba, Mn and Ca, were detected on 100% of the 360 water samples taken. There are no LDEQ RECAP levels for Calcium or Manganese. For Barium, an LDEQ RECAP level of 2 mg/L has been set. None of the samples contained a level of Barium that met or exceeded that level. Another five metals, Mg, Na, Fe, K and Zn, had detection percentages of 90% or higher. Only Zinc has an LDEQ RECAP level, which is 1.1 mg/L. Four percent of the samples tested for Zinc met or exceeded that level. Two samples taken in East Gentilly, at the intersection of Lake Forest Blvd and Glouster Rd, contained twenty and thirty times the Zinc RECAP level, respectively. Hexavalent chromium was found in 55% of the 209 water samples taken, but none had a level greater than or equal to the LDEQ RECAP level of 0.1 mg/L.

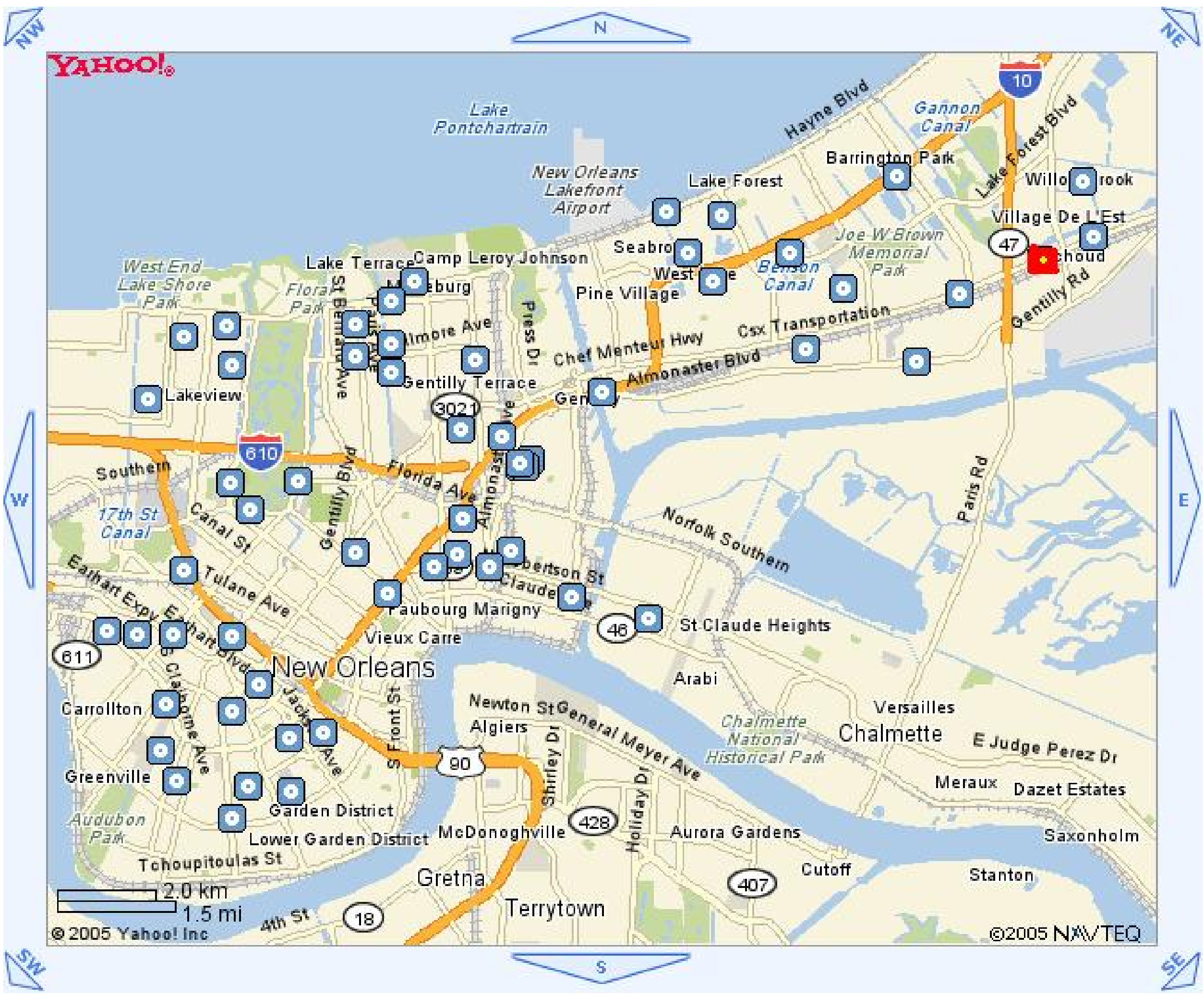

Figure 5. (BaP in Sediment > LDEQ RECAP)

Figure 5 shows detections of the PAH in sediments and soils, Benzo(a)pyrene, that are above LDEQ RECAP level of 0.33 mg/kg. Twenty three percent of the samples tested for BaP met or exceeded this level. Near the Agriculture St. Landfill, four samples ranging from 0.43 mg/kg to 17.7 mg/kg, were taken. The maximum level found, 35.5 mg/kg, was along the Chef Menteur Highway just east of I-510 in Michoud (depicted by the red square with yellow center in

Figure 5). High levels of benzo(a)pyrene may be due to the numerous spills of petroleum products, such as diesel fuel, during the hurricanes, or can be due to historic contamination from burning of debris (Solomon, et al, 2006).

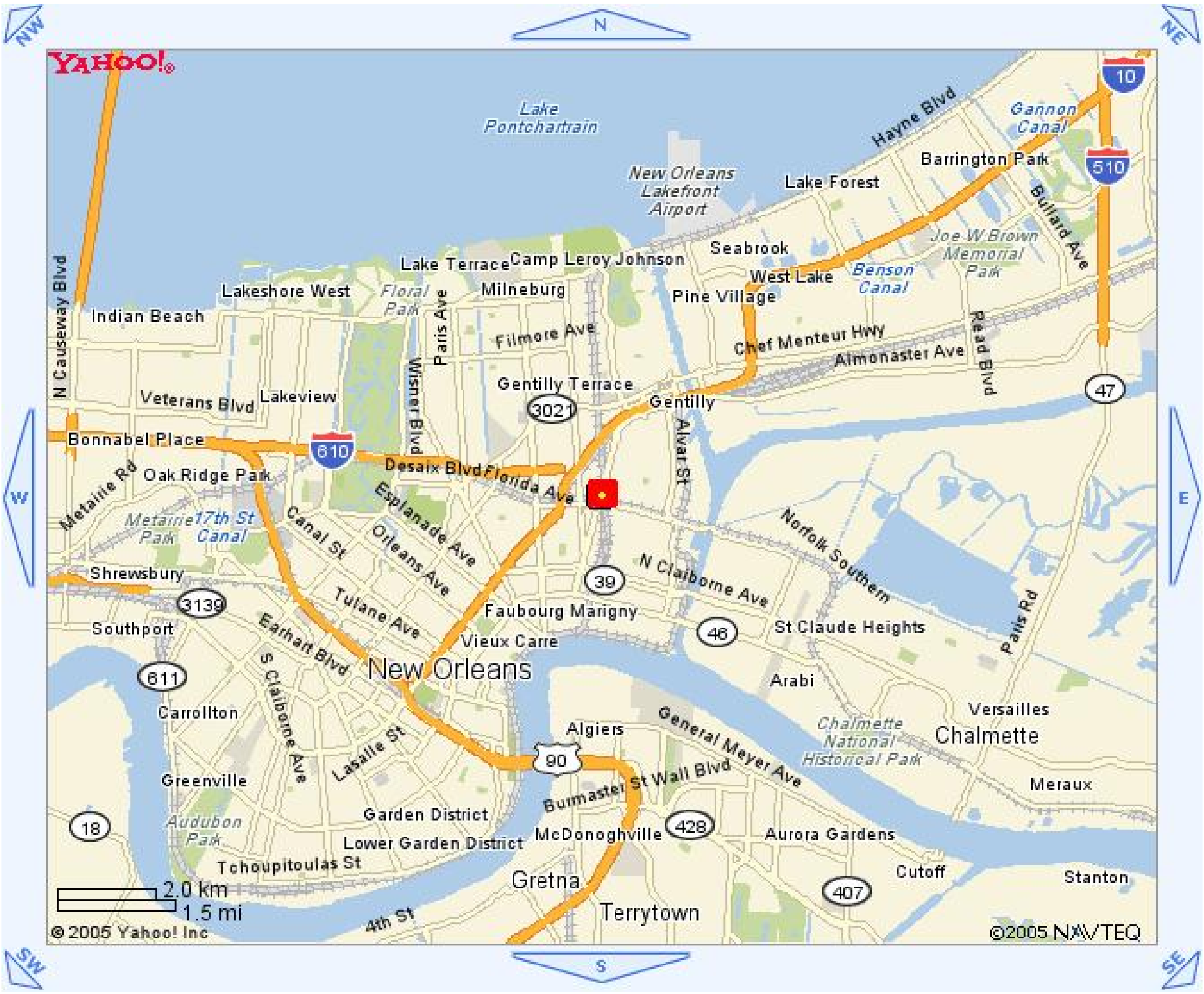

Figure 6. (BaP in Water > LDEQ RECAP)

Only one water sample in Orleans Parish had a Benzo(a)pyrene level higher than the LDEQ RECAP level of 0.0002 mg/L and it was an estimated concentration (Figure 6). The sample was taken near the intersection of Florida Ave and Almonaster Ave and had a level of 0.0004 mg/L.

Other hydrocarbons detected include Oil Range Organics (41 of 41), Petroleum Hydrocarbon Mix (151 of 159) and Diesel Range Organics (246 of 280), yielding an 87% detection rate or better in Orleans Parish sediment samples. For comparison, our PAH of interest, BaP was found in 48% of the sediment samples taken. Oil Range Organic detections exceeded the RECAP level of 180 mg/kg on 46% of the samples taken in Orleans Parish. Diesel Range Organics exceed the RECAP level of 65 mg/kg on 76% of the samples. The Petroleum Hydrocarbon Mix does not have a specific RECAP level because it is a group of hydrocarbons that are broken down individually in the LDEQ RECAP table. Chrysene, Fluoranthene, Benzo[b]fluoranthene and

Pyrene all had a higher percentage of positive results than did BaP. Benzo[a]pyrene was detected in only 1 of 266 water samples taken. All PAH compounds were less prevalent in the water samples than in sediment, with the most prevalent being Diesel Range Organics at a 35% detection frequency.

No sediment or water samples in Orleans Parish contained a DDE level greater than or equal to the 1.7 mg/kg or 0.0002 mg/L LDEQ RECAP levels, respectively.

Our pesticide of interest, DDE, was detected in 12% of the 280 sediment samples taken. For comparison, Chlordane, cis (30%), 1,1,1-Trichloro-2,2-bis(p-chlorophenyl)ethane (DDT) (24%), Chlordane (24%), Dieldrin (21%) and Dichlorodiphenyldichloroethane (DDD) (14%) all had higher percentages of concentrations greater than the detection limit. Chlordane, trans, was found in 59% of the 73 sediment samples that were tested. Chlordane, cis does not have an LDEQ RECAP level. For Chlordane, the RECAP level is 1.6 mg/kg and only one sample in two hundred seven exceeded that figure in Orleans Parish. Dieldrin's RECAP level is 0.03 mg/kg. That level was exceeded in 15% of the samples tested for Dieldrin. No sediment samples exceeded the LDEQ RECAP level for DDD or DDT. In water, only 3% of the 269 samples taken had a result greater than the detection limit for DDE.

Table 1 and 2 below present a summary of the sediment and water concentrations from the EPA STORET data set for Orleans Parish. The LDEQ RECAP limits and the percent of detections above the LDEQ RECAP limit for the four compounds are listed

Table 1
Summary of EPA STORET Sediment Data in Orleans Parish

Compound	Samples	Average (mg/kg)	Maximum (mg/kg)	LDEQ RECAP (mg/kg)	> LDEQ RECAP (%)
Arsenic	273	11.8	78	12	36%
Lead	265	117	1160	400	7%
BaP	277	0.50	35.5	0.33	23%
DDE	280	0.01	0.44	1.7	0%

Table 2
Summary of EPA STORET Water Data in Orleans Parish

Compound	Samples	Average (mg/L)	Maximum (mg/L)	LDEQ RECAP (mg/L)	> LDEQ RECAP (%)
Arsenic	458	0.005	0.357	0.01	13%
Lead	357	0.012	1.34	0.015	11%
BaP	258	0.000002	0.0004	0.0002	0.4%
DDE	261	0.0000009	0.00007	0.0002	0%

Plaquemines Parish

One sediment sample in Plaquemines Parish exceeded the RECAP level of 12 mg/kg for arsenic. It was found near Home Pl just off of Highway 23, north of Milan Dr and had an arsenic level of 14.5 mg/kg (See Figure 7).

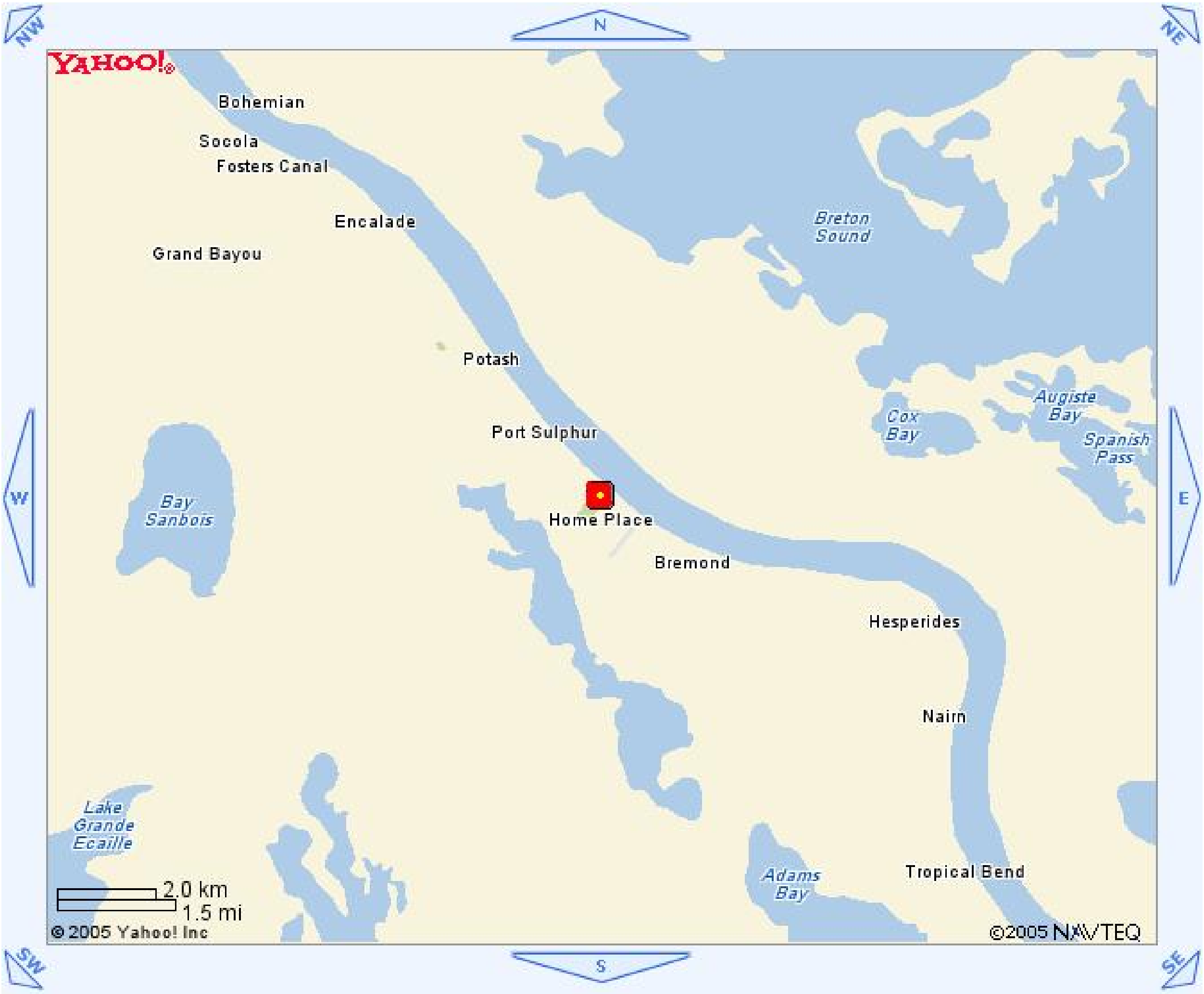

Figure 7. (Arsenic in Sediment > LDEQ RECAP)

Figure 8. (Arsenic in Water > LDEQ RECAP)

Arsenic levels in water greater than or equal to the LDEQ RECAP value of 0.01 mg/L were found in only 2 of the 87 samples tested. Of the two, the higher level of 0.047 mg/L of arsenic was found in a sample taken along Highway 11 just east of Cat Bay Rd, shown in Figure 8 as red square with yellow center.

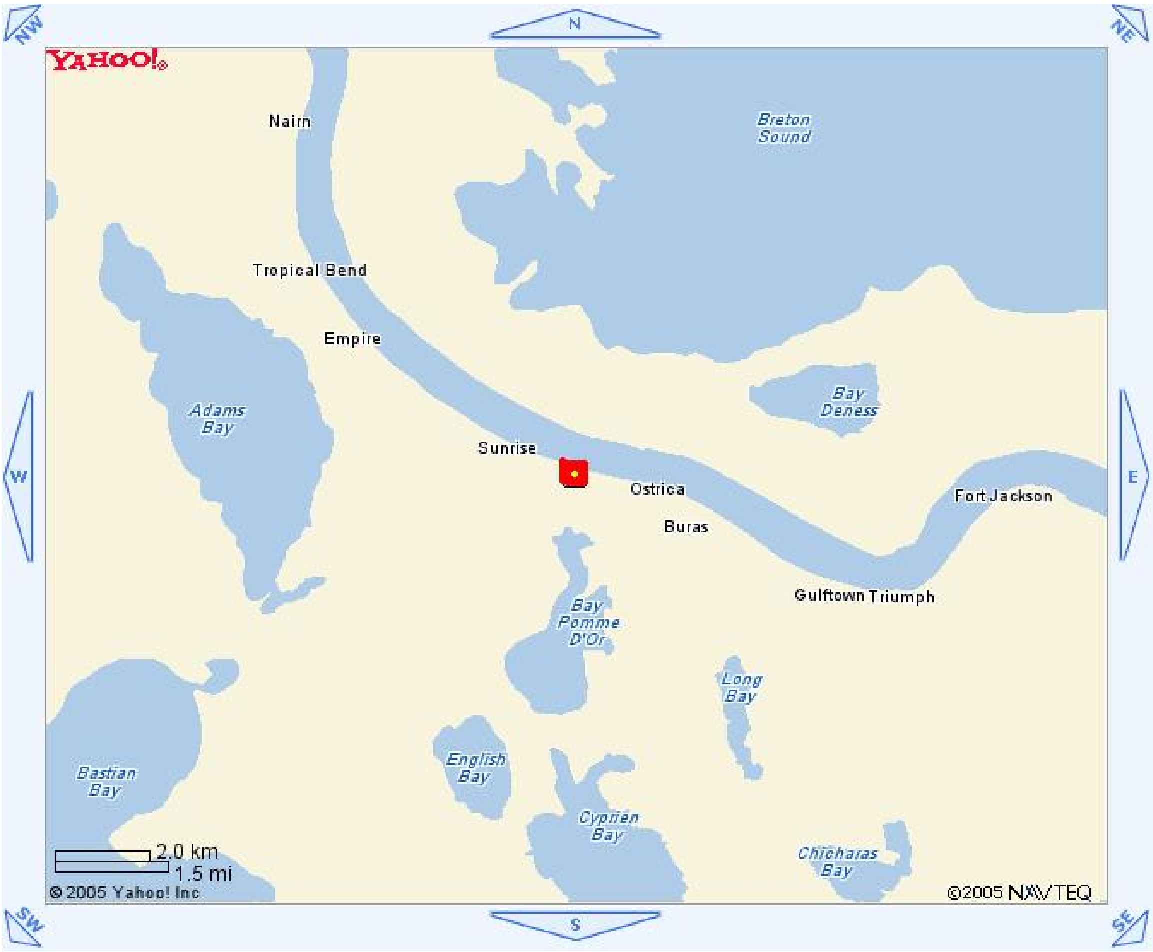

Figure 9. (BaP in Sediment > LDEQ RECAP)

Figure 9 shows a benzo(a)pyrene sample with a level of 12.2 mg/kg, which is nearly forty times greater than the RECAP level of 0.33 mg/kg. The sample was collected northwest of Buras at Bougon Ln and Highway 11. This was the only sediment sample that had a BaP detection for Plaquemines Parish.

This same sample also contained a benzo(a)anthracene level of 16.2 mg/kg, which is twenty-six times the RECAP level of 0.62 mg/kg. Another hydrocarbon analysis, for Diesel Range Organics, was reported above the RECAP level of 65 mg/kg in half of the samples tested. The highest level was found north of Nairn at Highway 11 and Becnal Ln, where a level of 12200 mg/kg was reported.

No water or sediment samples in Plaquemines Parish contained a DDE or Lead level equal to or greater than the LDEQ RECAP. Benzo(a)pyrene was not detected in any of the water samples taken.

Table 3 and 4 below present a summary of the sediment and water concentrations from the EPA STORET data set for Plaquemines Parish. The LDEQ RECAP limits and the percent of detections above the LDEQ RECAP limit for the four compounds are listed.

Table 3 Summary of EPA STORET Sediment Data in Plaquemines Parish					
Compound	**Samples**	**Average (mg/kg)**	**Maximum (mg/kg)**	**LDEQ RECAP (mg/kg)**	**> LDEQ RECAP (%)**
Arsenic	29	4.9	14.5	12	3%
Lead	29	22	60	400	0%
BaP	29	0.42	12.2	0.33	3%
DDE	29	0.01	0.26	1.7	0%

Table 4 Summary of EPA STORET Water Data in Plaquemines Parish					
Compound	**Samples**	**Average (mg/L)**	**Maximum (mg/L)**	**LDEQ RECAP (mg/L)**	**> LDEQ RECAP (%)**
Arsenic	87	0.001	0.047	0.01	2%
Lead	64	0.00001	0.008	0.015	0%
BaP	53	0	0	0.0002	0%
DDE	56	0	0	0.0002	0%

St. Bernard Parish

In Figure 10, one can see that only ten of the three hundred four sediment samples tested for arsenic exceeded the RECAP level of 12 mg/kg. The highest level detected was 22.8 mg/kg (red with yellow center on the map in Figure 10) in Kenilworth south of Bayou Rd on Billot Ln. Six of the ten samples were taken in Poydras. Levels ranged from 14.8 mg/kg at 2412 Meadowlark Street to 19.1 mg/kg at 1904 Goldfinch St.

Figure 10. (Arsenic in Sediment > LDEQ RECAP)

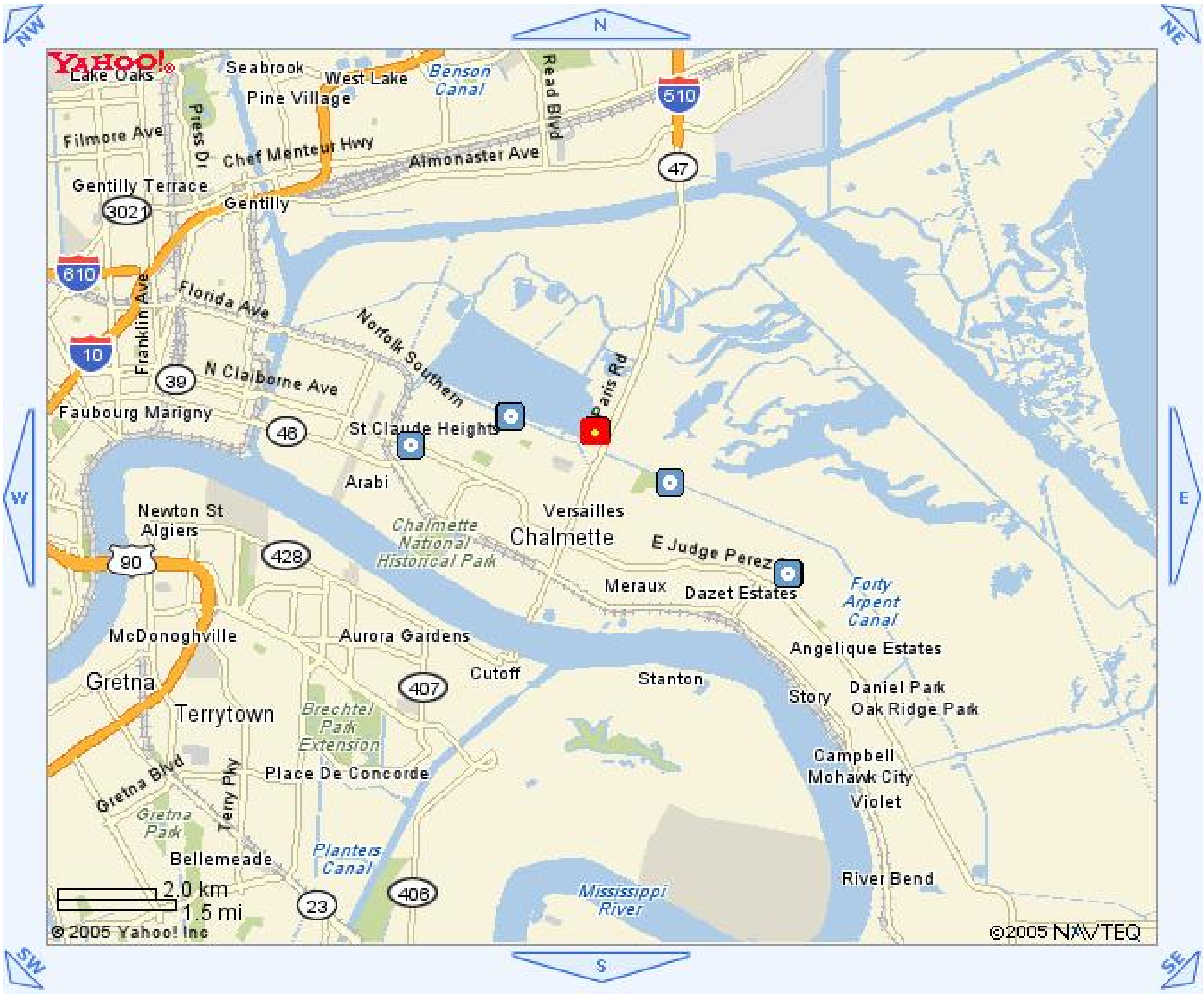

Figure 11. (Arsenic in Water > LDEQ RECAP)

Twelve percent of the water samples tested for arsenic in St. Bernard Parish had a level greater than or equal to the LDEQ RECAP level of 0.01 mg/L. The highest level of arsenic (0.059 mg/L) was found just north of Chalmette near the intersection of Highway 47 and Agriculture Street (See Figure 11).

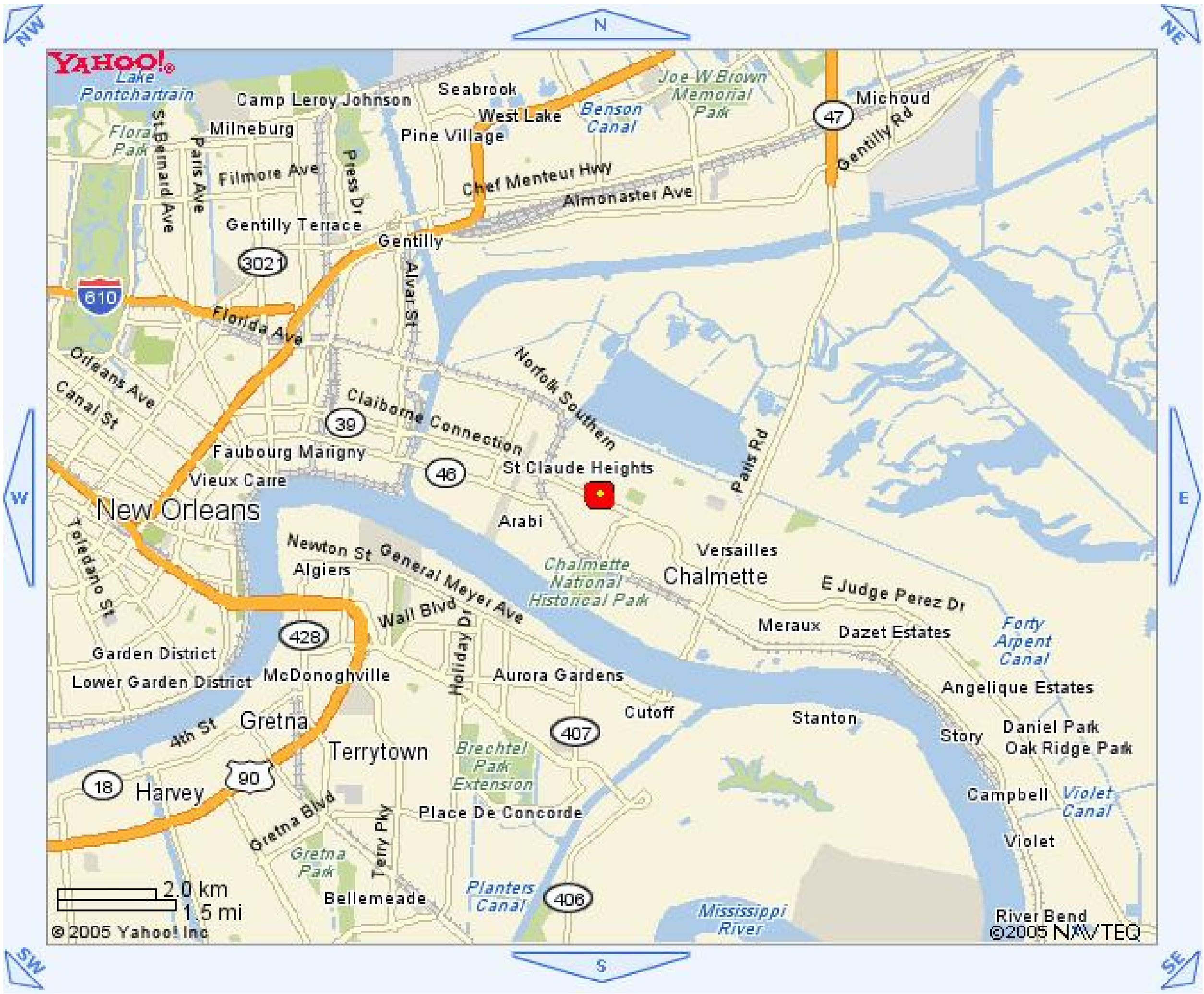

Figure 12. (BaP in Sediment > LDEQ RECAP)

With a level of 0.41 mg/kg, the lone sample that exceeded the sediment RECAP level for benzo(a)pyrene was taken on the west side of Chalmette near West Judge Perez Dr east of Norton Ave (Figure 12). Plumlee, et. al 2006, also reported elevated levels of benzo(a)pyrene in USGS sediment samples taken in Chalmette. No concentrations in water samples tested for BaP were above the detection limit.

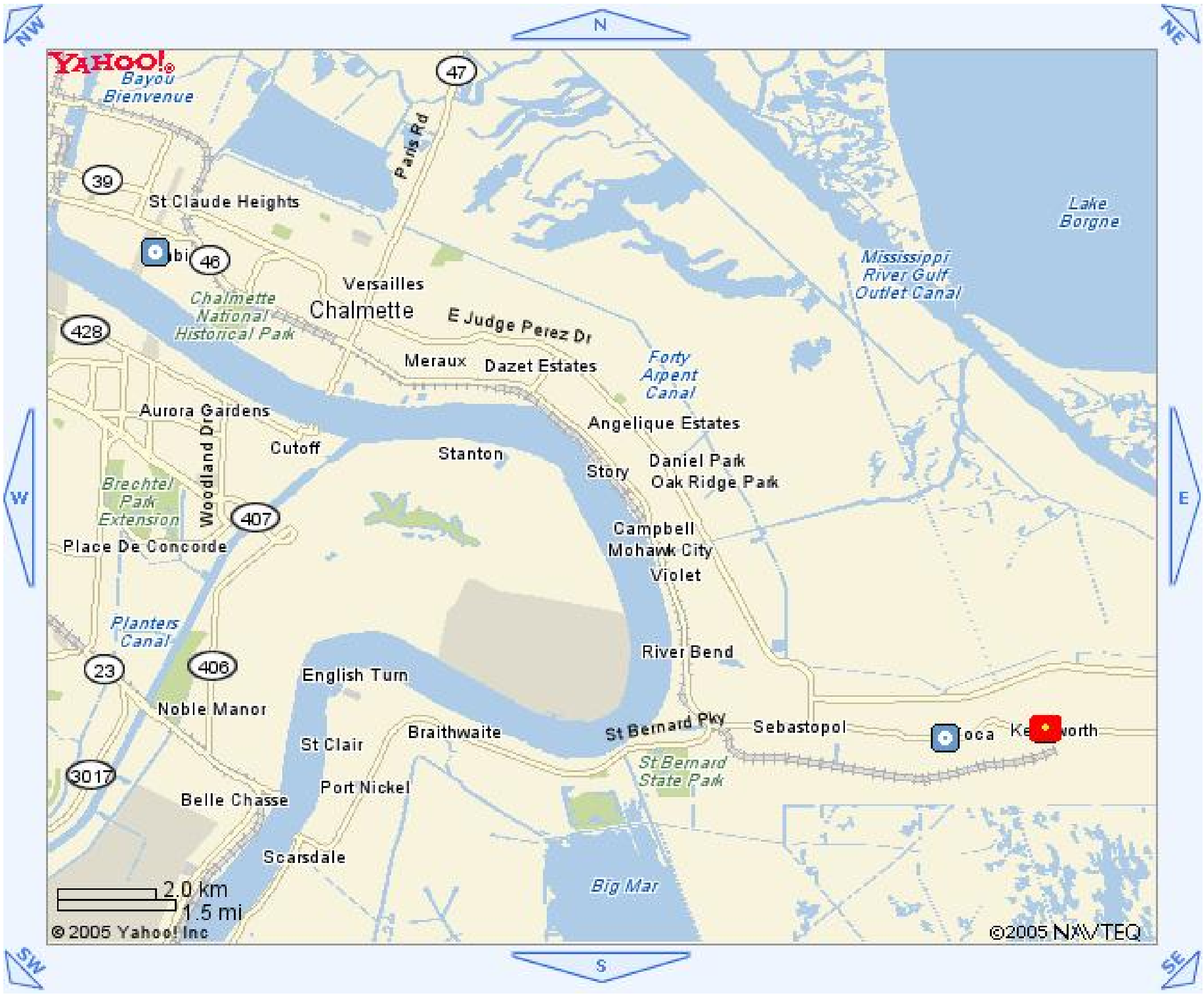

Figure 13. (Lead in Sediment > LDEQ RECAP)

Three of the three hundred four sediment samples in St. Bernard Parish tested for lead exceeded the RECAP level of 400 mg/kg. Like arsenic, the highest lead level detected (1370 mg/kg) was in Kenilworth along Bayou Rd just west of Billot Ln (Figure 13).

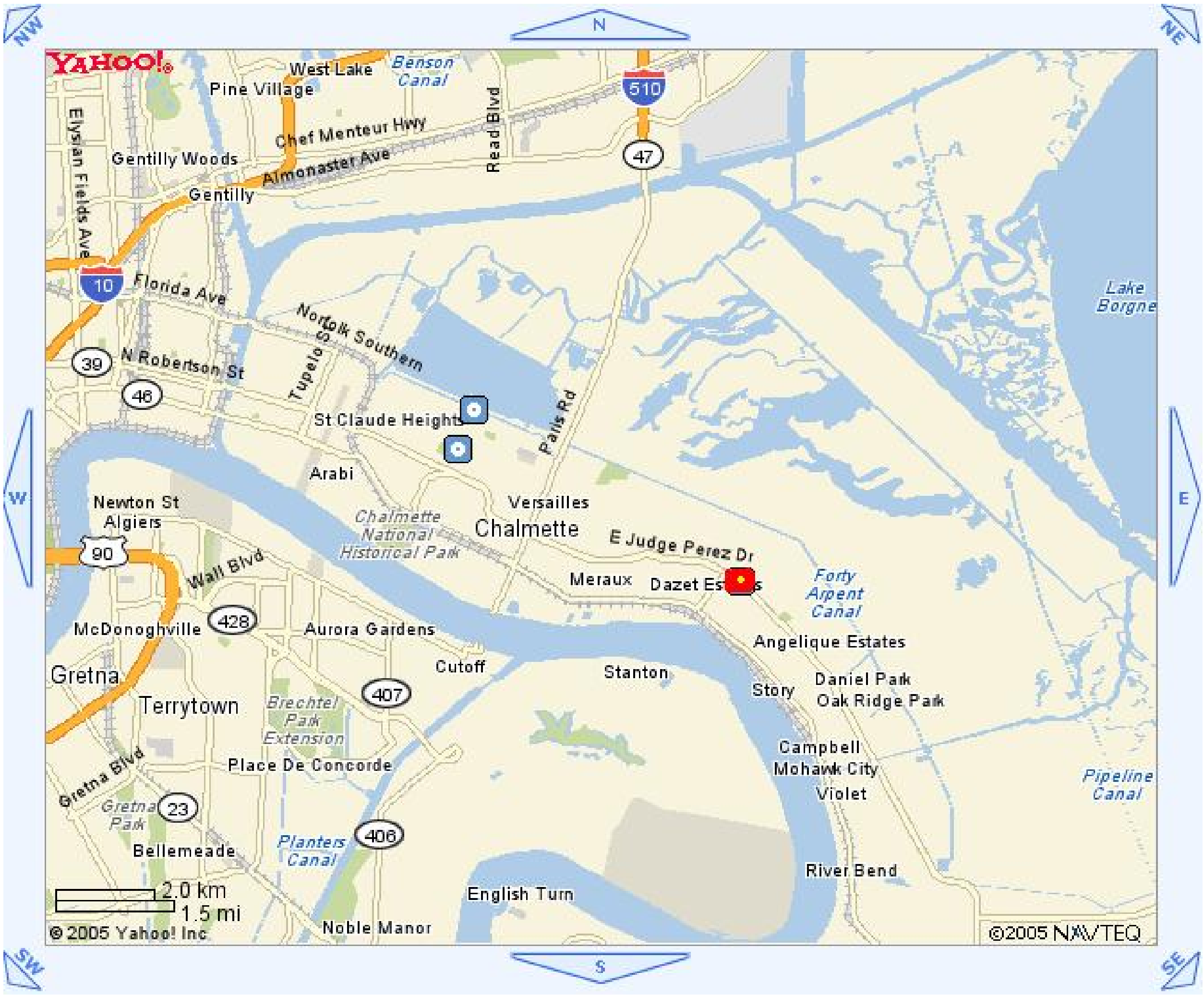

Figure 14. (Lead in Water > LDEQ RECAP)

Figure 14 shows the location of the only three water samples tested for lead that produced a level greater than or equal to the LDEQ RECAP level of 0.015 mg/L. A concentration of 0.022 mg/L was found near Archbishop Hannan High School in Chalmette (shown as red with yellow center marker in Figure 14).

No water or sediment samples in St. Bernard Parish contained a DDE level equal to or greater than the LDEQ RECAP level of 0.0002 mg/L or 1.7 mg/kg respectively.

Table 5 and 6 below present a summary of the sediment and water concentrations from the EPA STORET data set for St. Bernard Parish. The LDEQ RECAP limits and the percent of detections above the LDEQ RECAP limit for the four compounds are listed

Table 5 Summary of EPA STORET Sediment Data in St. Bernard Parish					
Compound	**Samples**	**Average (mg/kg)**	**Maximum (mg/kg)**	**LDEQ RECAP (mg/kg)**	**> LDEQ RECAP (%)**
Arsenic	304	5.7	22.8	12	3%
Lead	304	42	1370	400	1%
BaP	847	0.01	0.41	0.33	0.1%
DDE	308	0.01	0.76	1.7	0%

Table 6 Summary of EPA STORET Water Data in St. Bernard Parish					
Compound	**Samples**	**Average (mg/L)**	**Maximum (mg/L)**	**LDEQ RECAP (mg/L)**	**> LDEQ RECAP (%)**
Arsenic	57	0.003	0.059	0.01	12%
Lead	40	0.001	0.022	0.015	8%
BaP	31	0	0	0.0002	0%
DDE	31	0	0	0.0002	0%

Discussion and Conclusions

An exhaustive evaluation of the available data on the concentrations of organic and inorganic contamination in sediment and water prior to, during, and following the de-watering of New Orleans after the effects of Hurricane Katrina and the subsequent flooding shows no large scale increases in water or sediment levels as a result of the de-watering activity. The four contaminants used in this report were selected based on their presence in the current data set and the fact that they represented important classes of contamination with regards to contaminant behavior: divalent, cationic heavy metals (Pb), anionic heavy metals (As), and hydrophobic organics with various degrees of solubility and sorptive behavior (BaP) and (DDE). None of these four representative contaminants exhibited extensive changes in concentration in or mobility from soils or surface waters as a result of the dewatering effort. Comparisons between data available prior to the flooding events and data obtained both during and following the de-watering process do not show significant differences with regards to sediment and water concentrations. There can be no doubt that the volume of sediment within the city increased significantly and therefore the total mass of both organic and inorganic contaminants within these sediments increased, but this effect was a result of the effects of the hurricane and not the dewatering of the city. However, concentrations of the 4 analytes of interest were detected in sediment and water that sometimes exceeded drinking water and other regulatory levels.

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Appendix 5B
Chemical and Toxic Analysis

Environmental Consequences of the Failure of the New Orleans Levee System During Hurricane Katrina, Chemical and Toxicological Analysis

31 March 2006

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Executive Summary

Introduction

Hurricane Katrina came ashore along the Alabama, Mississippi, and Louisiana coasts on 29 August 2005, resulting in significant physical damage to infrastructure. As a result of the storm, levees were breached or overtopped, resulting in flooding of New Orleans and surrounding areas, including many areas in St. Bernard Parish. Within St. Bernard Parish, floodwaters in Chalmette and Violet, Louisiana were pumped into the adjacent Violet Marsh. There are potential undesirable environmental impacts on the marsh ecosystem resulting from levee breaches and pumping activities. One of the primary environmental concerns is chemical and biological contaminants. Thus, we conducted a study after the storm to compare chemistry and toxicity in sediment samples at sites in the immediate vicinity of active and inoperable pumping stations that discharge into Violet Marsh. The Interagency Performance Evaluation Taskforce (IPET) is investigating environmental impacts originating from the failure of the hurricane protection system to perform as designed around New Orleans, Louisiana during Hurricane Katrina. This study is needed to determine the extent to which Katrina floodwaters in the

New Orleans area may have had impacts to wildlife habitat and other biological resources in surrounding areas.

To assess the potential impacts of pumping water and suspended sediment from urban areas to adjacent ecosystems, the Corps of Engineers collected sediment samples from Violet Marsh, due to its proximity to urban areas, receipt of floodwaters pumped from the adjacent city of Chalmette, and potential importance as a buffer from hurricane-induced storm surges. Sediment samples were collected at four pump stations that could have transported contaminants from urban areas into the marsh. Sediments were also collected from a ditch that ran through portions of the Murphy Oil property and the outfall of a wastewater treatment plant (WWTP) to investigate these two potential contaminant sources. Sediment samples were also collected at various distances from these pumps in Violet Marsh to determine the range of transport of these contaminants into the marsh. Herein we present data regarding the effects of pumped floodwaters on sediment chemistry and benthic invertebrate toxicity near pumping stations that pumped floodwaters into marshes near Chalmette and Violet, Louisiana.

Materials and Methods

Sampling occurred on 14-15 February 2006. Sediment samples were collected using a grab sampler and deployed from the shore or boat. Sediments were thoroughly homogenized and aliquots of the homogenized sediments were partitioned for chemical analyses. Whole sediment acute (10-day) toxicity tests were conducted using the estuarine amphipod, *Leptocheirus plumulosus*. Samples were analyzed for volatile and semivolatile organic compounds, polychlorinated biphenyls (PCBs, as Aroclors), metals (including mercury), pesticides, diesel range organics (DRO), oil range organics (ORO) and total organic carbon (TOC) analyses using USEPA methods, as appropriate.

Results and Discussion

A comparison of sediment chemistry data from this study was made with two other studies that focused on sediment concentrations within the city of New Orleans and surrounding suburbs. The comparison showed that the relative concentrations for four representative chemicals (arsenic, benzo[a]pyrene, DDD [a breakdown product of DDT, a banned pesticide], and lead) with the exception of sediments collected near the WWTP, were lower than the concentrations reported within New Orleans by these other two studies. This suggests that sediments and the associated contaminants present within the levees may not have been pumped into the marsh. Furthermore, there do not appear to be any differences in chemical concentrations in sediments at functioning pump stations #4 and #6 versus inoperable pump stations #2 and #3.

A comparison of the bioassay and chemical analysis results suggest a relationship between the concentrations of several chemicals in the sediment (e.g., Cd, Cu, Pb, Zn, Ag, polycyclic aromatic hydrocarbons, DDD, and dieldrin) and significant mortality of *L. plumulosus* for several sampling stations. Canal stations having a larger percentage of sand and gravel generally had lower chemical concentrations and produced less mortality to *L. plumulosus.*

Spatially, there were trends that suggested that sediments close to the WWTP and pump stations had elevated chemical concentrations and significant mortality to *L. plumulosus*. Generally, sediments further from the levees into Violet Marsh had relatively lower levels of contaminants and resulted in less *L. plumulosus* mortality. Some inconsistencies between sediment chemistry and bioassay results were observed for sample locations BB-3 and BB-4, where significant mortality was observed in the bioassay but very few chemicals exceeded sediment screening values. These observed toxicities may be due to chemicals that were not measured or sensitivity to confounding factors other than chemical contamination (e.g., salinity, sediment grain size, predation).

There were no observable trends in sediment chemistry and toxicity results that suggest pump stations that were functioning following the flood event resulted in transport and deposition of contaminated sediments as compared to inoperable pump stations.

Uncertainty

There are several areas of uncertainty regarding the conclusions that can be drawn from the data collected in this study and what can be concluded regarding the ecological impacts of the dewatering of New Orleans following hurricane Katrina. Firstly, the sediment chemistry and bioassay results are limited due to the scope of the study, limited number of samples, and current tools available to assess toxicity and risk to ecological receptors. These results provide information regarding a single sampling event, with limited spatial coverage, and biological effects using a single test organism. The study was limited to a single wetland (Violet Marsh) so it is difficult to predict that similar impacts would be expected for other wetlands. There are also other risk pathways (bioaccumulation and biomagnification) that were not assessed as part of this study. Food web analysis should be conducted to determine the potential ecological risks posed by the elevated levels of the pesticides DDD and dieldrin, polycyclic aromatic hydrocarbons, and metals.

Introduction

Hurricane Katrina came ashore along the Alabama, Mississippi, and Louisiana coasts on 29 August 2005, resulting in significant physical damage to infrastructure. As a result of the storm, levees were breached or overtopped, leading to flooding of New Orleans and surrounding areas, including many areas in St. Bernard Parish. Within St. Bernard Parish, floodwaters in Chalmette and Violet, Louisiana were pumped into the adjacent Violet Marsh (Figure 1). There are potential undesirable environmental impacts on the marsh ecosystem resulting from levee breaches and pumping activities. The primary environmental concerns are elevated salinity and chemical and biological contaminants. This section focuses on chemical contamination: salinity and biological contamination issues are discussed elsewhere in this report. To address chemical concerns, we conducted a study after the storm to compare chemistry and toxicity in sediment samples at sites in the immediate vicinity of active and inactive (flooded during Katrina) pumping stations that discharge into Violet Marsh (Figure 1). This baseline investigation builds on a pilot study that was conducted in December 2005, which consisted of sampling sediments for chemical analysis and toxicity testing, benthic invertebrates and recording salinity measurements throughout Violet Marsh. Pilot study benthic invertebrate results are addressed in Ray (2006) and salinity results in Lin and Kleiss (2006), respectively; the baseline investigation of benthic invertebrates is presented elsewhere in this report. The pilot study by Suedel et al. (Attachment 2) describing the collection of sediment samples for chemical and toxicological analysis. This section describes a baseline study to discern patterns in chemical contamination and toxicity of sediments at select pumping stations in Violet Marsh.

Purpose

The Interagency Performance Evaluation Taskforce (IPET) is investigating environmental impacts originating from the failure of the hurricane protection system to perform as designed around New Orleans, Louisiana during Hurricane Katrina. This study is needed to determine the extent to which Katrina floodwaters in the New Orleans area may have had impacts to wildlife habitat and other biological resources in surrounding areas. Herein we present data regarding the effects of pumped floodwaters on sediment chemistry and benthic invertebrate toxicity near pumping stations that pumped floodwaters into marshes near Chalmette and Violet, Louisiana.

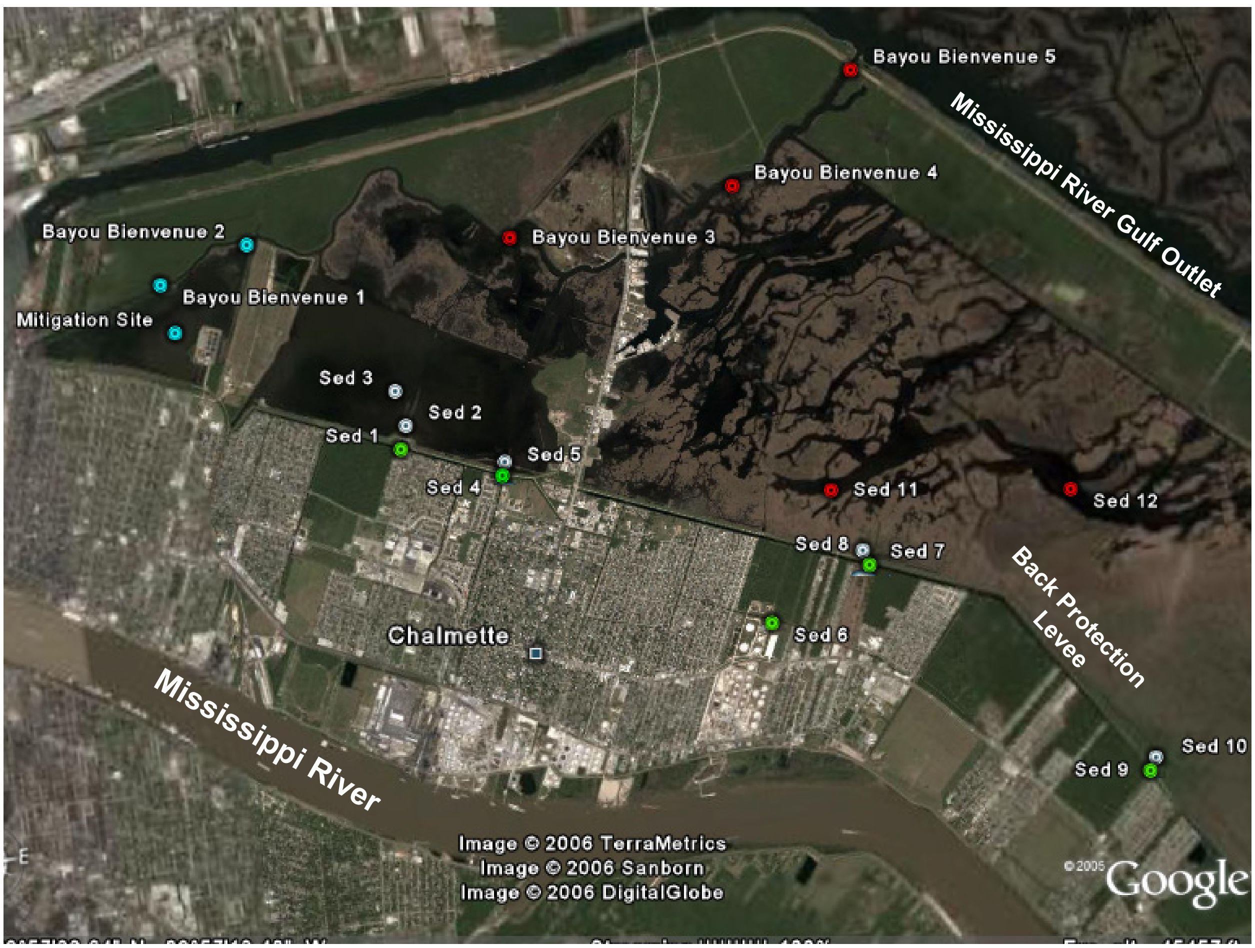

Figure 1. Overview of Violet Marsh and sampling locations.

Background and Rationale

To assess the potential impacts of pumping water and suspended sediment from urban areas to adjacent ecosystems, the Corps of Engineers collected sediment samples from Violet Marsh. Violet Marsh was selected for study because of its 1) proximity to urban areas, 2) receipt of floodwaters pumped from the adjacent city of Chalmette, and 3) potential importance as a buffer from hurricane-induced storm surges.

Violet Marsh covers an area of approximately 81.6 hectares (31.5 sq. miles) between Chalmette, Louisiana and Lake Borgne in St. Bernard Parish, Louisiana (Figure 1). Violet Marsh is bordered to the east by the Mississippi River Gulf Outlet (MRGO), to the north by the Intercoastal Waterway and to the south by the back protection levee. Thus the marsh is connected directly to both the Mississippi River and the MRGO. Bayou Bienvenue winds through the marsh from the west near the municipal waste water treatment plant (WWTP) to the MRGO to the east. The pumps used to remove floodwaters from Chalmette and surrounding suburbs are located along the back protection levee.

To assist in interpretation of the analytical and toxicological data, the 18 sediment sampling locations were divided into four groups depending on their proximity to potential sources of chemical contamination (Table 1). The groups were: (1) Outer Marsh and Bayou, located in the Violet Marsh just south of the MRGO; (2) Canals, located within the canals bordering the back protection levee; (3) Pump Station Outfalls, located in the receiving water basins in the marsh; and (4) Waste Water Treatment Plant (WWTP) Vicinity, located just east of the Mitigation site sampling location. Of the pumps sampled, only Pump Stations Meraux #4 and Jean Lafitte #6 operated in the aftermath of the storm to drain floodwaters from the Chalmette area, pumping over the back protection levee into Violet Marsh. Pump Stations Guichard #2 and Villere #3 were flooded by Katrina and were thus rendered inoperable.

Table 1 List of sediment samples and associated groupings and proximity to potential chemical contamination sources		
Group	**Station**	**Associated Pump Stations/Pump Station Activity**
WWTP Vicinity	Mitigation Site	NA (WWPT)
WWTP Vicinity	BB1	NA (WWTP)
WWTP Vicinity	BB2	NA (WWTP)
Pump Station Outfalls	Sed 2	#6/Active
Pump Station Outfalls	Sed 3	#6/Active
Pump Station Outfalls	Sed 5	#2/Inactive
Pump Station Outfalls	Sed 8	#3/Inactive
Pump Station Outfalls	Sed 10	#4/Active
Canals	Sed 1	#6/Active
Canals	Sed 4	#2/Inactive
Canals	Sed 7	#3/Inactive
Canals	Sed 9	#4/Active
Canals	Sed 6	NA (Murphy Oil refinery)
Outer Marsh and Bayou	BB3	NA
Outer Marsh and Bayou	BB4	NA
Outer Marsh and Bayou	BB5	NA
Outer Marsh and Bayou	Sed 11	#3/Inactive
Outer Marsh and Bayou	Sed 12	#4/Active
Note: WWTP = waste water treatment plant; NA = No association; BB = Bayou Bienvenue.		

Sediment samples were collected both immediately upstream and downstream of these four pump stations that could have transported contaminants from the urban areas and canals over the back protection levee and into Violet Marsh. Sediments were also collected from a ditch that ran through portions of the Murphy Oil property and the outfall of the WWTP to investigate these two potential contaminant sources. Sediment samples were also collected at various distances from these pumps in Violet Marsh to determine the range of transport of these contaminants into the marsh.

Materials and Methods

Sampling Procedures

The sampling event occurred in the New Orleans area, specifically Violet Marsh and Bayou Bienvenue, on 14-15 February 2006. Sediment samples were collected with a standard Ekman grab according to standard guidance (US EPA 2001) attached to a 6 ft aluminum pole deployed from shore or boat. Sediments were thoroughly homogenized to acquire consistent texture and water content. Aliquots of the homogenized sediments were partitioned for chemical analyses. Remaining sediment was archived in plastic bags and kept on wet ice. Several sediments were compromised during shipment to the ERDC Vicksburg, MS, so those samples were not used in this study.

Toxicity Testing

Whole sediment acute (10-day) toxicity tests using the estuarine amphipod, *Leptocheirus plumulosus*, were conducted according to standard guidance (U.S. EPA, 1994). Experimental conditions are outlined in Table 2. Test sediments were stored in the dark at 4 ± 1 °C and used in testing within eight weeks of collection, as recommended (US EPA / ACE, 1998). Sediments were homogenized using a motorized impeller mixer (Lightnin, Rochester, New York) prior to use and approximately 100 mL (1.5 cm depth) of each test sediment was added to each of five replicate test chambers (1-L beakers). Sediment was then overlain with 20 ‰ synthetic seawater (Crystal Sea® Marine Mix; Marine Enterprises International, Inc., Baltimore, MD, U.S.A.) and allowed to equilibrate in test chambers overnight. The test chambers were supplied trickle-flow aeration in a temperature (25.0 ± 1.0 °C) and photoperiod (continuous light) regulated water bath. At test initiation, *L. plumulosus* (500 – 750 µm) were obtained from ERDC in-house cultures and 20 amphipods were gently transferred into each test chamber. Water quality measurements (temperature, dissolved oxygen, pH, salinity, overlying water ammonia) were determined at test initiation and termination. Water quality was measured using a model ABMTC handheld refractometer (Aquafauna Bio-Marine, Hawthorne, California) for salinity, a model 315i meter (WTW; Weilheim, Germany) for pH and a model Oxi 330 meter (WTW; Weilheim, Germany) for D.O. Environmental chamber temperature (min/max) was monitored and recorded daily. Animals were not fed during the test.

The test assessment endpoint was survival. Test sediments were assessed along side a performance control sediment (Sequim, Washington, USA) and a reference sediment (Lake Pontchartrain, Louisiana, USA). For tests to be considered valid, at least 90% survival had to be observed in the performance control and overlying water quality (pH, temperature, dissolved oxygen) within the ranges specified by guidance (U.S. EPA, 1994). In order for test sediment to be considered "toxic," two decision criteria must be met; the survival in the test sediment must be statistically reduced relative to the reference sediment and the reduction must be greater than 20% of the reference survival value (U.S. EPA / U.S. ACE, 1998).

Chemical Analyses

Samples were prepared and analyzed for volatile and semivolatile organic compounds, polychlorinated biphenyls (PCBs, as Aroclors), metals (including mercury) using USEPA methods found in SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical* Methods (1986) and updates. Samples were analyzed for volatile organic compounds (VOCs) using method 8260B (gas chromatography/mass spectrometry (GC/MS)) and for semi-volatile organic compounds (SVOCs) using method 8270C (GC/MS). Metals were analyzed using method 6020B (Inductively Coupled Plasma (ICP) -Atomic Absorption (AA) Spectrometry) and mercury was analyzed using Method 7471A (Cold-Vapor AA). Pesticides and PCBs were analyzed using Method 8081A (GC) and 8082 (GC), respectively. Samples analyzed for diesel range organics (DRO) and oil range organics (ORO) following method 8015 (GC/flame ionization detector (FID)). Total organic carbon (TOC) analyses were quantified using the Lloyd Kahn method.

Statistical Analyses

Data normality (Kolmogorov-Smirnov test), homogeneity (Levene's Test) and treatment differences ($\alpha = 0.05$) compared to the reference sediment were determined at using SigmaStat statistical software (SPSS, Chicago, IL). Survival data were arcsine-square root transformed and a one-way ANOVA (Dunnett's post-hoc comparison) was used to determine if statistical differences existed between individual test sediments and the reference sediment.

Table 2
Conditions for conducting 10-day sediment toxicity tests with the estuarine amphipod, *Leptocheirus plumulosus*

Test type	Static non-renewal
Test duration	10 days
Temperature	25.0 ± 1.0°C
Salinity	20 ± 2 ppt
pH	7.8 ± 0.5
Light quality	Ambient Laboratory
Light intensity	500 – 1000 lux
Photoperiod	24:0 hr (light:dark)
Test chamber size	1 liter
Sediment volume (depth)	100 mL (1.5 cm)
Overlying water volume	Fill to 950 mL
Sediment settling time	Overnight
Water renewal	None
Age of test organisms	Neonates (500 – 750 µm)
Organisms/chamber	20
Replicates/treatment	5
Organisms/treatment	100
Feeding regime	None
Test chamber cleaning	None
Test solution aeration	> 40% O_2 saturation
Dilution water	20 ppt
Dilution series	None
Endpoint(s)	Survival

Results and Discussion

Chemical Analyses

To evaluate potential adverse effects on benthic organisms residing in Violet Marsh sediments, a comparison of sediment concentrations to numerical sediment quality guidelines (SQGs) was performed (see figures in Attachment 1). The SQGs used were the threshold effect levels (TELs) and probable effects levels (PELs) which are the most recently published SQGs for marine and estuarine sediments (MacDonald et al. 1996; Buchman 1999). The TELs are intended to identify chemical concentrations below which harmful effects on sediment-dwelling organisms only rarely occur. The PELs are intended to identify chemical concentrations above which adverse effects frequently occur. Values for TELs and PELs have been developed for 9 metals, 13 PAHs, total PCBs, and 7 pesticides (MacDonald et al. 1996).

An exceedance of a TEL or PEL is not indicative of adverse effects; rather, it signifies that further evaluation of sediments may be necessary. Sediment quality guidelines can be used as a simple first screen of potential hazards to benthos using the chemical analysis of sediments. SQG values can be used to:

- Identify the needs for additional benthic evaluations Determine that a sediment is not likely to cause effects to benthosFocus the scope of additional study (e.g., reduce number of contaminants of concern or pathways to be considered in baseline assessment)
- SQG values may be used in a weight-of-evidence approach with other data (benthic toxicity, biological indices, tissue residues, effects data)

Sediment quality guidelines have several limitations in their use (USACE 1998). The SQG values do not provide estimates of risk. There are many reasons they do not adequately consider risk including:

- Some pathways not considered (bioaccumulation and trophic transfer)
- SQG values do not address more than one chemical or their interactions
- Screening with SQG does not address or quantify exposure
- SQG values are not site specific
- Biological availability is not taken into account

Furthermore, it has been demonstrated the rate of false positives and false negatives in the application of SQG values are high. A study by O'Connor et al. (1998) reported that of 239 samples that exceeded at least one SGQ, the effects range median (ERM), only 38% were toxic to amphipods. In an additional study by Long et al. (1998), the probability of toxicity below the effects range low (ERL) was as high as 10%. Because of these limitations, SQG values should not be used as a remediation goal, to predict biological effects, or to estimate human or ecological risk. The U.S. EPA Superfund Office has the same technical position with regard to the use of SQG values for remediation goals.

Following hurricane Katrina, three studies described chemical concentrations in environmental media around the New Orleans area. Most of these data focused on the concentration of chemicals in the flood waters or sediment associated with settling of suspended material in the flood water. The U.S. Environmental Protection Agency has compiled a significant amount of information regarding the concentration of chemicals in floodwater and sediments in the city (U.S. EPA, 2005). Another study by Pardue et al. (2005) reported concentrations of chemicals in flood water samples collected within the levee walls. The last study by Presley et al. (2006) summarized an assessment of chemical and pathogen concentrations in sediment samples from within the levee walls. To date, there are no studies that have reported concentrations of chemicals in sediments in the wetlands that received the pumped floodwaters. A summary comparing sediment chemistry data from the current study to the U.S. EPA (2006) and Presley et al (2006) study is shown in Table 3. While the other two studies focus on sediment concentrations within the city, the comparison illustrates the relative concentrations for four chemicals; arsenic, benzo[a]pyrene, DDD (dichlorodiphenyldichloroethane), and lead. With the exception of the sediments collected near the outfall of the East Bank Wastewater Treatment Plant (WWTP), concentrations of the four representative chemicals were lower than the concentrations reported within New Orleans by these other two studies. This suggests that sediments and the associated contaminants present within levees may not have been transported by the pumped water to the wetlands. Furthermore, there do not appear to be any differences in chemical levels in sediments at functioning pump stations 4 and 6 that pumped water following the flood event (Sed-1,2,9,10) versus pump stations 2 and 3 that were non-functioning and did not pump water following the flood event (Sed-4,5,7,8). The section on analytical chemistry (IPET Report) goes into additional detail evaluating the other published results, however, analytical chemistry results should be used as an additional line of evidence to understand the impact of pumping on the wetlands.

Table 3
Summary of chemical analysis of sediments following hurricane Katrina. The table summarizes results from the current IPET study, Presley et al., 2005, and U.S. Environmental Protection Agency, 2005

	IPET Study, Suedel et al. 2006 [2]				Presley et al. 2005[1]	U.S. EPA. 2005		
Analyte	Outer Marsh Bayou	Canals	Pump Station Outfalls	WWTP Vacinity	East of Industrial Canal	New Orleans West of Industrial Canal	New Orleans East, N of MRGO	New Orleans South of MRGO
Arsenic (mg/kg)	4.2	6.3	8.7	7.6	24.2	8.65	9.97	4.66
	(4.2-11.1)	(3.6-8.8)	(3.9-10.9)	(6.7-8.4)	(5.7-24.2)	(0.3-78)	(0.82-45.5)	(0.54-29.5)
Benzo[a]pyrene (µg/kg)	ND	35	79	260	810	1745	1762	845
	(<0.59)	(<7.5-46)	(<6.5-200)	(93-670)	(0.00-1260)	(59-31,350)	(103-37,600)	(33-50,100)
DDD (µg/kg)[3]	0.261	5.4	27	52 [4]	NA	110	114	21
	(<0.1-4.4)	(<1.1-5.7)	(<0.2-61)	(<2.2-52)		(10-785)	(20-3,015)	(<2-540)
Lead (mg/kg)	14.6	54.3	84.7	202	642	87.5	43.7	25.4
	(12.1-29.2)	(15.4-83.9)	(32.2-129)	(105-285)	(341.5-642.0)	(1.17-1,160)	(9.21-295)	(14.4-689)
Sample number	5	5	5	3	3 metals, 5 organics	149-153	80-84	209

[1] Presley et al., 2005 reports geometric mean values of 2 measures per site. Reported value is geometric mean at Industrial canal. Range of values is from values reported in the study.
[2] Non-detects in IPET study and synthesis of U.S. EPA data were handled by taking ½ reporting limit.
[3] The DDD values were calculated by taking the geometric mean of detected values.
[4] Single detected value.

Sediment Bioassay

Bioassay results satisfied test acceptability criteria according to the performance control (survival >90%) and water quality parameters (Tables 2 and 4). Several of the sediments collected in Violet Marsh and Bayou Bienvenue caused reduced survival in the 10 d toxicity test (p=0.003), but when compared to the Lake Pontchartrain reference sediment (Control LP), none demonstrated a statistically significant reduction in survival based on Dunnett's Method (Table 5). However, the laboratory control sediment (Control SC) survival was much higher (97.4%) and when used a reference in this test, several of the sites (Sed 2, Sed 8, IHNC-MS, BB3, BB4) had statistically significant reductions in growth ($p<0.001$). Among the sediments that were statistically reduced relative to the control, PEL values were exceeded for Sed 2 (Zn, DDD), Sed 8 (Pb), IHNC – MS (Pb, Hg, Ag, DDD, dieldrin) and BB1 (Pb, Hg, Zn, Acenapthalene, Benzo[a]anthracene, fluroanthene, phenanthrene, DDD, and dieldrin). Sediments BB3 and BB4 did not have analytes that exceeded PEL values and were not particularly high in petroleum hydrocarbons. No sediments that were statistically similar to the control had analytes that exceeded PEL values.

Table 4
Mean physical parameters (ranges in parentheses) measured on Days 0 and 10 of the 10-day sediment toxicity test with the estuarine amphipod, *Leptocheirus plumulosus*.

Sample ID	Temperature (° C)	Salinity (‰)	pH (SU)	D.O. (mg/L)
Control (SC)	24.3 ± 1.9 (24.1 – 24.5)	22 ± 2 (20 – 25)	7.9 ± 0.1 (7.7 – 8.1)	7.3 ± 0.7 (6.3 – 8.0)
Reference (LP)	24.4 ± 0.0 (24.0 – 24.5)	20 ± 0 (20 – 20)	7.7 ± 0.2 (7.5 – 7.9)	7.7 ± 0.4 (7.0 – 8.0)
Sed 2	24.2 ± 2.2 (22.8 – 24.5)	21 ± 2 (20 – 27)	8.0 ± 0.1 (7.8 – 8.1)	7.9 ± 0.3 (7.5 – 8.2)
Sed 3	24.2 ± 1.6 (23.1 – 24.5)	21 ± 2 (20 – 25)	7.9 ± 0.2 (7.5 – 8.1)	7.8 ± 0.3 (7.1 – 8.2)
Sed 8	24.1 ± 1.4 (23.1 – 24.5)	21 ± 1 (20 – 24)	7.9 ± 0.1 (7.6 – 8.1)	7.9 ± 0.2 (7.5 – 8.2)
Sed 7	24.3 ± 1.0 (23.9 – 24.5)	21 ± 1 (20 – 23)	7.9 ± 0.2 (7.5 – 8.1)	7.9 ± 0.3 (7.5 – 8.1)
IHNC MS	24.3 ± 0.7 (24.0 – 24.5)	21 ± 1 (20 – 22)	8.0 ± 0.1 (7.9 – 8.1)	8.0 ± 0.2 (7.8 – 8.2)
BB 1	24.2 ± 1.3 (23.4 – 24.5)	21 ± 1 (20 – 24)	7.8 ± 0.3 (7.1 – 8.1)	7.8 ± 0.2 (7.4 – 8.0)
BB2	24.1 ± 1.8 (23.2 – 24.5)	22 ± 2 (21 – 25)	8.0 ± 0.1 (7.9 – 8.2)	7.4 ± 1.3 (3.8 – 8.2)
BB3	24.1 ± 1.5 (23.1 – 24.5)	24 ± 2 (21 – 25)	8.0 ± 0.1 (7.7 – 8.1)	7.8 ± 0.4 (6.7 – 8.3)
BB4	24.1 ± 1.3 (23.7 – 24.5)	22 ± 1 (21 – 24)	7.9 ± 0.1 (7.7 – 8.1)	7.9 ± 0.3 (7.5 – 8.2)

Table 5
Percent survival reported upon termination of the 10-day sediment toxicity test with the estuarine amphipod, *Leptocheirus plumulosus*

Sample ID	Percent Survival	Min / Max
Control (SC)	97 ± 7	85 – 100
Reference (LP)	81 ± 9	70 – 90
Sed 2	58 ± 37*	0 – 95
Sed 3	78 ± 10	65 – 90
Sed 7	89 ± 11	75 – 100
Sed 8	64 ± 17*	35 – 80
IHNC MS	52 ± 18*	30 – 75
BB 1	48 ± 13*	30 – 65
BB2	88 ± 12	75 – 100
BB3	57 ± 27*	15 – 85
BB4	53 ± 16*	35 – 70

* indicates treatment survival is statistically different ($p<0.05$) from SC sediment survival when analyzed using one way ANOVA and Dunnett's post-hoc test.

Comparison of the bioassay and chemical analysis results suggest a relationship between the levels of several chemicals in the sediment (PEL exceedances for Cd, Cu, Pb, Zn, Ag, polycyclic aromatic hydrocarbons, DDD, and dieldrin) and significant mortality of *L. plumulosus* (BB-1, 3, 4, Sed-2, 8). The use of sediment quality guideline values can be used to gain a better understanding of the toxicity observed in the bioassay. However, there are several other factors that must be considered when interpreting these results as outlined above (e.g., salinity, total organic carbon). Sediment grain size information (see Attachment 1) can also be used to better understand the chemistry results and bioassay data. Canal sites having a larger percentage of sand and gravel (Sed-4, 7, 9) generally had lower levels of chemicals and did not result in significant toxicity to *L. plumulosus.*

Spatially, there are trends that suggest that sediments close to the East Bank WWTP, and Pump Stations had elevated levels of chemicals and significant mortality to *L. plumulosus*. Generally, sediments further from the levees into the Violet Marsh had relatively lower levels of contaminants and less toxicity observed with *L. plumulosus*. Some inconsistencies between sediment chemistry and bioassay results were observed for sample locations BB-3 and BB-4, where significant mortality was observed in the bioassay but very few chemicals exceeded sediment screening values. The observed mortality may be due to chemicals that were not measured or sensitivity to confounding factors other than chemical contamination (e.g., salinity, sediment grain size, predation).

There were no observable trends in sediment chemistry results that suggest pump stations that were functioning following the flood event resulted in flow and deposition of contaminated sediments as compared to non functioning pump stations. This conclusion is further reinforced by the bioassay results for sites Sed 2 and 8 where toxicity was observed for a functioning pump station and non-functioning pump station, respectively.

Uncertainty of Study Results

Uncertainty is related to either the natural variability of a measurement or from unknown information that cannot be derived from the study. There are several areas of uncertainty regarding the conclusions that can be drawn from the data collected in this study and what can be concluded regarding the ecological impacts of the dewatering of New Orleans following hurricane Katrina. Firstly, the current study summarizes an assessment of sediment chemistry and bioassay results. These data are limited due to the scope of the study, limited number of samples, and current tools available to assess toxicity and risk to ecological receptors. For example, only nine (9) sediments from the Violet Marsh were assessed using the amphipod bioassay to determine the potential ecological impacts due to dewatering of the city. These results provide information regarding a single sampling event, with limited spatial coverage, and biological effects using a single test organism. The study was limited to a single wetland (Violet Marsh) so it is difficult to predict that similar impacts would be expected for other wetlands. While these data were used with chemical analysis data and benthic survey, care should be taken regarding the confidence by which conclusions can be drawn. There are also other risk pathways that were not assessed as part of this study. For example, bioaccumulation and biomagnification of contaminants were not assessed as part of this study. Food web analysis should be conducted to determine the potential ecological risks posed by the elevated levels of the pesticides DDD and dieldrin, polycyclic aromatic hydrocarbons, and metals.

Conclusions

1. Spatial trends were observed for concentrations of chemicals in sediment. The highest to lowest concentrations were reported in sediments within the city of New Orleans, wetlands receiving outfalls from pumps or WWTP, and wetland areas distant from pump stations.

2. Visible trends in sediment chemical concentrations were observed among sample location groups (e.g., outfall locations, WWTP, canals, wetlands); however, these trends were not always consistent with the bioassay results.

3. Pumping during the flood dewatering process did not result in chemical concentrations in marsh sediments greater than what would have occurred under normal (i.e., non-flood impacted) conditions.

4. There are several significant areas of uncertainty in the study. These results may not be representative of other wetland areas impacted by dewatering and ecological effects resulting from food web biomagnification of chemicals, especially pesticides and metals, was not assessed.

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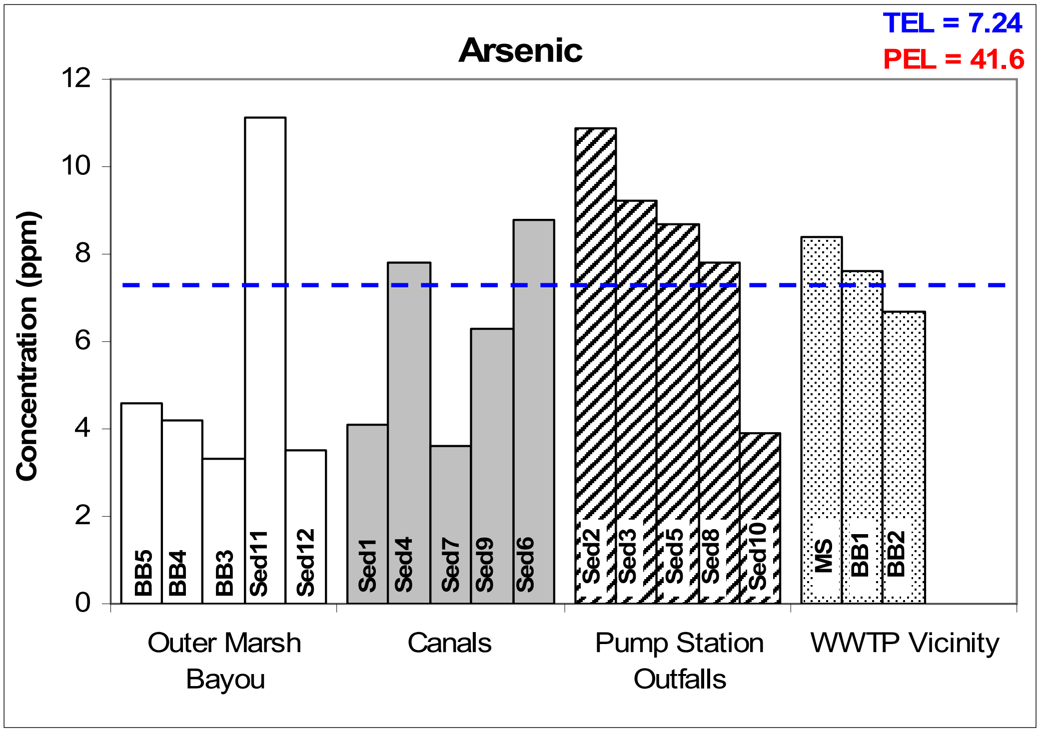
Attachment 1
Tables and Figures Summarizing Sediment Chemistry Data

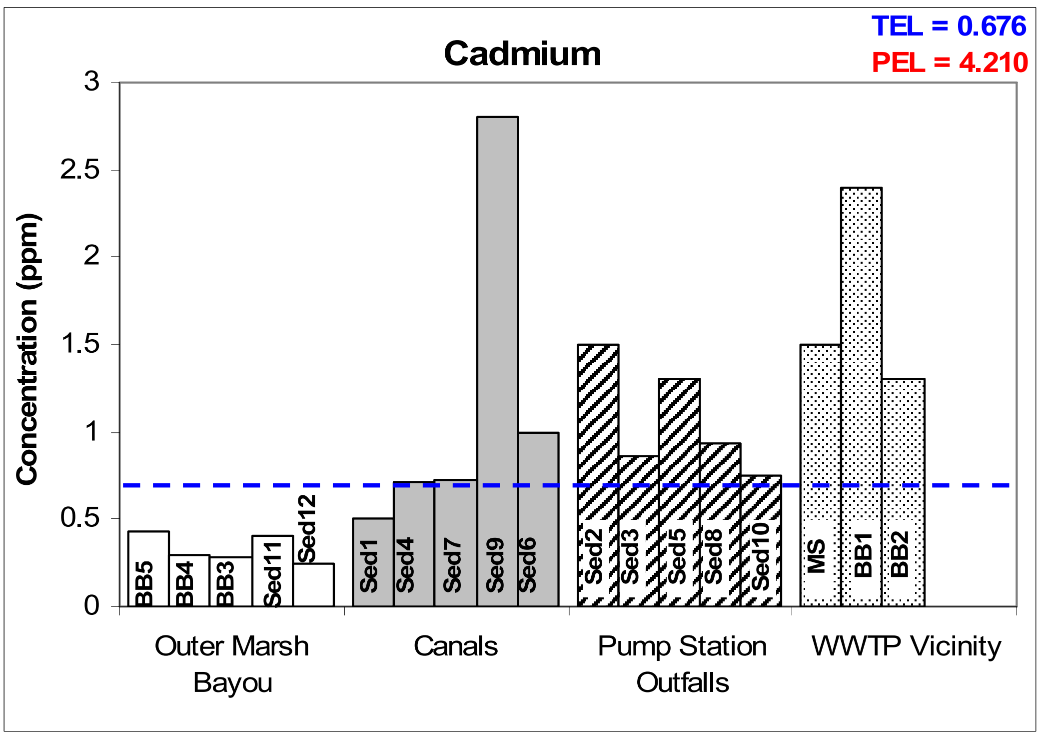
Table A-1
List of analytes not detected in any samples

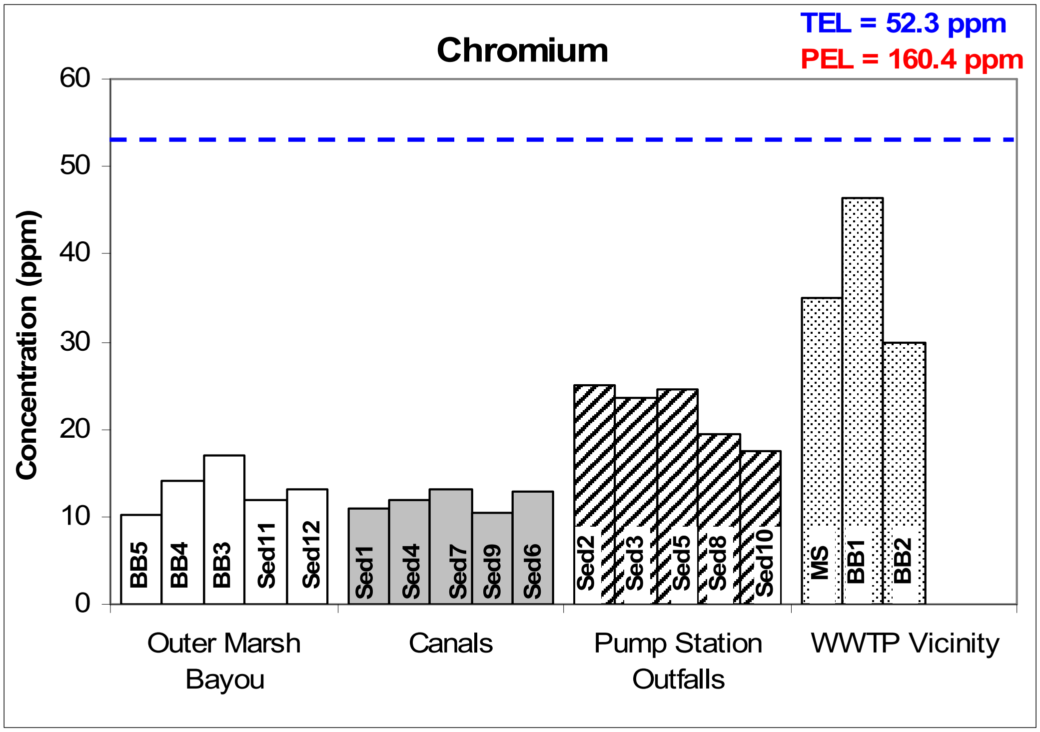
Petroleum Hydrocarbons	**Gasoline**		
Volatile Organics	1,1,1-Trichloroethane	2-Hexanone	Dibromochloromethane
	1,1,2,2-Tetrachloroethane	4-Methyl-2-pentanone	Dichlorodifluoromethane
	1,1,2-Trichloro-1,2,2-trifluoroethane	Benzene	Isopropylbenzene
	1,1,2-Trichloroethane	Bromodichloromethane	Methyl acetate
	1,1-Dichloroethane	Bromoform	Methyl tert-butyl ether
	1,1-Dichloroethene	Bromomethane	Methylcyclohexane
	1,2,4-Trichlorobenzene	Caprolactam	Methylene chloride
	1,2-Dibromo-3-chloropropane	Carbon tetrachloride	Styrene
	1,2-Dibromoethane	Chlorobenzene	Tetrachloroethene
	1,2-Dichlorobenzene	Chloroethane	trans-1,2-Dichloroethene
	1,2-Dichlorobenzene	Chloroform	trans-1,3-Dichloropropene
	1,2-Dichloroethane	Chloromethane	Trichloroethene
	1,2-Dichloropropane	cis-1,2-Dichloroethene	Trichlorofluoromethane
	1,3-Dichlorobenzene	cis-1,3-Dichloropropene	Vinyl chloride
	2-Butanone	Cyclohexane	
Semivolatile Organics (BNA)	1,1'-Biphenyl	3,3'-Dichlorobenzidine	Dimethyl phthalate
	1,4-Dichlorobenzene	3-Nitroaniline	Di-n-butyl phthalate
	2,2'-oxybis(1-Chloropropane)	4,6-Dinitro-2-methylphenol	Hexachlorobenzene
	2,4,6-Trichlorophenol	4-Bromophenyl phenyl ether	Hexachlorobutadiene
	2,4-Dichlorophenol	4-Chloro-3-methylphenol	Hexachlorocyclopentadiene
	2,4-Dimethylphenol	4-Chloroaniline	Hexachloroethane
	2,4-Dinitrophenol	4-Chlorophenyl phenyl ether	Isophorone
	2,4-Dinitrotoluene	4-Nitroaniline	Nitrobenzene
	2,6-Dinitrotoluene	4-Nitrophenol	N-Nitrosodi-n-propylamine
	2-Chloronaphthalene	Acetophenone	N-Nitrosodiphenylamine
	2-Chlorophenol	Benzaldehyde	Pentachlorophenol
	2-Nitroaniline	bis(2-Chloroethoxy)methane	Phenol
	2-Nitrophenol	bis(2-Chloroethyl) ether	
Pesticides	4,4'-DDE	Atrazine	gamma-BHC (Lindane)
	4,4'-DDT	beta-BHC	Heptachlor
	Aldrin	delta-BHC	Heptachlor epoxide
	alpha-BHC	Endosulfan I	Methoxychlor
	alpha-Chlordane	Endosulfan sulfate	Toxaphene
PCBs	Aroclor 1221	Aroclor 1242	
	Aroclor 1232	Aroclor 1248	

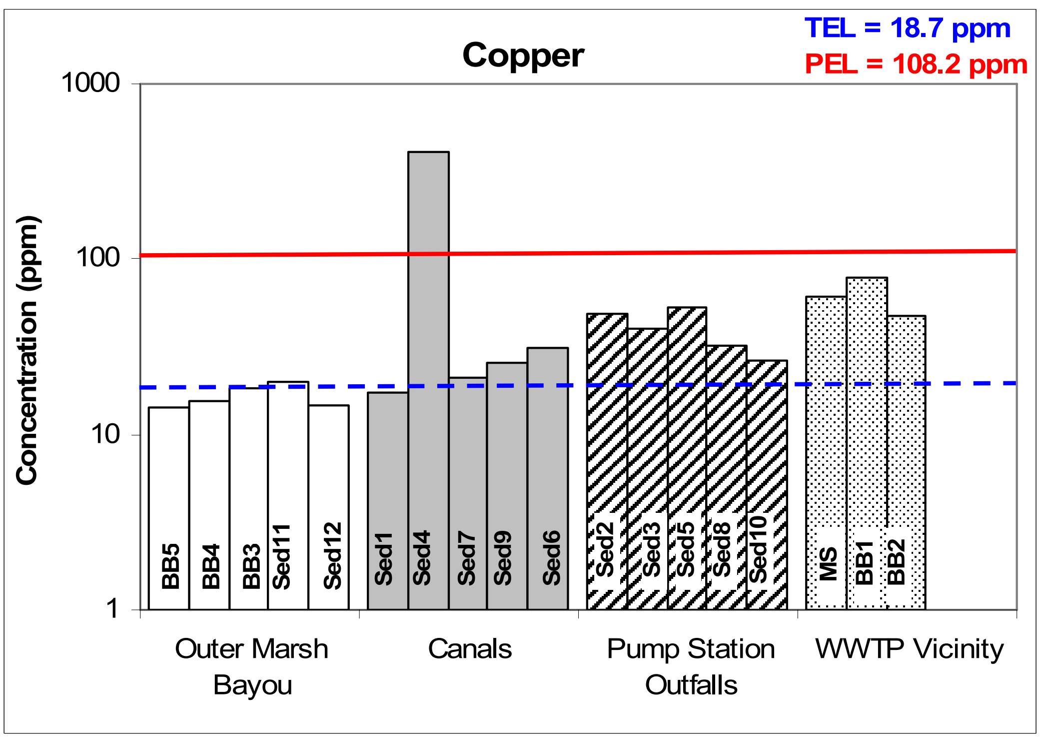
Table A-2 List of analytes detected in at least one sample		
Petroleum Hydrocarbons	**Motor Oil**	**Diesel Fuel**
Volatile Organics	Acetone	Toluene
Semivolatile Organics (BNA)	2-Methylnaphthalene	Carbazole
	2-Methylphenol	Carbon disulfide
	4-Methylphenol	Chrysene
	Acenaphthene	Dibenz(a,h)anthracene
	Acenaphthylene	Dibenzofuran
	Anthracene	Diethyl phthalate
	Benzo(a)anthracene	Di-n-octyl phthalate
	Benzo(a)pyrene	Fluoranthene
	Benzo(b)fluoranthene	Fluorene
	Benzo(ghi)perylene	Indeno(1,2,3-cd)pyrene
	Benzo(k)fluoranthene	Naphthalene
	bis(2-Ethylhexyl) phthalate	Phenanthrene
	Butyl benzyl phthalate	Pyrene
Pesticides	4,4'-DDD	Endrin aldehyde
	Dieldrin	Endrin ketone
	Endosulfan II	gamma-Chlordane
	Endrin	
PCBs	Aroclor 1016	Aroclor 1260
	Aroclor 1254	
Metals	Aluminum	Lead
	Arsenic	Magnesium
	Barium	Manganese
	Antimony	Mercury
	Beryllium	Nickel
	Cadmium	Potassium
	Calcium	Selenium
	Chromium	Silver
	Cobalt	Sodium
	Copper	Thallium
	Iron	

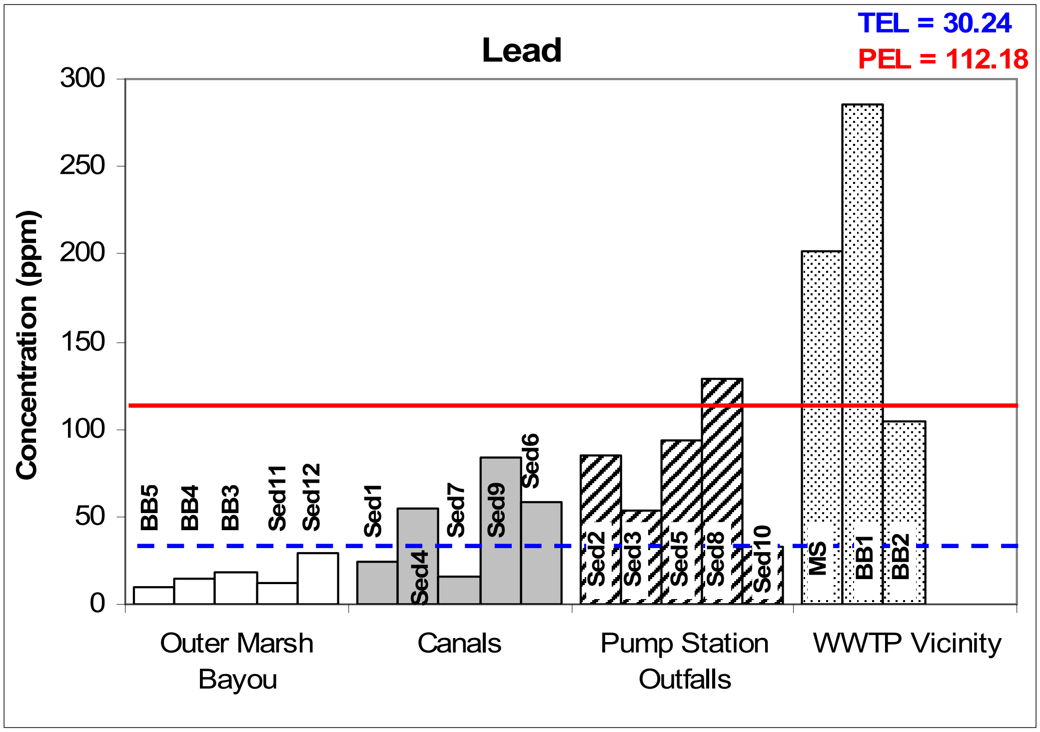
Note: Sediment quality benchmarks for individual chemicals are expressed in the following figures as threshold effects levels (TEL; dashed blue line) and probable effects levels (PEL; solid red line). Bars representing non-detected values have dashed borders and are marked with an asterisk.

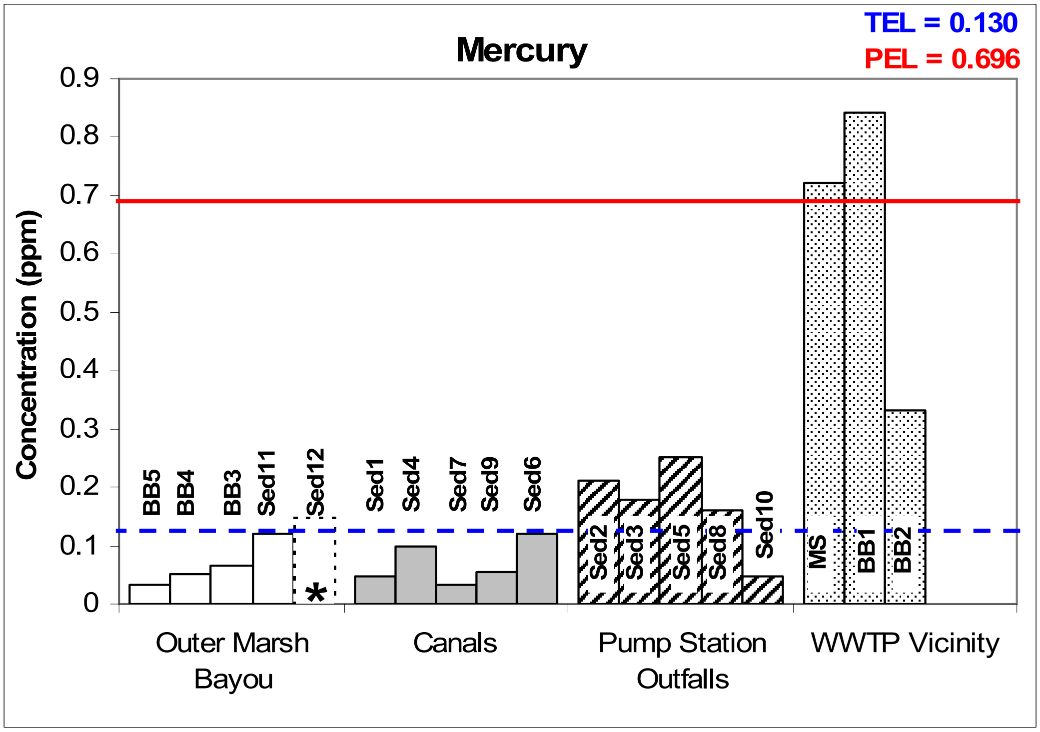

Arsenic
TEL = 7.24
PEL = 41.6
Concentration (ppm)
0
2
4
6
8
10
12
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

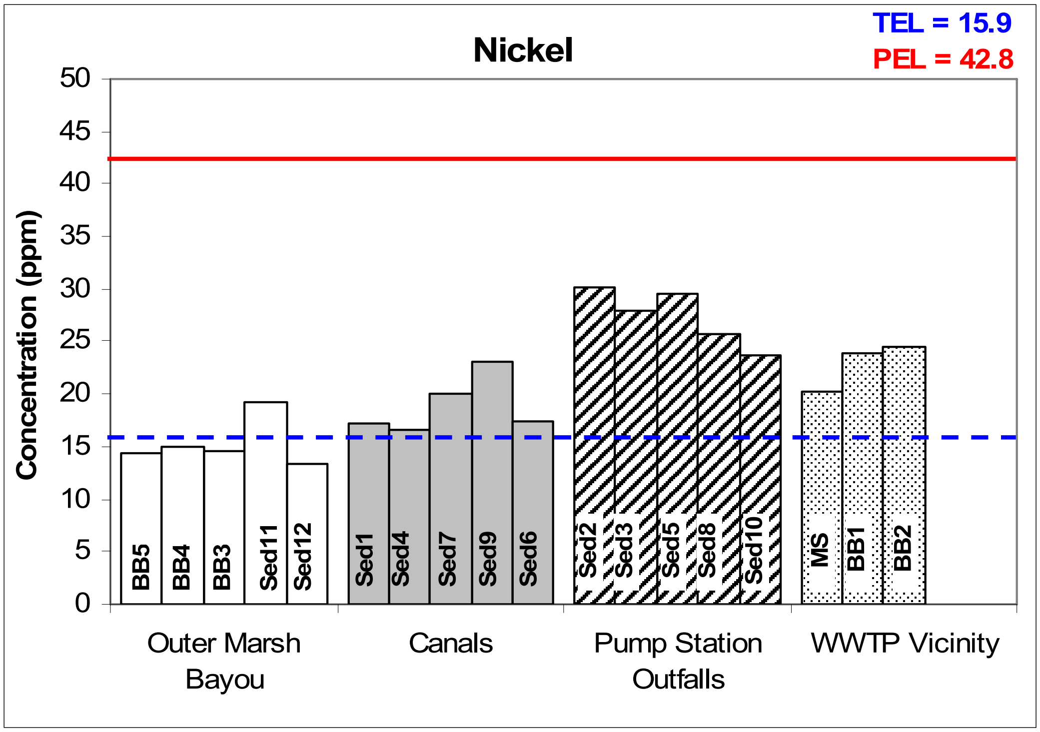

Cadmium
TEL = 0.676
PEL = 4.210
Concentration (ppm)
0
0.5
1
1.5
2
2.5
3
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

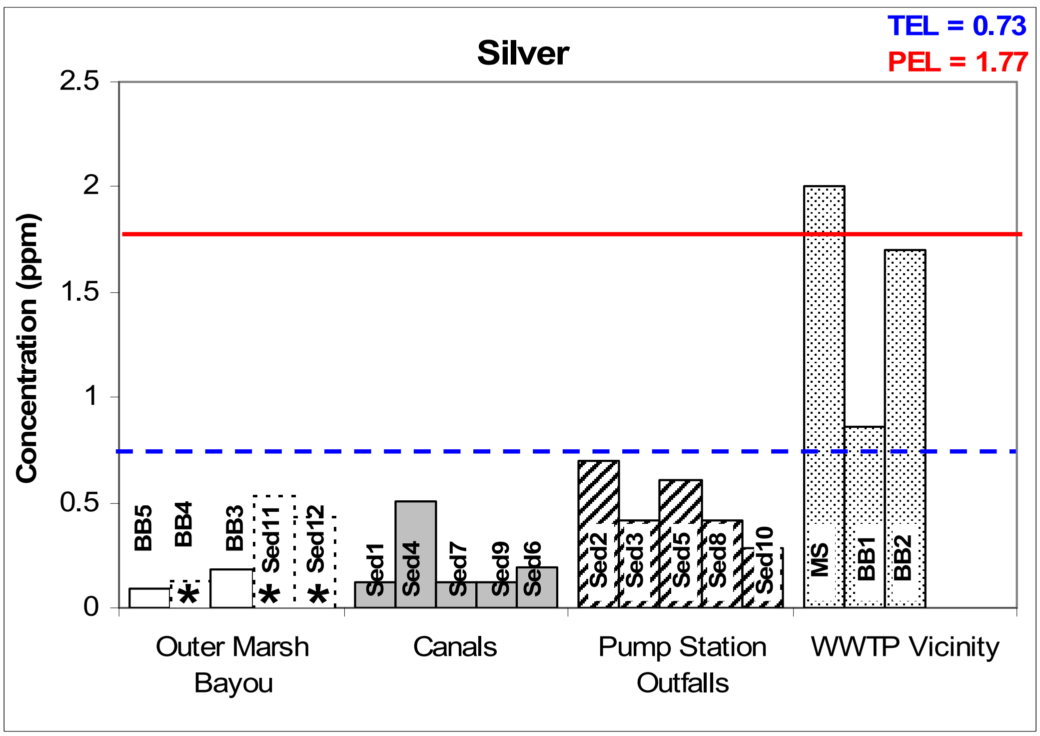

TEL = 52.3 ppm
PEL = 160.4 ppm
Chromium
Concentration (ppm)
60
50
40
30
20
10
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

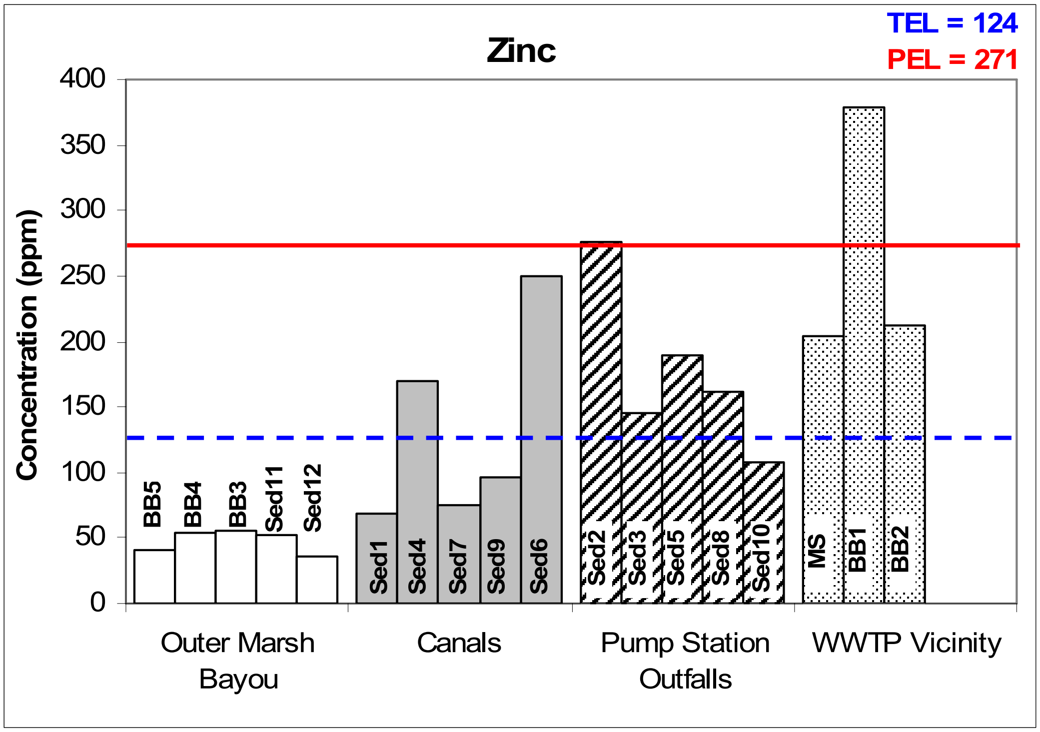

TEL = 18.7 ppm
PEL = 108.2 ppm
Copper
Concentration (ppm)
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

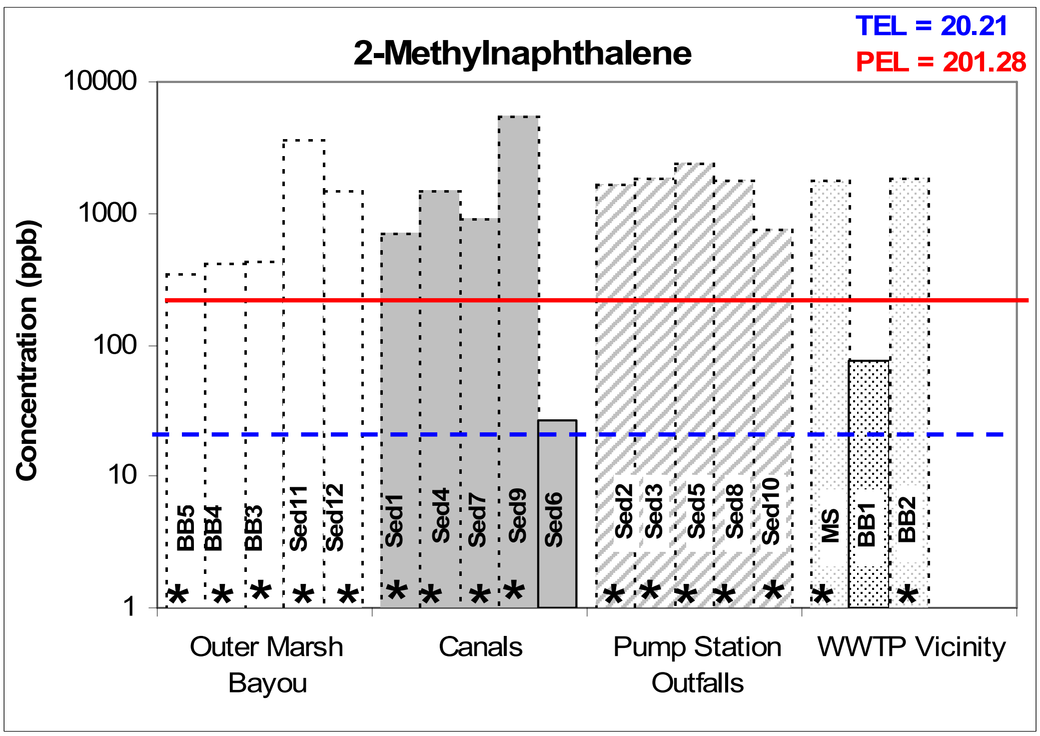

TEL = 30.24
PEL = 112.18
Lead
Concentration (ppm)
300
250
200
150
100
50
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

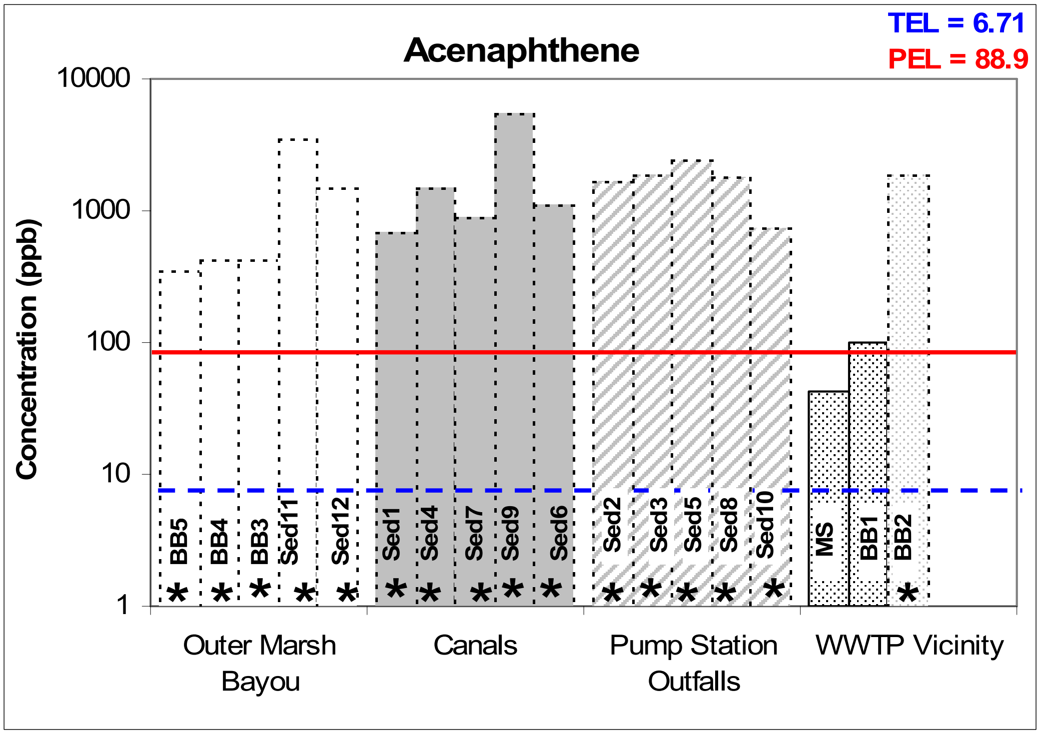

TEL = 0.130
PEL = 0.696
Mercury
Concentration (ppm)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
BB5
BB4
BB3
Sed11
Sed12
*
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

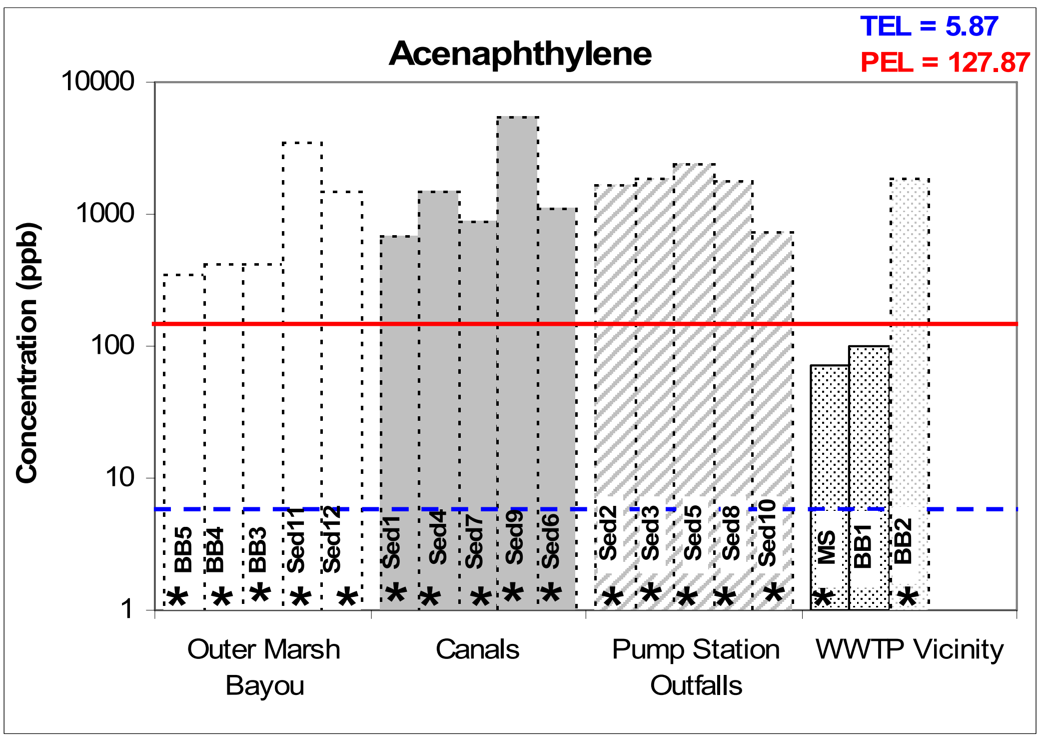

Nickel
TEL = 15.9
PEL = 42.8
Concentration (ppm)
50
45
40
35
30
25
20
15
10
5
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

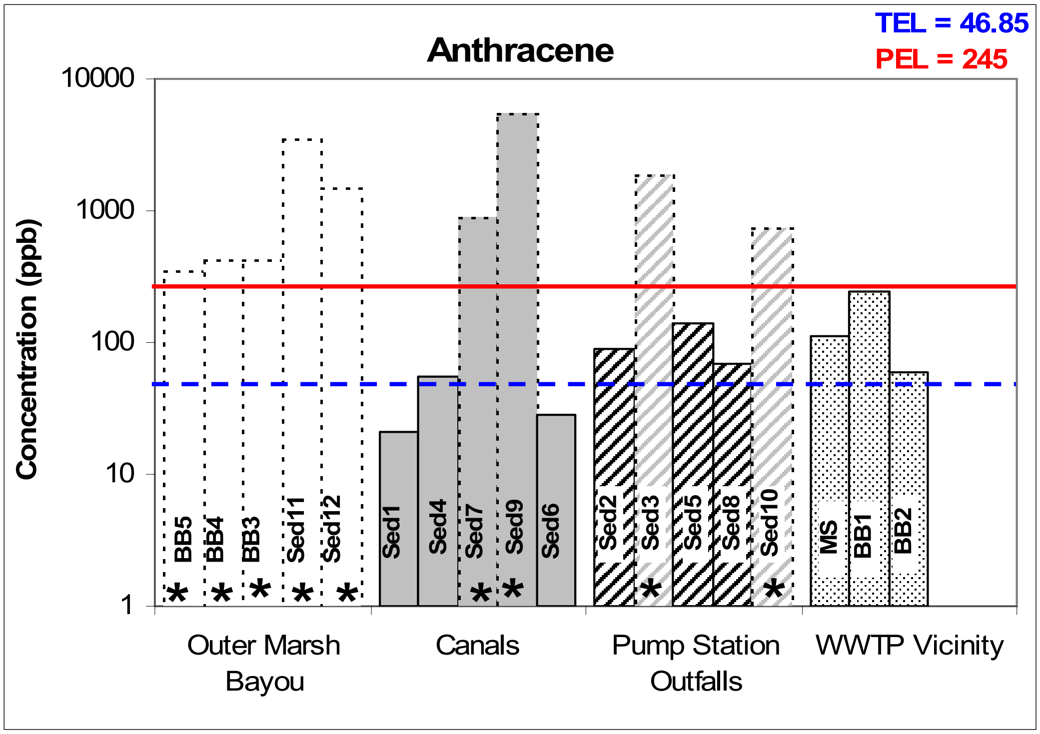

Silver
TEL = 0.73
PEL = 1.77
Concentration (ppm)
2.5
2
1.5
1
0.5
0
BB5
BB4
BB3
Sed11
Sed12
*
*
*
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

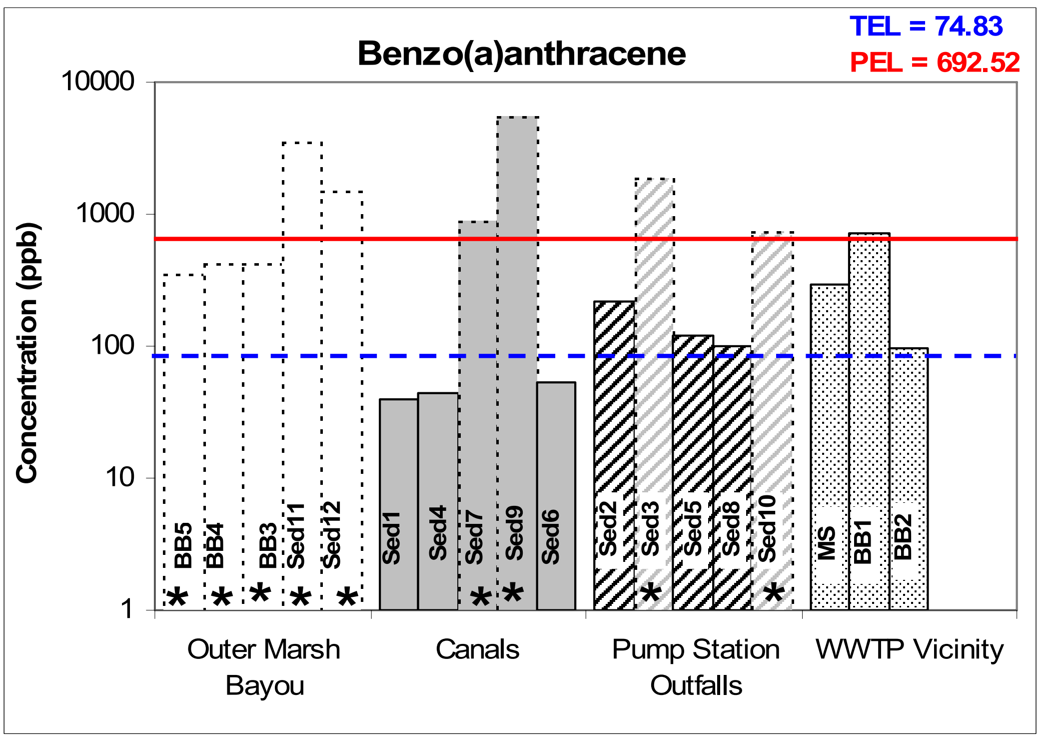

TEL = 124
PEL = 271
Zinc
Concentration (ppm)
400
350
300
250
200
150
100
50
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

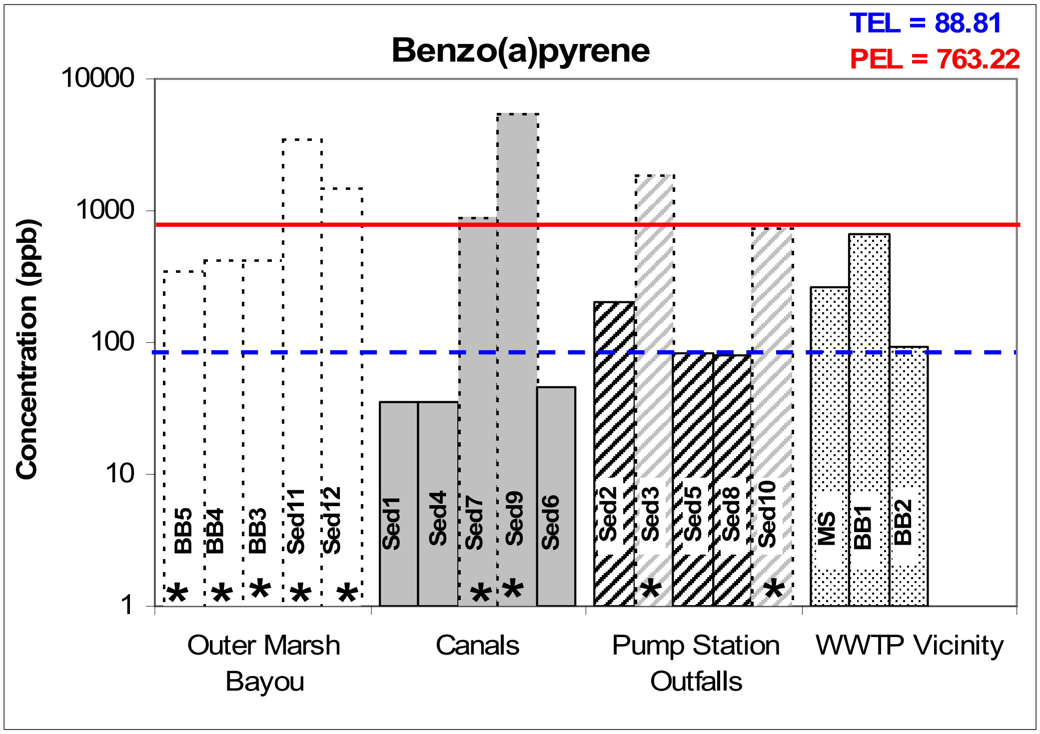

TEL = 20.21
PEL = 201.28
2-Methylnaphthalene
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Acenaphthene
TEL = 6.71
PEL = 88.9
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

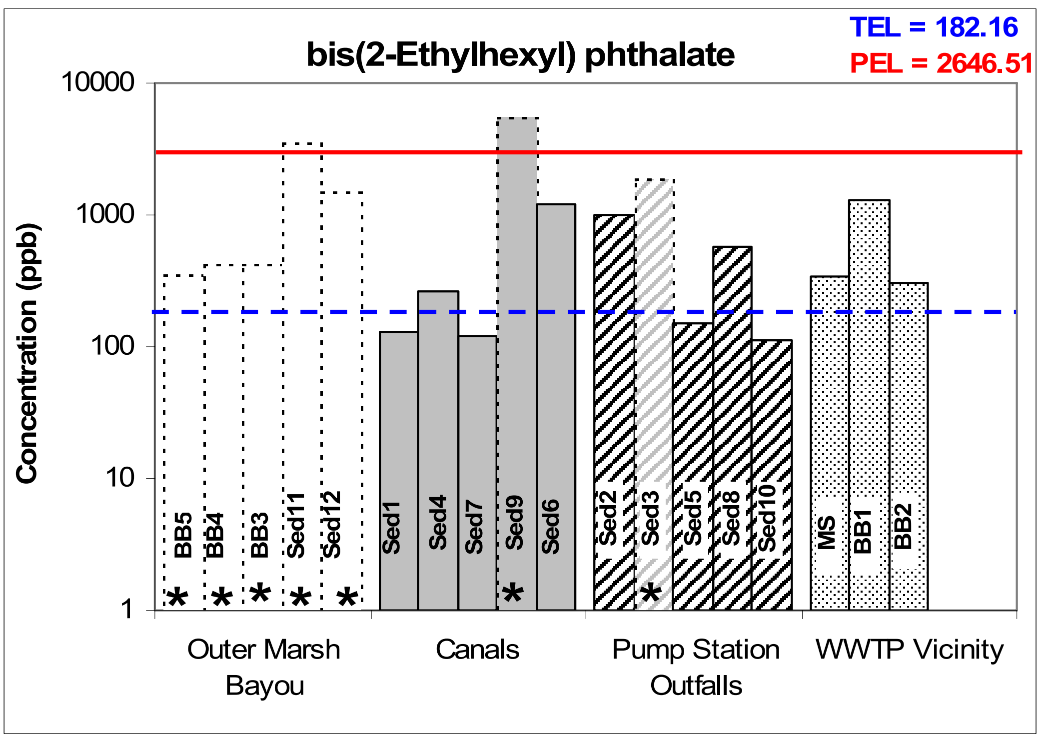

Acenaphthylene
TEL = 5.87
PEL = 127.87
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Anthracene
TEL = 46.85
PEL = 245
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

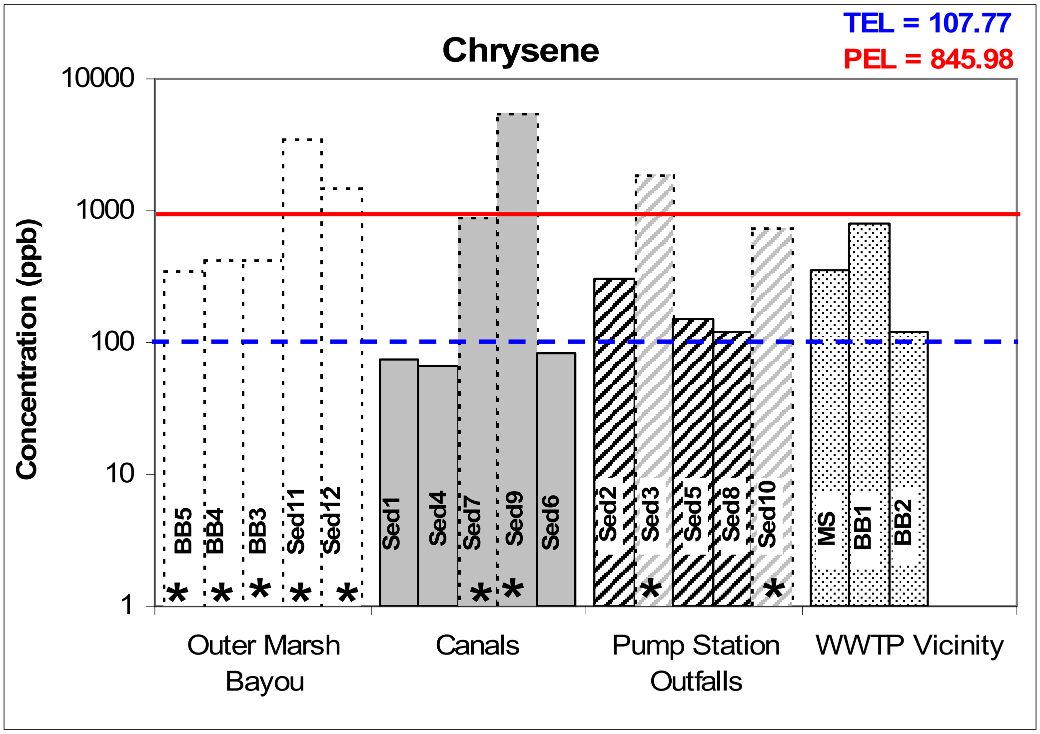

Benzo(a)anthracene
TEL = 74.83
PEL = 692.52
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity



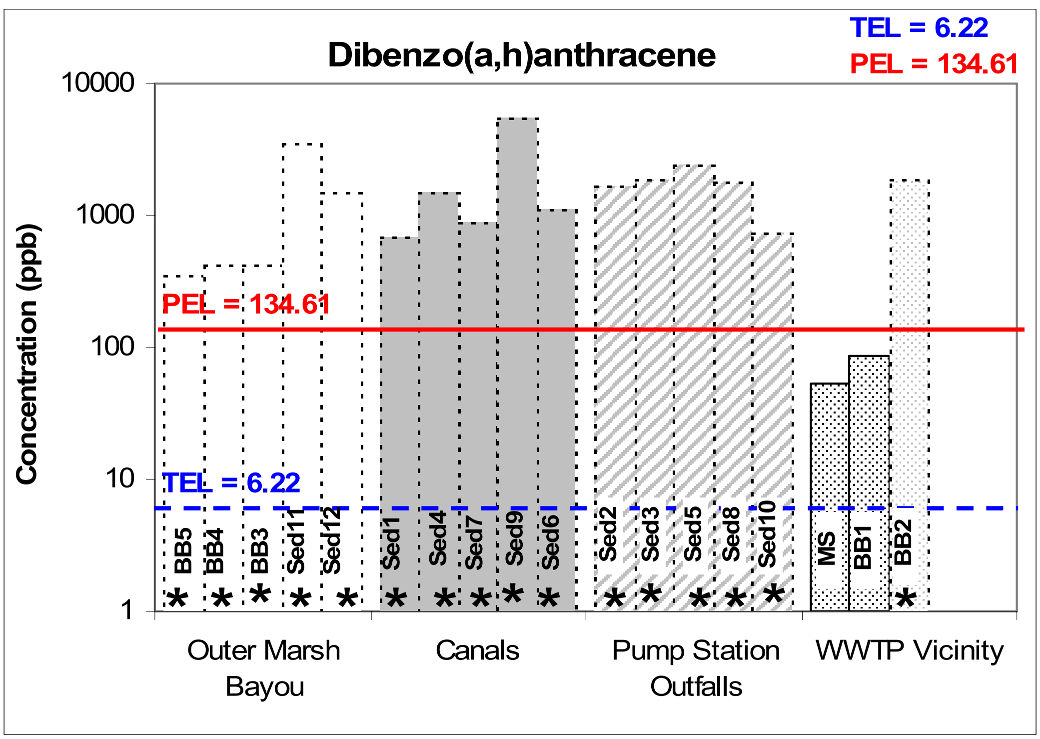
Benzo(a)pyrene
TEL = 88.81
PEL = 763.22
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity



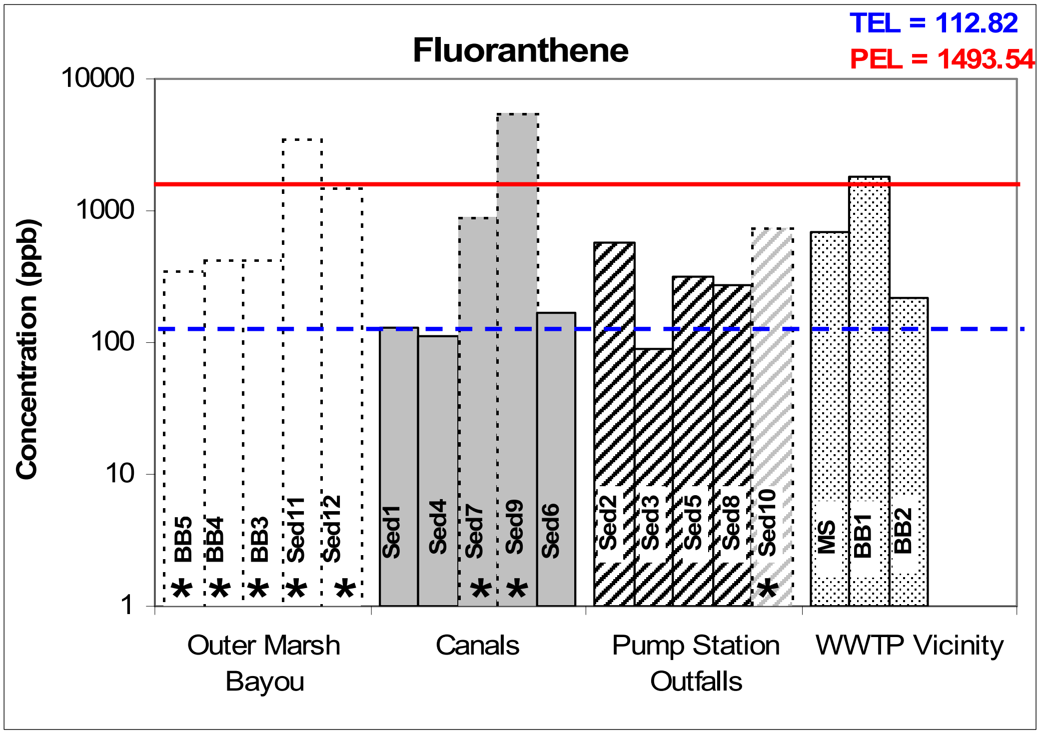
bis(2-Ethylhexyl) phthalate
TEL = 182.16
PEL = 2646.51
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

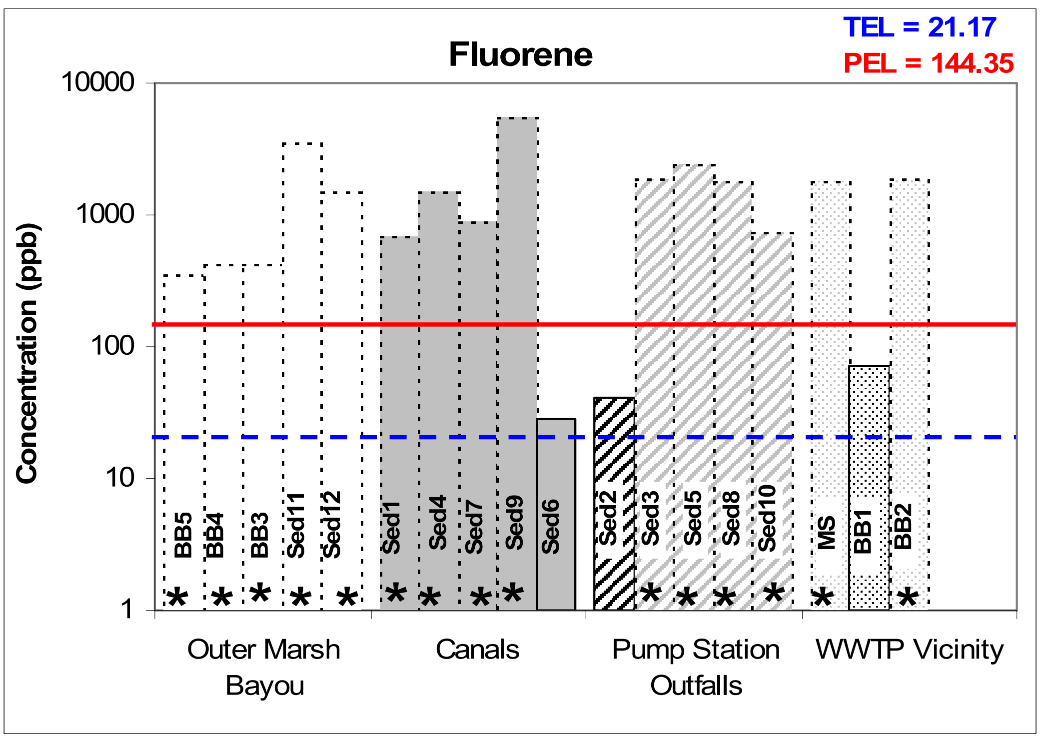


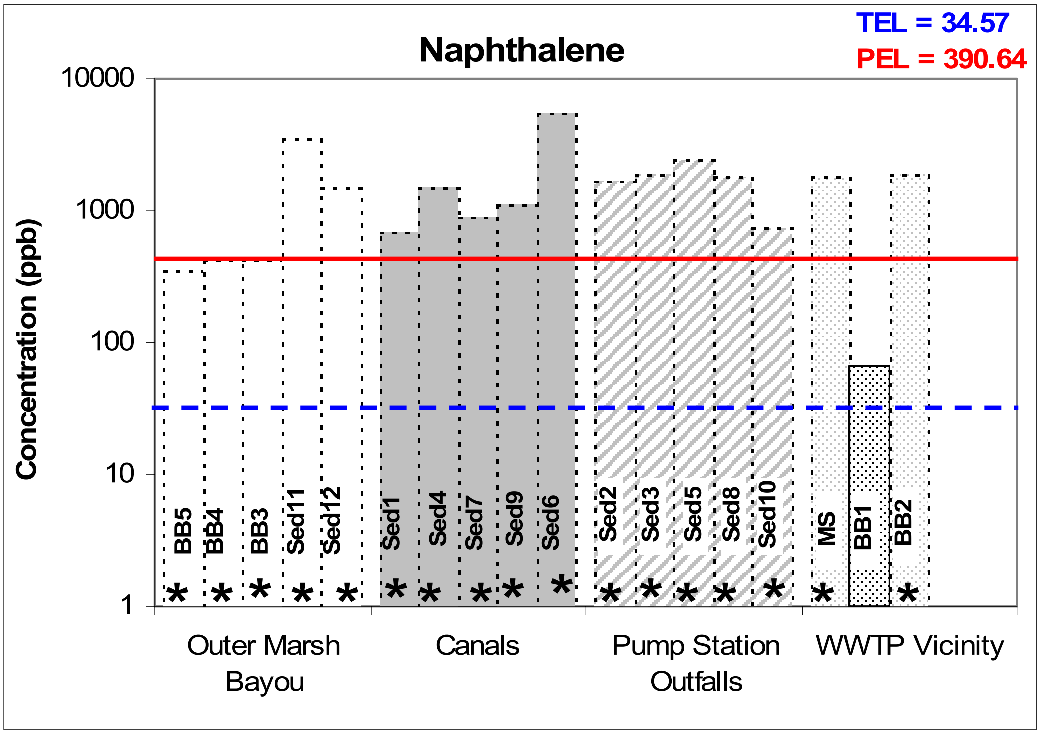
TEL = 107.77
PEL = 845.98
Chrysene
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

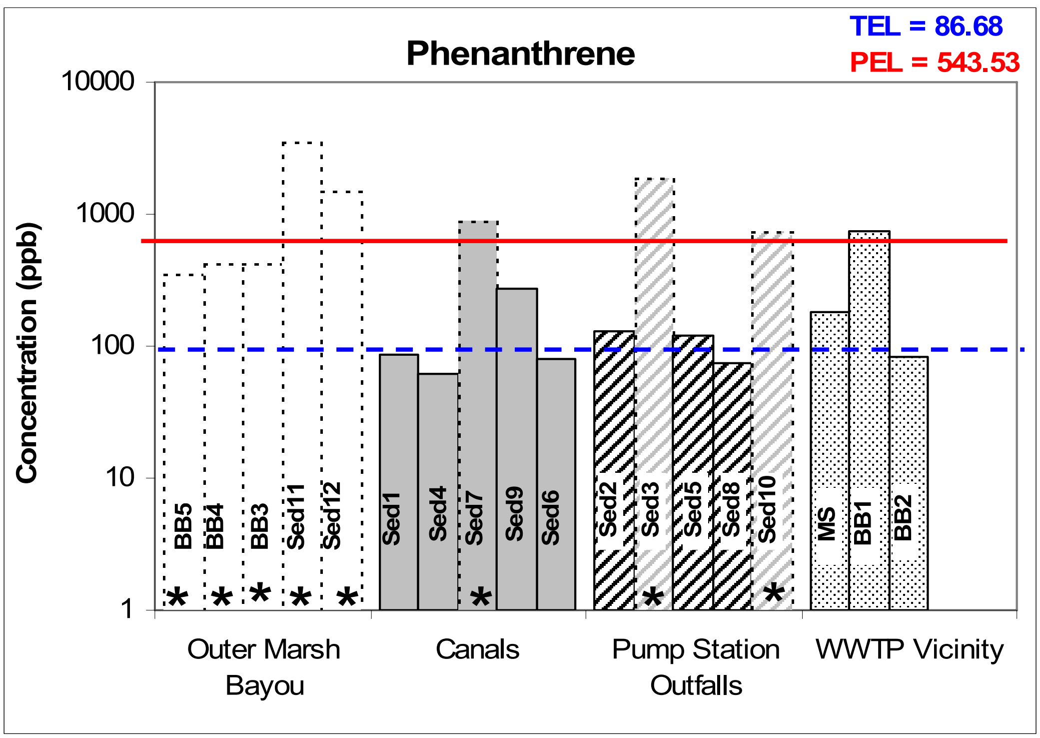


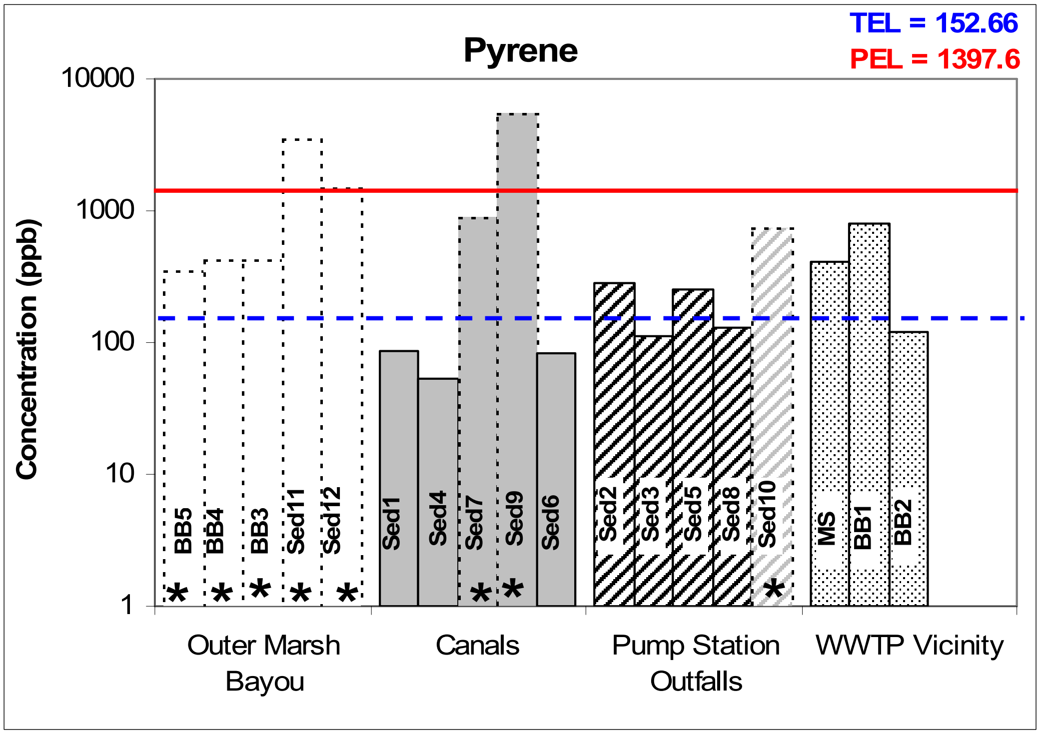
TEL = 6.22
PEL = 134.61
Dibenzo(a,h)anthracene
Concentration (ppb)
10000
1000
100
10
1
PEL = 134.61
TEL = 6.22
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

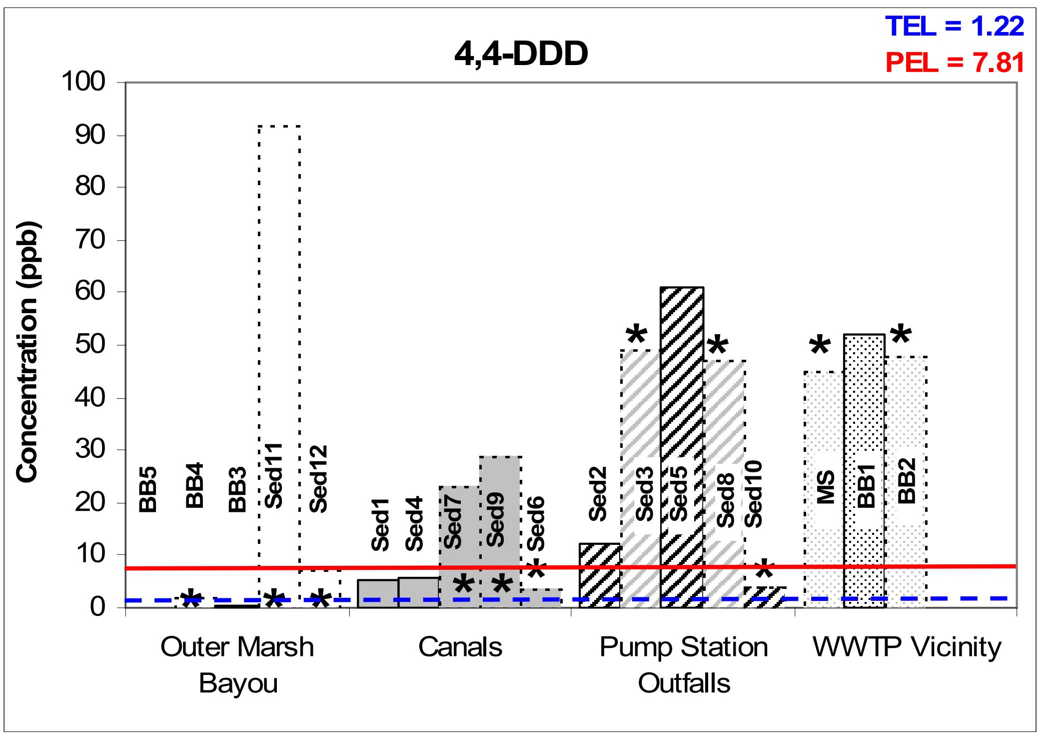

Fluoranthene
TEL = 112.82
PEL = 1493.54
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

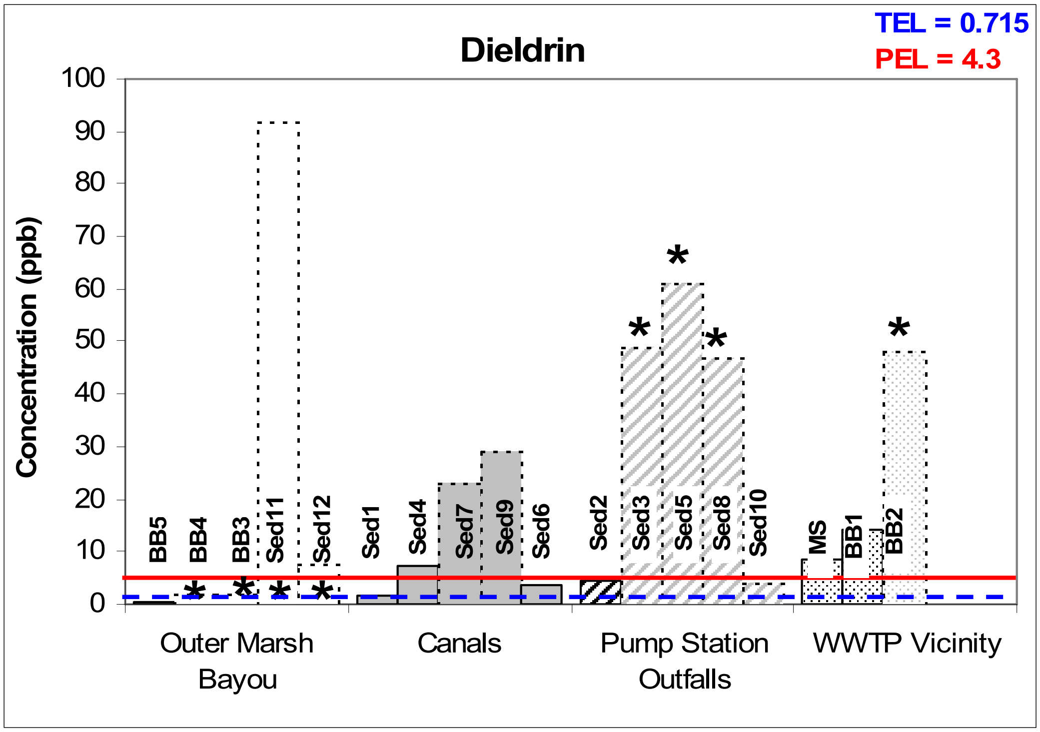

Fluorene
TEL = 21.17
PEL = 144.35
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

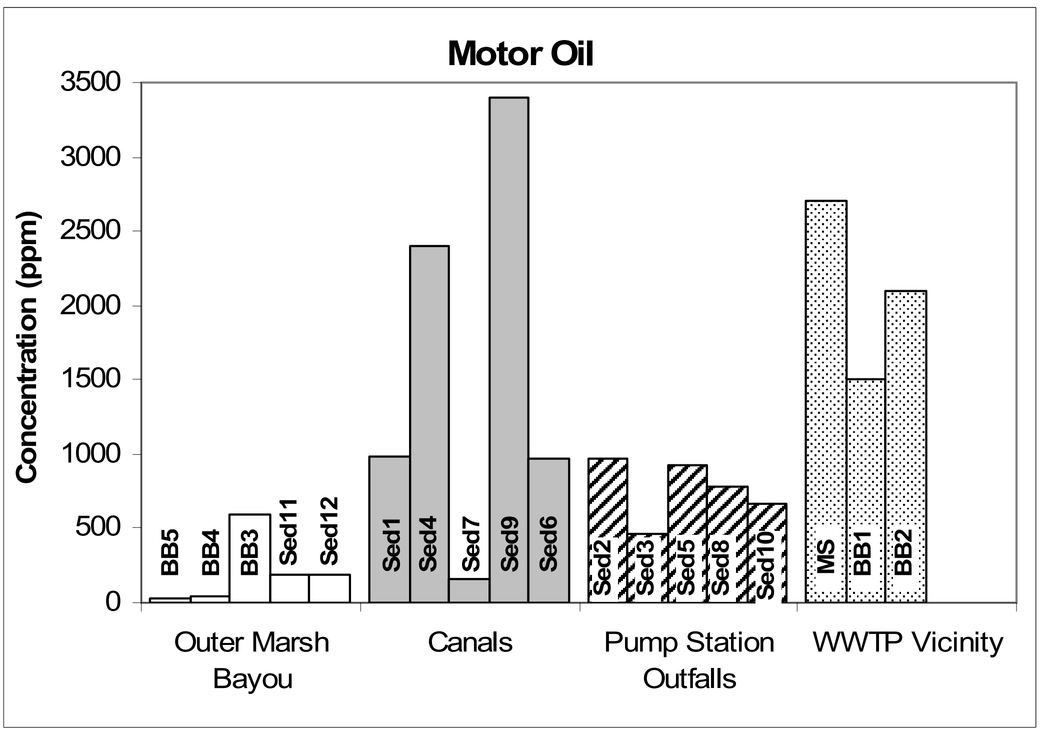

Naphthalene
TEL = 34.57
PEL = 390.64
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

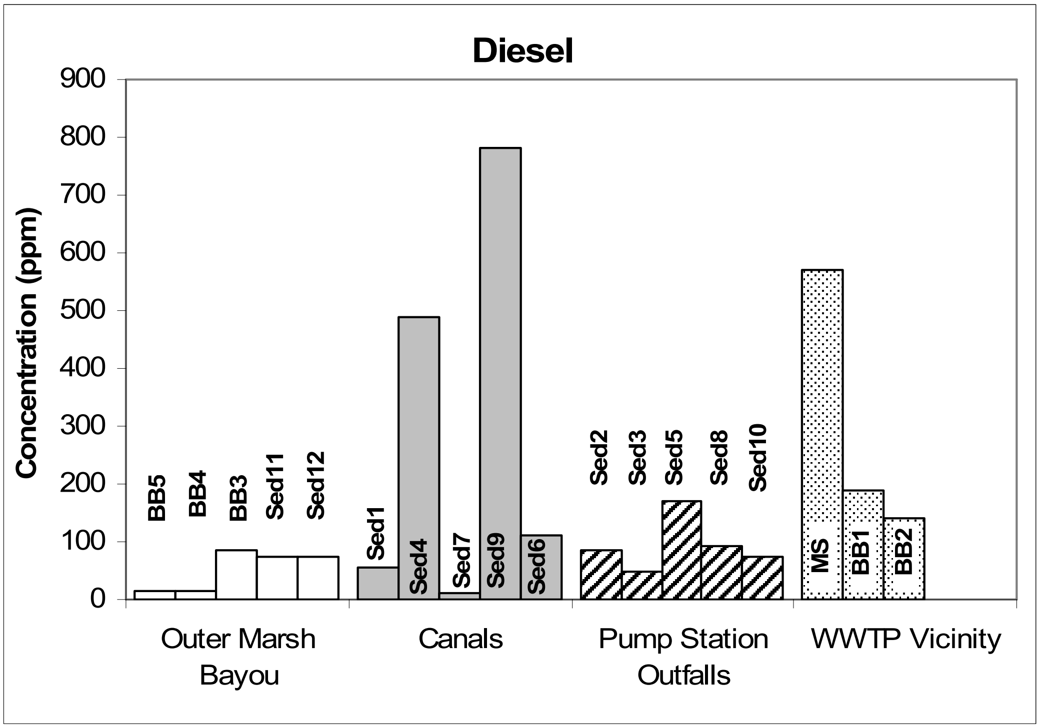

Phenanthrene
TEL = 86.68
PEL = 543.53
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

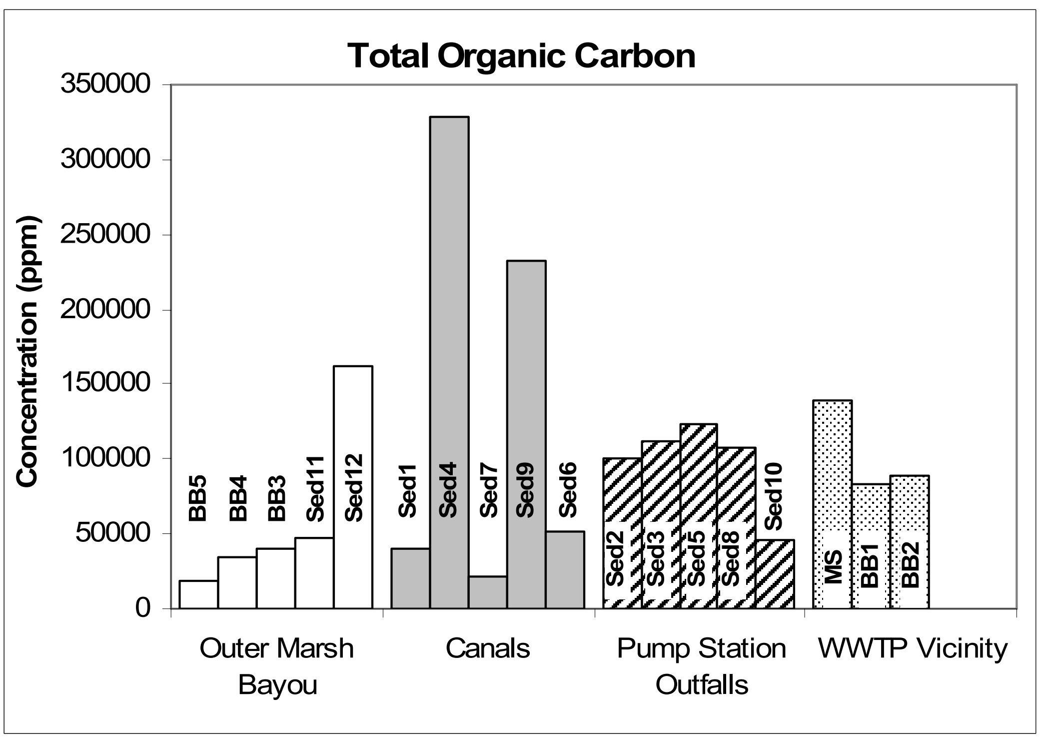

TEL = 152.66
PEL = 1397.6
Pyrene
10000
1000
100
10
1
Concentration (ppb)
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

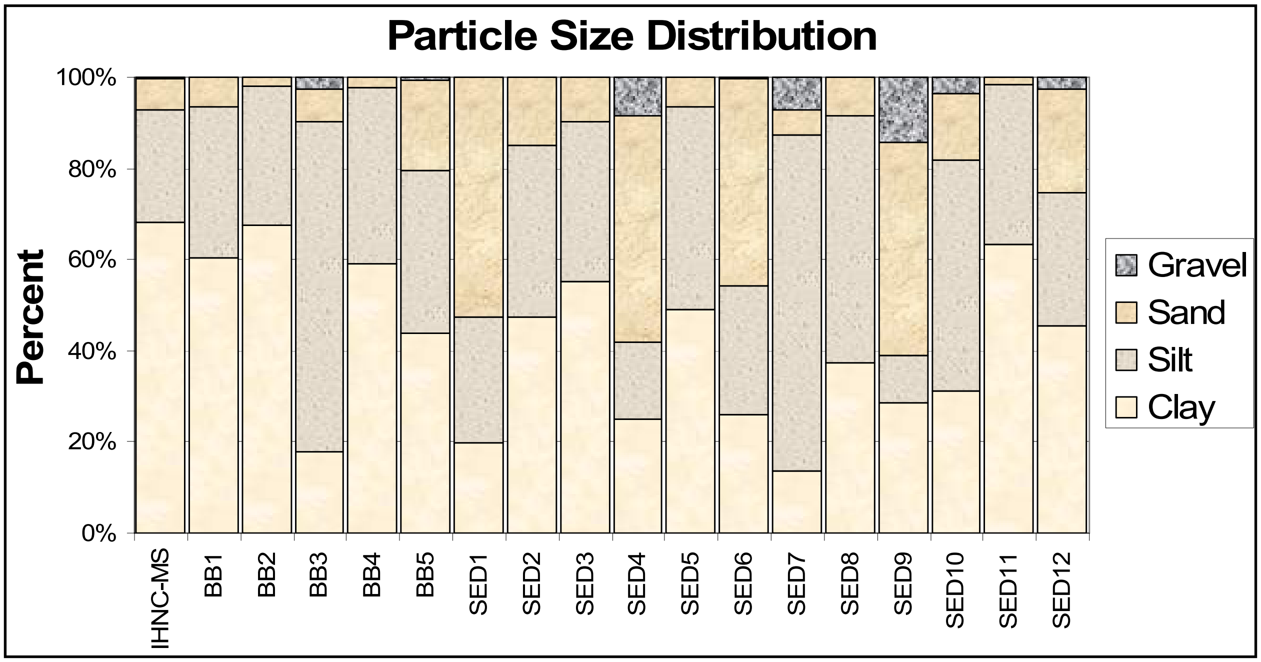

TEL = 1.22
PEL = 7.81
4,4-DDD
100
90
80
70
60
50
40
30
20
10
0
Concentration (ppb)
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Dieldrin
TEL = 0.715
PEL = 4.3
Concentration (ppb)
100
90
80
70
60
50
40
30
20
10
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Motor Oil
Concentration (ppm)
3500
3000
2500
2000
1500
1000
500
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Diesel
Concentration (ppm)
900
800
700
600
500
400
300
200
100
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Total Organic Carbon
Concentration (ppm)
350000
300000
250000
200000
150000
100000
50000
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity



Particle Size Distribution
Percent
100%
80%
60%
40%
20%
0%
IHNC-MS
BB1
BB2
BB3
BB4
BB5
SED1
SED2
SED3
SED4
SED5
SED6
SED7
SED8
SED9
SED10
SED11
SED12
Gravel
Sand
Silt
Clay

Attachment 2
A Pilot Study of the Effects of Post-Hurricane Katrina Floodwater Pumping on the Chemistry and Toxicity of Violet Marsh Sediments (Draft)

Burton C. Suedel, Jeffery A. Steevens and David E. Splichal

PURPOSE: The Interagency Performance Evaluation Taskforce (IPET) is investigating environmental impacts originating from the failure of the hurricane protection system to perform as designed around New Orleans, Louisiana during Hurricane Katrina. The study is needed to determine the extent to which Katrina floodwaters in the New Orleans area may have had impacts to wildlife habitat and other biological resources in surrounding areas. Herein we present preliminary data regarding the effects of pumped floodwaters on sediment chemistry and benthic invertebrate toxicity near pumping stations that pumped floodwaters into marshes near Chalmette and Violet, Louisiana.

BACKGROUND: Hurricane Katrina came ashore along the Alabama, Mississippi, and Louisiana coasts on August 29, 2005, resulting in significant physical damage to infrastructure. As a result of the storm, levees were breached or overtopped, resulting in flooding of New Orleans and surrounding areas, including many areas in St. Bernard Parish. Within St. Bernard Parish, floodwaters in Chalmette and Violet, Louisiana were pumped into the adjacent Violet Marsh. There are potential undesirable environmental impacts on the marsh ecosystem resulting from levee breaches and pumping activities. The primary environmental concerns are elevated salinity and chemical and biological contaminants. To address this concern, we conducted a pilot study after the storm to compare chemistry and toxicity in sediment samples at sites in the immediate vicinity of active and inactive (flooded during Katrina) pumping stations that discharge into Violet Marsh (Figure 1). The pilot study consisted of sampling benthic invertebrates, and recording salinity measurements throughout Violet Marsh, which are addressed in Ray (2006) and Lin and Kleiss (2006), respectively, and collecting sediment samples for chemical and toxicological analysis, which is the subject of the study described herein. This Technical Note describes a pilot study representing an initial effort to discern patterns in chemical contamination and toxicity of sediments at select pumping stations along Violet Marsh and will be used to guide potential future studies in the area.

Figure 2. Aerial view of study area and pump station locations.

STUDY AREA: Sediment samples were collected on 13-14 December 2005, approximately three and a half months after Hurricane Katrina made landfall. Four pumping stations located along the Back Protection Levee along the Forty Arpent Canal in Chalmette, Louisiana were chosen based on pumping activities after Hurricane Katrina (Figure 1). Pump Stations Meraux #4 and Jean Lafitte #6 were fully operational and pumped daily after the storm (Figures 2 and 3) whereas Pump Stations Guichard #2 and Bayou Villere #3 were selected because they were flooded during Katrina and were not operational during this time (Figures 4 and 5). Samples were collected within 50 m of the outfall from each pump station.

METHODS: One sediment sample was collected via aluminum boat or airboat at each pump station in water of approximately one-meter depth using a pole-mounted Ekman dredge (232 cm^3/sample). The top-mounted doors on the sampler were opened and the top 12-15 cm of sediment removed with a pre-cleaned polyethylene spoon. Samples were placed in a pre-cleaned 2-liter polyethylene container and held on wet ice until transport. Samples were transported to laboratory facilities at the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS where the samples were held at 4ºC until analysis.

Figure 2. Pump Station Meraux #4 sampling station (pumped).

Figure 3. Pump Station Jean Lafitte #6 sampling station (pumped).

Figure 4. Pump Station Guichard #2 sampling station (did not pump).

Figure 5. Pump Station Bayou Villere #3 sampling station (did not pump).

Chemistry

Samples were prepared and analyzed for volatile organics, total petroleum hydrocarbons, polycyclic aromatic hydrocarbons, and metals using EPA methods found in SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical* Methods (1986) and updates. Each pump station sample was prepared and analyzed for the following parameters using the referenced methods or a slight modification. Samples were analyzed for volatile organic compounds (benzene, toluene, ethylbenzene, total xylenes and gasoline range organics (GRO)) using methods 5035 (Purge-and-Trap) and 8260B (Gas Chromatography/Mass Spectrometry (GC/MS)). These methods were modified to include the GRO GC/MS fingerprint by analyzing an unleaded gasoline standard. Samples analyzed for semi-volatile organic compounds (including diesel range organics (DRO) and oil range organics (ORO)) were prepared following method 3540C (Soxhlet Extraction) and analyzed using method 8270C (Gas Chromatography/Mass Spectrometry (GC/MS)). These methods were modified to include the DRO and ORO GC/MS fingerprints by analyzing diesel fuel and motor oil standards. Samples analyzed for metals were prepared using method 3050B (Acid Digestion) and quantified using method 6010B (Inductively Coupled Plasma-Atomic Emission Spectrometry). Samples for total organic carbon (TOC) analysis were prepared and quantified following a modification of method 9060A for sediment samples.

Toxicity

Whole sediment acute toxicity tests using the estuarine amphipod, *Leptocheirus plumulosus*, were conducted according to standard guidance (U.S. EPA, 1994). Experimental conditions are outlined in Table 1. Test sediments were stored in the dark at 4 ± 1 °C and used in testing within eight days of collection. Sediments were thoroughly homogenized with a laboratory impeller mixer for five minutes prior to use and approximately 175 mL (2 cm depth) of each test sediment was added to each of five replicate test chambers (1-L beakers). Overlying water, 20 ‰ synthetic seawater (Crystal Sea® Marine Mix; Marine Enterprises International, Inc., Baltimore, MD, U.S.A.), was added and test chambers were allowed to equilibrate overnight. Test chambers were held under ambient light (16 h light: 8 h dark) and supplied trickle-flow aeration in a temperature (25.0 ± 1.0 °C) regulated water bath. At test initiation, *L. plumulosus* (500 – 750 µm) were obtained from ERDC in-house cultures and 20 amphipods were gently transferred randomly into each test chamber. Water quality measurements (temperature, dissolved oxygen, pH and salinity) were determined at test initiation and termination. Environmental chamber temperature (min/max) was monitored and recorded daily. Pore water ammonia was also measured in the bulk sediment using an ISE meter (Thermo Orion Electron Corp., Beverly, MA), equipped with a model 95-12 ammonia sensitive electrode (Thermo Orion Electron Corp., Beverly, MA). Animals were not fed during the test.

Table 1 Leptocheirus plumulosus Test Conditions	
Parameter	
Test duration	10 d
Test type	Static non-renewal
Temperature	20-25^{o}C
Salinity	20^{o}/oo (range 2-32)
Light quality (quantity)	Ambient laboratory (16 h light : 8 h dark)
Test chamber	1 L glass beaker
Sediment depth	2 cm
Age of test organisms	Mature 3-5 mm
Organisms per chamber	20
Replicates per treatment	5
Feeding regime	None
Test aeration	Trickle flow (< 100 bubbles / min)
Test acceptability criterion	$\geq$ 90% survival in controls

The test assessment endpoint was survival. Test sediments were assessed along side of a performance control sediment (Sequim, Washington, USA Lat. 48.0587 Long. -123.0235 and a reference sediment (Lake Pontchartrain, Louisiana, USA; Lat. -89.826389, Long. 30.220556; collected prior to Hurricane Katrina). Both performance control and reference sediments were collected from relatively pristine uncontaminated areas and have undergone rigorous biological and chemical analysis. For tests to be considered valid, at least 90% survival had to be observed in the performance control and overlying water quality (pH, temperature, dissolved oxygen) within the ranges specified by guidance (U.S. EPA, 1994). In order for a test sediment to be considered "toxic," two criteria must be met; the survival in the test sediment must be statistically reduced compared to the reference sediment and the reduction must be greater than 20% of the reference survival value (U.S. EPA / U.S. ACE, 1998). Data normality (Kolmogorov-Smirnov test), homogeneity (Levene's Test) and treatment differences (α = 0.05) compared to the reference sediment were determined at using SigmaStat statistical software (SPSS, Chicago, IL). Survival data were arcsine-square root transformed and a simple t-test was used to determine if statistical differences existed between individual test sediments and the reference sediment.

Results

Chemical Analysis

Visual analysis of samples upon collection indicated that all four sediments were composed of primarily fine, unconsolidated material with substantial amounts of decaying vegetative matter. Grain size analysis of sediments confirmed our visual analysis (Table 2). Water quality measurements were taken at the water surface using a YSI Model 85 meter. Salinity at the sampling sites ranged between 11 and 12 ‰ and temperatures ranged from 12^{o}C to 15^{o}C. Dissolved oxygen concentrations at the surface were all at or above 100% saturation. A distinct petroleum odor was detected in sediment and an oily sheen was observed at the water surface during sediment sampling at Pump Station #4.

Table 2
Test sediment grain size analysis

Treatment	Gravel (%)	Sand (%)	Fines (%)
SC (control)	0	6.2	93.8
LP (reference)	NT	NT	NT
PS-2	0	9.3	90.7
PS-3	0	6.5	93.5
PS-4	0	17.9	82.1
PS-6	0	2.3	97.7

NT = Not tested.

Volatile organic compounds and GRO were below detection limits for these compounds, 15 to 40 ug/kg and 250 to 730 ug/kg, respectively. Results from semi-volatile organics analyses show detectable levels of ORO in all samples. Trace levels of DRO were detected in Pump Station #4. Concentrations in the µg/kg range of four to six PAHs were detected in Pump Station #2 and #4 sediments. Bis(2-ethylhexyl)phthalate was detected in all four samples, as well as the method blank. Results from metals analyses show detectable levels, except for antimony and thallium, in all pump station samples. Slightly higher levels of lead were detected in Pump Stations #2 and #6 than in Pump Stations #3 and #4. Results from TOC analyses showed the highest levels in Pump Stations #2 and #6 with lesser values in Pump Stations #3 and #4.

Table 3 Summary Table of Hits at each Pump Station		Pumping Station #2	Pumping Station #3	Pumping Station #4	Pumping Station #6
		Result	Result	Result	Result
Oil Range Organics		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
ORO	(dry)	1300	1200	830	340 J
	(wet)	160	230	290	46 J
		Result	Result	Result	Result
Diesel Range Organics		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
DRO	(dry)	<790	<530	220 J	<720
	(wet)	<100	<98	78 J	<99
		Result	Result	Result	Result
Semivolatile Organics (BNA)		(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Fluoranthene		1600 J	<5300	500 J	<7200
Pyrene		1300 J	<5300	500 J	<7200
Benzo(a)anthracene		<7900	<5300	300 J	<7200
Chrysene		<7900	<5300	400 J	<7200
Bis(2-ethylhexyl) phthalate		1400 J,B	1700 J,B	1500 J,B	1700 J,B
Benzo(b)fluoranthene		1000 J,I	<5300	600 J,I	<7200
Benzo(k)fluoranthene		I	<5300	I	<7200
Benzo(a)pyrene		<7900	<5300	300 J	<7200
		Result	Result	Result	Result
Metals		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Aluminum		20900	20800	15100	23400
Arsenic		12 B	9.6 B	9.1 B	12 B
Barium		119	120	180	118
Beryllium		0.99	1	1.2	1.1
Cadmium		2.1	1.7	1.7	2.1
Calcium		5080	4400	6150	5410
Chromium		34.2 B	53.2 B	21.4 B	32.1 B
Cobalt		9.2	11	14	10
Copper		59.2	58.7	31	42.9
Iron		26100	26200	20900	25800
Lead		89.7	181	27.2	52
Magnesium		9130	7700	6090	9540
Manganese		409	460	463	741
Nickel		32.2	46.1	32.9	30.5
Potassium		4960	4470	3160	5330
Selenium		2 J	1 J	1 J	2 J
Silver		0.6 J	<1	<1	0.2 J
Sodium		21700	12700	6410	21000
Vanadium		49.8	43.7	36	51.3
Zinc		287	165	139	325
		Result	Result	Result	Result
Total Organic Carbon		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
TOC		100000	58000	35000	94000
J: Estimated concentration above method detection limit but below LRL.					
B: Compound also present in the method blank.					
I: Analytes reported as an isomeric pair due to insufficient baseline resolution.					

Toxicity Analysis

Leptocheirus plumulosus in test vessels were sieved from sediment at the termination of the 10-day exposure period. Test sediment was evaluated for total and unionized ammonia and determined to be suitable for testing without manipulations. Survival of amphipods in the control sediment from Sequim Bay, WA was above the 90% level required for test acceptability. Sediments from Pump Station #4 resulted in significant reductions in amphipod survival as compared to the reference Lake Pontchartrain sediment. Sediment from Pump Stations #2, #3, and #6 did not result in significant toxicity to *L. plumulosus*.

Table 4
Test Sediment Parameters

Sample Treatment	Sediment Moisture Content (%)	Pore Water			
		pH (SU)	Salinity (‰)	Total Ammonia (mg/L)	Unionized Ammonia (mg/L at 25°C)
SC (control)	54.3	7.18	6	17.5	0.15
LP (reference)	21.2	6.97	34	38.6	0.20
PS-2	76.1	7.00	15	19.2	0.11
PS-3	64.9	7.12	12	15.1	0.11
PS-4	35.9	7.28	12	15.1	0.16
PS-6	74.4	7.20	14	9.62	0.09

Table 5
Results from 10-day whole sediment toxicity test using *Leptocheirus plumulosus*. Statistically significant reductions (asterisks) compared to the reference sediment (Lake Pontchartrain, LA) are indicated for each treatment

Treatment	Mean Percent Survival	Coefficient of Variation (%)
Negative Control (Sequim Bay, WA)	90 ± 4	3.9
Reference (Lake Pontchartrain, LA)	95 ± 7	7.4
PS-2	89 ± 4	4.7
PS-3	91 ± 7	7.2
PS-4	76 ± 8 *	10.8
PS-6	97 ± 4	4.6

* Sediment PS-4 was statistically significantly reduced compared to both the control and reference sediments using Dunnett's Method (one-way ANOVA) and a t-test. Guidance recommends using a t-test, comparing each test sediment individually to the reference.

Discussion

Chemical Analysis

Although the results from volatile organics analysis suggested the absence of most volatile compounds and GRO, GC/MS results from Pump Station #4 showed a rise in the chromatogram after the GRO fingerprint (hydrocarbons with carbon number greater than approximately C9) indicating higher molecular weight compounds were present in this sample. This observation is essentially *qualitative* since GRO compounds are not calibrated past C9, but when used in conjunction with the semi-volatile chemical data, confirmed field observations that petroleum contaminants were present.

A low level of DRO (estimated concentration between the laboratory reporting limit and the method detection limit) was detected in sediments from Pump Station #4 but not detected in the other samples. Results show detectable levels of ORO in each sample with Pump Stations #2 and #3 containing the greatest amount. Since three of the four samples had comparable moisture content (Table 1) whereas the moisture content of Pump Station #4 was substantially lower, results for ORO were also calculated on a "wet-weight" basis. Results calculated on the "wet-weight" bases show Pump Station #4 as having the highest concentration of ORO. The detectable levels of the PAHs found in sediments from Pump Stations #2 and #4 also indicated petroleum contamination. Low levels of bis(2-ethylhexyl) phthalate, a plasticizer, were found in field collected sediments and quality control samples. It is likely that these are artifacts of the sampling, preparation, and analysis due to the ubiquitous use of plastics for containers. Results from metals analyses show similar concentrations of metals between the four samples. The results for TOC show the highest levels in Pump Stations #2 and #6 (10.0 and 9.4%, respectively) with lower concentrations in sediments from Pump Stations #3 and #4 (5.8 and 3.5%, respectively).

Toxicity Analysis

Toxicity and analytical chemistry results can be used together to determine the potential impact of chemical contaminants in the floodwaters on benthic organisms in Violet Marsh. While the effects assessed using benthic toxicity tests and sediment chemistry are not predictive of all ecological impacts on a wetland, they can be used as sentinel indicators of adverse effects. Analytical chemistry results indicated elevated levels of petroleum-based organics (e.g., motor oil, diesel fuel, and polycyclic aromatic hydrocarbons) and some metals (e.g., lead). Coupled with toxicity results these data indicate the potential for adverse effects through direct toxicity to benthic organisms and potential adverse impacts from bioaccumulation of organics and metals into the food-chain, especially in sediments in the vicinity of Pump Station #4.

Conclusions

The results of the current pilot study indicate a potential for adverse effects of chemicals present in Violet Marsh on benthic organisms. Further studies will be required to describe the potential for these effects with more certitude. As part of these studies, an assessment of marsh sediments receiving discharge from dewatering activities and assessment of bioaccumulation potential of chemical contaminants in these sediments should be completed.

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> Suedel, B.C., J.A. Steevens and D.E. Splichal. (2006). "A Pilot Study of the Effects of Post-Hurricane Katrina Floodwater Pumping on the Chemistry and Toxicity of Violet Marsh Sediments." Environmental Lab Technical Notes (ERDC/TN EL-06-XX). U.S. Army Engineer Research and Development Center, Vicksburg, MS. ***http://el.erdc.usace.army.mil/*** .

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Appendix Table. Summary of Non-Detected Analytes in Violet Marsh Sediments

		Pump Station #2	Pump Station #3	Pump Station #4	Pump Station #6
Volatile Organics		Result (ug/kg)	Result (ug/kg)	Result (ug/kg)	Result (ug/kg)
Benzene		<40	<25	<15	<30
Toluene		<40	<25	<15	<30
Ethylbenzene		<40	<25	<15	<30
Xylenes		<40	<25	<15	<30
Gasoline Range Organics		Result (ug/kg)	Result (ug/kg)	Result (ug/kg)	Result (ug/kg)
GRO		<730	<470	<250	<620
Oil Range Organics		Result (mg/kg)	Result (mg/kg)	Result (mg/kg)	Result (mg/kg)
ORO	(dry)	1300	1200	830	340 J
	(wet)	160	230	290	46 J
Diesel Range Organics		Result (mg/kg)	Result (mg/kg)	Result (mg/kg)	Result (mg/kg)
DRO	(dry)	<790	<530	220 J	<720
	(wet)	<100	<98	78 J	<99

	Pump Station #2	Pump Station #3	Pump Station #4	Pump Station #6
Semivolatile Organics (BNA)	Result (ug/kg)	Result (ug/kg)	Result (ug/kg)	Result (ug/kg)
Phenol	<7900	<5300	<2800	<7200
Bis(2-chloroethyl) ether	<7900	<5300	<2800	<7200
2-Chlorophenol	<7900	<5300	<2800	<7200
1,3-Dichlorobenzene	<7900	<5300	<2800	<7200
1,4-Dichlorobenzene	<7900	<5300	<2800	<7200
1,2-Dichlorobenzene	<7900	<5300	<2800	<7200
Benzyl alcohol	<79000	<53000	28000	<72000
2-Methylphenol	<7900	<5300	<2800	<7200
2,2'-Oxybis(1-chloropropane)	<7900	<5300	<2800	<7200
N-Nitrosodi-n-propylamine	<7900	<5300	<2800	<7200
Hexachloroethane	<7900	<5300	<2800	<7200
4-Methylphenol	<7900	<5300	<2800	<7200
Nitrobenzene	<7900	<5300	<2800	<7200
Isophorone	<7900	<5300	<2800	<7200
2-Nitrophenol	<16000	<11000	<5600	<14000
2,4-Dimethylphenol	<16000	<11000	<5600	<14000
Bis(2-chloroethoxy)methane	<7900	<5300	<2800	<7200
2,4-Dichlorophenol	<7900	<5300	<2800	<7200

	Pump	Pump	Pump	Pump
	Station #2	**Station #3**	**Station #4**	**Station #6**
Semivolatile Organics (BNA)	Result (ug/kg)	Result (ug/kg)	Result (ug/kg)	Result (ug/kg)
Benzoic acid	<79000	<53000	<28000	<72000
1,2,4-Trichlorobenzene	<7900	<5300	<2800	<7200
Naphthalene	<7900	<5300	<2800	<7200
4-Chloroaniline	<16000	<11000	<5600	<14000
Hexachlorobutadiene	<7900	<5300	<2800	<7200
4-Chloro-3-methylphenol	<16000	<11000	5600	<14000
2-Methylnaphthalene	<7900	<5300	<2800	<7200
Hexachlorocyclopentadiene	<32000	<21000	<11000	<29000
2,4,6-Trichlorophenol	<7900	<5300	<2800	<7200
2,4,5-Trichlorophenol	<7900	<5300	<2800	<7200
2-Chloronaphthalene	<7900	<5300	<2800	<7200
2-Nitroaniline	<79000	<53000	<28000	<72000
Acenaphthylene	<7900	<5300	<2800	<7200
Dimethyl phthalate	<7900	<5300	<2800	<7200
2,6-Dinitrotoluene	<7900	<5300	<2800	<7200
3-Nitroaniline	<79000	<53000	<28000	<72000
Acenaphthene	<7900	<5300	<2800	<7200
2,4-Dinitrophenol	<79000	<53000	<28000	<72000
Dibenzofuran	<7900	<5300	<2800	<7200
4-Nitrophenol	<79000	<53000	<28000	<72000
2,4-Dinitrotoluene	<7900	<5300	<2800	<7200
Fluorene	<7900	<5300	<2800	<7200
Diethyl phthalate	<7900	<5300	<2800	<7200
4-Chorophenyl phenyl ether	<7900	<5300	<2800	<7200
4-Nitroaniline	<79000	<53000	<28000	<72000
4,6-Dinitro-2-methylphenol	<79000	<53000	<28000	<72000
N-Nitrosodiphenylamine	<7900	<5300	<2800	<7200
Hexachlorobenzene	<7900	<5300	<2800	<7200
4-Bromophenyl phenyl ether	<7900	<5300	<2800	<7200
Pentachlorophenol	<79000	<53000	<28000	<72000
Phenanthrene	<7900	<5300	<2800	<7200
Anthracene	<7900	<5300	<2800	<7200
Di-n-butyl phthalate	<7900	<5300	<2800	<7200
Fluoranthene	1600 J	<5300	500 J	<7200
Pyrene	1300 J	<5300	500 J	<7200
Butyl benzyl phthalate	<7900	<5300	<2800	<7200
Benzo(a)anthracene	<7900	<5300	300 J	<7200
3,3'-Dichlorobenzidine	<32000	<21000	<11000	<29000
Chrysene	<7900	<5300	400 J	<7200
Bis(2-ethylhexyl) phthalate	1400 J,B	1700 J,B	1500 J,B	1700 J,B
Di-n-octyl phthalate	<7900	<5300	<2800	<7200
Benzo(b)fluoranthene	1000 J,I	<5300	600 J,I	<7200
Benzo(k)fluoranthene	I	<5300	I	<7200
Benzo(a)pyrene	<7900	<5300	300 J	<7200
Indeno(1,2,3-cd)pyrene	<7900	<5300	<2800	<7200
Dibenzo(a,h)anthracene	<7900	<5300	<2800	<7200
Benzo(g,h,i)perylene	<7900	<5300	<2800	<7200

Metals	Pump Station #2 Result (mg/kg)	Pump Station #3 Result (mg/kg)	Pump Station #4 Result (mg/kg)	Pump Station #6 Result (mg/kg)
Aluminum	20900	20800	15100	23400
Antimony	<4	<4	<4	<4
Arsenic	12 B	9.6 B	9.1 B	12 B
Barium	119	120	180	118
Beryllium	0.99	1	1.2	1.1
Cadmium	2.1	1.7	1.7	2.1
Calcium	5080	4400	6150	5410
Chromium	34.2 B	53.2 B	21.4 B	32.1 B
Cobalt	9.2	11	14	10
Copper	59.2	58.7	31	42.9
Iron	26100	26200	20900	25800
Lead	89.7	181	27.2	52
Magnesium	9130	7700	6090	9540
Manganese	409	460	463	741
Nickel	32.2	46.1	32.9	30.5
Potassium	4960	4470	3160	5330
Selenium	2 J	1 J	1 J	2 J
Silver	0.6 J	<1	<1	0.2 J
Sodium	21700	12700	6410	21000
Thallium	<6	<6	<6	<6
Vanadium	49.8	43.7	36	51.3
Zinc	287	165	139	325

Total Organic Carbon	Result (mg/kg)	Result (mg/kg)	Result (mg/kg)	Result (mg/kg)
TOC	100000	58000	35000	94000

J: Estimated concentration above method detection limit but below LRL.
B: Compound also present in the method blank.
I: Analytes reported as an isomeric pair due to insufficient baseline resolution.

Appendix 5C
Microbiological Analysis

Environmental Consequences of the Failure of the New Orleans Levee System During Hurricane Katrina, Microbiological Analysis

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Executive Summary

Multiple failures of the levee system protection for the City of New Orleans in the aftermath of Hurricane Katrina August 2005 led to the flooding of the metropolitan area. The flood waters and sediments contained some dissolved and entrained chemical and microbial contaminants. Subsequent pumping of flood water from the city to the adjacent environment and the ongoing removal of sediment and sediment-coated debris are potential mechanisms to distribute these contaminants to the local environment. For this report we focused on the analysis of several specific contaminants that, due to the frequency and levels that they were reported to be present in the flooded city and their ability to cause environmental harm, provided the opportunity to evaluate the environmental distribution of contaminants that resulted from the failure of the New Orleans levee systems.

Data on the recalcitrant hydrocarbon benzo[a]pyrene (BaP) and indicators of potentially infectious sewage waste were gathered and analyzed. We first determined the levels of these contaminants in three different drainage areas (polders) in the flooded city and the trends in changes in their levels as the city was pumped out. The reduced data were provided to the U.S. Army Engineer Research and Development Center (ERDC) environmental modeling group for use as source terms in their corresponding analyses of the distributions and potential impacts

of these contaminants of the environment surrounding New Orleans. This environmental modeling information is presented in a separate report in this volume (Dortch et al., 2006). Further analyses of the chemical contaminants were presented in a separate chemical analyses report in this volume (Bednar et al., 2006). In this report we also present data on these contaminants produced from our own sampling and analysis of the Violet Marsh outside the levee from the Lower Ninth Ward of New Orleans and from the Chalmette area of St. Bernard parish, and discuss potential environmental impacts.

Due to the strategy used to pump out the flooded city and the hydraulic flows resulting from this operation and the levee systems, the flooded city of New Orleans was divided into three separate drainage areas or polders: New Orleans proper, New Orleans East, and St. Bernard Parish and the Lower Ninth Ward. The unified Katrina database of the U.S. Environmental Protection Agency (EPA) and the Louisiana Department of Environmental Quality (LADEQ) database was used to determine the levels of fecal coliforms and BaP in the waters and sediments in each of theses three polders, and changes in their levels as the city was pumped dry. Water fecal coliform counts (colony forming units (cfu) per 100 mL of water) ranged from 100 to 490,000 (mean=21,381, standard deviation=74,541, median=2,200) in New Orleans proper, 10 to 30,000 (mean=3,308, SD=8,093, median=200) in New Orleans East, and 17 to 25,000 (mean=1,287, SD=4,381, median= 100) in St. Bernard Parish and the Lower Ninth Ward polders. The LADEQ primary contact recreational water quality criterion for fecal coliforms is 400 cfu/100 mL. The flood water in all three polders frequently exceeded this standard, and no trend (increasing or decreasing cfu/100 mL) was evident with time as the water was pumped out.

Health advisories were issued during the flood and effects were seen. Of the 10,047 New Orleans patient visits during and immediately after the flooding for which information was available to the Center for Disease Control and Prevention the most common were due to gastrointestinal, acute respiratory and skin infections. Our analysis of the EPA/LADEQ database showed BaP levels in water (μg/L) were all non-detect except one data point at 0.42 μg/L in New Orleans proper. BaP is a hydrophobic organic contaminant that would tend to sorb to sediment particles and settle from the water standing in the city. The EPA Region 6 water quality criterion MCL for BaP is 0.20 which was exceeded by the 1 sample. As a result of our analyses of the EPA/DEQ data we provided the medians and protective 95% upper confidence level values of 70,000, 33,000 and 1,700 cfu/100 mL to the environmental modelers to be used as source term load values for water pumped from New Orleans proper, New Orleans East, and St. Bernard Parish and the Lower Ninth Ward polders, respectively, and non-detects for the medians and 95% upper confidence levels of BaP in each polder.

In order to assess the potential impacts of pumping contaminated water and sediment from the city on local ecosystems the ERDC collected sediment core samples from Violet Marsh, analyzed them for markers of infectious waste and BaP, and attempted to identify sources of these contaminants in the Lower Ninth Ward and the Chalmette area. Undisturbed sediment cores were collected from ditches draining the Murphy Oil Corporation property in Chalmette and the outfall of the New Orleans metropolitan sewage treatment plant over the levee from the Lower Ninth Ward to profile these two potential contaminant sources. Core samples were collected from both the immediate influent and immediate effluent of the pumps that could have transported contaminants from these two sources into Violet Marsh. Sediment core samples were also collected at various distances from these pumps out into Violet Marsh to determine the range of transport of these contaminants into the Marsh. Contaminants in sediments in the top of the cores were used to indicate the most recently deposited contaminants. Sediments in the bottom of the cores were used to indicate contaminants deposited before the failure of the levees.

BaP levels (µg/gm dry weight) in sediments taken from the bottoms of the sediment cores ranged from non-detectable to 11.8 (mean=1.5, SD=3.6, median=0.0). Nine of the 18 sediments from the bottom of the cores exceed the EPA sediment quality criterion (0.062 µg/gdw), and 6 of these 18 exceeded the LADEQ criterion (0.33). BaP levels in top sediments ranged from non-detect to 31.2 (mean=2.8, SD=7.1, median=1.1). The most recently deposited sediment exceed the EPA criterion in 16 of the 18 sediment samples and the DEQ criterion in 14 of the 18 sediment samples. Violet Marsh apparently has had a history of BaP contamination that could have been made worse by the failure of the levees. This BaP contamination appeared to have entered Violet Marsh through Bayou Bienvenue and not through the pumps (e.g., pump #6) that would have removed water contaminated from the Murphy Oil spill.

The potential for the presence of infectious waste was indicated using two different approaches, viable indicator bacteria (total coliform, fecal coliform and fecal streptococci) and fecal sterols. Fecal streptococci exceed the detection limits in only one surface sediment sample (Murphy Oil). All the Bayou Bienvenue surface sediment samples were below the detection levels for all viable bacterial indicators measured. Total coliform and fecal coliform measurements indicated a current input of potentially infectious waste from Chalmette into Violet Marsh. None of the 5 surface sediment samples from Bayou Bienvenue exceeded the 40 CFR 503 Biosolids criterion of 1,000 cfu fecal coliform/gdw. All 12 of the remaining surface sediment samples from the Violet Marsh and Chalmette exceeded this 1,000 cfu fecal coliform criterion.

Fecal sterols provided an alternative means of assessing the impacts of infectious waste derived from fecal material. Coprostanol is formed from cholesterol in the human gut track and is the most abundant sterol (40-60%) in human feces (averaging 3,430 µg/gdw). Environmental scientists have suggested environmental quality criteria ranging from 0.1 – 1.0 nmole coprostanol/gdw. The sedimentary coprostanol levels measured in this study were comparable to those of other sewage impacted wetlands. The coprostanol levels in sediments from the bottom of the cores ranged from non-detect to 61.2 nmol/gdw (mean= 16.9, SD= 23.1, median= 8.0). Fifteen of the 18 sediment samples from the bottom of the cores were greater that the most lenient criterion suggested as 1.0 nmol/dgw. Historically, the Bayou Bienvenue (sewage treatment plant) has been the major contributor of fecal material to the Marsh with the Chalmette pump stations playing a lesser role. The coprostanol levels in sediments from the tops of the cores ranged from 3.0 to 61.3 nmol/gdw (mean= 20.2, SD= 14.4, median= 20.7). All 18 sediment samples from the top of the cores were greater than that of the suggested criterion of 1.0 nmol/gdw. The coprostanol levels in the upper sediment indicated that the operating pumps may have recently contributed relatively more fecal material to the Marsh.

The work presented here starts to provide an objective framework and first impression of some of the most obvious environmental consequences of the failure of the levee system around New Orleans and the subsequent pump out operations. Although the levels of fecal coliform bacteria were frequently high above the regulatory concern level for recreational, these levels are expected abate with distance and time. However, fecal coliform bacteria are not a good predictor of human disease in estuarine water, and we are only beginning to understand the environmental parts of the life cycles of microbial pathogens of humans. The absence of environmental impacts shown from the fecal coliform bacteria data should not be interpreted as an absence of environmental impact. Using our own data we show that Violet Marsh has had a history of fecal and BaP contamination, much presumably coming primarily from the sewage treatment plant that drains into Bayou Bienvenue. The flooding of New Orleans and the subsequent pump out resulted in higher levels of fecal material and BaP in the surface sediments of the Marsh and a wider distribution of these contaminants throughout the Marsh. While the data supported these general conclusions, time and financial constraints required us to make major assumptions, precluded sufficient replicate analyses and minimized the number of Violet Marsh locations sampled and the number of different analyzes performed on each sample. Inclusion of analyses of recalcitrant hydrophobic compounds in addition to BaP would enable more accurate sediment source tracking. Additional analyses are required to remove the uncertainty due to assumptions we made and the minimal statistical design of our Violet Marsh survey, and to better quantify these impacts.

Introduction

IPET Relevance - During the period when New Orleans was flooded and during the period when the flood waters were being pumped out the U.S. Environmental Protection Agency (EPA) and the Louisiana Department of Environmental Quality (LADEQ) collected hundreds of samples of water and sediment and analyzed these samples for a long list of potential contaminants. The flooded area under consideration is the urbanized area on the east side of the Mississippi River, seen north of the River in Figure 1.

Figure 1. Map showing the New Orleans area

Of all the water quality parameters measured only a few stood out as a cause for concern for people coming into contact with water and sediment in the city, or to areas receiving the water as it was pumped out of the city. Elevated levels of bacterial indicators of pathogens derived from sewage were well above the concern levels in many areas of the city, which resulted in special warnings from the EPA and posted on EPA's Katrina website. Petroleum hydrocarbons were also frequently detected. Benzo[a]pyrene (BaP) is a particularly mutagenic polycyclic hydrocarbon (PAH) that was frequently detected in these samples. A major oil spill occurred at the Murphy Oil Corporation in Chalmette when a storage tank slid from its foundation during the flood.

To address our charge of determining the environmental effects of the failure of the New Orleans levee system we focused on several indicators of infectious waste derived from sewage, and BaP. These contaminants were chosen because 1) they were frequently detected above regulatory concern levels in flooded New Orleans; 2) some of these analytes were targeted by EPA and LADEQ in their water and sediment analyses so the data coverage with respect to space (inner regions, near regions and far regions) and time (pre-Katrina and after Katrina) were some of the best available; 3) some of the analytes retain fingerprint type identifying information on sources and processes; and 4) they are contaminants that affect both human and environmental health.

Scope and structure of report - The microbiology portion of the IPET Task 9 Consequences Assessment was included in the Section 3.4 Environmental Subtask. Indicators of changes and levels of selected pathogens and other contaminants in sediment were identified.

Existing data were consolidated. Suggested values and statistics were provided to environmental modelers, and corroborative data was collected to help determine the potential for impacts indicated by microbiological considerations in the environmental consequences of levee failure.

The most urbanized portions of the metropolitan area of New Orleans are protected within the innermost of a complex system of levees. As indicated in Figure 2, the levees radiating from the turning basin in the Inner Harbor Navigation Canal (IHNC) provided a consistent basis to consider the urbanized portions divided into three main polders. This inner ecosystem has historically high levels of urban soil contamination, including metals and PAHs (Mielke et al. 2004). New Orleans proper is considered to be that portion of Orleans Parish west of the IHNC, while New Orleans East is the urbanized area of Orleans Parish east of the IHNC and north of the Intracoastal Waterway leading to the Mississippi River Gulf Outlet (MRGO). The urbanized areas east of the IHNC and south of the Intracoastal Waterway are primarily the Lower Ninth Ward of Orleans Parish and the Chalmette area of St. Bernard Parish. Many of the normal pumps that operate to drain the New Orleans area failed due to the effects of Katrina and the aftermath. The normal operating pumps and the emergency pumps that pumped out flooded New Orleans proper and New Orleans East drain into Lake Pontchartrain. This nearby ecosystem was impacted as discussed in the environmental modeling report in this volume (Dortch et al., 2006).

Figure 2. Map illustrating the drainage areas

Only Pump Stations #3 and #6 operated in the aftermath to drain the flood from the Lower Ninth Ward and Chalmette polder, pumping over the levee into the marsh beyond. Bayou Bienvenue winds through the marsh from the north near the municipal sewage treatment plant. The marshy area east of the levee and west of the MRGO is often accessed primarily by the Violet canal to the south, and is referred to uniformly as the Violet Marsh in this report. This nearby ecosystem was impacted as discussed in the environmental modeling report in this volume (Dortch et al., 2006).

Several further outlying areas, including the Mississippi Sound and the Mississippi River Delta, are likely to have environmental impacts from the levee failures that are more dilute than the nearby ecosystems. These more remote ecosystems are not modeled in this report, and samples were not collected from the remote areas.

Conditions to be considered by task - The Task 9 Consequences Assessment Team envisioned three conditions to comparatively assess: The pre-Katrina conditions, the actual Katrina conditions with levee failure, and the hypothetical Katrina conditions without levee failure. However, this subtask only has data to analyze from pre-Katrina conditions and actual

Katrina conditions. Modeling may predict some of the hypothetical conditions without levee failure.

Regarding the pre-Katrina conditions the soil of the inner ecosystems has been well studied, particularly in a series of studies by Prof. Howard Mielke of Tulane University. The surface waters in the inner ecosystems have been less reported, although the measured concentrations in the Katrina storm water pump-out were reported to be similar to normal rainfall pump-out (Pardue et al., 2005). The Lake Pontchartrain Basin Foundation provided historical water quality data to be used for validating the environmental modeling that established pre-Katrina conditions in Lake Pontchartrain. There was a lack of corresponding published data from Violet Marsh. The sediment data collected for this report was intended to provide a partial remedy for that void. The topmost portion of the collected sediment cores was expected to be the most recently deposited. Sediments in the bottom of the cores were used to indicate levels of contaminants that may have been historically deposited before the failure of the levees. However, to this point the collection and analyses of these sediments have been limited by constraints in funding and reporting time. The data interpretations in this report serve mainly to develop hypotheses which, when warranted, should be tested with more detailed studies using appropriate experimental and statistical designs.

Bacterial indicators of infectious wastes - Prior to 1986 EPA recommended the use of fecal coliform as a water quality indicator to help protect prevent bathers from contracting gastr-ointestinal illness from recreational waters. These bacteria often did not cause illness directly, but demonstrated characteristics that made them useful as indicators of the presence of microorganisms that did cause these illnesses. In 1986 EPA published "Ambient Water Quality Criteria for Bacteria" where they revised their recommendations of indicator bacteria. In this document EPA recommended the use of *Escherichia coil* as an indicator in fresh water and enterococci for both fresh and marine recreational waters. These revisions were based on epidemiological studies conducted by EPA which evaluated the use of several indicator microorganisms. Accidental ingestion of recreational water was the most prevalent exposure pathway. The most common bacterial infections contracted in this way included cholera, salmonellosis, shigellosis, and gastroenteritis. Common viral infections included infectious hepatitis, gastroenteritis, and intestinal disease caused by enterovirus. Protozoan infections included cryptosporidiosis, amoebic dysentery, and giardiasis.

Many federal state, local and tribal organizations were slow to adopt EPA's 1986 guidance so EPA published an "Implementation Guidance for Ambient Water Quality Criteria for Bacteria" in 2002 (Draft) (EPA 2002) to assist these organizations in implementing the 1986 recommendations. The amendment to the Clean Water Act known as the Beaches Environment Assessment and Coastal Health (BEACH) Act required coastal and Great Lake states to have adopted EPA recommended water quality criteria by April 2004. The National Academy of Science's National Research Council (NRC 2004) recommended that the current use of indicator microorganisms be supplemented with the use of a tool box of microbiological, molecular biology and analytical chemistry techniques to better enable the protection of public health as mandated by the Clean Water Act and the Safe Drinking Water Act. Regulatory criteria are expected to transition from earlier indicator-based measurement to more direct and defensible criteria. This shift is reflected in the EPA document "Standardized Analytical Methods for use

During Homeland Security Events" (EPA 2004) where microbial indicators are used in the early stages (Triage and Screening) of a response, and methods that can provide more quantitative information with respect to microbial risk assessment (ILSI, 2000) are to be used in the Determination stage of the response.

Use of fecal sterols as indicators - In many circumstances microbial indicators are not suitable for determining fecal pollution. The use of fecal coliform as indicators in tropical waters was shown to be particularly problematic because some indicators may grow in such waters (Isobe et al., 2004). Studies of runoff from New Orleans into Lake Pontchartrain have shown that many indicator bacteria are associated with particles in the water column and quickly settle to the sediment where resuspension of the shallow waters serves as a secondary source (Jin et al., 2004). Logistical constraints are imposed by the fact that samples can not be stored for long periods of time before culture and analysis. Live bacterial indicators do not persist over long periods of time in the environment so it is not possible to reconstruct historic records of previous impact using this approach. Because many animals produce fecal bacterial markers in addition to humans and contribute them to the environment, it can be difficult to distinguish different sources of environmental fecal contamination using these markers.

Biochemical markers such as fecal sterols offer important advantages in selected applications. The average human excretes 0.2 – 1.0 g coprostanol per day (Walker et al., 1982). Coprostanol comprises 4-60% of excreted fecal sterols and averages 3.43 mg/gram dry weight of feces (Nichols et al., 1996). Coprostanol is produced from the hydrogenation of cholesterol by bacteria in the digestive system (Eneroth et al., 1964; Murtaugh and Bunch, 1967). In aerobic water columns coprostanol is microbially degraded and half-lives of <10 days at 20^{o} C have been reported (Ogura, 1983). However, coprostanol like other fecal sterols is hydrophobic and associated with particulate matter in sewage and water columns (Takada et al., 1994). Coprostanol is readily incorporated into bottom sediments, where it has been shown to persist under anaerobic conditions without significant degradation for over 450 days at 15^{o} C (Nishimura and Koyama, 1983). Coprostanol can serve as a useful biochemical marker for determining current and long term inputs of fecal matter to aquatic systems (Arscott et al., 2004). Based on surveys of rivers in the United States and Canada, environmental scientists have recommended three different environmental quality criteria for coprostanol; 40 ppb (1.0 nmol/gdw; Kirchmer, 1971), 20 ppb (0.52 nmol/gdw; Murtaugh and Bunch, 1967), and 0.5 ppb (0.13 nmol/gdw; Dutka et al., 1974).

The same GC/MS analysis used to determine levels of coprostanol can produce data on other fecal sterols and non-fecal sterols. The resulting sterol profile can provide additional useful information on the nature of the fecal pollution (Leeming et al., 1996). Ratios of coprostanol to cholesterol that are greater than one have been used as an indicator of fecal contamination in aquatic systems. Figure 3 illustrates the formation processes and transformations of several fecal sterols. The formation of epicoprostanol is favored in sewage treatment plants and the ratio of epicoprostanol to coprostanol has been suggested for use as an indicator of input of treated sewage relative to untreated sewage. Although coprostanol is directly formed in the human gut by the bacterial reduction of cholesterol, it can also be formed under environmental conditions in a multi-step process where cholestenone is an intermediate. The $5\beta/(5\beta+5\alpha)$ cholestan-3-one ratio has been recommended for use in highly productive aquatic systems with relatively low levels of coprostanol (Grimalt et al., 1990).

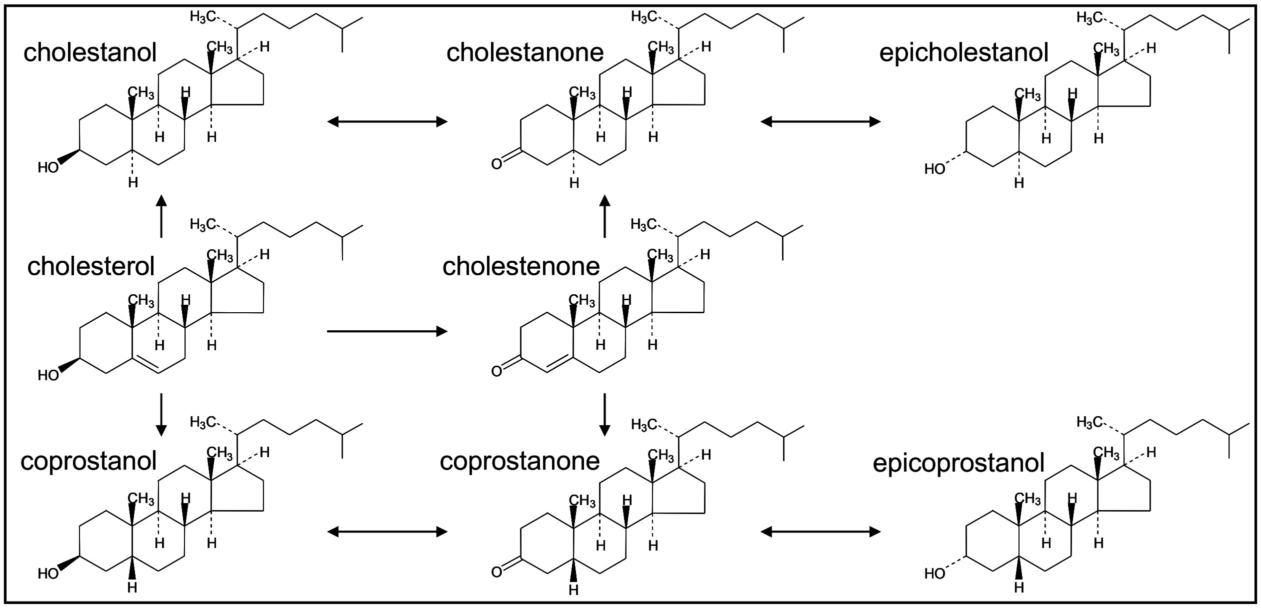

Figure 3. Structures and transformation pathways of some fecal sterols

Benzo[a]pyrene as hydrocarbon tracer - BaP is one of the 16 EPA designated priority pollutant polycyclic aromatic hydrocarbons (PAH; EPA Method 8310). It is a 5-ring PAH with a molecular weight of 252 u. and, due to transformation products formed during liver metabolism, it is the most carcinogenic known of the 16 (Irwin et al., 1997). Depending on the relative levels, much of the regulatory concern from total PAH contamination often devolves upon the BaP. Usually the other PAHs are assigned BaP equivalency factors for the purposes of toxicity assessments. There over 100 PAHs commonly found in environmental samples. These PAHs are all hydrophobic and recalcitrant, with heavier PAHs being more hydrophobic and recalcitrant.

Many other hydrocarbons are found along with PAHs. Usually the most common petroleum hydrocarbons are gasoline range alkanes with 6 to 12 carbons, diesel range alkanes with 12 - 28 carbons, and lubrication oil range with 28 - 36 carbons. Many of the lower molecular weight alkanes are volatile, and most are amenable to microbial degradation in various environmental media. Thus, recalcitrant hydrocarbons such as PAHs can serve as longer term indicators of petroleum hydrocarbons, or more generally, industrial activity.

BaP occurs with several other 5-ring PAHs with a molecular weight of 252. Figure 4 shows a portion of the raw GC/MS data, selected ion 252, from a Violet Marsh sediment sample with a relatively low BaP value of 0.76 µg/gdw. Of the six 5-ring PAHs with molecular weight 252 shown, BaP is the fifth one, near retention time 33.1 minutes. These PAHs all have simple mass spectra with strong molecular weight base peaks.

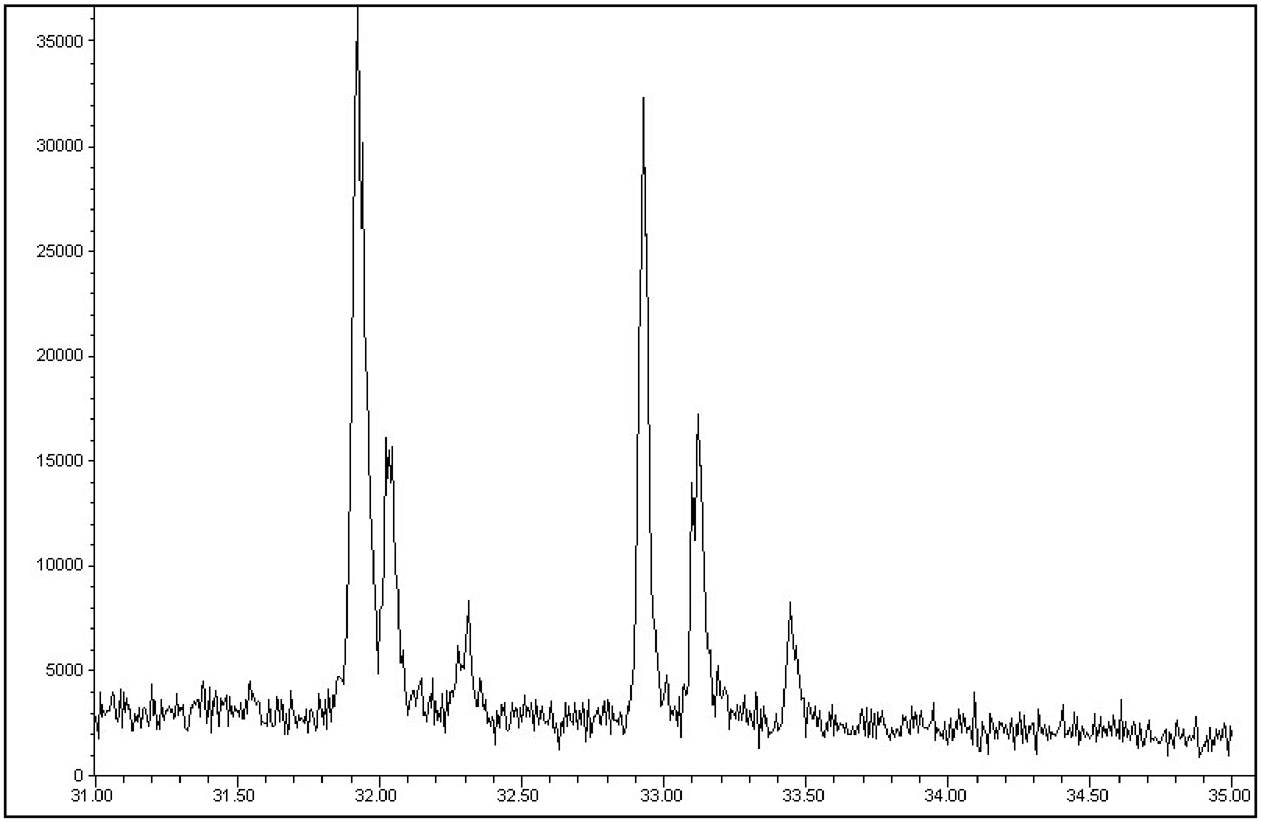

Figure 4. Selected ion (m/z=252) chromatogram of Violet Marsh sediment extract.

The proper aromatic Simplified Molecular Input Line Entry System (SMILES) description of the linked BaP molecule is c1\cc2\cc/cc3ccc4cc5ccccc5c1c4c23. The BaP structure is shown in Figure 5. The environmental recalcitrance and the lack of daughter ions in the mass spectra are due to the visibly highly aromatic structure.

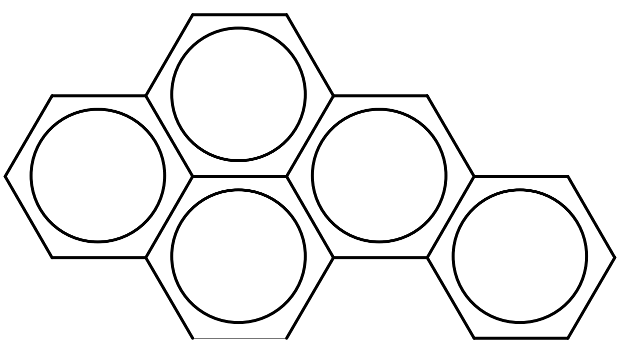

Figure 5. Aromatic structure of benzo[a]pyrene

Like all PAHs, BaP is seldom of concern for acute exposure. The chronic effects of long term exposure to metabolic products are the toxicological problem. Specifically, the cytochrome P450 system produces the ultimate carcinogen (+)-7R,8S-dihydroxy-9S,10R-epoxy-7,8,9,10-tetrahydro-benzo[a]pyrene (Chang et al. 2006). This product intercalates with DNA and causes errors in transcription (Kang et al. 2005).

Due to the hydrophobicity of BaP (log $K_{OW} > 6$), very little is ever present in water. The EPA Region 6 water quality criterion MCL for BaP is 0.20 µg/L. BaP preferentially binds to the organic carbon in solids such as sediments. The EPA Region 6 residential soil screening level for BaP is 62 µg/kg. The applicable LADEQ criterion is 0.33 µg/g.

BaP New Orleans data - Mielke et al. 2001 found that pre-Katrina levels of BaP in New Orleans city soil ranged from 52 to 6102 µg/kg, and found in agreement with other studies that PAHs in runoff sediments were higher than in the soils. In this context the flooded city of New Orleans acted as a BaP source to the local environment as the water was pumped out of the city.

Because the levees failed in multiple areas, all three polders were deeply flooded at about the same time with brackish storm surge water, Lake Pontchartrain water, and Mississippi River water. The depth of flooding can be envisioned from the U.S. Army Corps of Engineers map from the New Orleans District Figure 6 and was up to 20 feet in isolated spots. The flood water remained for weeks. The three polders behind their levees, after they were patched, became three separate contaminant sources for nearby ecosystems. New Orleans proper and New Orleans East were pumped into Lake Pontchartrain, and the Lower Ninth Ward and Chalmette area were pumped into Violet Marsh. Some of the sediment was entrained and pumped out with the water, and more was flushed out with other runoff.

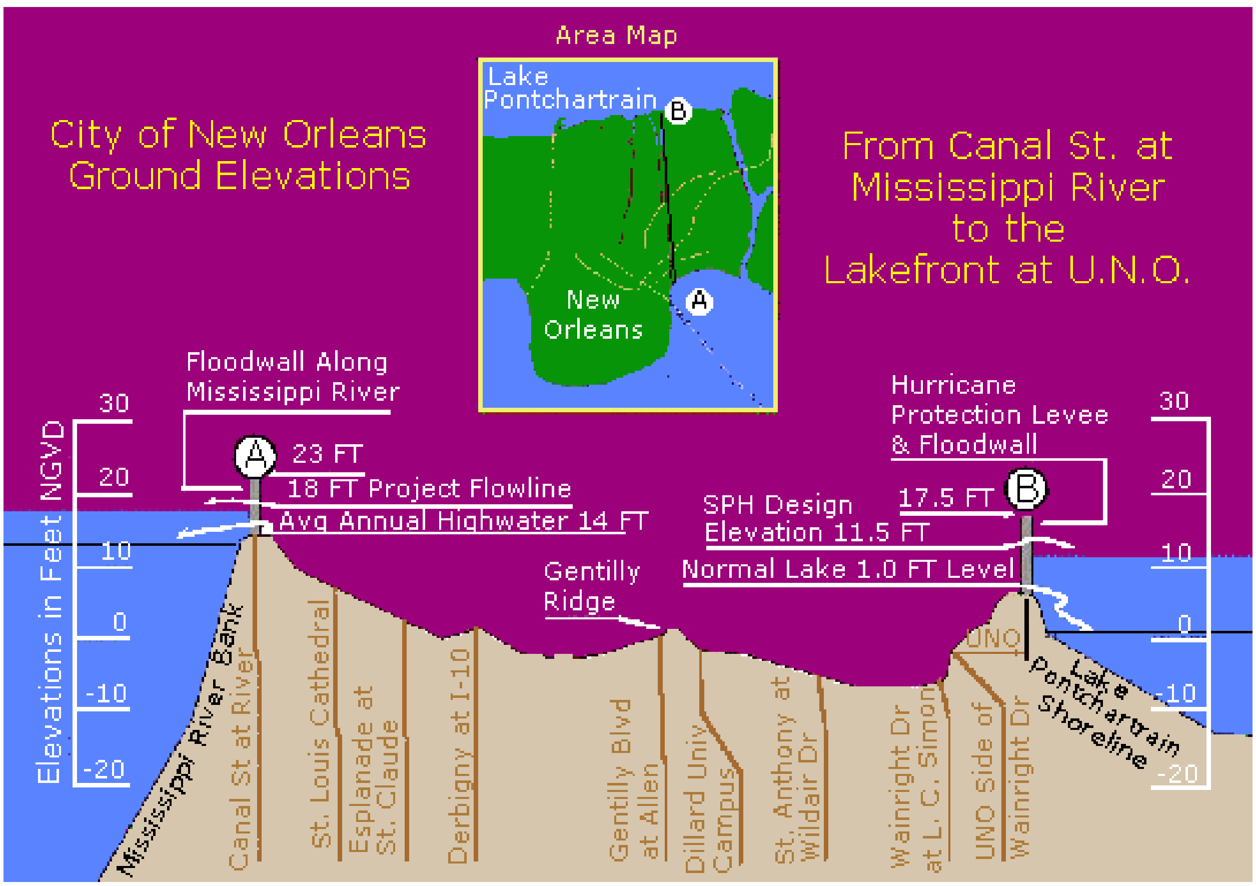

Figure 6. Cross section of New Orleans proper showing elevations

It is thought the storm surge up the Mississippi River Gulf Outlet (MRGO) and the elevated Lake levels provided the hydrological force for most of the levee breaches. The subsided New Orleans area quickly flooded. Many of the details of the flooding and flows have been modeled in Corps of Engineers reports.

Some of the major sources of contamination in New Orleans proper included the contaminated urban soil and structures (Mielke et al. 2004). The flooded New Orleans East area is heavily industrialized. In Chalmette at least one entire oil storage tank at the Murphy Oil Corporation site was breached and completely failed, and the entire site was flooded. Near the Lower Ninth Ward, over the levee by Bayou Bienvenue, the main New Orleans area sewage treatment plant was flooded, damaged, and inoperable for weeks. The Corps of Engineers began to pump out the flood water, and the final flood water was declared pumped out on October 11, 2005. This flood water provided a nearly steady state source of contamination to nearby ecosystems. The hydrological flows and transport processes of the pumping out are treated in detail in the environmental modeling report in this volume.

The U.S. EPA and the LADEQ conducted extensive measurement operations throughout the flooded urbanized New Orleans area from September through December 2005. Louisiana State University (Pardue et al., 2005) and Texas Tech University (Presley et al., 2006) led independent sampling expeditions in flooded New Orleans, principally in limited parts of New Orleans proper. They reported on a greater variety of contaminants over a more limited area than the EPA data. The data sources used in this report are summarized in Table 1.

Table 1
Sources of information used for chemical microbiological analyses

	Inner Region		Nearby Regions			
Region:	Urban		Violet Marsh		Lake Pontchartrain	
	Infectious	Chemical	Infectious	Chemical	Infectious	Chemical
Condition:						
Pre-Katrina	Inferred and anecdotal Fecal sterols-core bottoms	Mielke, 1999 BaP from core bottoms	Fecal sterols-core bottoms	BaP from core bottoms	LPBF - coliform	LPBF-WQ data
Actual Post-Katrina	EPA database Tot. Colif. -core tops Fec. Coilf. -core tops Fec. Strep. -core tops Fecal sterols-core tops	EPA database BaP-core tops	Tot. Colif. -core tops Fec. Coilf. -core tops Fec. Strep. -core tops Fecal sterols-core tops	BaP-core tops	LPBF - coliform	LPBF-WQ data

Experimental Methods

ERDC Sediment Sampling - As part of the Environmental Subtask the ERDC conducted a sampling trip 14-16 February 2006 to Violet Marsh outside the polder of the Lower Ninth Ward and the Chalmette area, using an airboat to access the Marsh. The ERDC metals fabrication shop modified a commercially available stainless steel (SS) soil coring device for the purpose of retrieving undisturbed sediment cores from wetlands (Figure 7). The SS coring device consisted of three SS parts: the main part was the cylindrical coring tube with dimensions of 4.25” outside diameter (o.d.) and 4.00” inside diameter (i.d.), and 11.625” length. Attached to the bottom of the coring tube was a fitted, lock-in-place, stainless steel ring with protruding cutting teeth with dimensions of 4.25” o.d., 4.00” i.d., and 1.5” in length. This piece acted both as the cutting part of the tube and as the securing ring for holding an autoclaved acrylic coring sleeve in place within the SS coring tube. The third component of the coring tube was a SS disk that measured 0.35” in thickness and 3.87” in diameter that rested on top of the acrylic core sleeve within the coring tube. This disk was held in place by two screws set into the rim of the top of the coring tube that protruded approx 0.125” into the interior of the coring tube.

Figure 7.Sediment coring device

The coring tube was gently pushed down into the sediment over the course of a minute using the ratcheting “T-bar” handle. The teeth cut in the direction of ratcheting. The coring continued until the sediment reached the disk, and then the coring tube was brought up into the airboat, or up onto dry land where the cutting ring was removed and the acrylic core containing the sample was allowed to slide partway out of the coring tube (Figure 8). Immediately a plastic cap was secured onto the bottom of the acrylic core sleeve to cover and protect the core sample material inside. Once the bottom cap was secure, the acrylic core sleeve was then allowed to slide fully out of the SS coring tube and was sat upright onto a flat surface. The SS disk was then removed from the top of the acrylic core sleeve where it had acted as a temporary cap to prevent the loss of material, and a second plastic cap was placed on top of the core sleeve to enclose the sediment sample. The secured sample was then placed on ice into a cooler and transported to ERDC after all samples had been collected.

Figure 8. ERDC Team in Violet Marsh

The coring tube, cutting ring, and SS disk were then scrubbed in water with a brush to free them of any remaining sediment, and the insides and outsides were sprayed with a 99% Isopropyl alcohol solution for disinfection and allowed to air dry for a minute after there was no visible liquid alcohol residue. Then a fresh autoclaved acrylic sleeve was placed into the interior of the coring tube, the SS disk was positioned on top of the sleeve within the inside of the coring tube, and the cutting ring was secured to the bottom of the coring tube in preparation for the next core sample to be taken.

In the ERDC Environmental Microbiology laboratory ice cold cores were placed in chemical fume hoods and the top caps were removed from the acrylic cores. The first 5 cm were aseptically removed from the top of each core (Figure 9) and thoroughly mixed with a sterile spatula. Separately the lowest 5 cm were aseptically removed from the bottom of each core and mixed. Portions of this homogenized sediment were frozen and aliquots set aside for the various physical, chemical and microbiological analyses. Dry weights were determined by drying an aliquot in the hood in ambient air for a day.

Figure 9. Removing and weighing sediment

Bacterial indicators of pathogens in sewage - Microbiological analyses for total coliform (SM 9222-D), fecal coliform (SM 9222-D) and fecal streptococci (SM 9230-C) were performed on sediment samples using standard microbiological methods (Standard Methods, 2005).

Benzo[a]pyrene and fecal sterol analyses - Fecal sterols and polycyclic aromatic hydrocarbons were extracted from sediment samples using the methods described in Ringelberg et al. 2001. All glassware was solvent washed and treated in a muffle furnace before use. Sterol standards were purchased from Sigma-Aldrich, Co. (coprostanol, 5ß-cholestan-3ß-ol; epicoprostanol, 5ß-cholestan-3α-ol; ß-sitosterol, 24-ethylcholest-5-en-3ß-ol; stigmastanol, 24-ethyl-5α-cholestan-3ß-ol) and Applied Science Labs, State College, Pa. (coprostanone, 5ß-cholestanone; cholesterol, cholest-5-en-3ß-ol; campesterol, 24-methylcholest-5-en-3ß-ol). An 11g aliquot (wet weight) of sediment was weighed out, and a known amount of deuterated pyrene was mixed into the wet sediment to serve as a recovery standard. A mixture of dichloromethane:methanol:water (1:2:0.8, v:v:v) was added to the sample. The sediment sample was then extracted for 1 hour in an ultrasonic water bath at 10 ^{o}C , and then allowed to stand overnight. Equal volumes of dichloromethane (DCM) and water were added to break the liquid phases and the entire volume was centrifuged at 5000 rpm for 10 minutes. The DCM phase containing the total extractable lipids was recovered using a glass pipette. The DCM was reduced in volume under a stream of dry nitrogen to approximately 100 µL and then brought to a final volume of 2 mL with clean DCM. A subsample (100 µL) of this total lipid extract was derivatized using trimethylchlorosilane for fecal sterol analysis.

Fecal sterols and BaP by GC/MS were determined using slight modifications to the standard method proposed by the Florida Department of Natural Resource Protection (1998). After TMS derivatization fecal sterol samples were analyzed using a gas chromatograph equipped with a 60 m x 0.25 mm (ID) DB-5MS capillary column (0.1 µm film thickness, J&W Scientific, Folsom, CA) and a Mass Selective Detector (Hewlett Packard GC6890-5973). Peak identities were confirmed by comparing retention times and fragment ion masses (with electron impact ionization at 70 eV) to standards and the NIST MS database. Areas under the peaks were converted to concentrations, corrected to the efficiency of recovery of the deuterated pyrene and then normalized to the gram dry weight of the wet aliquot extracted. Ion mass patterns were used to confirm the identities of the benzo[a]pyrene and sterol GC peaks.

The recovery efficiency of the deuterated pyrene was very consistent and low ~30%. All BaP and fecal sterols levels were corrected to each sample's deuterated pyrene recovery. The lower limit for quantization (LLQ) of BaP was determined by adding an extra 0.1 µg/gdw of BaP to three different sediment samples. The LLQ was measured as 3 times the standard deviation of these matrix spikes. The lower limit of detection (LLD) was determined as 3 times the standard deviation of the noise in blanks. The BaP LLQ for these samples and this analysis system was 0.067 µg/gdw and the LLD was 0.009 µg/gdw. Both the LLQ and LLD for the fecal sterols were 0.1 nmol/gdw.

Results

Mining the EPA/LADEQ data - The microbiological raw data downloaded from EPA's STORET Katrina Central Data Warehouse (http://oaspub.epa.gov/storetkp/dw) for Orleans and St. Bernard parishes are in Appendix A. These data included 139 water and 569 sediment sampling results in Orleans and St. Bernard parishes, with sampling dates from 10 September 2005 to 20 November 2005. Some of the samples were taken outside the polder areas. Values were reported as non-detects or present non-quantitated for 19 water and 406 sediment samples in the polders. There were several analytical procedures reportedly used. The sample quantitation limits (SQL) were not reported. The sediment fecal coliform units were erroneously reported in cfu per 100 mL, as for water, instead of the correct cfu/g (EPA 2004b).

All of the EPA/LADEQ Katrina flood water and sediment sampling sites in Orleans and St. Bernard parishes are marked in Figure 10 by green stars. This figure was produced by EPA's EnviroMapper utility.

These sampling points were distributed into three main drainage areas or polders, as defined by the system of levees radiating from the turning basin in the Inner Harbor Navigation Canal, illustrated in Figure 11. New Orleans proper was considered to be that portion of Orleans Parish west of the IHNC, while New Orleans East was the urbanized area of Orleans Parish east of the IHNC and north of the Intracoastal Waterway leading to the Mississippi River Gulf Outlet. The urbanized areas east of the IHNC and south of the Intracoastal Waterway were primarily the Lower Ninth Ward of Orleans Parish and the Chalmette area of St. Bernard Parish. The EPA/LADEQ sampling points which correspond to each polder are given in Appendix B.

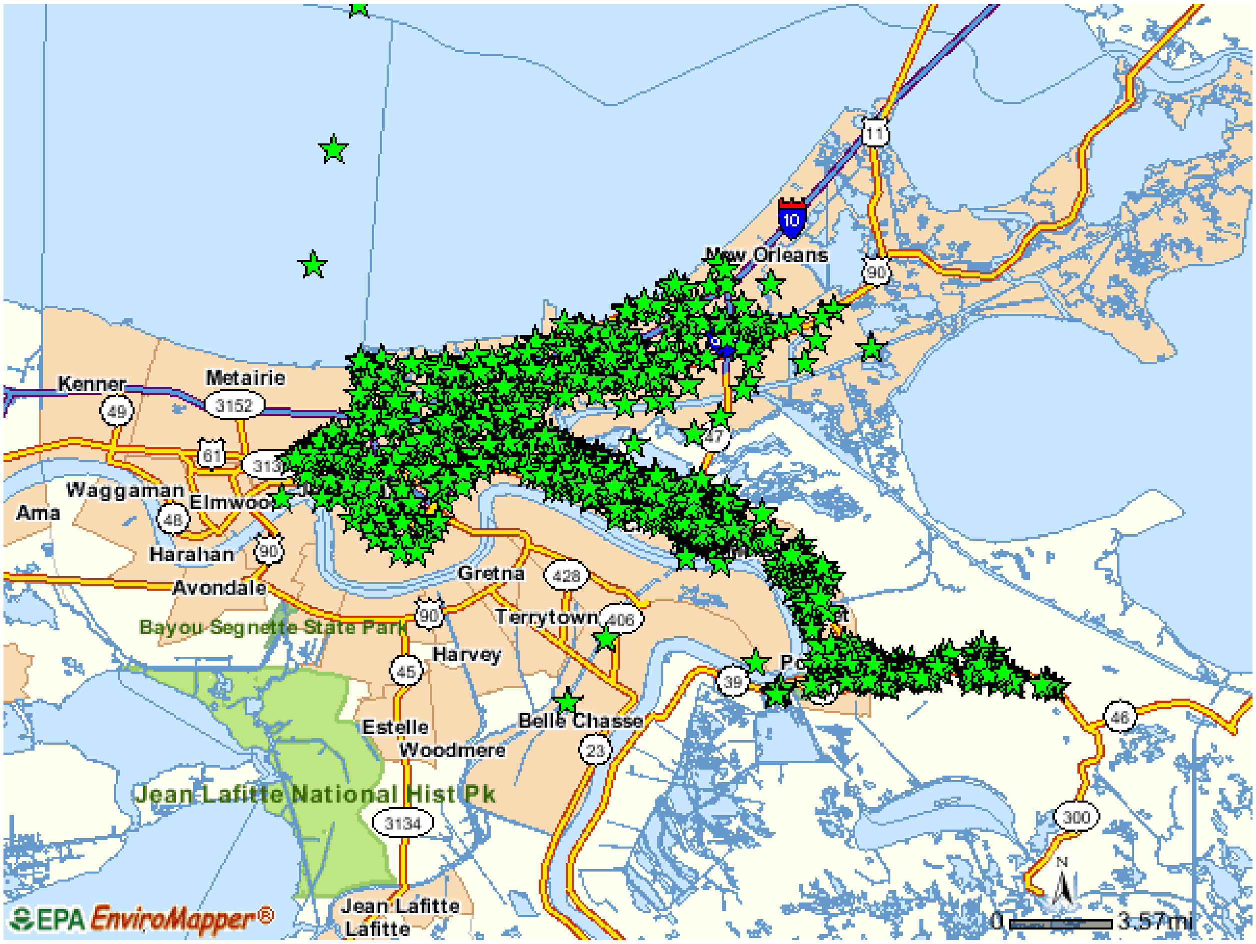

Figure 10. Map showing location of EPA samples in Orleans and St. Bernard Parishes

EPA/LADEQ summary statistics - EPA/LADEQ water fecal coliform counts (colony forming units per 100 mL of water) ranged from non-detect to 490,000 (mean 21,381, median 2,200, standard deviation 74,541) in New Orleans proper, non-detect to 30,000 (mean 3,308, median 200, SD 8,093) in New Orleans East, and non-detect to 25,000 (mean 1,287, median 100, SD 4,381) in St. Bernard and the Lower Ninth Ward polders. EPA/LADEQ sediment fecal coliform (cfu per gram dry weight of sediment) ranged from non-detect to 996,260 (mean 31,645, median non-detect, SD 116,783) in New Orleans proper, non-detect to 416,250 (mean 9,980, median non-detect, SD 47,327) in New Orleans East, and non-detect to 1,115,800 (mean 30,196, median non-detect, SD 119,808) in St. Bernard and the Lower Ninth Ward polders. The polders had different values which could be described statistically.

EPA's STORET Katrina Central Data Warehouse yielded 295 flood water measurements of BaP, with 294 non-detects. The sole detect was 0.42 µg/L. There were 1,110 sediment samples tested for BaP, ranging from non-detect to 35,500 µg/kg, with 894 non-detects. 152 samples exceed the EPA screening standard. The flood sediment in all three polders frequently exceeded the standard. Further analyses of the chemical contaminants in the EPA/LADEQ database is presented in a separate report in this volume (Bednar et al., 2006).

Statistical distribution parameter estimation - For randomly diluted samples a lognormal distribution was expected, in the same way that a normal distribution was expected for randomly additive samples. To develop a lognormal fit to the data, the natural logarithm of each data point, plus an irrelevant small constant offset if there were to be zero or negative data, was calculated and these logarithms were binned. The size of the bins was judiciously chosen to have sufficient data points as well as sufficient resolution. The resulting histogram of the logarithms was then fit by a Gaussian curve. The parameters for curve height, width and location (and offset) were chosen by a global least squares minimization for goodness of fit.

As illustrated in Figure 11 for sediments, the data without the non-detects was indeed roughly lognormal ($r^2 = 0.70$). For a lognormal distribution the 95% UCL is defined (EPA 1992) as

$$95\%\ \ \mathrm{UCL} \equiv e^{\left(\frac{s^2}{2} + l + \frac{h \cdot s}{\sqrt{n-1}}\right)}$$

where n is the number of data points, *l* is the average of the logarithms of the data (with offset), s is the standard deviation of the logarithms, and h is Land's h statistic. Tables of the h statistic have been compiled (Gilbert 1987) and values are also available through commercial software packages.

For further analyses and inclusion into a lognormal distribution, the non-detects cannot be taken to be zero, and in practice were assumed to be on average at half the SQL (EPA 1992). As seen in Figure 11 for the sediments, the large number of non-detects cause another histogram peak at half the SQL. This bimodal distribution could not in general be well fit by any unimodal distribution such as the lognormal, and thus the calculations of distribution-based parameters such as the 95% UCL were much less meaningful for the bimodality reflected in the data. Even simpler parameters such as mode, standard deviation and median are much less useful in describing nonunimodal distributions.

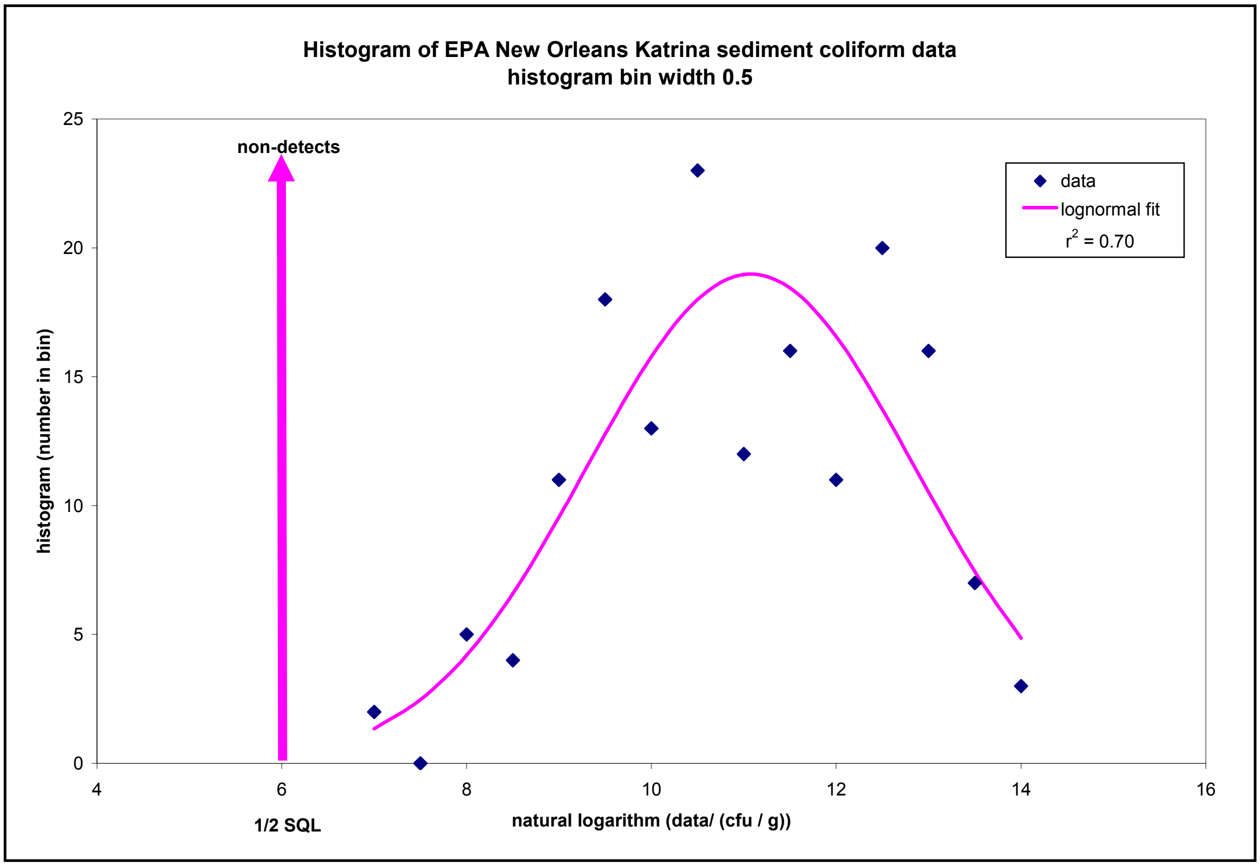

Figure 11. Bimodal historgram of EPA Katrina sediment data

Temporal trend analyses - No trend (neither increasing nor decreasing) was evident with time for the EPA/LADEQ microbiological water data as the flood water was pumped out and then after flood pumping ceased on October 11. As seen in Figure 12, the fecal coliform data were uncorrelated ($r^2 = 0.012$) with time. The data in neither of other polders were correlated with time. In particular they did not decrease.

The half lives of fecal coliform in New Orleans surface waters are of the order of a couple of days at most (Davies et al. 1995). Thus, that the fecal coliform did not decrease suggested that the post-flood sewage system was not properly operational throughout the time the data was collected. Many of the data frequently exceeded the primary recreational water standard of 400 cfu/100 mL; 53 of the 139 data points exceeded the standard.

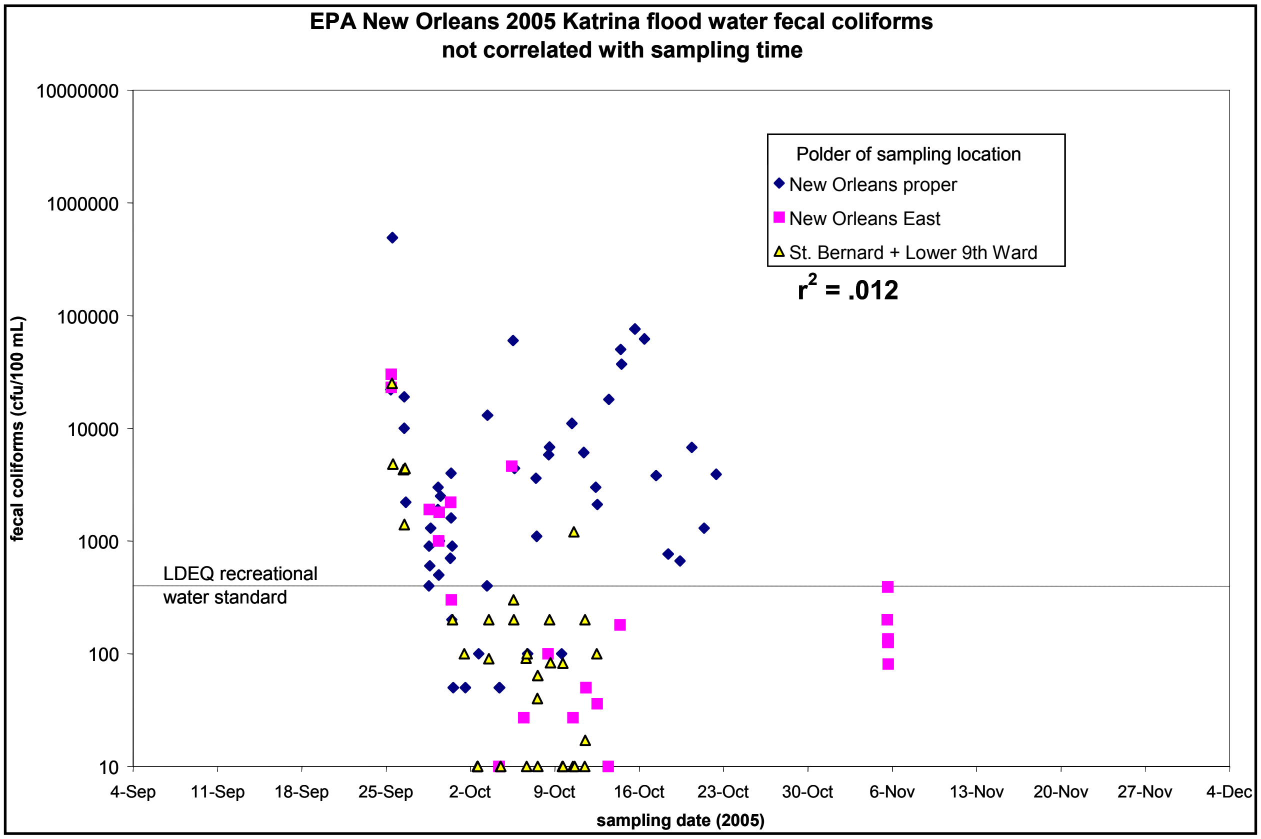

Figure12. EPA New Orleans 2005 Katrina flood water fecal coliforms vs sampling time

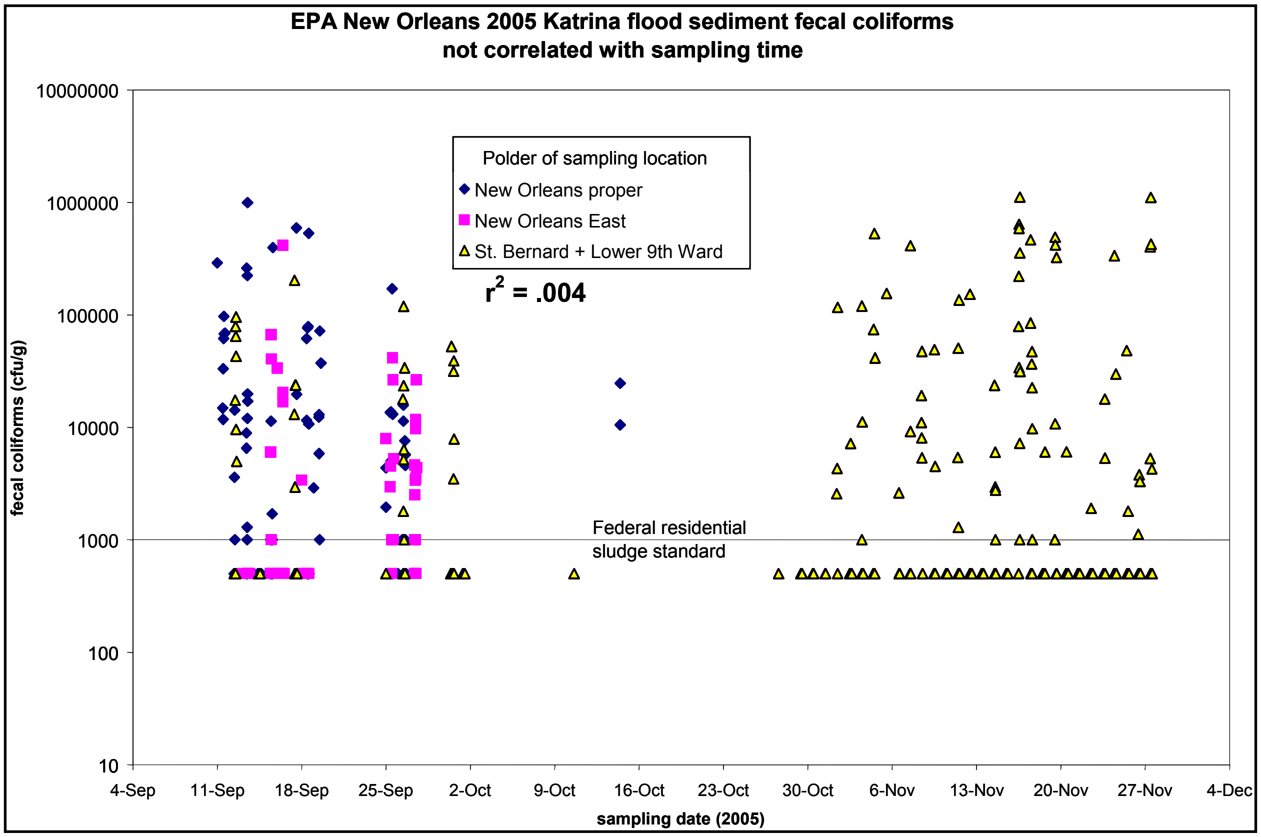

Figure 13. EPA New Orleans 2005 Katrina sediment fecal coliforms vs sampling time

Similarly no trend (neither increasing nor decreasing) was evident with time for the EPA/LADEQ microbiological sediment data as the flood water was pumped out and then after flood pumping ceased on October 11. As seen in Figure 13, the fecal coliform data were uncorrelated ($r^2 = 0.004$) with time. The data in neither of the other polders were correlated with time. In particular they did not decrease.

The half lives of fecal coliform in New Orleans surface sediments are of the order of a couple weeks at most (Burton et al. 1987). Thus, that the fecal coliform did not decrease suggests that the post-flood sewage system was not properly operational throughout the time the data was collected. Many of the data again frequently exceeded the federal residential biosolids standard of 1000 cfu/g; this standard was exceeded by 162 of the 569 EPA Katrina sediment samples from Orleans and St. Bernard parishes.

Data reduction for environmental modeling - As part of the microbiological data mining products, suggested values and statistics were provided to the environmental modeling team. The lack of temporal trend meant that single characteristic values could be used for the entire modeled time. The selected statistics were the medians and the 95% UCL as presented in Table 2.

Table 2
Microbiological values for environmental modeling

all values in cfu / 100 mL	New Orleans Proper	New Orleans East	St. Bernard + Lower 9th Ward
sediment median, neglecting nondetects	**14200**	**9700**	**23800**
sediment median, 1/2 SQL = 500	**500**	**500**	**500**
sediment 95% UCL, neglecting nondetects	**164000**	**55000**	**244000**
sediment 95% UCL, 1/2 SQL = 500	**87000**	**7200**	**334000**
water median, neglecting nondetects	**3600**	**200**	**200**
water median, 1/2 SQL = 50	**2200**	**200**	**100**
water 95% UCL, neglecting nondetects	**41000**	**43000**	**7200**
water 95% UCL, 1/2 SQL = 50	**70000**	**33000**	**1700**

ERDC Sediment Core Locations - Sediment core sample locations were selected to capture potentially major primary contaminant sources located at Murphy Oil Corporation, and the municipal sewage treatment plant. Some samples were collected as close to these sources as possible. Canals drain the Murphy Oil property and conduct water to the large stationary pumps that pumped the water over the levees. Core samples were collected from both the immediate influent and immediate effluent of the pumps that could have transported contaminants from these two sources into Violet Marsh. Sediment core samples were also collected at various distances from these pumps out into Violet Marsh to determine the range of transport of these contaminants into the Marsh. All locations from which ERDC collected core samples were are shown in as yellow circles in Figures 14 and 15 and the GPS coordinates of these sites are given in Table 3. Almost all the ERDC sites are outside the inner urban levees. A few of the nearby EPA sampling sites are shown in red circles for visual comparison. Almost all the EPA sites are inside the inner urban levees.

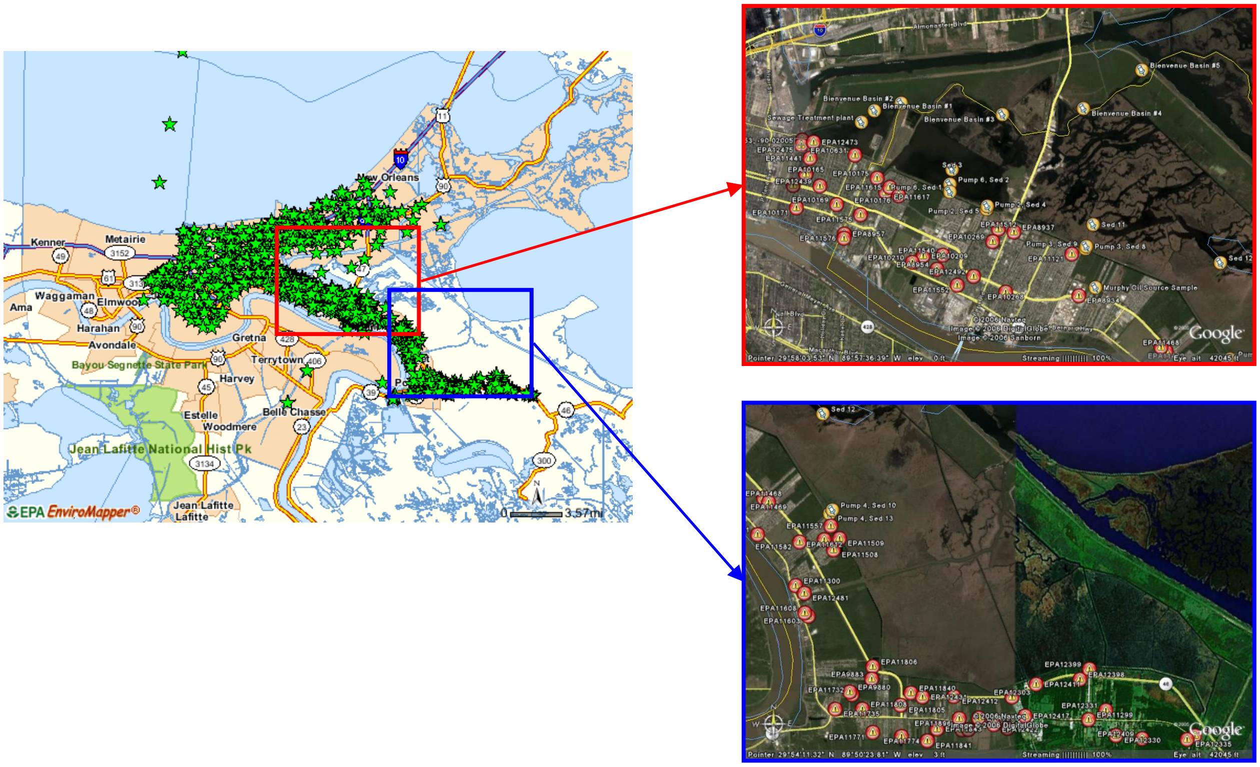

Figure 14. Locations of ERDC core samples and relation to EPA samples

Figure 15. The ERDC locations in more resolution

Table 3
The ERDC sampling locations descriptions

Sample Name	Latitude	Longitude	Description
Sewage Plant	29.984166	-90.001866	Northwest of treatment plant in marsh
Murphy Oil Site	29.940866	-89.931083	Munster Ln, North of Judge Perez, intersection of drainage canal running N.W.
Pump 2 Sed 4	29.961400	-89.963983	Before pump #2
Pump 2 Sed 5	29.962183	-89.963783	After pump #2
Pump 3 Sed 8	29.951633	-89.933833	After pump #3
Pump 3 Sed 9	29.951050	-89.934100	Before pump #3
Pump 4 Sed 10	29.922100	-89.890416	After pump #4
Pump 4 Sed 13	29.921133	-89.891266	Before pump #4
Pump 6 Sed 1	29.965925	-89.975072	Before pump #6
Pump 6 Sed 2	29.967916	-89.975088	After pump #6
Sed 3	29.971766	-89.974433	Due north of pump #6, middle of marsh
Sed 11	29.957350	-89.931783	NNE of pump #3, middle of marsh
Sed 12	29.947333	-89.893266	Due north of pump #4 middle of marsh
Bienvenue Basin 1	29.987200	-89.997950	adjacent to treatment plant areator within discharge canal
Bienvenue Basin 2	29.989166	-89.989816	beginning of treatment plant discharge canal
Bienvenue Basin 3	29.986166	-89.959183	towards the end of treatment plant discharge canal
Bienvenue Basin 4	29.987733	-89.934683	north shore of marsh between discharge canal and intracoastal waterway lock
Bienvenue Basin 5	29.997783	-89.917000	adjacent to intracoastal waterway canal lock

Fecal Bacteria Indicator Culture Data – Sediment cores were transported back to the Vicksburg laboratory on ice and samples from the top 5 cm from each were taken as previously described and analyzed using the Standard Methods Most Probable Number Analyses for total coliform, fecal coliform and fecal streptococci (Table 5). Samples from the bottoms of these cores were not analyzed because these fecal bacteria were not thought to be able to survive for extended periods of time in sediments. Fecal streptococci are the indicators currently recommended by the EPA for estuarine and marine systems, but no sediment quality standards were currently recommended. Only one fecal strep sample from the top of the Murphy Oil drainage canal produced a reading that was above the lower detection limit of the analysis. In contrast, all the total coliform analyses except those from the two outermost samples of Bayou Bienvenue produced moderate to high counts. The highest coliform values were not at the sewage treatment plant outfall but from the Murphy Oil drainage canal and locations indicating input from Chalmette into Violet Marsh. Fecal coliform counts exceeded the standard for biosolids set by 40 CFR 503 (1000 cfu/gdw) for all sample locations except the sewage treatment plant and all samples from the Bayou Bienvenue. The reason for relatively low total and fecal coliform bacteria in these locations was not clear but may be biological (i.e. not just due housing location or dilution) via inhibition of bacterial growth by co-occurring chemical contaminants and/or active coliphage (not measured) activity in these chronically polluted areas.

Fecal sterol data – Coprostanol levels in the tops and bottoms of almost all cores collected indicated significant historic and recent fecal impacts on Violet Marsh (Table 6). These levels are comparable to those in heavily sewage impacted marshes in Barcelona, Spain and Havana, Cuba (Table 7). Analysis of the sterol content from the bottom of the cores provided some insights into the input of fecal matter into Violet Marsh before Katrina struck (Table 6). In these earlier deposited sediments the levels of coprostanol were highest in the two most western sampling stations in the Bayou Bienvenue; BB1 (61.2 nmol/gdw) and BB2 (87.8 nmol/gdw). Coprostanol levels rapidly decreased with distance to the east (BB3-5; 3.4-6.0 nmol/gdw). Together, these data suggested the sewage treatment plant (or other source in this area) constituted a major long-term source of fecal contamination but the distribution of this fecal material into Violet Marsh was rather limited. High to moderate levels of coprostanol were found in the bottom of the core taken closest to the sewage plant outfall (20.3 nmol/gdw) and pump stations #2 (32.8 nmol/gdw), #3 (12.6 nmol/gdw) and #6 (8.0 nmol/gdw), indicating a long-term source of fecal contamination from these sources. It is important to note that almost all of the sediments analyzed exceeded the most lenient coprostanol sediment quality standard suggested of 1 nmol/gdw indicating that Violet Marsh has been chronically impacted by fecal material.

The coprostanol levels in sediment from the top of the cores also showed significant impacts from fecal contamination (Table 6). The average level of coprostanol in the most recent sediment was higher (20.2 nmol/gdw) than that of the bottom sediment (16.9 nmol/gdw), which suggested increasing fecal input. Additionally, the relative coprostanol distribution pattern in the most recent sediments was different from that observed from the analysis of core bottoms. The levels of coprostanol in the surface sediments of the eastern location in the Bayou Bienvenue (BB1=28.3 nmol/gdw; BB2=28.5 nmol/gdw) were approximately half of those found in the sediments of the bottoms of these cores. This may reflect the lack of input due to the failure of the sewage treatment system that resulted from the flooding. In contrast, the surface sediments associated with pump stations #2, #3, #4 and #6 all contained higher levels of coprostanol than their respective core bottoms. This suggested that the flooding resulted in a greater fecal load to Violet Marsh than originated from Chalmette along the northern levee.

Ratios of the levels of various other sterols recovered from wetland sediment cores have been used as aids to data interpretation, particularly in highly productive systems where coprostanol levels were below 2 nmol/gdw and other sources of sterols had become significant. We did not find any of these sterol ratios particularly helpful in the context of gaining additional information from our data (Table 6). The ratio of coprostanol / coprostanol+cholestanol did not change much with location or sediment depth suggesting the relative importance of the different cholesterol reduction pathways did not change very much with time or location in the Marsh. The ratio of epicoprostanol (formed from coprostanol in activated sludge) to coprostanol has been used as an indication of treated *vs* non-treated sewage. Although this ratio fluctuated it was difficult to rationalize these differences in terms of extent of sewage treatment.

Benzo[a]pyrene data - The Violet Marsh has had a history of BaP contamination and the recent flooding has made this contamination more pervasive through the Marsh. BaP levels in the bottom sediments from 9 of the 18 core samples collected exceeded the EPA sediment criterion of 0.062 µg/gdw. The sediments that chronically exceeded this criterion came from Bayou Bienvenue, the sewage treatment plant, and around pump stations #2 and #3. This historic BaP contamination did not extend far into the Marsh (e.g., sediment 12 = 0.0 µg/gdw). When considering the most recently deposited sediments, the number of cores showing measurable BaP levels and the levels of BaP in these sediments indicated that the flooding resulted in the addition of BaP to the marsh in excess of the historically deposited levels. The EPA BaP sediment criterion was exceeded in the sediments most recently deposited in 16 of the 18 cores collected. The averaged level of BaP in the most recent sediments was 2.8 µg/gdw compared to 1.5 µg/gdw in the historic sediments. The highest levels in both the top and bottom sediments were detected in the eastern Bayou Bienvenue.

Discussion

During the Category 3-4 hurricane Katrina, on 28-29 August 2005, 6 - 10 inches of rain fell in the New Orleans area. This amount was not significantly greater than many other storms. The Katrina storm surge on the Mississippi coast exceeded 20 feet in some areas, but ranged from 10-15 feet on the Louisiana coast east of New Orleans. Lake Pontchartrain was elevated a few feet for an extended time. By 29 August New Orleans levees were breached in several locations, and by 30 August 80% of New Orleans was flooded with up to 20 feet of brackish water.

For several days the flood water remained high in the urbanized areas, and began to slowly recede as the levee breaches were patched and pumps were brought in or became operational. Tens of thousands of people who remained in the area were without basic necessities, and without a working sewage system. The main sewage treatment plant was submerged, damaged, and completely out of operation for several weeks. The smaller plant on the west bank received extensive storm damage and was also not operational.

The effects of several inches of rain and wind from the Category 3 hurricane Rita caused several refailures of the levees in New Orleans on 23-24 September, and reflooding up to 10 feet. The operational pumps pumped huge volumes of flood water and sediment continuously for 4-5 weeks. The last of the flood waters was declared pumped out on October 11. The flooding and flows are detailed in the modeling report in the volume (Dortch et al., 2006). The pump out of the flooded city and the hydraulic flows resulting from this operation and the levee systems was accomplished with three separate drainage areas or polders: New Orleans proper, New Orleans East, and St. Bernard Parish and the Lower Ninth Ward. Lake Pontchartrain received the bulk of the pumped flood water, from New Orleans proper and New Orleans East. The Violet Marsh received the pumped flood water from the Lower Ninth Ward and Chalmette area.

The U.S. EPA and the LADEQ conducted extensive measurement operations throughout the urbanized New Orleans area from September through December. The only EPA and LADEQ flood water and sediment microbiology data available is for fecal coliform bacteria. LSU (Pardue et al., 2005) and Texas Tech (Presley et al., 2006) led independent sampling expeditions in flooded New Orleans, principally in limited parts of New Orleans proper. They reported on a greater variety of contaminants over a more limited area than the EPA data. Much of the sewerage system was antiquated and permanently damaged from the flooding. Even during normal storms without flooding, the sewers cross flow into storm drainage (Pardue et al., 2005). The main EPA warning concerning contaminants in the flood water was to avoid contact due to elevated sewage levels. http://www.epa.gov/katrina/precautions.html. Much raw sewage, particularly in the Lower Ninth Ward and Chalmette area polder, was still evident in surface waters when we sampled (February 2006).

The recreational (swimming) water criteria for bodily contact and accidental or incidental ingestion are developed in terms of other groups of organisms. The applicable standard is the primary contact recreational water quality criterion which is 400 cfu/100 mL for fecal coliform bacteria (EPA 2003, LADEQ 2004). This standard was exceeded in 53 of the 139 EPA Katrina water samples from Orleans and St. Bernard parishes. The averages of the fecal coliform bacteria in cfu/100 mL reported in the EPA Katrina water samples from the three polders were 21,381 in

New Orleans proper, 3,308 in New Orleans East and 1,287 in St. Bernard Parish and the Lower Ninth Ward. There are very few bacteriological sediment standards. The large National Sediment Quality Survey (EPA 2004b) contains no bacteriological data. The federal Biosolids rules are applicable to transported sediments which have been impacted by sewage sludge. The Biosolids residential standard (40 CFR 503.32) for fecal coliform bacteria is 1000 cfu/g. This standard was exceeded by 162 of the 569 EPA Katrina sediment samples from Orleans and St. Bernard parishes. The averages of the fecal coliform bacteria in cfu/g reported in the EPA Katrina sediment samples from the three polders were 31,645 in New Orleans proper, 9,980 in New Orleans East, and 30,196 in St. Bernard Parish and the Lower Ninth Ward.

The potential for infections from pathogens in sewage waste was the primary Katrina-related health concern of the EPA and CDC. Air-borne molds are another microbial concern in New Orleans. The EPA issued flood-related mold warnings, especially concerning the black molds related to *Stachybotrys chartarum*. (http://www.epa.gov/katrina/healthissues.html#floodmold). This report does not cover air borne pathogens, only the pathogens reported in the flood waters and sediment.

The ERDC Environmental Microbiology Team supported the environmental modeling effort required for the IPET Task 9 by obtaining and reducing data on fecal contamination and providing it to ERDC environmental modelers (Table 2). The fecal coliform data as a whole do not appear to result from random dilutions of a fecal source or sources because of the large number of non-detects reported. Once the non-detect values are removed the remaining numerical values do tend to follow an expected unimodal lognormal distribution characteristic of random dilutions of a fecal source or sources. The reported non-detects appear to result from a separate source or sources of more dilute material, resulting in a bimodal distribution for the fecal coliform data as a whole. Several further outlying areas, including the Mississippi Sound and the Mississippi River Delta, are likely to have environmental impacts from the levee failures that are more dilute than the nearby ecosystems. These remote ecosystems are not modeled in this report, and samples were not collected from the remote areas.

Screening of New Orleans water and sediment samples for the coliform bacteria found in fecal material and correlated to infectious human disease frequently showed fecal coliform bacterial levels high above the regulatory levels of concern. As a result health advisories due to infectious material in the flooded New Orleans were issued. The advisories were warranted. Assessment of the actual human health impacts due to infectious agents as a result of the flood is an ongoing process. Of the 10,047 New Orleans patient visits during and immediately after the flooding for which information was available to the Center for Disease Control and Prevention (CDC, 2006) the most common were gastrointestinal, acute respiratory and skin infections. However, it will probably not be possible to capture all the data on illness of New Orleans residents who left the area and received medical treatments for infections. In the context of this report it is important to point out that the high levels of fecal coliform bacterial revealed by the screening procedures did detect a human health risk due to infectious agents, health advisories were issued and some summaries of impacts of human infections have been recently published. This series of events identifies a potential source of infectious materials that constitute a real environmental risk of unknown magnitude and duration on the environment around New Orleans as the city was pumped out and debris is removed.

Extending the fecal coliform indicator screening level analysis to areas adjacent to New Orleans is one of the few options open to use the data that is currently available. Simple water dilution calculations and coliform bacteria die-off rates in estuarine water indicate that fecal coliform counts would be below levels of concern for the majority of Lake Pontchartrain. This is indeed observed in the most recent data from the Lake Pontchartrain Basin Foundation. While this is good news these data should not be equated to the lack of an environmental problem. According to EPA guidance and federal law (BEACH Act) fecal streptococci should have been used as the fecal indicator in estuarine water and not fecal coliform bacteria. The very high levels of fecal coliform bacteria in the flood water indicated an obvious health risk. However, the interpretation of low fecal coliform counts in estuarine water in terms of risk to human health is problematic. Lack of correlation between low fecal coliform counts and human illness is one of the reasons EPA in 1986 changed its guidance in estuarine waters to the use of fecal streptococci. Additionally, recent literature has revealed that we are only beginning to understand the part of the life cycle of microbial pathogens of humans that occurs outside the human host. Taken together the message here is that the current lack of an indicator of fecal waste problem in New Orleans and Lake Pontchartrain should not be interpreted as the absence of an environmental problem. On the other hand, Lake Pontchartrain itself is a recovering ecosystem with a long history of fecal and chemical pollution. It is not possible with the data we currently have available to evaluate the impact of the pump out on the already impacted Lake.

In contrast, much of the Violet Marsh is confined by levees and this small confined area received a great volume of material that was pumped out of the urbanized area of New Orleans. We were able to select our own tests and sample sites, and perform our own quick survey of this system. As a result we were able to show a probable environmental impact of BaP and fecal contamination that resulted from the pump out of the Lower Ninth Ward of New Orleans and the Chalmette area that exceeded the historic level of BaP and fecal contamination that this system normally receives. The Violet Marsh was shown to have levels of contamination and ranges of indicators similar to other sewage impacted wetlands areas (Grimalt et al. 1990) that are well above suggested sediment quality criteria (Kirchmer 1971; Murtaugh and Bunch 1967; Dutka et al. 1974). Other chemical tracers of anthropogenic contamination were also evident in our GC/MS analyses, but time did not permit a more detailed environmental forensics analysis of the data. Additional analyses are required to remove uncertainty due to assumptions we made and the minimal statistical design of our Violet Marsh survey, and to quantify these impacts.

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List of Abbreviations

IPET	Inter-agency Performance Evaluation Team
BaP	benzo[a]pyrene
ERDC	Engineer Research and Development Center
US EPA	United States Environmental Protection Agency
SD	standard deviation
LADEQ	Louisiana Department of Environmental Quality
ng	nanogram
L	liter
cfu	colony forming unit
mL	milliliter
µg	microgram
g	gram
DEQ	Department of Environmental Quality
CFR	Code of Federal Regulations
gdw	gram dry weight
ILSI	International Life Sciences Institute
pmol	pico-mol
nmol	nano-mol
ppb	parts per billion
GC/MS	gas chromatography mass spectrometer
TPH	total petroleum hydrocarbons

NO	New Orleans
COE	Corps of Engineers
SS	stainless steel
v.v.v.v	volume to volume to volume to volume
DCM	dichloromethane
LLQ	lower limit for quantization
LLD	lower limit of detection
TMS	trimethylchlorosilane
µm	micro-meter
eV	electron volts
USGS	United States Geological Survey
LSU	Louisiana State University
STORET	EPA/LADEQ Katrina Central Data Warehouse (http://oaspub.epa.gov/storetkp/dw)
SQL	Sample quantization level
UCL	Upper confidence level
MPN	Most probable number

Table 4
Benzo[a]pyrene levels in Violet Marsh sediments.

Table Concentration of Benzo(A)Pyrene in Top and Bottom of Cores				
Sample		BaP ug/g *dw*	EPA criteria	LDEQ criteria
Location			0.062	0.33
Bienvenue Basin 1	TOP	31.2	>	>
Bienvenue Basin 2	TOP	2.8	>	>
Bienvenue Basin 3	TOP	1.0	>	>
Bienvenue Basin 4	TOP	0.0	-	-
Bienvenue Basin 5	TOP	0.4	>	>
Sewage Plant	TOP	3.1	>	>
Murphy Oil Site	TOP	1.6	>	>
Pump 2 Sed 4	TOP	1.4	>	>
Pump 2 Sed 5	TOP	1.4	>	>
Pump 3 Sed 8	TOP	0.9	>	>
Pump 3 Sed 9	TOP	1.3	>	>
Pump 4 Sed 10	TOP	1.5	>	>
Pump 4 Sed 13	TOP	0.2	>	-
Pump 6 Sed 1	TOP	1.1	>	>
Pump 6 Sed 2	TOP	1.2	>	>
Sed 11	TOP	0.0	-	-
Sed 12	TOP	0.1	>	-
Sed 3	TOP	1.1	>	>
Mean		2.8		
Standard Deviation		7.1		
Median		1.1		
Bienvenue Basin 1	Bottom	11.8	>	>
Bienvenue Basin 2	Bottom	11.0	>	>
Bienvenue Basin 3	Bottom	0.1	>	-
Bienvenue Basin 4	Bottom	0.0	-	-
Bienvenue Basin 5	Bottom	0.1	>	-
Sewage Plant	Bottom	0.5	>	>
Murphy Oil Site	Bottom	0.8	>	>
Pump 2 Sed 4	Bottom	0.8	>	>
Pump 2 Sed 5	Bottom	2.5	>	>
Pump 3 Sed 8	Bottom	0.0	-	-
Pump 3 Sed 9	Bottom	0.3	>	-
Pump 4 Sed 10	Bottom	0.0	-	-
Pump 4 Sed 13	Bottom	0.0	-	-
Pump 6 Sed 1	Bottom	0.0	-	-
Pump 6 Sed 2	Bottom	0.0	-	-
Sed 11	Bottom	0.0	-	-
Sed 12	Bottom	0.0	-	-
Sed 3	Bottom	0.0	-	-
Mean		1.5		
Standard Deviation		3.6		
Median		0.0		

Table 5
Fecal indicator bacteria levels in Violet Marsh sediments

Table	Plate count results from Top of Soil Core				
		Total	Fecal	Fecal	40 CFR 503
Sample		Coliforms	Coliforms	Streptococci	BioSolid Res Std FecColif
Location		CFU/gm	CFU/gm	CFU/gm	1000
Bienvenue Basin 1	TOP	17,000	< 1,000	<1,000	–
Bienvenue Basin 2	TOP	12,000	< 1,000	<1,000	–
Bienvenue Basin 3	TOP	<1000	< 1,000	<1,000	–
Bienvenue Basin 4	TOP	<1000	< 1,000	<1,000	–
Bienvenue Basin 5	TOP	3,000	< 1,000	<1,000	–
Sewage Plant	TOP	10,000	< 1,000	<1,000	–
Murphy Oil Site	TOP	1,600,000	630,000	100	>
Pump 2 Sed 4	TOP	57,000	14,000	<100	>
Pump 2 Sed 5	TOP	133,000	25,000	<100	>
Pump 3 Sed 8	TOP	84,000	5,000	<100	>
Pump 3 Sed 9	TOP	630,000	70,000	<100	>
Pump 4 Sed 10	TOP	77,000	10,000	<100	>
Pump 4 Sed 13	TOP	128,000	15,000	<100	>
Pump 6 Sed 1	TOP	30,000	8,000	<100	>
Pump 6 Sed 2	TOP	65,000	2,000	<100	>
Sed 11	TOP	33,000	3,000	<100	>
Sed 12	TOP	>200000	4,000	<1,000	>
Sed 3	TOP	2,100	3,000	<100	>
Mean		192,073	65,750		
Standard Deviation		419,233	178,681		
Median		57,000	9,000		

Table 6
Fecal Sterol levels in Violet Marsh sediments

Table X. Fecal sterol content of sediment from the tops and bottoms of cores.									
		A	B	C	D	Ratio	Ratio	Ratio	Ratio
Sample		coprostanol	epicoprostanol	cholesterol	cholestanol	A/D	B/A	A/C	A/A+D
Location		nmol/gm dw	nmol/gm dw	nmol/gm dw	nmol/gm dw				
Bienvenue Basin 1	Top	28.3	1.6	43.5	3.8	7.37	0.06	0.65	0.88
Bienvenue Basin 2	Top	28.5	41.4	355.2	41.0	0.70	1.45	0.08	0.41
Bienvenue Basin 3	Top	9.2	0.8	43.6	7.9	1.16	0.08	0.21	0.54
Bienvenue Basin 4	Top	9.1	2.6	42.7	5.0	1.81	0.29	0.21	0.64
Bienvenue Basin 5	Top	4.2	0.4	110.9	5.1	0.82	0.10	0.04	0.45
Sewage Plant	Top	27.3	18.1	29.2	6.5	4.20	0.66	0.93	0.81
Murphy Oil Site	Top	20.8	0.6	17.2	1.3	15.58	0.03	1.21	0.94
Pump 2 Sed 4	Top	3.0	3.7	67.7	3.8	0.79	1.24	0.04	0.44
Pump 2 Sed 5	Top	61.3	4.6	344.7	30.3	2.02	0.07	0.18	0.67
Pump 3 Sed 8	Top	20.6	1.8	145.8	10.0	2.06	0.09	0.14	0.67
Pump 3 Sed 9	Top	39.1	2.2	90.0	9.1	4.31	0.06	0.44	0.81
Pump 4 Sed 10	Top	28.1	2.0	32.4	5.9	4.72	0.07	0.87	0.83
Pump 4 Sed 13	Top	13.4	1.0	68.6	6.3	2.11	0.08	0.20	0.68
Pump 6 Sed 1	Top	22.0	1.7	117.4	10.5	2.09	0.08	0.19	0.68
Pump 6 Sed 2	Top	9.5	0.8	44.3	6.8	1.39	0.08	0.21	0.58
Sed 11	Top	21.5	6.0	90.3	7.0	3.06	0.28	0.24	0.75
Sed 12	Top	4.3	0.7	40.6	7.3	0.58	0.17	0.10	0.37
Sed 3	Top	14.3	1.1	67.5	11.0	1.31	0.07	0.21	0.57
Mean		20.2	5.1	97.3	9.9	3.1	0.3	0.3	0.7
Standard Deviation		14.4	10.0	98.0	9.8	3.6	0.4	0.3	0.2
Median		20.7	1.8	67.6	6.9	2.0	0.1	0.2	0.7
Bienvenue Basin 1	Bottom	61.2	2.5	80.2	6.5	9.38	0.04	0.76	0.90
Bienvenue Basin 2	Bottom	87.8	4.6	115.4	11.3	7.78	0.05	0.76	0.89
Bienvenue Basin 3	Bottom	3.4	0.5	23.4	3.0	1.15	0.14	0.15	0.53
Bienvenue Basin 4	Bottom	6.0	0.5	33.2	7.0	0.86	0.09	0.18	0.46
Bienvenue Basin 5	Bottom	3.4	0.5	22.0	5.0	0.68	0.14	0.15	0.40
Sewage Plant	Bottom	20.3	2.7	91.8	19.8	1.02	0.13	0.22	0.51
Murphy Oil Site	Bottom	23.9	1.2	15.3	4.6	5.18	0.05	1.56	0.84
Pump 2 Sed 4	Bottom	8.1	0.7	84.5	4.8	1.67	0.09	0.10	0.63
Pump 2 Sed 5	Bottom	32.8	3.2	99.2	19.1	1.72	0.10	0.33	0.63
Pump 3 Sed 8	Bottom	0.9	0.1	4.9	0.4	2.16	0.08	0.19	0.68
Pump 3 Sed 9	Bottom	12.6	0.5	20.3	5.1	2.50	0.04	0.62	0.71
Pump 4 Sed 10	Bottom	0.0	0.0	2.7	0.9	0.00	-	0.00	0.00
Pump 4 Sed 13	Bottom	0.0	0.0	2.1	0.4	0.00	-	0.00	0.00
Pump 6 Sed 1	Bottom	5.0	0.5	24.0	3.5	1.41	0.10	0.21	0.59
Pump 6 Sed 2	Bottom	8.0	1.1	56.5	10.0	0.79	0.13	0.14	0.44
Sed 11	Bottom	14.2	1.4	84.5	12.3	1.15	0.10	0.17	0.54
Sed 12	Bottom	6.0	1.3	55.6	9.8	0.61	0.22	0.11	0.38
Sed 3	Bottom	11.2	1.1	63.3	18.4	0.61	0.10	0.18	0.38
Mean		16.9	1.2	48.8	7.9	2.1	0.1	0.3	0.5
Standard Deviation		23.1	1.2	36.8	6.2	2.6	0.0	0.4	0.3
Median		8.0	0.9	44.4	5.8	1.2	0.1	0.2	0.5

Table 7
Comparison of Fecal Sterols in other Tropical Wetlands

Sample	A Coprostanol nmoles/gdw	B Epicoprostanol nmoles/gdw	C Cholesterol nmoles/gdw	D Cholestanol nmoles/gdw	A/D	B/A	A/C	A/A+D
Human feces[1]	8,824.29		746.08				11.83	
Barcelona S1[2]	1,003.34	12.86	205.81	41.16	24.38	0.01	4.88	0.96
Barcelona S2[2]	115.77	5.15	25.73	18.01	6.43	0.04	4.50	0.87
Barcelona S3[2]	87.47	3.86	23.15	10.29	8.50	0.04	3.78	0.89
Barcelona S4[2]	61.74	2.57	51.45	7.72	8.00	0.04	1.20	0.89
Barcelona S5[2]	38.59	1.29	30.87	7.72	5.00	0.03	1.25	0.83
Barcelona S7[2]	3.34	0.26	2.57	1.03	3.25	0.08	1.30	0.76
Barcelona S7[2]	2.57	0.21	1.29	0.64	4.00	0.08	2.00	0.80
Havana, Cuba S8[2]	2.83	0.26	8.23	1.75	1.62	0.09	0.34	0.62
Havana, Cuba S9[2]	1.05	0.10	2.57	1.41	0.75	0.10	0.41	0.43
Kirchmer criterion[3]	1.03							
Murtaugh criterion[4]	0.51							
Dutka criterion[5]	0.13							

[1]Nichols et al., 1996
[2]Grimalt et al., 1990
[3]Kirchmer, 1971
[4]Murtaugh and Bunch, 1967
[5]Dutka et al., 1974

Appendix A. LPBF data

Lake Pontchartrain Basin Foundation
Basin-Wide Water Quality Monitoring Program

LPBF Master Database 2005									
Site	Date	Water Temp °C	Diss Oxy mg/L	Spec Cond mS/cm	Salinity ppt	Turbidity NTU	pH	Fecal Coliform MPN/100 mL	Enterococci MPN/100 mL
1	1/4/2005	12.1	9.48	9.28	5.2	3.18	7.98	33	
2	1/4/2005	13	9.19	8.02	4.5	1.05	7.78	13	
3	1/4/2005	11.6	8.72	8.91	5	2.88	7.62	23	
4	1/4/2005	11.7	10.06	9.11	5.1	2.48	7.45	79	
5	1/4/2005	13.5	8.97	10.19	5.8	1.16	7.76		
6	1/4/2005	17.5	7.55	0.04	0	5.25	7.29	130	
7	1/4/2005	15.6	8.24	2.63	1.4	6.89	6.97	79	
8	1/4/2005	16.8	10.1	8.95	5	3.53	7.67	170	
9	1/4/2005	18.6	8.58	9.09	5.1	2.67	7.48	4.5	
10	1/4/2005	16.2	10.83	7.15	4	8.02	7.62	49	
1	1/11/2005	15.7	8.6	9.11	5.1	3.17	7.46	49	
2	1/11/2005	15.5	5.31	9.14	5.1	2.03	7.52	110	
3	1/11/2005	15.1	7.1	8.83	4.9	1.65	7.47	11	
4	1/11/2005	14.6	7.41	8.98	5	1.8	7.27	79	
5	1/11/2005	15	6.89	9.64	5.5	0.87	7.62		
6	1/11/2005	16	8.52	0.04	0	13.3	6.65	920	
7	1/11/2005	16.2	6.15	1.5	0.8	18.1	6.48	920	
8	1/11/2005	16.9	7.43	6.19	3.4	5.61	6.69	1600	
9	1/11/2005	17.3	8.97	9.12	5.1	2.95	7		
10	1/11/2005	17.7	9.74	9.27	5.2	6.01	7.44	49	
1	1/12/2005	15.8	7.76	9.37	5.3	1.5	7.46	49	
2	1/12/2005	15.4	6.28	9.37	5.3	2.08	7.12	33	
3	1/12/2005	15.5	7.12	9.17	5.2	2.54	7.11	33	
4	1/12/2005	15.2	6.87	9.28	5.2	1.75	7.09	70	
5	1/12/2005	16.3	7.09	9.71	5.5	0.91	7.45	23	
6	1/12/2005	17	7.9	0.04	0	12.4	6.76	540	
7	1/12/2005	16.7	6.37	1.26	0.6	16	6.26	920	
8	1/12/2005	17	8.57	8.24	4.6	4.68	6.73	920	
9	1/12/2005	18.2	8.18	9.09	5.1	12.9	6.88	79	
10	1/12/2005	18.2	9.36	9.26	5.2	4.21	7.54	350	
1	1/18/2005	9.6	10.13	8.45	4.7	52.5	7.61	240	75
2	1/18/2005	9.2	10.08	8.4	4.6	37	7.6	79	20
3	1/18/2005	10.4		9.34	5.2	28.6	7.59	49	10
4	1/18/2005	9.8		9.67	5.4	33.8	7.53	130	10
5	1/18/2005	6.2		9.42	5.2	24.5	7.66	70	42
6	1/18/2005	8.7				11.6	7.68	240	164
7	1/18/2005	11				22.7	6.6	1600	42
8	1/18/2005	10.1				4.63	6.82	130	75
9	1/18/2005	7.4				1.18	7.16	7.8	5
10	1/18/2005	6.8				4.67	7.48	33	5
1	1/25/2005	10	8.92	7.25	4	13.6	8.2	22	10

LPBF Master Database 2005									
Site	Date	Water Temp °C	Diss Oxy mg/L	Spec Cond mS/cm	Salinity ppt	Turbidity NTU	pH	Fecal Coliform MPN/100 mL	Enterococci MPN/100 mL
2	1/25/2005	10.3	7.48	8.43	4.7	16.9	7.83	46	10
3	1/25/2005	10.5	8.63	8.72	4.9	21.6	7.64	79	20
4	1/25/2005	10.6	8.79	10.17	5.8	6.82	7.6	13	5
5	1/25/2005	8	9.68	10.35	5.8	12.3	7.66	17	5
6	1/25/2005	9.3	9.9	0.04	0	6.3	7.6	27	137
7	1/25/2005	9.7	8.85	3.69	2	9.52	6.94	49	20
8	1/25/2005	9.9	9.37	8.23	4.6	5.65	7.05	170	10
9	1/25/2005	8.8	10.53	8.96	5	14.3	7.05	7.8	5
10	1/25/2005	10.1	10.18	9.18	5.1	33.5	7.29	130	5
1	2/1/2005	11.9	9.51	6.31	3.5	59.3	7.73	540	453
2	2/1/2005	12.1	9.67	5.45	2.9	56.7	7.78	350	1091
3	2/1/2005	12	9.75	7.12	3.9	25.8	7.64	540	1184
4	2/1/2005	11.9	9.9	7.5	4.2	17.9	7.46	540	738
5	2/1/2005	12	9.42	9.26	5.2	39.2	7.51	350	504
6	2/1/2005	12.1	9.19	0.05	0	19.6	7.6	1700	2100
7	2/1/2005								
8	2/1/2005	11.9	8.2	8.02	4.5	3.91	6.83	1600	1091
9	2/1/2005	11.9	9.8	9.24	5.2	2.06	6.88	21	5
10	2/1/2005	11.8	9.43	11.97	6.9	4.66	6.99	130	192
1	2/2/2005	12.5	9.73	5.02	2.7	58.4	7.68	1700	2100
2	2/2/2005	12.3	8.91	6.53	3.6	29.4	7.72	1600	2100
3	2/2/2005	12.1	9.48	7.35	4.1	24.4	7.51	350	207
4	2/2/2005	12	8.59	7.84	4.4	19	7.53	220	478
5	2/2/2005	12.4	8.95	10.04	5.7	3.48	7.48	49	178
6	2/2/2005	11.5	9.54	0.03	0	52.2	6.41	1700	2100
7	2/2/2005								
8	2/2/2005	12	8.51	3.6	1.9	22.6	6.34	1700	2100
9	2/2/2005	12.2	9.68	9.03	5.1	6.19	6.62	920	406
10	2/2/2005	12.4	9.28	14.09	8.2	8.01	6.85	23	75
1	2/15/2005	13.7	9.33	6.52	3.6	4.84	10.1	1600	254
2	2/15/2005	13.8	6.16	7.04	3.9	4.07	7.8	130	31
3	2/15/2005	13.5	8.68	6.15	3.4	2.72	8.02	49	5
4	2/15/2005	13.7	8.61	7.38	4.1	3.67	7.79	33	10
5	2/15/2005	14.6	6.17	7.41	4.1	1.54	8.24	17	10
6	2/15/2005	14.6	9.7	0.04	0	23.6	7.13	1700	2100
7	2/15/2005	15	7.78	1.62	0.8	13.2	6.53	79	75
8	2/15/2005	14.8	8.49	7.15	4	14.8	6.63	1600	2100
9	2/15/2005	15.3	9.86	8.71	4.9	5.38		4.5	5
10	2/15/2005	15.5	10.17	8.26	4.6	5.63	6.97	110	10
1	2/22/2005	17.5	7.24	5.86	3.2	4.34	7.67	4.5	5
2	2/22/2005	16.7	6.74	7.24	4	2.31	7.38	46	31
3	2/22/2005	16.6	6.48	6.78	3.7	2.68	7.46	130	5
4	2/22/2005	17	5.79	7.35	4.1	3.2	7.48	31	5
5	2/22/2005	18.9	4.48	9.04	5.1	1.19	7.66	7.8	31
6	2/22/2005	18	7.93	0.04	0	6.71	7.2	220	75
7	2/22/2005	17.6	7.63	1.97	1	13.3	6.43	49	20

LPBF Master Database 2005									
Site	**Date**	**Water Temp °C**	**Diss Oxy mg/L**	**Spec Cond mS/cm**	**Salinity ppt**	**Turbidity NTU**	**pH**	**Fecal Coliform MPN/100 mL**	**Enterococci MPN/100 mL**
8	2/22/2005	17.9	7.73	6.89	3.8	7.81	6.64	350	53
9	2/22/2005	19.2	8.06	8.79	4.9	15.4	6.8	4.5	5
10	2/22/2005	17.9	9.12	8.57	4.8	3.45	6.95	33	5
1	2/23/2005	16.2	6.72	6.17	3.4	3.17	10.1	23	10
2	2/23/2005	17.2	6.64	7	3.9	3.46	7.78	49	99
3	2/23/2005	16.9	5.95	7.12	3.9	2.26	7.51	79	64
4	2/23/2005	16.8	5.76	7.12	3.9	3.16	7.16	13	5
5	2/23/2005	17.5	4.34	8.24	4.6	1.22	7.1	1	5
6	2/23/2005	18.9	7.84	0.04	0	8.63	7.04	110	150
7	2/23/2005	18.9	7.45	1.62	0.8	11.9	6.44	17	20
8	2/23/2005	18.7	8.23	8.36	4.7	6.81	6.66	140	20
9	2/23/2005	18.7	8.62	8.65	4.8	3.41	6.86	7.8	5
10	2/23/2005	19.1	8.58	8.53	4.8		6.96	140	31
1	3/1/2005	14.5	9.06	5.69	3.1	26.6	7.66	350	42
2	3/1/2005	14.1	9.5	6.22	3.4	24.3	7.65	280	53
3	3/1/2005	14.1	10.76	6.66	3.9	29.2	7.62	350	53
4	3/1/2005	14.5	9.25	7.21	4.1	30.8	7.48	280	31
5	3/1/2005	13.2	10.22	8.05	4.5	25	7.8	79	10
6	3/1/2005								
7	3/1/2005	14.4	6.93	1.88	1	14.3	7.7	49	87
8	3/1/2005	14.2	6.49	4.15	2.2	20.9	6.88	350	207
9	3/1/2005	11.9	10.17	7.12	3.9	28.1	6.96	49	53
10	3/1/2005	14.6	9.49	7.74	4.3	29.1	7.14	49	31
1	3/8/2005	15.3	9.37	6.29	3.5	46.9	7.55	110	99
2	3/8/2005	14.6	9.04	7.95	4.4	49.4	7.71	920	560
3	3/8/2005	15.2	9.9	8.61	4.8	45.2	7.7	1700	207
4	3/8/2005	15	9.86	8.51	4.6	47.4	7.69	1700	99
5	3/8/2005	14.5	8.96	9.63	5.4	25.2	7.89	130	87
6	3/8/2005	15	8.44	0.4	0	11	8	140	406
7	3/8/2005	15.3	7.85	3.04	1.6	12.2	7.31	49	10
8	3/8/2005	15.5	8.35	6.09	3.3	9.9	7.17	79	10
9	3/8/2005	14.2	9.63	6.64	3.7	32.5	7.27	49	31
10	3/8/2005	16	8.71	7.7	4.3	47.3	7.32	140	75
1	3/15/2005	16.7	8.75	5.33	2.9	50.2	7.73	79	64
2	3/15/2005	15.9	9.13	6.3	3.5	29.7	7.62	240	20
3	3/15/2005	16.5	9.45	6.37	3.6	29.6	7.75	33	42
4	3/15/2005	15.8	8.06	6.72	3.7	18.7	7.64	33	42
5	3/15/2005	15.1	5.05	9.47	5.3	26.9	7.71	130	64
6	3/15/2005	15.7	7.84	0.04	0	5.15	8.07	49	99
7	3/15/2005	16.6	7.88	3.5	1.8	7.91	7.19	6.8	10
8	3/15/2005	16.6	7.77	5.8	3.2	5.29	7.13	33	5
9	3/15/2005	15.5	8.43	6.32	3.5	4.12	7.32	7.8	5
10	3/15/2005	15.4	9.09	8	4.5	18.7	7.62	7.8	10
1	3/22/2005	16.7	8.61	5.71	3.1	16.1	7.73	11	31
2	3/22/2005	16.5	8.03	6.28	3.5	5.67	7.68	23	5
3	3/22/2005	15.9	7.4	7	3.9	5.1	7.58	7.8	10

LPBF Master Database 2005									
Site	Date	Water Temp °C	Diss Oxy mg/L	Spec Cond mS/cm	Salinity ppt	Turbidity NTU	pH	Fecal Coliform MPN/100 mL	Enterococci MPN/100 mL
4	3/22/2005	15.8	7.4	8.2	4.6	4.99	7.45	46	10
5	3/22/2005	17	7.13	10.01	5.7	2.01	7.56	70	5
6	3/22/2005	17.4	8.14	0.04	0	51.6	7.57	49	87
7	3/22/2005	17.6	7.95	2.82	1.5	11.2	6.81	49	20
8	3/22/2005	17.6	8.46	5.99	3.3	14	6.75	240	53
9	3/22/2005	18.9	8.21	6.31	3.4	15.1	6.82	49	31
10	3/22/2005	17.5	9.26	5.94	3.2	5.97	7.1	130	10
1	3/29/2005	18.3	5.14	5.25	2.8	15.9	7.92	33	20
2	3/29/2005	17.9	7.98	5.96	3.3	10.7	7.58	49	5
3	3/29/2005	18.2	9.55	6.11	3.3	13.1	7.91	49	5
4	3/29/2005	18.2	6.91	6.58	3.6	15.5	7.68	110	31
5	3/29/2005	18.5	9.47	7.47	4.1	12.8	7.6	23	5
6	3/29/2005	15.8	7.45	0.04	0	6.07	7.79	350	254
7	3/29/2005	18.9	5.75	3	1.6	8.98	6.86	7.8	10
8	3/29/2005	19.3	6.27	5.95	3.2	9.19	6.86	33	42
9	3/29/2005	17.6	8.36	6.76	3.7	21.2	7.13	11	10
10	3/29/2005	20.4	9.52	6.4	3.5	21.5	8.2	130	10
1	4/5/2005	19.2				10.1	7.45	130	5
2	4/5/2005	18.8				9.25	7.44	23	5
3	4/5/2005	18.9				12.5	7.3	33	453
4	4/5/2005	18.8				6.45	7.48	350	64
5	4/5/2005	19.2				4.37	7.32	33	20
6	4/5/2005	17.4	6.96	0.04	0	14.8	7.4	920	150
7	4/5/2005	19.2	5.84	1.85	0.9	9.79	6.72	110	10
8	4/5/2005	19.4	5.68		2.8	11.6	6.71	49	87
9	4/5/2005	19	7.18	6.59	3.6	49.6	7.01	33	5
10	4/5/2005	20.5	7.51	5.54	3	33.6	7.49	240	42
1	4/11/2005	21.3	7.58	4.62	2.5	23	7.68	49	10
2	4/11/2005	20.9	7.55	5.3	2.9	5.92	7.47	49	5
3	4/11/2005	20.7	7.42	5.71	3.1	7.28	7.39	79	271
4	4/11/2005	20.6	7.33	5.96	3.2	6.51	7.22	79	20
5	4/11/2005	20.8	8.06	7.59	4.2	2.34	7.55	22	10
6	4/11/2005	19.8	7.62	0.04	0	7.99	7.41	130	238
7	4/11/2005	21.1	7.12	2.74	1.4	10.8	6.65	49	5
8	4/11/2005	21.7	7.34	6.49	3.6	10.2	6.84	110	42
9	4/11/2005	21	8.1	6.68	3.7	19.4	7.06	49	20
10	4/11/2005	21.2	8.42	3.06	1.6	35	7.05	240	87
1	4/12/2005	21.1	7.06	4.1	2.2	49.1	7.58	1700	2100
2	4/12/2005	20.5	7.63	5.22	2.8	15.4	7.41	1700	2100
3	4/12/2005	20.4	8.51	5.25	2.8	23.1	7.5	1700	2100
4	4/12/2005	20	7.77	4.24	2.3	31.7	7.28	1700	2100
5	4/12/2005	20.2	7.98	5.18	2.8	40.9	7.55	1700	2100
6	4/12/2005	18.7	7.28	0.03	0	96.1	7.23	1700	2100
7	4/12/2005	21	5.8	4.17	2.2	14.5	6.45	220	406
8	4/12/2005	21.8	4.7	5.15	2.8	9.47	6.42	1600	1652
9	4/12/2005	21.1	7.64	5.75	3.1	32.1	6.96	130	164

LPBF Master Database 2005									
Site	Date	Water Temp °C	Diss Oxy mg/L	Spec Cond mS/cm	Salinity ppt	Turbidity NTU	pH	Fecal Coliform MPN/100 mL	Enterococci MPN/100 mL
10	4/12/2005	21.1	7.82	3.1	1.6	34.9	6.91	240	738
1	4/19/2005	21.3	8.48	6.06	3.3	5.36	7.56	13	31
2	4/19/2005	20.7	8.08	6.4	3.5	3.86	7.26	23	31
3	4/19/2005	20.7	8.39	7.23	4	7.79	7.4	23	20
4	4/19/2005	20.7	7.85	7.63	4.2	5.75	7.15	49	10
5	4/19/2005	20.9	8.38	7.49	4.1	3.07	7.76	13	5
6	4/19/2005	18.1	7.67	0.04	0	8.65	7.68	130	178
7	4/19/2005	20.5	5.2	0.59	0.3	19.2	6.65	46	20
8	4/19/2005	21.6	7.09	6.07	3.3	6.91	6.73	70	10
9	4/19/2005	20.6	7.74	6.32	3.5	23	7.11	13	5
10	4/19/2005	22	8.59	5.66	3.1	15.8	7.87	110	5
1	4/26/2005	20.1	8.79	5.97	3.3	21.8	7.7	70	53
2	4/26/2005	20	8.07	6.65	3.6	15.1	7.46	23	5
3	4/26/2005	20.5	7.91	6.92	3.8	9.42	7.36	13	5
4	4/26/2005	20.6	7.23	6.97	3.8	7.3	7.24	33	31
5	4/26/2005	19.9	8.46	8.03	4.5	4.09	8.03	45	5
6	4/26/2005	16.7	7.65	0.05	0	11.9	8.25	1600	1445
7	4/26/2005	20.2	6.73	2.83	1.5	10.8	6.94	23	31
8	4/26/2005	21	6.68	5.76	3.1	9.11	6.9	170	75
9	4/26/2005	18.9	7.9	5.83	3.2	44.8	7.04	240	99
10	4/26/2005	20.6	7.68	4.16	2.2	37.4	7.04	49	124
1	5/3/2005	21.2	7.51	6.41	3.5	76.5	7.52	350	75
2	5/3/2005	19.8	8.15	7.02	3.9	68.1	7.4	350	150
3	5/3/2005	20.4	8.07	9.15	5.1	21.3	7.53	110	87
4	5/3/2005	20.3	8.01	9.57	5.4	21.1	7.53	79	10
5	5/3/2005	19.4	7.39	7.01	3.9	28.8	7.83	49	42
6	5/3/2005	17.7	7.37	0.04	0	11	7.98	1600	150
7	5/3/2005	20	5.12	0.64	0.3	15	7.45	140	111
8	5/3/2005	20.2	5.89	4.16	2.2	10.1	7.36	240	111
9	5/3/2005	20.1	7.69	5.57	3	2.53	7.34	17	23
10	5/3/2005	20.9	8.25	3.97	2.1	9.5	7.61	33	20
1	5/10/2005	22.4	6.41	6.85	3.8	3.87	7.53	7.8	5
2	5/10/2005	22.6	6.76	7.71	4.3	2.74	7.48	2	5
3	5/10/2005	22.6	6.38	7.66	4.2	4.95	7.95	13	5
4	5/10/2005	22.8	6.11	8.5	4.7	3.14	7.53	4.5	5
5	5/10/2005	22.2	6.26	8.72	4.9	2.1	8.46	2	5
6	5/10/2005	20.1	7.17	0.05	0	7.89	7.91	1600	192
7	5/10/2005	22.3	4.79	1.12	0.6	9.85	6.85	21	111
8	5/10/2005	23.2	6.77	5.59	3	5.12	6.96	23	531
9	5/10/2005	23.2	7.7	6.08	3.3	3.91	7.18	2	5
10	5/10/2005	24.2	7.99	6.01	3.3	7.02	7.35	49	5
1	5/17/2005	24.8	5.78	7.4	4.1	9.68	7.22	7.8	20
2	5/17/2005	24.3	5.75	7.66	4.2	19.1	6.93	130	5
3	5/17/2005	24.3	6.72	7.46	4.1	7.4	7.1	1700	2100
4	5/17/2005	24.4	5.87	7.49	4.1	12.6	7.04	33	31
5	5/17/2005	24.8	6.09	9.17	5.1	11.6	7.31	11	10

LPBF Master Database 2005									
Site	**Date**	**Water Temp °C**	**Diss Oxy mg/L**	**Spec Cond mS/cm**	**Salinity ppt**	**Turbidity NTU**	**pH**	**Fecal Coliform MPN/100 mL**	**Enterococci MPN/100 mL**
6	5/17/2005	21.8	6.46	0.04	0	5.43	7.97	130	124
7	5/17/2005	24.6	5.5	2.46	1.3	8.12	6.98	33	42
8	5/17/2005	25.7	6.62	6.53	3.6	3.81	7.04	33	5
9	5/17/2005	25.3	6.9	6.98	3.8	3.07	7.27	1	5
10	5/17/2005	26.1	7.05	6.28	3.4	8.2	7.39	11	10
1	5/24/2005	28.9	4.44	7.57	4.2	4.35	7.03	33	10
2	5/24/2005	28.6	5.15	8.01	4.4	4.97	7.1	4.5	10
3	5/24/2005	28.7	6.88	7.98	4.6	14.2	7.35	4.5	20
4	5/24/2005	28.3	6.21	8.39	4.6	15.2	7.29	140	406
5	5/24/2005	27.4	7.27	8.88	4.7	16.9	7.68	17	87
6	5/24/2005	25.3	6.15	0.05	0	6.49	7.06	49	222
7	5/24/2005	29.4	5.38	6.16	3.3	4.6	6.88	4.5	10
8	5/24/2005	28.6	5.39	2.52	1.3	14.2	6.78	17	5
9	5/24/2005	27.1	7.75	6.18	3.4	23.8	7.2	11	10
10	5/24/2005	28.4	6.73	6.71	3.6	94.7	7.09	26	254
1	5/31/2005	26.8	5.92	7.48	4.1	10.8	7.51	1600	178
2	5/31/2005	26.6	5.9	8.47	4.7	5.14	7.26	540	64
3	5/31/2005	26.8	6.33	8.66	4.8	3.45	7.15	350	324
4	5/31/2005	26.7	5.59	8.64	4.8	2.97	7.02	540	99
5	5/31/2005	25.7	6.09	9.14	5.1	4.82	7.29	23	164
6	5/31/2005	21.5	6.6	0.03	0	42.1	6.29	1600	2100
7	5/31/2005	24.7	3.87	1.16	0.6	10.8	6.26	920	1298
8	5/31/2005	23.6	4.47	1.67	0.8	14.2	6.16	1700	2100
9	5/31/2005	25.2	6.88	5.16	2.8	6.94	6.39	540	53
10	5/31/2005	25.5	6.78	7.24	4	13.6	6.62	170	164
1	6/7/2005	27.6	5.23	6.74	3.7	4.88	7.26	920	324
2	6/7/2005	27.2	5.51	7.36	4	2.45	7.12	1600	324
3	6/7/2005	27.5	5.46	8.6	4.8	2.24	7.16	140	254
4	6/7/2005	27.4	5.25	8.52	4.7	2.36	7.07	350	137
5	6/7/2005	26.8	5.77	9.47	5.3	4.87	7.64	1	10
6	6/7/2005	23.5	6.43	0.05	0	9.26	7.22	130	137
7	6/7/2005	27.2	3.52	2.59	1.3	6.49	6.01	79	64
8	6/7/2005	27.9	3.74	4.83	2.6	4.37	6.02	170	150
9	6/7/2005	27.6	6.68	6.15	3.3	7.55	6.48	7.8	5
10	6/7/2005	28.1	6.73	6.96	3.8	5.86	6.7	13	10
1	6/14/2005	29.2	5.45	7.38	4	4.15	7.49	13	5
2	6/14/2005	29.3	4.93	8.28	4.6	3.14	7.18	13	20
3	6/14/2005	29.6	6.09	9.19	5.1	2.94	7.72	1	5
4	6/14/2005	29.5	6.3	9.41	5.2	3.24	7.68	6.8	5
5	6/14/2005	28.2	4.37	9.63	5.4	2.9	7.34	2	20
6	6/14/2005	27.1	6.31	0.05	0	6.76	7.09	130	64
7	6/14/2005	29.8	4.33	2.82	1.4	6.12	6.6	13	10
8	6/14/2005	30.2	4.23	4.97	2.6	3.97	6.53	23	75
9	6/14/2005	30.4	6.33	6.07	3.3		6.86	33	10
10	6/14/2005	30.4	6.96	7.42	4.1	7.95	7.18	7.8	5
1	6/15/2005	29.9	5.25	7.45	4.1	3.2	7.11	4.5	5

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Race Structure

Neighborhood	Total Population	Percent White	Percent Black	Percent Asian	Percent Native American	Percent 2 or More Races	Percent Other Races	Percent Hispanic
New Orleans Cit	484674	28.1	67.3	2.3	0.2	1.3	1.0	3.1
Algiers Point	2381	70.6	25.2	0.9	0.5	1.5	1.3	4.7
Audubon/Univers	14898	89.3	5.1	2.5	0.2	1.9	1.0	4.4
B.W. Cooper Pro	4339	0.3	99.0	0.0	0.0	0.6	0.1	0.9
Bayou St. John	4861	27.7	68.4	0.9	0.5	1.2	1.3	3.2
Behrman	10430	15.0	78.1	1.6	0.3	1.9	3.1	6.6
Black Pearl	1772	58.1	37.3	2.7	0.1	1.1	0.7	4.2
Broadmoor	7232	27.8	68.9	0.6	0.2	1.7	0.8	3.7
Bywater	5096	34.8	62.2	0.6	0.3	1.1	1.0	4.8
Central Busines	1794	57.0	33.4	5.9	0.3	2.2	1.2	3.2
Central City/Ma	19072	10.5	87.5	0.6	0.2	0.9	0.4	1.6
City Park	2813	85.5	9.6	1.4	0.2	2.1	1.2	5.3
Desire Area	3791	3.8	94.6	0.2	0.1	0.7	0.6	1.4
Desire Project	660	0.0	98.3	0.8	0.0	0.9	0.0	0.2
Dillard	6471	7.8	88.9	0.3	0.1	2.0	0.9	2.1
Dixon	1772	3.4	95.4	0.1	0.0	0.7	0.5	1.5
Donna Villa/Cam	5564	17.1	80.7	0.8	0.2	0.6	0.6	2.4
East Carrollton	4438	63.8	31.6	1.6	0.3	1.6	1.1	4.5
East Riverside	3220	33.1	64.3	0.3	0.4	1.1	0.7	3.6
Edgelake/Little	44311	10.2	86.8	0.9	0.1	1.3	0.6	1.6
Fairgrounds/Bro	6575	27.5	69.8	0.2	0.2	1.1	1.3	3.3
Fillmore	6983	38.2	57.7	1.6	0.0	1.7	0.8	3.8
Fischer Project	2034	0.5	99.2	0.0	0.0	0.2	0.0	0.1
Florida Area	3171	0.4	99.0	0.0	0.0	0.4	0.1	0.8
Florida Project	1604	0.2	98.9	0.0	0.2	0.6	0.0	0.9
Freret	2446	13.7	83.0	0.4	0.4	1.3	1.2	1.8
Garden District	1970	93.0	2.9	0.9	0.4	1.9	1.0	5.1
Gentilly Terrac	10542	26.5	70.2	0.5	0.2	1.4	1.1	3.0
Gentilly Woods	4387	25.8	69.1	2.7	0.3	1.0	1.0	2.4
Gerrtown/Zion C	4748	3.2	94.9	0.5	0.0	0.9	0.4	1.3
Hollygrove	6919	3.0	95.3	0.1	0.0	1.0	0.5	1.5
Holy Cross	5507	9.9	88.0	0.2	0.5	1.0	0.4	1.4
Iberville Proje	2540	0.9	98.6	0.0	0.0	0.5	0.0	0.8
Irish Channel	4270	27.6	68.8	0.2	0.3	1.9	1.1	3.9
Lake Catherine/	1760	95.2	2.0	2.2	0.0	0.4	0.2	1.0
Lake Forest Eas	9596	2.1	96.2	0.4	0.2	0.9	0.2	1.3
Lake Kenilworth	5092	10.0	87.8	0.3	0.4	1.0	0.5	1.0
Lake Terrace/ L	2162	75.1	19.0	3.8	0.1	1.3	0.6	3.7
Lakeshore/Lake	3615	96.1	0.7	2.1	0.1	0.9	0.1	2.7
Lakeview	9875	96.9	0.7	0.8	0.1	0.9	0.6	3.7
Lakewood	1962	96.1	1.7	1.2	0.3	0.8	0.0	2.3
Lakewood/West E	4724	94.4	1.7	1.7	0.1	1.1	1.0	5.1
Leonidas/West C	8953	21.6	75.9	0.5	0.1	1.0	0.8	2.2
Lower Ninth War	14008	0.5	98.6	0.0	0.0	0.6	0.2	0.5
Marigny	3145	76.2	18.0	1.0	0.7	2.3	1.8	6.0
Marlyville/Font	6740	65.3	28.1	3.5	0.2	1.4	1.5	4.2
McDonogh	2815	10.1	87.9	0.6	0.2	0.9	0.4	1.3
Mid-City	19909	27.7	65.0	1.3	0.4	1.9	3.7	10.0
Milan	7480	22.6	74.2	1.1	0.2	1.1	0.9	2.5
Milneburg	5640	20.1	76.0	0.7	0.1	1.9	1.2	4.2
Navarre	2908	92.3	3.6	0.7	0.1	2.0	1.3	5.3
New Aurora/Engl	5672	17.3	68.5	13.0	0.1	0.6	0.5	1.3
Old Aurora	15807	62.7	31.2	2.7	0.5	1.6	1.3	4.8
Plum Orchard/Bo	7005	4.6	93.7	0.1	0.0	1.1	0.5	1.3
Pontchartrain P	2630	0.9	97.0	0.1	0.3	0.8	0.8	0.8
Seventh Ward	16955	3.3	94.5	0.1	0.2	1.2	0.8	1.9
Sherwood Forest	8240	17.1	73.7	6.9	0.4	1.5	0.5	1.4
St. Anthony	5318	33.0	58.6	4.1	0.3	1.8	2.1	5.6
St. Bernard Are	6427	1.2	98.2	0.0	0.0	0.5	0.0	0.8
St. Claude	11721	7.3	91.2	0.2	0.1	0.8	0.5	1.7
St. Roch	11975	4.9	92.7	0.2	0.2	1.2	0.8	3.2
St. Thomas	6116	59.6	34.4	1.5	0.2	2.6	1.7	6.6
St. Thomas Proj	2957	4.7	93.7	0.1	0.2	0.6	0.7	2.0
Tall Timbers/Br	12177	38.3	54.8	3.7	0.3	1.5	1.4	4.3

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Race Structure

Neighborhood	Total Population	Percent White	Percent Black	Percent Asian	Percent Native American	Percent 2 or More Races	Percent Other Races	Percent Hispanic
Touro	3242	77.3	18.6	1.6	0.2	1.1	1.3	4.7
Treme'	8853	5.3	93.1	0.1	0.3	0.6	0.6	1.5
Tulane/Gravier	4234	14.3	78.8	5.0	0.3	0.7	1.0	2.6
U.S. Naval Base	2902	32.3	64.0	0.8	0.1	1.7	1.2	4.2
Uptown	6681	59.9	36.3	1.1	0.3	1.5	1.0	3.5
Viavant/Venetia	1883	15.6	77.3	3.3	0.1	1.2	2.4	4.4
Vieux Carre	4176	91.9	4.3	1.2	0.5	1.5	0.6	2.6
Village de l'es	12912	3.9	56.6	37.2	0.1	1.7	0.5	2.4
West Riverside	5232	59.4	36.5	0.7	0.5	1.9	1.0	4.2
Whitney	2564	11.7	85.5	0.5	0.2	1.1	0.9	2.3

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Race/Ethnic Diversity

Neighborhood	Total Population	Percent NonHisp White	Percent NonHisp Black	Percent NonHisp Asian	Percent Hispanic	Percent NonHisp Other	IQV - Race Ethnic Diversity
New Orleans Cit	484674	26.6	66.7	2.3	3.1	1.4	59.3
Algiers Point	2381	67.4	25.1	0.8	4.7	2.0	54.5
Audubon/Univers	14898	86.1	5.1	2.4	4.4	2.0	24.6
B.W. Cooper Pro	4339	0.2	98.4	0.0	0.9	0.6	4.0
Bayou St. John	4861	26.7	67.8	0.9	3.2	1.4	57.8
Behrman	10430	12.8	77.4	1.6	6.6	1.6	46.7
Black Pearl	1772	55.1	36.7	2.7	4.2	1.4	65.6
Broadmoor	7232	25.8	68.2	0.6	3.7	1.7	57.0
Bywater	5096	32.4	61.1	0.6	4.8	1.2	62.9
Central Busines	1794	55.2	32.9	5.9	3.2	2.7	70.2
Central City/Ma	19072	9.9	87.0	0.6	1.6	0.9	29.0
City Park	2813	81.9	9.4	1.4	5.3	2.0	32.1
Desire Area	3791	3.5	94.1	0.2	1.4	0.8	14.1
Desire Project	660	0.0	98.2	0.8	0.2	0.9	4.4
Dillard	6471	6.9	88.4	0.3	2.1	2.4	26.4
Dixon	1772	3.2	94.9	0.1	1.5	0.3	12.3
Donna Villa/Cam	5564	16.2	79.9	0.8	2.4	0.8	41.5
East Carrollton	4438	60.8	31.5	1.6	4.5	1.7	61.4
East Riverside	3220	30.9	63.8	0.3	3.6	1.3	60.2
Edgelake/Little	44311	9.8	86.2	0.9	1.6	1.5	30.7
Fairgrounds/Bro	6575	26.0	69.1	0.2	3.3	1.4	55.7
Fillmore	6983	36.4	56.9	1.6	3.8	1.4	66.1
Fischer Project	2034	0.5	99.1	0.0	0.1	0.3	2.2
Florida Area	3171	0.4	98.3	0.0	0.8	0.4	4.2
Florida Project	1604	0.2	98.0	0.0	0.9	0.9	4.9
Freret	2446	13.5	82.7	0.4	1.8	1.7	37.1
Garden District	1970	89.2	2.7	0.9	5.1	2.1	16.4
Gentilly Terrac	10542	24.9	69.7	0.5	3.0	1.9	55.3
Gentilly Woods	4387	24.8	68.5	2.7	2.4	1.7	57.8
Gerrtown/Zion C	4748	2.9	94.5	0.5	1.3	0.8	13.2
Hollygrove	6919	2.6	94.7	0.1	1.5	1.1	12.7
Holy Cross	5507	9.4	87.3	0.2	1.4	1.6	28.5
Iberville Proje	2540	0.7	98.0	0.0	0.8	0.5	4.9
Irish Channel	4270	26.0	68.3	0.2	3.9	1.5	56.9
Lake Catherine/	1760	94.3	2.0	2.2	1.0	0.5	11.6
Lake Forest Eas	9596	2.0	95.4	0.4	1.3	1.0	11.1
Lake Kenilworth	5092	9.7	87.5	0.3	1.0	1.5	28.0
Lake Terrace/ L	2162	72.4	18.9	3.8	3.7	1.2	49.7
Lakeshore/Lake	3615	93.7	0.6	2.1	2.7	0.9	9.4
Lakeview	9875	93.9	0.7	0.7	3.7	1.0	7.4
Lakewood	1962	94.0	1.7	1.2	2.3	0.8	9.4
Lakewood/West E	4724	90.5	1.7	1.6	5.1	1.0	13.2
Leonidas/West C	8953	20.6	75.4	0.5	2.2	1.2	48.0
Lower Ninth War	14008	0.5	98.3	0.0	0.5	0.7	4.2
Marigny	3145	72.6	17.7	1.0	6.0	2.7	47.9
Marlyville/Font	6740	62.6	27.9	3.5	4.2	1.8	61.6
McDonogh	2815	9.3	87.7	0.6	1.3	1.2	27.5
Mid-City	19909	23.2	64.3	1.2	10.0	1.3	62.4
Milan	7480	21.6	73.8	1.0	2.5	1.1	50.4
Milneburg	5640	17.7	75.4	0.7	4.2	2.0	48.6
Navarre	2908	89.0	3.2	0.6	5.3	1.9	18.0
New Aurora/Engl	5672	16.9	68.1	13.0	1.3	0.7	61.1
Old Aurora	15807	60.0	30.9	2.7	4.8	1.6	63.5
Plum Orchard/Bo	7005	4.4	93.0	0.1	1.3	1.2	16.6
Pontchartrain P	2630	0.6	96.7	0.1	0.8	1.7	8.1
Seventh Ward	16955	3.0	93.6	0.1	1.9	1.4	15.3
Sherwood Forest	8240	16.6	73.3	6.8	1.4	2.0	53.5
St. Anthony	5318	29.8	58.0	4.0	5.6	2.6	68.7
St. Bernard Are	6427	1.1	97.7	0.0	0.8	0.3	5.7
St. Claude	11721	6.9	90.6	0.2	1.7	0.7	21.7
St. Roch	11975	3.9	91.5	0.2	3.2	1.2	19.9
St. Thomas	6116	55.4	34.2	1.5	6.6	2.3	65.3
St. Thomas Proj	2957	4.2	93.1	0.1	2.0	0.6	16.3
Tall Timbers/Br	12177	35.8	54.6	3.7	4.3	1.6	69.0

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Race/Ethnic Diversity

Neighborhood	Total Population	Percent NonHisp White	Percent NonHisp Black	Percent NonHisp Asian	Percent Hispanic	Percent NonHisp Other	IQV - Race Ethnic Diversity
Touro	3242	74.0	18.4	1.6	4.7	1.3	45.7
Treme'	8853	4.9	92.4	0.1	1.5	1.1	17.9
Tulane/Gravier	4234	13.5	78.2	5.0	2.6	0.7	45.6
U.S. Naval Base	2902	30.2	63.1	0.7	4.2	1.7	61.9
Uptown	6681	57.8	36.0	1.1	3.5	1.7	63.7
Viavant/Venetia	1883	14.3	76.6	3.3	4.4	1.4	48.2
Vieux Carre	4176	89.8	4.3	1.2	2.6	2.1	19.0
Village de l'es	12912	3.6	55.4	37.1	2.4	1.5	69.1
West Riverside	5232	56.9	36.1	0.7	4.2	2.2	64.3
Whitney	2564	11.1	84.9	0.5	2.3	1.2	33.1

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Geo-Mobility

Neighborhood Name	Planning District Code	% Born in Louisiana	% Foreign Born	% Lived Same House 1995	%Different House-Same County	% Different County-Same State	% Different State 1995
New Orleans City	.	77.4	4.2	56.8	28.6	6.0	7.1
Algiers Point	12	56.7	5.3	36.6	32.5	11.7	17.3
Audubon/Universi	3	49.4	6.0	40.2	20.7	7.1	28.3
B.W. Cooper Proj	4	90.8	0.3	71.7	24.4	2.6	0.6
Bayou St. John	4	80.0	3.8	53.0	34.8	5.2	6.4
Behrman	12	80.9	6.0	55.2	30.1	7.1	5.5
Black Pearl	3	63.3	3.9	43.9	30.5	7.7	16.5
Broadmoor	3	78.3	3.7	60.6	28.9	4.2	4.9
Bywater	7	73.3	3.6	58.9	28.8	2.7	7.5
Central Business	1	49.6	10.6	32.6	19.6	13.7	29.8
Central City/Mag	2	84.3	2.4	60.2	30.8	3.3	3.9
City Park	5	59.5	7.1	43.6	34.9	10.1	9.2
Desire Area	7	83.7	2.0	65.5	30.5	0.9	3.0
Desire Project	7	96.8	0.0	87.6	11.3	0.0	1.1
Dillard	6	83.3	2.0	63.1	24.5	3.9	8.1
Dixon	3	89.4	0.4	61.4	30.1	5.8	2.8
Donna Villa/Came	9	86.2	2.7	65.5	29.9	1.6	2.6
East Carrollton	3	52.6	6.3	45.4	23.4	6.4	22.4
East Riverside	2	77.9	2.8	53.0	32.7	5.8	7.9
Edgelake/Little	9	85.1	2.5	57.6	35.1	3.4	3.2
Fairgrounds/Broa	4	81.0	4.0	61.9	27.8	6.4	3.8
Fillmore	6	75.7	4.9	69.0	21.3	3.6	5.4
Fischer Project	12	96.8	0.0	84.9	13.6	1.5	0.0
Florida Area	7	89.3	0.2	70.1	27.4	0.1	1.5
Florida Project	7	97.9	0.0	62.0	36.5	1.0	0.0
Freret	3	83.3	1.6	59.1	31.5	2.7	5.8
Garden District	2	44.7	7.4	49.0	20.6	6.3	19.2
Gentilly Terrace	6	86.5	2.9	64.3	28.7	3.1	3.0
Gentilly Woods	6	72.6	6.4	61.0	20.4	1.9	12.6
Gerrtown/Zion Ci	4	67.5	3.3	35.5	30.1	14.4	17.2
Hollygrove	3	86.7	0.4	68.5	25.6	3.7	1.9
Holy Cross	8	88.2	1.9	65.4	29.3	3.5	1.5
Iberville Projec	4	98.6	0.3	73.7	24.0	0.9	0.4
Irish Channel	2	75.8	3.5	47.9	38.9	3.8	7.6
Lake Catherine/F	11	80.7	2.4	65.4	8.7	24.4	0.6
Lake Forest East	9	88.1	1.4	34.6	54.5	3.9	5.7
Lake Kenilworth/	9	89.1	1.3	65.5	31.1	1.9	1.5
Lake Terrace/ La	6	67.0	10.1	57.6	12.3	14.6	12.1
Lakeshore/Lake V	5	69.4	4.2	67.1	25.0	4.4	3.5
Lakeview	5	75.3	4.0	57.4	23.2	11.4	7.8
Lakewood	5	71.7	3.5	72.4	15.9	7.4	3.6
Lakewood/West En	5	70.0	7.1	49.4	24.3	17.1	6.0
Leonidas/West Ca	3	78.6	2.5	56.0	30.4	5.7	6.8
Lower Ninth Ward	8	91.9	0.5	73.5	23.5	1.2	1.4
Marigny	7	52.8	7.6	53.3	26.9	6.7	12.5
Marlyville/Fonta	3	62.9	6.9	50.5	22.2	7.5	14.9
McDonogh	12	87.4	1.1	53.9	32.5	6.4	7.0
Mid-City	4	67.6	6.6	40.5	23.6	24.8	9.6
Milan	2	73.7	3.1	50.2	33.9	4.0	9.8
Milneburg	6	84.8	6.3	64.7	29.0	3.3	2.3
Navarre	5	74.1	3.0	49.1	24.4	18.8	6.8
New Aurora/Engli	13	77.3	9.4	67.0	22.4	4.5	5.0
Old Aurora	12	66.7	6.3	56.9	23.6	10.4	8.1
Plum Orchard/Bon	9	89.1	1.0	73.0	24.1	0.9	1.1
Pontchartrain Pa	6	87.8	0.0	73.6	22.9	1.6	1.9
Seventh Ward	4	89.7	1.5	58.7	34.9	2.9	2.1
Sherwood Forest/	9	79.4	5.2	68.8	28.1	1.6	1.3
St. Anthony	6	79.4	9.0	59.1	25.1	6.1	5.8
St. Bernard Area	4	95.6	0.4	72.0	24.7	1.4	0.9
St. Claude	7	87.5	1.2	61.0	33.4	2.3	3.1
St. Roch	7	88.1	2.4	61.5	31.4	4.0	2.1
St. Thomas	2	55.2	7.9	45.1	26.8	5.8	18.7
St. Thomas Proje	2	91.6	1.1	76.7	18.5	2.4	0.3
Tall Timbers/Bre	12	61.4	6.2	37.3	32.0	11.5	16.2

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Geographic Mobility

Neighborhood Name	Planning District Code	% Born in Louisiana	% Foreign Born	% Lived Same House 1995	%Different House-Same County	% Different County-Same State	% Different State 1995
Touro	2	53.2	6.6	40.7	26.2	11.0	20.2
Treme'	4	91.3	0.3	60.5	33.0	1.6	3.6
Tulane/Gravier	4	81.2	7.1	45.6	34.3	10.5	6.3
U.S. Naval Base	12	57.4	2.8	47.1	14.0	4.1	30.2
Uptown	3	63.0	5.2	50.9	24.9	8.8	13.1
Viavant/Venetian	11	76.7	3.8	42.6	42.8	12.3	1.7
Vieux Carre	1	38.7	5.8	46.3	20.4	7.3	24.0
Village de l'est	10	65.0	24.2	57.7	32.9	3.8	4.2
West Riverside	3	63.7	4.4	51.2	29.8	5.0	13.1
Whitney	12	87.1	2.7	72.9	15.7	6.2	3.5

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Education

Neighborhood Name	Planning District Code	% Less Than High School	% High School Graduate	% Some College	% Associate Degree	% College Graduate	% Advanced Degree
New Orleans City	.	25.3	23.4	21.9	3.6	15.0	10.7
Algiers Point	12	11.7	22.8	28.9	4.8	17.9	13.9
Audubon/University	3	5.6	7.2	13.1	2.7	34.6	36.8
B.W. Cooper Project	4	52.9	28.5	15.7	2.4	0.4	0.0
Bayou St. John	4	28.1	22.8	22.1	4.0	13.8	9.3
Behrman	12	31.2	32.2	21.7	4.8	7.6	2.4
Black Pearl	3	15.0	14.8	20.0	6.2	25.7	18.3
Broadmoor	3	25.4	24.5	22.0	2.4	14.7	11.0
Bywater	7	35.8	24.9	17.3	2.1	13.4	6.5
Central Business Dis	1	22.4	19.0	14.6	3.7	23.2	17.1
Central City/Magnoli	2	43.7	26.3	15.5	1.9	7.1	5.5
City Park	5	6.1	14.8	20.4	4.3	30.3	24.1
Desire Area	7	44.4	23.7	20.1	3.2	4.7	4.0
Desire Project	7	48.6	36.1	15.3	0.0	0.0	0.0
Dillard	6	23.5	28.2	21.7	4.0	13.6	9.0
Dixon	3	40.1	29.9	13.4	3.9	9.2	3.6
Donna Villa/Camelot	9	19.6	29.4	27.1	4.9	12.8	6.3
East Carrollton	3	12.9	12.5	21.0	1.3	32.6	19.7
East Riverside	2	23.4	33.1	19.1	3.0	12.1	9.2
Edgelake/Little Wood	9	16.9	24.6	30.0	4.6	15.9	8.0
Fairgrounds/Broad	4	23.2	25.8	24.7	5.8	13.3	7.1
Fillmore	6	11.5	21.7	22.4	4.3	19.5	20.5
Fischer Project	12	61.5	28.0	5.7	0.4	2.5	1.8
Florida Area	7	48.7	26.5	19.4	0.7	3.5	1.2
Florida Project	7	63.5	29.0	7.4	0.0	0.0	0.0
Freret	3	31.3	29.8	18.5	5.0	6.3	9.1
Garden District	2	4.7	5.4	14.1	2.4	41.5	31.9
Gentilly Terrace	6	16.3	25.0	25.8	5.7	17.5	9.7
Gentilly Woods	6	19.4	24.0	26.1	2.6	16.8	11.1
Gerrtown/Zion City	4	43.1	25.2	15.3	2.6	6.7	7.0
Hollygrove	3	34.9	29.5	21.5	2.8	6.7	4.5
Holy Cross	8	37.8	25.6	24.1	3.6	5.9	3.1
Iberville Project	4	57.0	33.6	9.4	0.0	0.0	0.0
Irish Channel	2	29.3	22.4	21.3	3.7	14.3	9.0
Lake Catherine/Fort	11	26.5	35.5	22.6	1.9	10.8	2.7
Lake Forest East	9	17.9	28.6	29.0	6.3	13.4	4.9
Lake Kenilworth/Geor	9	22.7	27.9	31.4	4.4	8.0	5.6
Lake Terrace/ Lake O	6	5.7	10.7	21.3	2.2	26.9	33.2
Lakeshore/Lake Vista	5	4.8	10.8	21.4	1.6	34.3	27.1
Lakeview	5	7.2	16.1	22.9	4.0	29.1	20.8
Lakewood	5	1.9	7.8	20.1	0.8	30.7	38.7
Lakewood/West End	5	11.2	19.0	24.7	4.2	21.9	18.9
Leonidas/West Carrol	3	29.3	23.0	21.7	3.2	12.8	10.0
Lower Ninth Ward	8	40.3	28.7	21.4	2.8	5.4	1.5
Marigny	7	16.3	15.4	30.7	4.0	19.2	14.3
Marlyville/Fontainbl	3	13.6	11.1	17.0	2.4	26.3	29.7
McDonogh	12	38.9	27.4	18.3	3.8	9.5	2.0
Mid-City	4	45.6	19.8	18.6	2.3	8.3	5.3
Milan	2	27.9	18.9	22.6	3.8	13.9	12.9
Milneburg	6	22.9	30.2	24.4	3.8	12.2	6.4
Navarre	5	12.0	13.9	24.3	4.5	26.1	19.2
New Aurora/English T	13	27.5	28.0	22.4	2.3	10.1	9.8
Old Aurora	12	10.8	21.6	24.3	6.2	23.8	13.3
Plum Orchard/Bonita	9	25.5	32.1	22.2	4.2	10.8	5.3
Pontchartrain Park	6	22.3	16.3	25.5	4.4	19.8	11.6
Seventh Ward	4	40.4	31.9	17.3	3.0	5.6	1.8
Sherwood Forest/lake	9	17.1	23.3	23.3	7.2	19.6	9.5
St. Anthony	6	18.1	27.4	28.2	3.3	15.5	7.5
St. Bernard Area/Pro	4	44.7	30.4	17.2	2.8	2.5	2.4
St. Claude	7	35.3	30.2	22.0	2.0	7.8	2.7
St. Roch	7	37.8	29.0	20.6	2.7	6.8	3.0
St. Thomas	2	17.8	15.6	20.6	4.1	23.9	18.0
St. Thomas Project	2	48.1	38.5	9.4	0.0	3.5	0.5
Tall Timbers/Brechte	12	13.2	21.3	26.9	5.2	18.0	15.4

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Education

Neighborhood Name	Planning District Code	% Less Than High School	% High School Graduate	% Some College	% Associate Degree	% College Graduate	% Advanced Degree
Touro	2	14.4	13.2	16.4	2.9	27.6	25.5
Treme'	4	39.1	32.3	18.3	1.9	5.9	2.6
Tulane/Gravier	4	43.2	24.4	18.3	0.5	6.5	7.2
U.S. Naval Base	12	19.7	31.1	26.9	4.7	9.8	7.8
Uptown	3	13.1	11.4	19.9	2.7	24.2	28.8
Viavant/Venetian Isl	11	40.6	31.5	8.8	2.9	9.7	6.5
Vieux Carre	1	5.9	13.3	22.0	5.3	30.0	23.5
Village de l'est	10	36.8	22.2	21.6	4.2	10.7	4.6
West Riverside	3	18.0	21.9	18.9	3.4	20.9	16.9
Whitney	12	30.6	30.9	22.4	4.9	7.0	4.3

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Work Issues

Neighborhood Name	Planning District Code	% with a Disability	% Households linguistically Isolated	% Not In the Labor Force	Civilian Labor Force Unemployed	Work in County of Residence	Work in Different State
New Orleans City	.	23.2	1.7	42.2	9.5	78.2	0.9
Algiers Point	12	21.1	1.7	23.5	3.7	74.2	1.7
Audubon/University	3	10.2	1.4	40.2	3.9	81.1	1.6
B.W. Cooper Project	4	39.3	0.7	53.1	27.7	89.3	1.1
Bayou St. John	4	24.1	1.7	34.1	9.3	77.3	0.9
Behrman	12	22.8	1.8	40.5	10.1	64.4	0.6
Black Pearl	3	22.5	1.1	39.9	8.4	80.8	0.0
Broadmoor	3	27.4	1.0	42.8	9.6	78.6	1.4
Bywater	7	26.8	0.9	44.4	9.7	81.9	0.8
Central Business Dis	1	20.7	4.4	46.3	12.5	73.9	4.4
Central City/Magnoli	2	31.1	1.3	53.1	20.4	85.0	0.5
City Park	5	13.0	3.5	23.4	6.7	74.1	1.1
Desire Area	7	37.2	1.1	52.7	9.1	83.2	0.5
Desire Project	7	34.4	0.0	56.0	28.8	84.4	0.0
Dillard	6	26.4	1.4	45.9	10.2	79.0	0.6
Dixon	3	26.9	1.6	41.7	15.0	73.3	0.0
Donna Villa/Camelot	9	23.4	1.1	38.5	6.3	83.5	2.0
East Carrollton	3	17.0	2.4	40.3	4.8	80.8	1.3
East Riverside	2	25.1	1.0	40.1	11.5	80.8	2.4
Edgelake/Little Wood	9	18.2	0.8	32.3	7.6	80.9	0.8
Fairgrounds/Broad	4	25.5	2.0	41.7	7.1	77.5	0.9
Fillmore	6	22.7	0.7	41.7	6.5	74.3	1.9
Fischer Project	12	21.5	0.0	64.8	24.7	67.9	0.0
Florida Area	7	28.1	0.0	58.2	15.0	83.3	0.0
Florida Project	7	22.5	0.0	64.4	53.2	82.0	0.0
Freret	3	37.8	1.9	51.7	20.6	78.1	0.0
Garden District	2	9.5	2.7	36.1	2.4	87.2	1.6
Gentilly Terrace	6	20.8	1.2	36.2	5.7	78.6	0.4
Gentilly Woods	6	18.0	3.4	35.4	9.0	75.7	0.7
Gerrtown/Zion City	4	24.0	1.0	40.8	42.5	74.1	0.8
Hollygrove	3	29.5	0.1	45.8	9.7	67.6	0.2
Holy Cross	8	28.6	1.0	48.1	13.9	74.6	0.5
Iberville Project	4	19.6	0.0	59.1	44.9	86.1	0.0
Irish Channel	2	21.5	0.9	39.1	12.4	83.0	0.4
Lake Catherine/Fort	11	26.5	0.6	48.1	1.4	70.4	0.6
Lake Forest East	9	21.5	1.0	32.1	11.1	85.4	0.0
Lake Kenilworth/Geor	9	18.8	0.4	33.5	9.7	78.3	0.6
Lake Terrace/ Lake O	6	13.3	0.0	35.9	5.5	84.1	0.0
Lakeshore/Lake Vista	5	15.6	0.0	45.1	1.3	68.6	1.8
Lakeview	5	17.4	2.0	34.1	2.0	66.6	0.6
Lakewood	5	13.3	0.0	41.6	0.0	67.9	1.8
Lakewood/West End	5	21.3	2.4	36.4	1.9	65.0	0.8
Leonidas/West Carrol	3	27.4	1.4	41.6	10.5	77.3	0.8
Lower Ninth Ward	8	30.9	0.0	52.1	13.5	78.2	0.7
Marigny	7	26.2	2.3	31.1	7.9	88.9	0.6
Marlyville/Fontainbl	3	16.9	1.0	35.6	4.7	78.5	1.2
McDonogh	12	36.0	1.2	52.6	16.3	71.1	1.9
Mid-City	4	25.8	5.1	63.0	9.5	81.0	0.6
Milan	2	27.1	0.8	41.4	9.3	83.4	0.5
Milneburg	6	24.5	0.9	35.8	6.6	81.9	0.9
Navarre	5	16.9	0.3	32.0	4.4	68.3	0.0
New Aurora/English T	13	24.3	5.0	44.0	10.8	66.3	0.7
Old Aurora	12	16.5	1.8	35.7	5.0	63.1	0.8
Plum Orchard/Bonita	9	31.1	0.0	46.8	8.5	78.7	1.4
Pontchartrain Park	6	26.7	0.0	53.7	6.6	86.1	1.7
Seventh Ward	4	30.2	0.8	49.4	13.8	86.1	0.6
Sherwood Forest/lake	9	19.1	2.2	38.8	4.0	79.0	0.9
St. Anthony	6	20.7	3.2	32.3	7.1	81.2	0.6
St. Bernard Area/Pro	4	25.7	0.0	53.2	20.8	82.4	0.0
St. Claude	7	25.9	1.4	49.4	13.8	86.2	0.0
St. Roch	7	27.3	1.1	48.2	14.4	83.7	0.3
St. Thomas	2	23.2	3.4	32.6	6.9	88.0	1.4
St. Thomas Project	2	31.2	0.0	61.9	24.2	90.0	0.0
Tall Timbers/Brechte	12	18.9	2.8	34.1	6.9	63.2	1.4

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Work Issues

Neighborhood Name	Planning District Code	% with a Disability	% Households linguistically Isolated	% Not In the Labor Force	Civilian Labor Force Unemployed	Work in County of Residence	Work in Different State
Touro	2	15.9	1.0	37.4	1.8	81.7	1.0
Treme'	4	29.5	0.0	52.4	21.4	84.8	0.0
Tulane/Gravier	4	25.0	4.5	56.6	16.0	82.3	0.0
U.S. Naval Base	12	21.7	1.4	39.2	7.7	67.4	1.8
Uptown	3	17.5	1.5	34.9	6.1	85.4	1.1
Viavant/Venetian Isl	11	28.0	3.5	59.2	10.3	80.0	0.0
Vieux Carre	1	14.6	4.3	23.5	4.8	87.1	0.4
Village de l'est	10	19.9	11.1	40.6	10.6	76.9	2.1
West Riverside	3	21.0	3.0	34.9	6.9	78.0	2.1
Whitney	12	29.6	3.3	51.2	14.7	75.7	0.0

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Household Income

Neighborhood Name	Planning District Code	Household Income Less than 20000	Household Income 20000-50000	Household Income 50000-100000	Household Income 100,000 or more
New Orleans City	.	38.9	35.0	18.3	7.8
Algiers Point	12	23.4	41.6	25.3	9.7
Audubon/University	3	22.5	23.6	22.4	31.5
B.W. Cooper Project	4	82.8	15.1	0.5	1.6
Bayou St. John	4	44.5	35.7	15.4	4.5
Behrman	12	41.0	42.9	13.7	2.5
Black Pearl	3	38.2	29.4	22.2	10.1
Broadmoor	3	40.4	34.6	19.1	5.9
Bywater	7	49.6	34.6	12.5	3.2
Central Business Dis	1	40.9	22.8	21.6	14.7
Central City/Magnoli	2	62.8	27.4	7.1	2.7
City Park	5	27.7	37.8	25.6	8.8
Desire Area	7	56.9	26.8	14.5	1.8
Desire Project	7	77.7	19.9	2.4	0.0
Dillard	6	36.3	39.7	19.6	4.3
Dixon	3	53.8	29.8	14.9	1.5
Donna Villa/Camelot	9	22.9	40.4	31.6	5.1
East Carrollton	3	36.9	32.8	15.5	14.8
East Riverside	2	47.1	33.5	15.9	3.5
Edgelake/Little Wood	9	27.7	41.1	25.1	6.1
Fairgrounds/Broad	4	34.0	46.8	16.4	2.8
Fillmore	6	20.8	28.5	37.7	13.0
Fischer Project	12	85.4	13.3	0.0	1.2
Florida Area	7	50.4	40.5	7.0	2.1
Florida Project	7	88.2	11.8	0.0	0.0
Freret	3	55.4	27.3	12.4	4.9
Garden District	2	21.1	32.2	21.1	25.5
Gentilly Terrace	6	28.9	41.8	23.5	5.8
Gentilly Woods	6	20.4	49.4	26.6	3.6
Gerrtown/Zion City	4	59.8	30.0	7.7	2.5
Hollygrove	3	47.2	37.8	12.6	2.4
Holy Cross	8	48.0	36.5	12.4	3.2
Iberville Project	4	89.0	11.0	0.0	0.0
Irish Channel	2	47.8	32.7	16.6	2.9
Lake Catherine/Fort	11	27.0	35.2	28.4	9.4
Lake Forest East	9	41.1	40.2	16.3	2.4
Lake Kenilworth/Geor	9	25.1	43.4	29.3	2.3
Lake Terrace/ Lake O	6	7.3	20.6	25.2	46.9
Lakeshore/Lake Vista	5	8.7	25.9	28.3	37.1
Lakeview	5	16.2	33.2	33.5	17.1
Lakewood	5	6.0	15.4	22.0	56.7
Lakewood/West End	5	18.9	38.7	26.5	15.9
Leonidas/West Carrol	3	46.6	32.7	16.8	4.0
Lower Ninth Ward	8	50.5	37.1	10.9	1.6
Marigny	7	39.7	39.3	14.8	6.2
Marlyville/Fontainbl	3	23.7	30.6	29.7	16.0
McDonogh	12	58.5	31.4	8.3	1.8
Mid-City	4	45.6	39.5	11.9	3.0
Milan	2	46.0	33.3	15.9	4.8
Milneburg	6	30.4	42.9	22.9	3.8
Navarre	5	25.2	32.6	28.4	13.9
New Aurora/English T	13	35.9	34.9	13.6	15.6
Old Aurora	12	17.9	33.3	37.0	11.9
Plum Orchard/Bonita	9	38.3	41.0	16.5	4.2
Pontchartrain Park	6	21.4	47.2	23.0	8.4
Seventh Ward	4	57.5	33.7	7.5	1.4
Sherwood Forest/lake	9	19.6	33.7	34.2	12.6
St. Anthony	6	33.4	46.2	18.1	2.4
St. Bernard Area/Pro	4	71.6	19.7	6.8	1.9
St. Claude	7	49.4	38.2	10.1	2.2
St. Roch	7	51.1	35.5	11.3	2.1
St. Thomas	2	35.4	38.9	13.7	12.1
St. Thomas Project	2	72.3	23.2	0.6	3.9
Tall Timbers/Brechte	12	31.5	32.5	20.8	15.3

Table C-5-1 (continued) Demographic Overview of New Orleans Parish Neighborhoods

Household Income

Neighborhood Name	Planning District Code	Household Income Less than 20000	Household Income 20000-50000	Household Income 50000-100000	Household Income 100,000 or more
Touro	2	30.9	38.7	20.5	9.9
Treme'	4	63.6	28.6	7.0	0.9
Tulane/Gravier	4	74.2	21.6	2.8	1.5
U.S. Naval Base	12	30.7	43.3	21.4	4.7
Uptown	3	33.4	31.1	21.6	13.8
Viavant/Venetian Isl	11	62.6	28.7	7.6	1.2
Vieux Carre	1	28.2	37.8	20.6	13.4
Village de l'est	10	35.7	42.4	17.4	4.5
West Riverside	3	34.3	38.7	17.4	9.7
Whitney	12	46.0	32.8	18.7	

Source: US Bureau of Census. Note: New Orleans Neighborhoods are listed by associate Census Tract and Planning District below:

Census Tract Number	Tract Population 2000	Neighborhood Code	Neighborhood Name	Planning District Code	City Planning District
22071000100	2381	1	Algiers Point	12	Algiers
22071000400	2564	2	Whitney	12	Algiers
22071000601	2034	3	Fischer Project	12	Algiers
22071000200	1347	4	McDonogh	12	Algiers
22071000300	1468	4	McDonogh	12	Algiers
22071000605	2902	5	U.S. Naval Base	12	Algiers
22071000606	4400	6	Old Aurora	12	Algiers
22071000607	3746	6	Old Aurora	12	Algiers
22071000608	7661	6	Old Aurora	12	Algiers
22071000602	2957	7	Behrman	12	Algiers
22071000603	2342	7	Behrman	12	Algiers
22071000604	5131	7	Behrman	12	Algiers
22071000611	4525	8	New Aurora/English Turn	13	English Turn
22071000612	1147	8	New Aurora/English Turn	13	English Turn
22071000613	4630	9	Tall Timbers/Brechtel	12	Algiers
22071000614	7547	9	Tall Timbers/Brechtel	12	Algiers
22071012500	1772	10	Black Pearl	3	Uptown and Carrollton
22071012600	1929	11	East Carrollton	3	Uptown and Carrollton
22071012700	2509	11	East Carrollton	3	Uptown and Carrollton
22071007501	3100	12	Hollygrove	3	Uptown and Carrollton
22071007502	3819	12	Hollygrove	3	Uptown and Carrollton
22071012900	1572	13	Leonidas/West Carrollton	3	Uptown and Carrollton
22071013000	1993	13	Leonidas/West Carrollton	3	Uptown and Carrollton
22071013100	2156	13	Leonidas/West Carrollton	3	Uptown and Carrollton
22071013200	3232	13	Leonidas/West Carrollton	3	Uptown and Carrollton
22071002700	2510	14	Seventh Ward	4	Mid-City
22071002800	2085	14	Seventh Ward	4	Mid-City
22071002900	2309	14	Seventh Ward	4	Mid-City
22071003000	1972	14	Seventh Ward	4	Mid-City
22071003100	1936	14	Seventh Ward	4	Mid-City
22071003400	2008	14	Seventh Ward	4	Mid-City
22071003500	1861	14	Seventh Ward	4	Mid-City
22071003600	2274	14	Seventh Ward	4	Mid-City
22071001703	3739	15	Desire Area	7	Marigny, Bywater, St. Claude, St. Roch
22071001706	52	15	Desire Area	7	Marigny, Bywater, St. Claude, St. Roch
22071001714	660	16	Desire Project	7	Marigny, Bywater, St. Claude, St. Roch
22071001401	3171	17	Florida Area	7	Marigny, Bywater, St. Claude, St. Roch
22071001600	1604	18	Florida Project	7	Marigny, Bywater, St. Claude, St. Roch
22071001100	2892	19	Bywater	7	Marigny, Bywater, St. Claude, St. Roch
22071001200	2204	19	Bywater	7	Marigny, Bywater, St. Claude, St. Roch
22071000702	2976	20	Holy Cross	8	Lower Ninth Ward/Holy Cross
22071000800	2531	20	Holy Cross	8	Lower Ninth Ward/Holy Cross
22071001800	1519	21	Marigny	7	Marigny, Bywater, St. Claude, St. Roch
22071002600	1626	21	Marigny	7	Marigny, Bywater, St. Claude, St. Roch
22071000701	3278	22	Lower Ninth Ward	8	Lower Ninth Ward/Holy Cross
22071000901	2737	22	Lower Ninth Ward	8	Lower Ninth Ward/Holy Cross
22071000902	2943	22	Lower Ninth Ward	8	Lower Ninth Ward/Holy Cross
22071000903	2640	22	Lower Ninth Ward	8	Lower Ninth Ward/Holy Cross
22071000904	2410	22	Lower Ninth Ward	8	Lower Ninth Ward/Holy Cross
22071001301	3022	23	St. Claude	7	Marigny, Bywater, St. Claude, St. Roch
22071001302	1969	23	St. Claude	7	Marigny, Bywater, St. Claude, St. Roch
22071001303	781	23	St. Claude	7	Marigny, Bywater, St. Claude, St. Roch
22071001304	721	23	St. Claude	7	Marigny, Bywater, St. Claude, St. Roch
22071001402	3202	23	St. Claude	7	Marigny, Bywater, St. Claude, St. Roch
22071001500	2026	23	St. Claude	7	Marigny, Bywater, St. Claude, St. Roch

Table C5-1 Note (cont)

Census Tract Number	Tract Population 2000	Neighborhood Code	Neighborhood Name	Planning District Code	City Planning District
22071001900	2524	24	St. Roch	7	Marigny, Bywater, St. Claude, St. Roch
22071002000	2155	24	St. Roch	7	Marigny, Bywater, St. Claude, St. Roch
22071002100	1522	24	St. Roch	7	Marigny, Bywater, St. Claude, St. Roch
22071002200	2049	24	St. Roch	7	Marigny, Bywater, St. Claude, St. Roch
22071002300	3725	24	St. Roch	7	Marigny, Bywater, St. Claude, St. Roch
22071003701	2151	25	Fairgrounds/Broad	4	Mid-City
22071003702	4424	25	Fairgrounds/Broad	4	Mid-City
22071003305	1173	26	St. Bernard Area/Project	4	Mid-City
22071003306	5254	26	St. Bernard Area/Project	4	Mid-City
22071003307	1689	27	Dillard	6	Gentilly
22071003308	4782	27	Dillard	6	Gentilly
22071002401	2175	28	Gentilly Terrace	6	Gentilly
22071002402	3707	28	Gentilly Terrace	6	Gentilly
22071002503	2035	28	Gentilly Terrace	6	Gentilly
22071002504	2625	28	Gentilly Terrace	6	Gentilly
22071001702	4387	29	Gentilly Woods	6	Gentilly
22071002501	2541	30	Milneburg	6	Gentilly
22071002502	3099	30	Milneburg	6	Gentilly
22071001701	2630	31	Pontchartrain Park	6	Gentilly
22071003303	2514	32	St. Anthony	6	Gentilly
22071003304	2804	32	St. Anthony	6	Gentilly
22071003301	2818	33	Fillmore	6	Gentilly
22071003302	4165	33	Fillmore	6	Gentilly
22071013302	2162	34	Lake Terrace/ Lake Oaks	6	Gentilly
22071013301	3615	35	Lakeshore/Lake Vista	5	Lakeview
22071007605	1772	36	Dixon	3	Uptown and Carrollton
22071005601	2926	37	Lakeview	5	Lakeview
22071005602	3160	37	Lakeview	5	Lakeview
22071005603	1843	37	Lakeview	5	Lakeview
22071005604	1946	37	Lakeview	5	Lakeview
22071007604	1962	38	Lakewood	5	Lakeview
22071007603	4724	39	Lakewood/West End	5	Lakeview
22071005500	2908	40	Navarre	5	Lakeview
22071004800	2540	41	Iberville Project	4	Mid-City
22071003900	1447	42	Treme'	4	Mid-City
22071004000	2582	42	Treme'	4	Mid-City
22071004401	2320	42	Treme'	4	Mid-City
22071004402	2504	42	Treme'	4	Mid-City
22071004100	1720	43	Bayou St. John	4	Mid-City
22071004500	3141	43	Bayou St. John	4	Mid-City
22071004600	2813	44	City Park	5	Lakeview
22071005000	1666	45	Mid-City	4	Mid-City
22071005400	1636	45	Mid-City	4	Mid-City
22071006300	2494	45	Mid-City	4	Mid-City
22071006400	3193	45	Mid-City	4	Mid-City
22071006500	3312	45	Mid-City	4	Mid-City
22071007100	7608	45	Mid-City	4	Mid-City
22071004900	2968	46	Tulane/Gravier	4	Mid-City
22071006000	1266	46	Tulane/Gravier	4	Mid-City
22071005700	510	47	Central Business District	1	Vieux Carre, CBD, Warehouse District
22071005800	487	47	Central Business District	1	Vieux Carre, CBD, Warehouse District
22071005900	797	47	Central Business District	1	Vieux Carre, CBD, Warehouse District
22071003800	1726	48	Vieux Carre	1	Vieux Carre, CBD, Warehouse District
22071004200	2055	48	Vieux Carre	1	Vieux Carre, CBD, Warehouse District
22071004700	395	48	Vieux Carre	1	Vieux Carre, CBD, Warehouse District
22071001724	5642	49	Edgelake/Little Woods	9	New Orleans East
22071001725	7773	49	Edgelake/Little Woods	9	New Orleans East
22071001726	74	49	Edgelake/Little Woods	9	New Orleans East
22071001728	8269	49	Edgelake/Little Woods	9	New Orleans East
22071001737	4099	49	Edgelake/Little Woods	9	New Orleans East
22071001738	9931	49	Edgelake/Little Woods	9	New Orleans East
22071001739	3232	49	Edgelake/Little Woods	9	New Orleans East
22071001740	5291	49	Edgelake/Little Woods	9	New Orleans East
22071001720	5092	50	Lake Kenilworth/Georgetown/Pines	9	New Orleans East
22071001722	7005	51	Plum Orchard/Bonita Park	9	New Orleans East
22071001732	8240	52	Sherwood Forest/lake Forest/Eastover	9	New Orleans East
22071001723	5564	53	Donna Villa/Camelot	9	New Orleans East
22071001733	1883	54	Viavant/Venetian Isles	11	New Orleans East
22071001735	5338	55	Lake Forest East	9	New Orleans East
22071001736	4258	55	Lake Forest East	9	New Orleans East
22071001730	2213	56	Village de l'est	10	New Orleans East
22071001741	1711	56	Village de l'est	10	New Orleans East
22071001742	8988	56	Village de l'est	10	New Orleans East
22071011500	1692	57	Audubon/University	3	Uptown and Carrollton
22071011600	1529	57	Audubon/University	3	Uptown and Carrollton
22071011700	3019	57	Audubon/University	3	Uptown and Carrollton
22071011900	1764	57	Audubon/University	3	Uptown and Carrollton

Table C5-1 Note (cont)

Census Tract Number	Tract Population 2000	Neighborhood Code	Neighborhood Name	Planning District Code	City Planning District
22071012000	1351	57	Audubon/University	3	Uptown and Carrollton
22071012101	2233	57	Audubon/University	3	Uptown and Carrollton
22071012102	3310	57	Audubon/University	3	Uptown and Carrollton
22071012200	2191	58	Marlyville/Fontainbleau	3	Uptown and Carrollton
22071012400	1873	58	Marlyville/Fontainbleau	3	Uptown and Carrollton
22071012800	2676	58	Marlyville/Fontainbleau	3	Uptown and Carrollton
22071008101	2551	59	St. Thomas Project	2	Central City/Garden District
22071008102	406	59	St. Thomas Project	2	Central City/Garden District
22071006900	4339	60	B.W. Cooper Project	4	Mid-City
22071006700	643	61	Central City/Magnolia	2	Central City/Garden District
22071006800	1938	61	Central City/Magnolia	2	Central City/Garden District
22071007900	847	61	Central City/Magnolia	2	Central City/Garden District
22071008000	870	61	Central City/Magnolia	2	Central City/Garden District
22071008400	1239	61	Central City/Magnolia	2	Central City/Garden District
22071008500	1778	61	Central City/Magnolia	2	Central City/Garden District
22071008600	1599	61	Central City/Magnolia	2	Central City/Garden District
22071009100	2569	61	Central City/Magnolia	2	Central City/Garden District
22071009200	1950	61	Central City/Magnolia	2	Central City/Garden District
22071009301	1190	61	Central City/Magnolia	2	Central City/Garden District
22071009302	2259	61	Central City/Magnolia	2	Central City/Garden District
22071009400	2190	61	Central City/Magnolia	2	Central City/Garden District
22071007000	2172	62	Gerrtown/Zion City	4	Mid-City
22071007200	2576	62	Gerrtown/Zion City	4	Mid-City
22071010300	3423	63	Broadmoor	3	Uptown and Carrollton
22071011200	1534	63	Broadmoor	3	Uptown and Carrollton
22071012300	2275	63	Broadmoor	3	Uptown and Carrollton
22071011100	2446	64	Freret	3	Uptown and Carrollton
22071009000	1970	65	Garden District	2	Central City/Garden District
22071010000	2355	66	Milan	2	Central City/Garden District
22071010100	2429	66	Milan	2	Central City/Garden District
22071010200	2696	66	Milan	2	Central City/Garden District
22071009900	3242	67	Touro	2	Central City/Garden District
22071010700	1849	68	Uptown	3	Uptown and Carrollton
22071010800	1449	68	Uptown	3	Uptown and Carrollton
22071010900	3383	68	Uptown	3	Uptown and Carrollton
22071009600	1610	69	East Riverside	2	Central City/Garden District
22071009700	1610	69	East Riverside	2	Central City/Garden District
22071008700	768	70	Irish Channel	2	Central City/Garden District
22071008800	1967	70	Irish Channel	2	Central City/Garden District
22071008900	1535	70	Irish Channel	2	Central City/Garden District
22071007700	1628	71	St. Thomas	2	Central City/Garden District
22071007800	1186	71	St. Thomas	2	Central City/Garden District
22071008200	1886	71	St. Thomas	2	Central City/Garden District
22071008300	1416	71	St. Thomas	2	Central City/Garden District
22071010400	395	72	West Riverside	3	Uptown and Carrollton
22071010500	1421	72	West Riverside	3	Uptown and Carrollton
22071010600	1574	72	West Riverside	3	Uptown and Carrollton
22071011400	1842	72	West Riverside	3	Uptown and Carrollton
22071001734	1760	73	Lake Catherine/Fort Pike	11	New Orleans East

Table C-C1 Detailed Demographic Overview of Parishes in Study

	Jefferson Parish	Orleans Parish	Plaquemines Parish	St. Bernard Parish	St. Charles Parish	St. Tammany Parish
Total Population	455466	484674	26757	67229	48072	191268
Sex Ratio, 20 to 64 Years Old	92.9	88.5	101.3	95.8	93.2	95.1
Median Age	35.9	33.1	33.7	36.6	34.2	36.3
% of Population 65 or More Years	11.9	11.7	9.8	13.8	9.0	10.0
Total Dependency Ratio	66.2	71.7	72.1	72.1	72.6	69.7
Average Household Size	2.6	2.5	2.9	2.6	2.9	2.7
% Non-Hispanic White	65.4	26.6	68.8	84.4	70.5	85.3
% Non-Hispanic Black	22.7	66.7	23.3	7.6	25.1	9.8
% Non-Hispanic Asian	3.1	2.3	2.6	1.3	0.6	0.7
% Hispanic	7.1	3.1	1.6	5.1	2.8	2.5
% Non-Hispanic Other	1.7	1.4	3.7	1.7	1.1	1.7
Race/Ethnic Diversity(IQV)	56.9	59.3	57.0	26.4	51.5	29.1
Number of Housing Units	187907	215091	10481	26790	17430	75398
Number of Occupied Housing Units	176234	188251	9021	25123	16422	69253
% Occupied Housing Units	93.8	87.5	86.1	93.8	94.2	91.9
% Owner Occupied Housing Units	63.9	46.5	78.9	74.6	81.4	80.5
% 1 Person Housing Units	26.7	33.2	18.6	22.9	16.7	19.7
Household Income:						
1999:						
Median	38435	27133	38173	35939	45139	47883
Gini Index	45.9	54.6	46.6	43.0	42.7	45.3
2003:						
Median	38018	27408	38329	36156	45423	51175
Family Income 1999:						
Median	45834	32338	42610	42785	50562	55346
Gini Index	43.2	53.0	43.4	38.5	39.8	41.8
Non-Family Income 1999:						
Median	24594	19453	17490	17525	21482	23520
Per Capita Income	19953	17258	15937	16718	19054	22514
% Persons Below Poverty:						
1999	13.7	27.9	18.0	13.1	11.4	9.7
2003	15.7	22.5	15.3	14.2	12.5	10.5
Median Contract Rent	455	378	401	374	390	493
Median Value Owner Occupied Homes	102800	88100	68900	82900	96300	116000
Civilian Labor Force Unemployed	5.6	9.5	6.7	5.8	5.2	3.8
% Not In Labor Force	36.1	42.2	44.6	40.3	35.4	35.4
% Less Than High School	20.7	25.3	31.3	26.9	20.0	16.1
% College Graduate	21.5	25.7	10.8	8.9	17.5	28.4
% With a Disability	21.0	23.2	19.1	23.4	17.1	17.6
% Households Linguistically Isolated	2.6	1.7	2.	1.4	1.1	0.5
% Born in Louisiana	75.9	77.4	80.8	86.1	81.9	67.7
% Lived Same House 1995	61.4	56.8	65.5	65.1	66.5	54.7
% Different House-Same County	23.7	28.6	16.4	23.6	15.5	20.2
% Lived in Orleans 1995	85.1	85.4	81.9	88.7	82.0	74.9
% Households - No Vehicle	9.3	27.3	9.6	10.3	6.4	4.4
% Households - No Phone	1.9	4.4	5.2	2.6	2.5	2.2

Source: US Bureau of Census, 2000 Census of the Population and Housing STF 3 Files.

Table C-C-2 T-Test Analysis of Race, Income and Level of Flooding.

Households - Race, Income, and Level of Flooding

	0 – 4 Feet	Over 4 Feet	N
Total	52.1%	47.9%	179543
Panel A			
Black	43.6%	56.4%	113428
White	66.6%	33.4%	66115
Panel B			
0 to $49,999	51.6%	48.4%	132663
$50,000 or More	53.5%	46.5%	46880
Panel C1: Income 0 to $49,999			
Black	45.7%	54.3%	93571
White	65.6%	34.4%	39092
Panel C2: Income $50,000 or More			
Black	33.8%	66.2%	19857
White	68.0%	32.0%	27023
Panel D1: Black			
0 to $49,999	45.7%	54.3%	93571
$50,000 or More	33.8%	66.2%	19857
Panel D2: White			
0 to $49,999	65.6%	34.4%	39092
$50,000 or More	68.0%	32.0%	27023

Household Income by Race of Householder

	0 to $49,999	$50,000 or More	N
Total	73.8%	26.2%	180380
Panel E			
Black	82.5%	17.5%	113437
White	59.2%	40.8%	66943

Note: A review of the U.S. Bureau of Census data for neighborhoods in New Orleans shows that African-Americans (56.36%) are about 23% more likely to have experienced heavy flooding (greater than 4 feet) than Whites (33.41%). This difference is statistically significant ($p < .0001$). Households with incomes less than $50,000 are about 2% (48.42% - 46.47%) more likely to have experienced flooding over 4 feet. Although this difference is statistically significant, it is substantively small. Although 40.83% of Whites have household incomes of $50,000 or more, only 17.5% of African-American households have this level of income. This difference of

23.33% is statistically significant ($p < .0001$). The analysis indicate there is little relationship between household income and level of flooding but a strong relationship between race and both level of flooding and household income.

There is a strong relationship between race and level of flooding taking into account household income level. Among households with less than $50,000 income, African-Americans are about 20% more likely to have experienced heavy flooding. As noted the difference between levels of flooding between blacks and whites was 23% with out taking income into account. However, for African-American households with an income of $50,000 or more, this difference has increased to 34%. Almost 2 in 3 (66.21%) higher-income African American households experienced more than 4 feet of flooding. About 32% of white households experienced that level of flooding. Both of these differences are statistically significant ($p < .0001$).

Among white households, lower-income households are 2.44% (34.41% – 31.97%) more likely to have experienced heavy flooding than higher-income households were. Within the African-American community, this pattern reverses: Higher-income African Americans households are almost 12% (66.21% - 54.27%) more likely to have experienced heavy flooding than lower-income households were.

We are seeing the effect of the differential impact of flooding in the observations conducted in New Orleans neighborhoods. Middle- and upper-middle-class African American areas that experienced heavy flooding have had few residents return to their homes. Middle- and upper-middle-class neighborhoods—such as Edgelake/Little Woods, Gentilly Terrace, and Plum Orchard--have 75% to 80% of their homes gutted and empty, or the houses simply stand empty and boarded-up. Almost 2 in 3 (66.21%) of higher-income African American households experienced flooding of greater than 4 feet. Although some hardy souls are struggling to recover in these empty and isolated neighborhoods, most have not come back in the 8 months since Katrina.

Appendix 4
Sub-Appendix D. Cultural and Historic Terminology

Local Cultural Terms. A variety of terms are used to describe New Orleans physical features and social groups, and cultural features (Lewis 2003). "Bayou" is a Choctaw term for a small stream with a slow current. "Cajun" describes descendents of the Acadian immigrants from Nova Scotia. "Creole" describes native Orleanians with French Canadian or Spanish ancestry. "Faubourgs" represents the neighborhoods of New Orleans, formerly representing small island enclaves prior to incorporation. "Islenos" are Spanish settlers from the Canary Islands living mostly in St. Bernard's Parish today.

Historical Terms (Obtained from http://www.cr.nps.gov). Comprehensive Historic Preservation Planning describes the organization of preservation information into a logical sequence pertaining to identification, evaluation, registration and treatment of historic properties, and then setting priorities for accomplishing preservation activities.

The following historic terms are used in this report:

- Historic Context. A unit created for planning purposes, which categorizes information about historic properties based on a shared theme, specific time period and geographical area.

- Historic Property. A district, site, building, structure or object significant in American history, architecture, engineering, archeology or culture at the national, State, or local level.

- Integrity. The authenticity of a property's historic identity, as evidenced by the survival of physical characteristics of the property, which existed during the property's historic or prehistoric period.

- Intensive Survey. A systematic, detailed examination of an area designed to gather information about historic properties sufficient to evaluate them against predetermined criteria of significance within specific historic contexts.

- Inventory. A list of historic properties determined to meet specified criteria of significance.

- National Register Criteria. Established criteria that are used in evaluating the eligibility of properties for inclusion into the National Register of Historic Places.

- Preservation (treatment). The act or process of applying measures to sustain the existing form, integrity and material of a building or structure, and the existing form and vegetative cover of a site. It may include initial stabilization work, where necessary, as well as ongoing maintenance of the historic building materials. [Current definition of this treatment standard, as revised in The Secretary of the Interior's Standards for the Treatment of Historic Properties, 1995: Preservation is defined as the act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property. Work, including preliminary measures to protect and stabilize the property, generally focuses upon the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. New exterior additions are not within the scope of this treatment; however, the limited and sensitive upgrading of mechanical, electrical, and plumbing systems and other code-required work to make properties functional is appropriate within a preservation project.

- Property Type. A grouping of individual properties based on a set of shared physical or associative characteristics.

- Protection (treatment). The act or process of applying measures designed to affect the physical condition of a property by defending or guarding it from deterioration, loss or attack, or to cover or shield the property from danger or injury. In the case of buildings and structures, such treatment is generally of a temporary nature and anticipates future historic preservation treatment; in the case of archeological sites, the protective measure may be temporary or permanent. This treatment standard and definition was deleted in The Secretary of the Interior's Standards for the Treatment of Historic Properties, 1995.

- Reconnaissance Survey. An examination of all or part of an area, that is accomplished in sufficient detail to make generalizations about the types and distributions of historic properties that may be present.

- Reconstruction (treatment). The act or process of reproducing by new construction the exact form and detail of a vanished building, structure, or object, or any part thereof, as it appeared at a specific period of time. Current definition of this treatment standard, as revised in The Secretary of the Interior's Standards for the Treatment of Historic Properties, 1995: Reconstruction is defined as the act or process of depicting, by means of new construction, the form, features, and detailing of a non-surviving site, landscape, building, structure, or object for the purpose of replicating its appearance at a specific period of time and in its historic location.

- Rehabilitation (treatment). The act or process of returning a property to a state of utility through repair or alteration which makes possible an efficient contemporary use while preserving those portions or features of the property which are significant to its historical, architectural and cultural values. The current definition of this treatment standard, as revised in The Secretary of the Interior's Standards for the Treatment of Historic Properties, 1995, is “Rehabilitation is defined as the act or process of making possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features which convey its historical, cultural, or architectural values.”

- Restoration [treatment]. The act or process of accurately recovering the form and details of a property and its setting as it appeared at a particular period of time by means of the removal of later work or by the replacement of missing earlier work. The current definition of this treatment standard, as revised in The Secretary of the Interior's Standards for the Treatment of Historic Properties, 1995: “Restoration is defined as the act or process of accurately depicting the form, features, and character of a property as it appeared at a particular period of time by means of the removal of features from other periods in its history and reconstruction of missing features from the restoration period. The limited and sensitive upgrading of mechanical, electrical, and plumbing systems and other code-required work to make properties functional is appropriate within a restoration project.”

- Sample Survey. A survey of a representative sample of lands within a given area, in order to generate or test predictions about the types and distributions of historic properties in the entire area.

- Stabilization (treatment). The act or process of applying measures designed to reestablish a weather resistant enclosure and the structural stability of an unsafe or deteriorated property while maintaining the essential form as it exists at present. This treatment standard and its definition was deleted in The Secretary of the Interior's Standards for the Treatment of Historic Properties, 1995.

Appendix 5A
Chemical Indicators of Contamination

Water and Sediment Data for Chemical Indicators of Contamination

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Executive Summary

The Engineer Research and Development Center Environmental Laboratory (ERDC-EL) was tasked with collection and condensation of available chemical concentration data in floodwaters and sediments related to the flooding and dewatering events in New Orleans, LA. The investigation focused on available sources of this data, including peer-reviewed scientific journal articles, documents from private organizations, and Federal and State Government agency projects. By far, the largest single source of data was the US Environmental Protection Agency's STORET database which housed thousands of data points collected in the weeks and months following the flooding and dewatering of the city. In addition to this data, however, 'snapshots' of the floodwaters and sediments were obtained from two journal articles published by University researchers that document the floodwaters and deposited sediments immediately after the flooding event. Historical data for some analytes of interest were also found in the published literature and were used to establish analyte concentrations prior to the flooding event. Furthermore, the ERDC-EL made two expeditionary sampling trips to New Orleans during December 2005 and March 2006 to secure additional, site-specific, samples to provide data on discharge of potential contaminants into surrounding ecosystems, specifically, the Violet Marsh. The compilation of these data gathering and collection efforts are discussed in the following report.

Introduction

In this subtask of the Interagency Performance Evaluation Team (IPET) Task 9 project, we focused on data mining and compilation for chemical results in four Louisiana parishes affected by flooding from Hurricanes Katrina and Rita – Orleans, Plaquemines, St. Bernard and St. Charles. The compounds of interest are arsenic, lead, benzo[a]pyrene (BaP) and 1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene (DDE), selected by consensus as likely candidates because of availability of data following the flooding events (Hurricanes Katrina and Rita) and chemical variability between them. Arsenic and lead, although both inorganic analytes, would behave differently based on soil:solution chemistry, with lead sorbing to soil as a traditional cation, whereas arsenic speciation [As(III) or (V)] would yield little sorption in reduced environments as As(III), compared to increased sorption in the case of As(V) being favored in oxidizing environments. Benzo[a]pyrene is an organic polycyclic aromatic hydrocarbon which could be used to trace petroleum impacted floodwaters. The pesticide DDE was selected because of it's presence at superfund sites in the New Orleans area and historical production and usage in the area.

Three distinct time frames are of interest for this work: 1) Pre-Katrina, roughly defined as prior to 28 August 2005; 2) Immediately after the flooding events, roughly 1-2 weeks after Hurricanes Katrina and Rita affected the area; and 3) The post dewatering of New Orleans time period. Possible data sources for this information were ultimately narrowed down primarily to two Federal Government Agencies and two journal articles authored by University Researchers, as described below. Investigations of the US Geological Survey National Water Information System (NWIS) database provided only simple water quality parameters, such as pH, Total Suspended Solids, Dissolved Oxygen, etc., and not specific analytes of interest found in the US Environmental Protection Agency (USEPA) and US Army Corps of Engineers (USACE) studies.

The USEPA provided the most temporally and spatially useful data. The USEPA began an extensive sediment and water sampling plan within days of the flooding event, providing thousands of data points in the on-line STORET (STOrage and RETrieval System) database. The US Army Corps of Engineers Environmental Laboratory (ERDC EL) made sampling trips to New Orleans in December 2005 and again in March 2006 to collect additional data from pump locations where floodwaters were discharged into marshes surrounding the urban areas. These data were considered 'perishable' because of the limited sampling by other agencies and the time since the floodwaters were discharged. The data published by the Principle University Researchers at Louisiana State University and Texas Technical University provide intimate temporal and spatial data in the weeks immediately after the flood event while the city was being dewatered.

Pre-Katrina Data

Using the EPA's STORET data warehouse http://oaspub.epa.gov/stormodb/DW_resultcriteria_geo , no results were found for the period January 1, 2001 through August 24, 2005 for the parishes of interest. A search of the Legacy STORET data warehouse provided some results from the early 1990s, but none of the data was usable for this study. Dave Walters with the US Geological Survey New Orleans Office was able to locate four water quality data samples from the NWIS database (http://waterdata.usgs.gov/nwis) from 2001 and 2002. None of the four compounds of interest were included in the analyses of these four samples. A search of the Louisiana Department of Environmental Quality database (http://www.deq.louisiana.gov/portal/) also turned up no results for our study period and analytes of interest. In general, most of the data available from these sources for the Pre-Katrina time period consists of simple water quality parameters, and not specific analytes of interest.

A review of the peer-reviewed scientific literature yields two articles of interest (Mielke *et al*., 2001; Mielke *et al*., 2004) which report concentrations of PAH and metals in New Orleans inner-city and suburban soils. Benzo[a]pyrene concentrations reported for New Orleans soils ranged from 0.091-6.859 mg/kg, whereas sediment concentrations for spillways and bayous ranged from nondetects to 4.044 mg/kg. Lead concentrations in city soils ranged from 32-4298 mg/kg, whereas bayou sediment concentrations were in the 4-1587 mg/kg range (Mielke *et al*., 2001). In a more recent article, Mielke *et al.* (2004) used census tract information to partition off sections of the city for more detailed spatial analysis of analytes of interest. In addition, site descriptions were used to isolate sources of contamination, i.e. busy streets, residential streets, open areas, etc. The results reported indicate that for most metals and PAHs, 'busy streets' had a higher median concentration than did less impacted areas, such as 'open areas' (Mielke *et al*., 2004).

Immediately After Flooding

Although some data was found in the EPA STORET database for the first weeks after the flooding, perhaps the most detailed data is obtained from the two publications in the Journal *Environmental Science and Technology*. The articles, authored by Pardue *et al.,* (2005*)* and Presley *et al.,* (2006), ["LSU" and "TX Tech" articles, respectively] contain water chemistry data parameters for three of the four analytes of interest, Benzo[a]pyrene, arsenic, and lead. Statements are made in the LSU article about the water quality of the floodwater to the effect: "…Katrina floodwater is similar to normal stormwater runoff but with elevated [lead] and [volatile organic compound] concentrations", yet no specific references or data are given in the article to support this conclusion (Pardue *et al.,* 2005*)*.

Concentrations were not reported in the LSU and TX Tech articles for DDE, although sediment concentrations of Benzo[a]pyrene were reported by TX Tech (Presley *et al.,* 2006). Dissolved metal concentrations were also reported, and ranged from 17-54 µg/L for arsenic and 1-72 µg/L for lead. Sediment samples reported in the TX Tech article list arsenic and lead concentrations as 6-24 and 340-640 mg/kg, respectively, in close agreement to the pre-Katrina values reported by the Mielke *et al*. (2001) study. In fact, the 2001 study found its highest lead concentration in soil to be an order of magnitude higher than the highest value reported by TX Tech (Mielke *et al*., 2001; Pardue *et al*., 2005; Presley *et al*., 2006) The benzo[a]pyrene concentrations reported by TX Tech ranged from 0.01-1.26 mg/kg, also in close agreement to the available Pre-Katrina data.

Post-Katrina Data

Using the EPA's STORET Katrina Central Warehouse, http://oaspub.epa.gov/storetkp/DW_resultcriteria_geo, for the same four Louisiana parishes provided a much different data set for the Post-Katrina and Rita period. The period from August 28, 2005 through February 13, 2006 produced 4729 results for the four parishes and compounds of interest with the exception being St. Charles parish. No samples were taken in St. Charles parish, post-Katrina, according to the STORET Katrina Central Warehouse.

Concentrations for arsenic and lead in soil ranged from 5-12 and 20-117 mg/kg, respectively, in close agreement to those previously reported and discussed for pre-Katrina and immediately after the flooding event timeframes. The organic compounds of interest also showed similar levels as reported prior to the flooding event, with Benzo[a]pyrene ranging from 0.01-0.5 mg/kg and DDE ranging from 0.007-0.013 mg/kg. The one outlying point would be the maximum concentrations of Benzo[a]pyrene reported by Mielke *et al*., (2001) of over 6.5 mg/kg. Water concentrations for arsenic, lead, Benzo[a]pyrene, and DDE in the EPA database ranged from 1-5, 1-100, nondetect-2 and nondetect-1 μg/L, respectively, which also agree closely with the limited pre-Katrina values available.

Water samples were not collected for analysis on the two ERDC-EL sampling trips in the New Orleans and Violet Marsh areas in December 2005 and March 2006. Of the sediment samples collected, arsenic and lead concentrations found ranged from 3-13 and 27-181 mg/kg, respectively. The DDE concentrations found ranged from 0.003-0.015 mg/kg. These values are in close agreement with the limited Pre-Katrina data available, as well as the USEPA data reported after the flooding events.

General Analyte Trends and Observations

The Louisiana Department of Environmental Quality (LDEQ) Risk Evaluation/Corrective Action Program (RECAP) standards for residential soil and water were used to qualify the EPA STORET data. LDEQ developed RECAP to address risks to human health and the environment posed by the release of chemical constituents to the environment. The LDEQ RECAP Table can be found at the following URL: http://www.deq.louisiana.gov/portal/Portals/0/technology/recap/2003/RECAP%202003%20Text%20Table%201.pdf.

Orleans Parish

Figure 1 (Arsenic in Sediment > LDEQ RECAP)

Of the samples tested for arsenic, 36% had a level greater than or equal to the LDEQ RECAP level of 12 mg/kg. The average arsenic level in sediment for Orleans Parish was 11.8 mg/kg (Table 1). In the Mid-City district, at the intersection of Euphrosine and S. Lopez St, a sample with an arsenic level of 78 mg/kg was taken. This was the maximum level found in a sediment sample in Orleans Parish and is the red square with yellow center on the map shown in Figure 1. All other locations that had an arsenic detection greater than the RECAP level are also shown in Figure 1. In New Orleans, elevated metals levels, including arsenic and lead, may result in large part from the incorporation of the pre-hurricane local urban soil (Mielke *et al*., 2001; Plumlee, *et al*, 2006). Arsenic may also be so widespread in the New Orleans area because of past use of arsenic based pesticides, trash incineration, leakage from industrial sites and the use of building materials pressure-treated with chromium-copper arsenate (Solomon, et al, 2006).

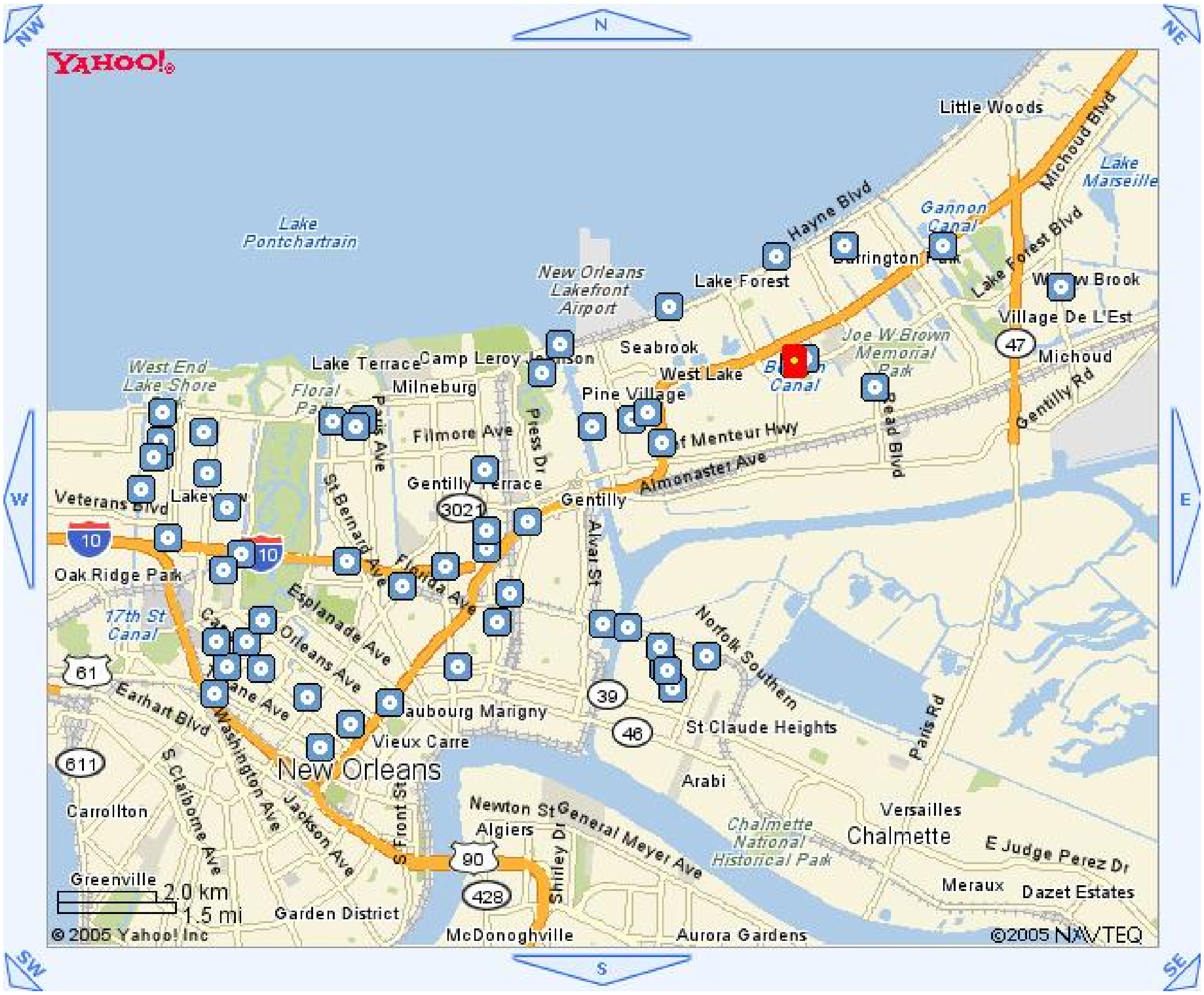

Figure 2. (Arsenic in Water > LDEQ RECAP)

The LDEQ RECAP level for arsenic in groundwater is 0.01 mg/L. Figure 2 shows locations of all samples that exceeded the RECAP level with the maximum level location shown in red with yellow center. Thirteen percent of the floodwater samples taken in Orleans Parish had an arsenic level of 0.01 mg/L or greater. In East Gentilly, a sample taken at the intersection of Lake Forest Blvd and Glouster Rd had an arsenic level of 0.357 mg/L. This was the highest level of arsenic found in Orleans Parish. Three other samples taken along Lake Forest Blvd had levels between 0.05 and 0.27 mg/L.

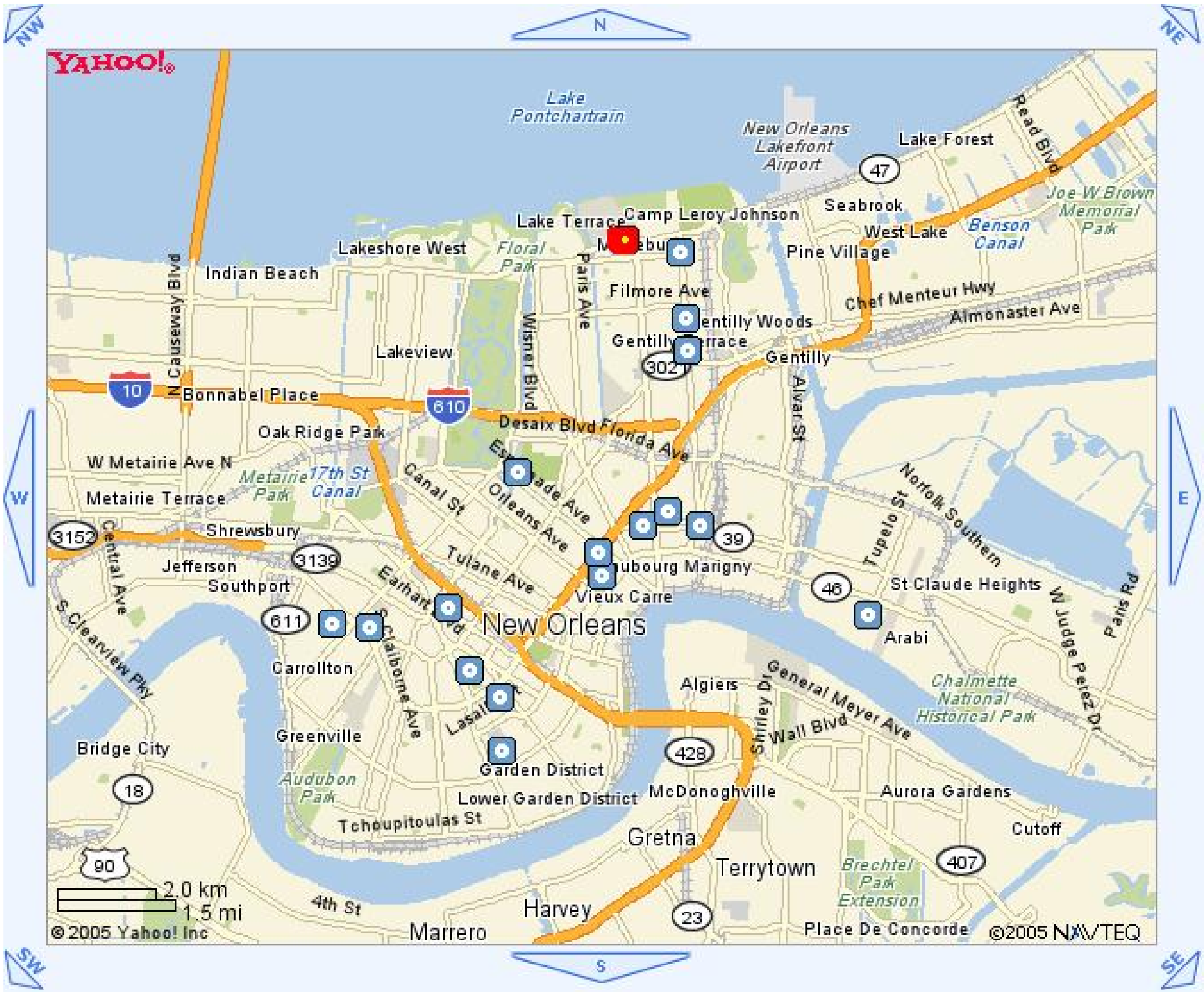

Figure 3. (Lead in Sediment > LDEQ RECAP)

For Lead, the sediment RECAP level is 400 mg/kg. Only 7% of the samples (shown in Figure 3) had a level above the RECAP level. The highest level of lead, 1160 mg/kg, was found on the south side of the University of New Orleans Campus at the intersection of Leon C. Simon Dr and Milneburg Rd. The high levels of lead found in the Orleans' sediments are likely due to past use of lead in paint and gasoline, or from leakage from industrial sites in and around New Orleans (Solomon, et al, 2006).

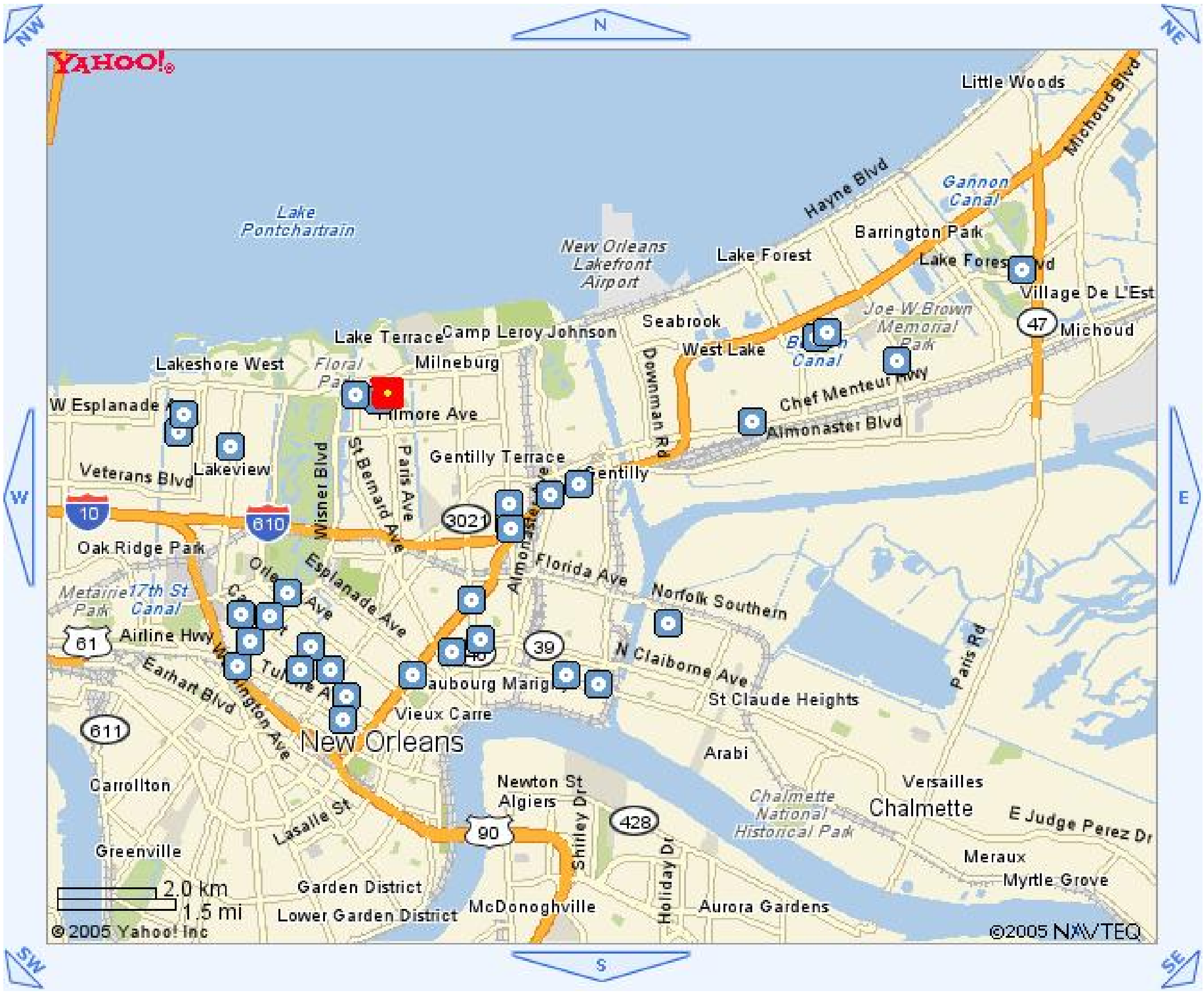

Figure 4. (Lead in Water > LDEQ RECAP)

Lead concentrations in water greater than or equal to the LDEQ RECAP level of 0.15 mg/L was found in 11% of the samples in Orleans parish. (See Figure 4) The highest level of lead in water, 1.34 mg/L, was found in the northwest part of the Gentilly district near the intersection of Paris Ave. and Burbank Dr. In the Bywater district, seven samples with lead levels above the RECAP level were found ranging from 0.846 mg/L near the I-10 exit 236 and 0.026 mg/L at the intersection of Marais and Poland Ave.

In Orleans Parish, fifteen of the metals analytes were found in all 265 sediment samples – Al, Ba, Be, Ca, Cr, Co, Fe, Pb, Mg, Mn, Ni, Na, K, V, and Zn. Another four analytes, Cu, As, Cd, Hg, were detected on at least 90% of the 265 sediment samples taken. Since Cadmium and Mercury are known to be especially toxic to humans, we compared these results to the LDEQ RECAP levels of 3.9 and 2.3 mg/kg respectively. Only one sample exceeded the Mercury RECAP level. Seventeen percent of the Cadmium concentrations found were higher than the RECAP level, with the maximum level of 45.3 mg/kg found at the same location (the intersection of Euphrosine and S. Lopez St) as the maximum level of arsenic.

For comparison, only three metals analytes, Ba, Mn and Ca, were detected on 100% of the 360 water samples taken. There are no LDEQ RECAP levels for Calcium or Manganese. For Barium, an LDEQ RECAP level of 2 mg/L has been set. None of the samples contained a level of Barium that met or exceeded that level. Another five metals, Mg, Na, Fe, K and Zn, had detection percentages of 90% or higher. Only Zinc has an LDEQ RECAP level, which is 1.1 mg/L. Four percent of the samples tested for Zinc met or exceeded that level. Two samples taken in East Gentilly, at the intersection of Lake Forest Blvd and Glouster Rd, contained twenty and thirty times the Zinc RECAP level, respectively. Hexavalent chromium was found in 55% of the 209 water samples taken, but none had a level greater than or equal to the LDEQ RECAP level of 0.1 mg/L.

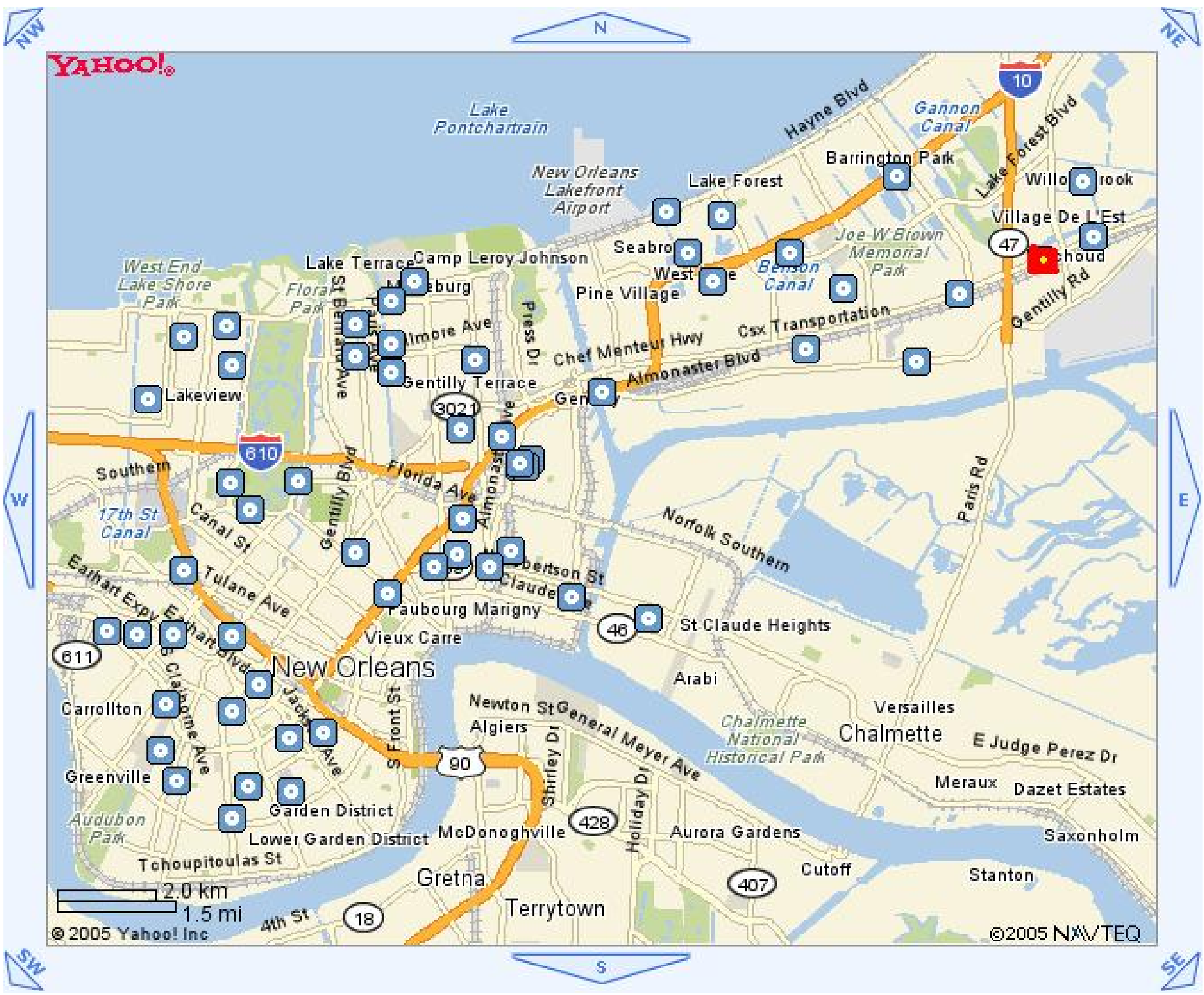

Figure 5. (BaP in Sediment > LDEQ RECAP)

Figure 5 shows detections of the PAH in sediments and soils, Benzo(a)pyrene, that are above LDEQ RECAP level of 0.33 mg/kg. Twenty three percent of the samples tested for BaP met or exceeded this level. Near the Agriculture St. Landfill, four samples ranging from 0.43 mg/kg to 17.7 mg/kg, were taken. The maximum level found, 35.5 mg/kg, was along the Chef Menteur Highway just east of I-510 in Michoud (depicted by the red square with yellow center in

Figure 5). High levels of benzo(a)pyrene may be due to the numerous spills of petroleum products, such as diesel fuel, during the hurricanes, or can be due to historic contamination from burning of debris (Solomon, et al, 2006).

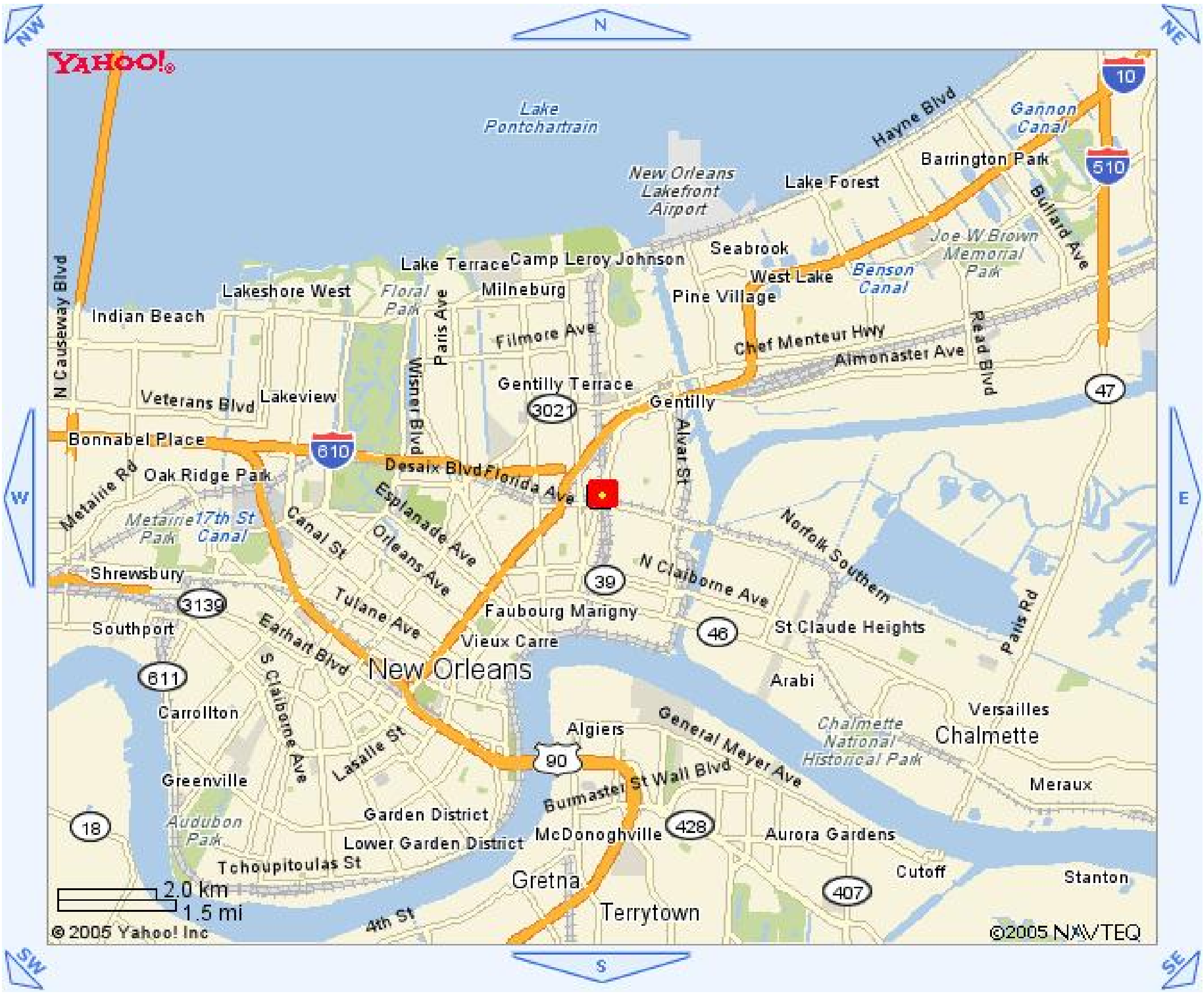

Figure 6. (BaP in Water > LDEQ RECAP)

Only one water sample in Orleans Parish had a Benzo(a)pyrene level higher than the LDEQ RECAP level of 0.0002 mg/L and it was an estimated concentration (Figure 6). The sample was taken near the intersection of Florida Ave and Almonaster Ave and had a level of 0.0004 mg/L.

Other hydrocarbons detected include Oil Range Organics (41 of 41), Petroleum Hydrocarbon Mix (151 of 159) and Diesel Range Organics (246 of 280), yielding an 87% detection rate or better in Orleans Parish sediment samples. For comparison, our PAH of interest, BaP was found in 48% of the sediment samples taken. Oil Range Organic detections exceeded the RECAP level of 180 mg/kg on 46% of the samples taken in Orleans Parish. Diesel Range Organics exceed the RECAP level of 65 mg/kg on 76% of the samples. The Petroleum Hydrocarbon Mix does not have a specific RECAP level because it is a group of hydrocarbons that are broken down individually in the LDEQ RECAP table. Chrysene, Fluoranthene, Benzo[b]fluoranthene and

Pyrene all had a higher percentage of positive results than did BaP. Benzo[a]pyrene was detected in only 1 of 266 water samples taken. All PAH compounds were less prevalent in the water samples than in sediment, with the most prevalent being Diesel Range Organics at a 35% detection frequency.

No sediment or water samples in Orleans Parish contained a DDE level greater than or equal to the 1.7 mg/kg or 0.0002 mg/L LDEQ RECAP levels, respectively.

Our pesticide of interest, DDE, was detected in 12% of the 280 sediment samples taken. For comparison, Chlordane, cis (30%), 1,1,1-Trichloro-2,2-bis(p-chlorophenyl)ethane (DDT) (24%), Chlordane (24%), Dieldrin (21%) and Dichlorodiphenyldichloroethane (DDD) (14%) all had higher percentages of concentrations greater than the detection limit. Chlordane, trans, was found in 59% of the 73 sediment samples that were tested. Chlordane, cis does not have an LDEQ RECAP level. For Chlordane, the RECAP level is 1.6 mg/kg and only one sample in two hundred seven exceeded that figure in Orleans Parish. Dieldrin's RECAP level is 0.03 mg/kg. That level was exceeded in 15% of the samples tested for Dieldrin. No sediment samples exceeded the LDEQ RECAP level for DDD or DDT. In water, only 3% of the 269 samples taken had a result greater than the detection limit for DDE.

Table 1 and 2 below present a summary of the sediment and water concentrations from the EPA STORET data set for Orleans Parish. The LDEQ RECAP limits and the percent of detections above the LDEQ RECAP limit for the four compounds are listed

Table 1
Summary of EPA STORET Sediment Data in Orleans Parish

Compound	Samples	Average	Maximum	LDEQ RECAP	> LDEQ RECAP
		(mg/kg)	(mg/kg)	(mg/kg)	(%)
Arsenic	273	11.8	78	12	36%
Lead	265	117	1160	400	7%
BaP	277	0.50	35.5	0.33	23%
DDE	280	0.01	0.44	1.7	0%

Table 2
Summary of EPA STORET Water Data in Orleans Parish

Compound	Samples	Average	Maximum	LDEQ RECAP	> LDEQ RECAP
		(mg/L)	(mg/L)	(mg/L)	(%)
Arsenic	458	0.005	0.357	0.01	13%
Lead	357	0.012	1.34	0.015	11%
BaP	258	0.000002	0.0004	0.0002	0.4%
DDE	261	0.0000009	0.00007	0.0002	0%

Plaquemines Parish

One sediment sample in Plaquemines Parish exceeded the RECAP level of 12 mg/kg for arsenic. It was found near Home Pl just off of Highway 23, north of Milan Dr and had an arsenic level of 14.5 mg/kg (See Figure 7).

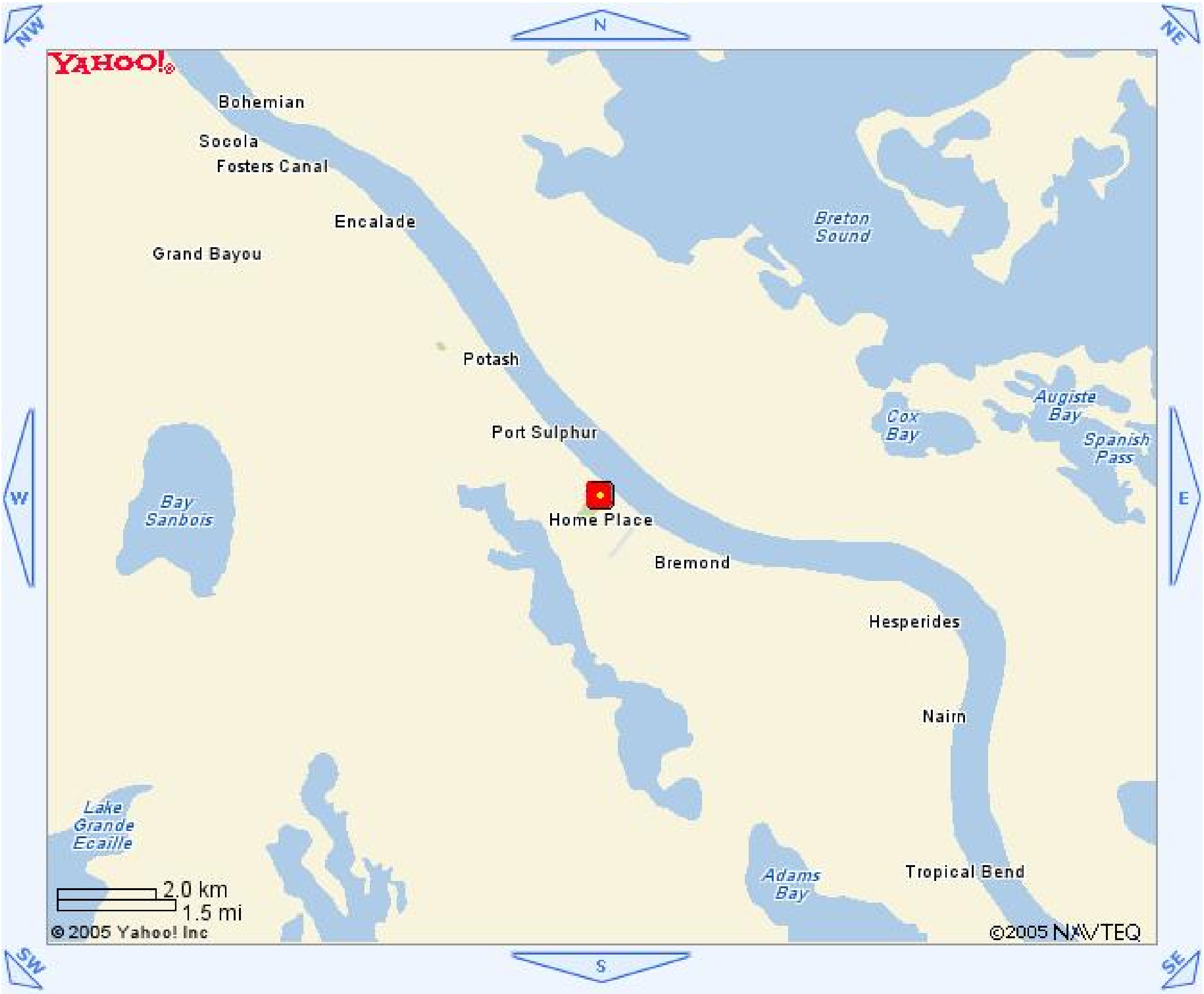

Figure 7. (Arsenic in Sediment > LDEQ RECAP)

Figure 8. (Arsenic in Water > LDEQ RECAP)

Arsenic levels in water greater than or equal to the LDEQ RECAP value of 0.01 mg/L were found in only 2 of the 87 samples tested. Of the two, the higher level of 0.047 mg/L of arsenic was found in a sample taken along Highway 11 just east of Cat Bay Rd, shown in Figure 8 as red square with yellow center.

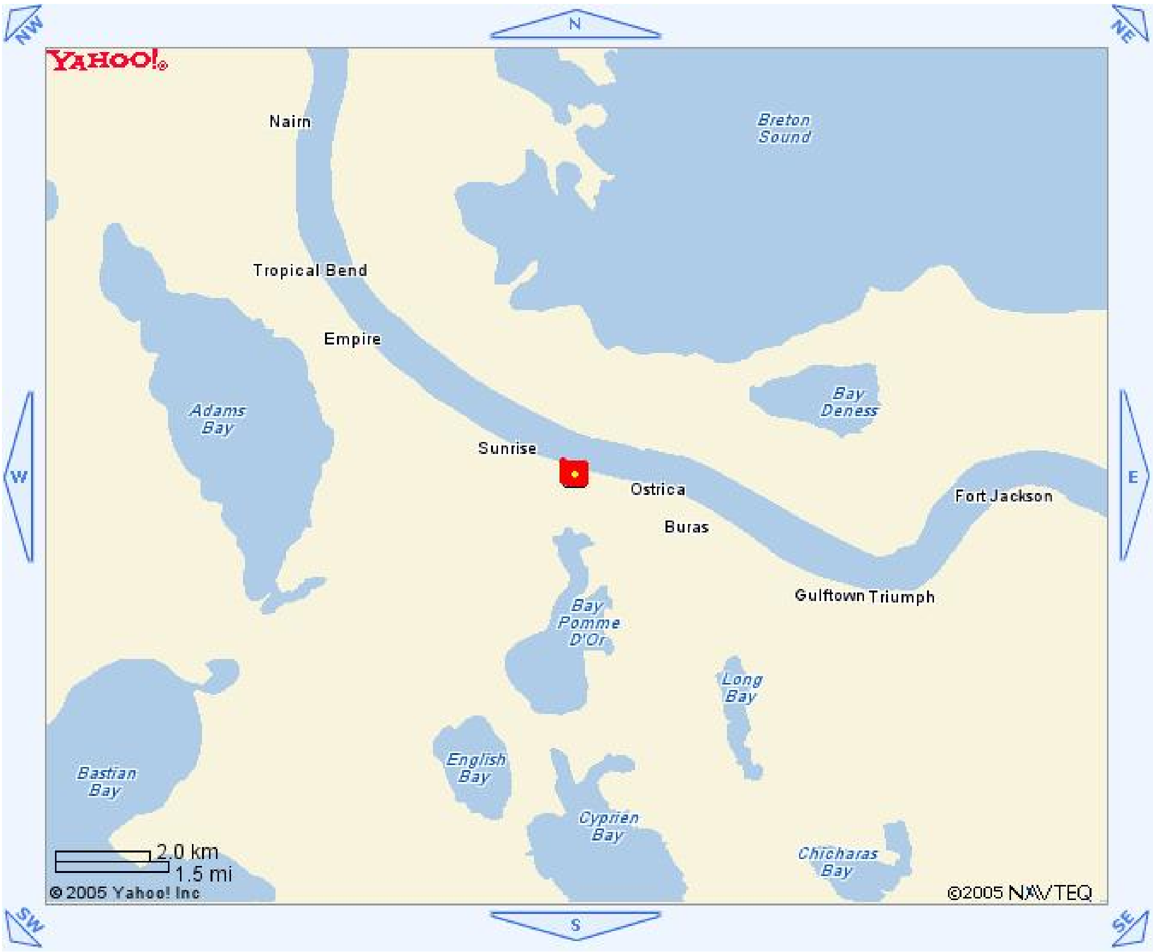

Figure 9. (BaP in Sediment > LDEQ RECAP)

Figure 9 shows a benzo(a)pyrene sample with a level of 12.2 mg/kg, which is nearly forty times greater than the RECAP level of 0.33 mg/kg. The sample was collected northwest of Buras at Bougon Ln and Highway 11. This was the only sediment sample that had a BaP detection for Plaquemines Parish.

This same sample also contained a benzo(a)anthracene level of 16.2 mg/kg, which is twenty-six times the RECAP level of 0.62 mg/kg. Another hydrocarbon analysis, for Diesel Range Organics, was reported above the RECAP level of 65 mg/kg in half of the samples tested. The highest level was found north of Nairn at Highway 11 and Becnal Ln, where a level of 12200 mg/kg was reported.

No water or sediment samples in Plaquemines Parish contained a DDE or Lead level equal to or greater than the LDEQ RECAP. Benzo(a)pyrene was not detected in any of the water samples taken.

Table 3 and 4 below present a summary of the sediment and water concentrations from the EPA STORET data set for Plaquemines Parish. The LDEQ RECAP limits and the percent of detections above the LDEQ RECAP limit for the four compounds are listed.

Table 3 Summary of EPA STORET Sediment Data in Plaquemines Parish					
Compound	**Samples**	**Average (mg/kg)**	**Maximum (mg/kg)**	**LDEQ RECAP (mg/kg)**	**> LDEQ RECAP (%)**
Arsenic	29	4.9	14.5	12	3%
Lead	29	22	60	400	0%
BaP	29	0.42	12.2	0.33	3%
DDE	29	0.01	0.26	1.7	0%

Table 4 Summary of EPA STORET Water Data in Plaquemines Parish					
Compound	**Samples**	**Average (mg/L)**	**Maximum (mg/L)**	**LDEQ RECAP (mg/L)**	**> LDEQ RECAP (%)**
Arsenic	87	0.001	0.047	0.01	2%
Lead	64	0.00001	0.008	0.015	0%
BaP	53	0	0	0.0002	0%
DDE	56	0	0	0.0002	0%

St. Bernard Parish

In Figure 10, one can see that only ten of the three hundred four sediment samples tested for arsenic exceeded the RECAP level of 12 mg/kg. The highest level detected was 22.8 mg/kg (red with yellow center on the map in Figure 10) in Kenilworth south of Bayou Rd on Billot Ln. Six of the ten samples were taken in Poydras. Levels ranged from 14.8 mg/kg at 2412 Meadowlark Street to 19.1 mg/kg at 1904 Goldfinch St.

Figure 10. (Arsenic in Sediment > LDEQ RECAP)

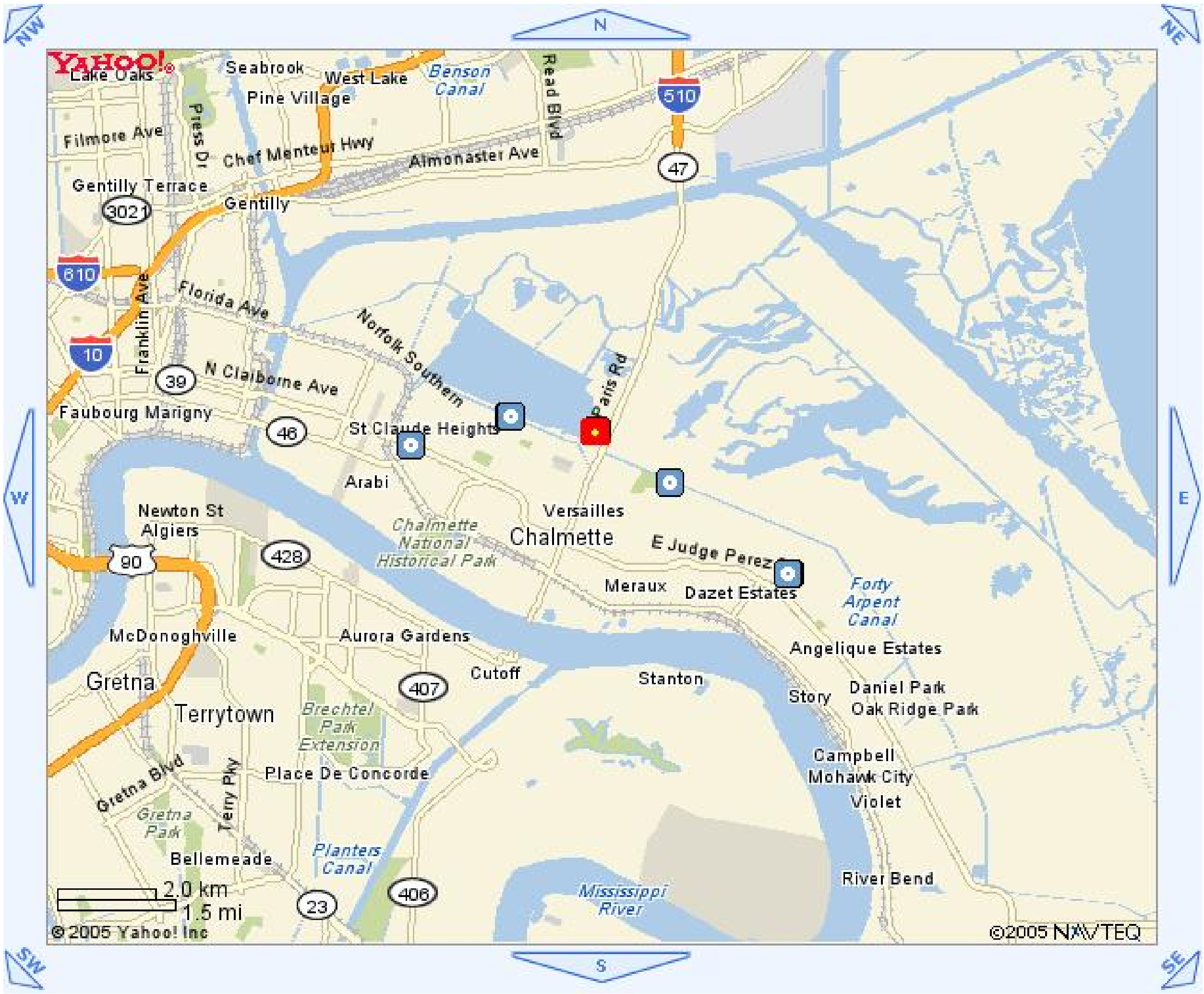

Figure 11. (Arsenic in Water > LDEQ RECAP)

Twelve percent of the water samples tested for arsenic in St. Bernard Parish had a level greater than or equal to the LDEQ RECAP level of 0.01 mg/L. The highest level of arsenic (0.059 mg/L) was found just north of Chalmette near the intersection of Highway 47 and Agriculture Street (See Figure 11).

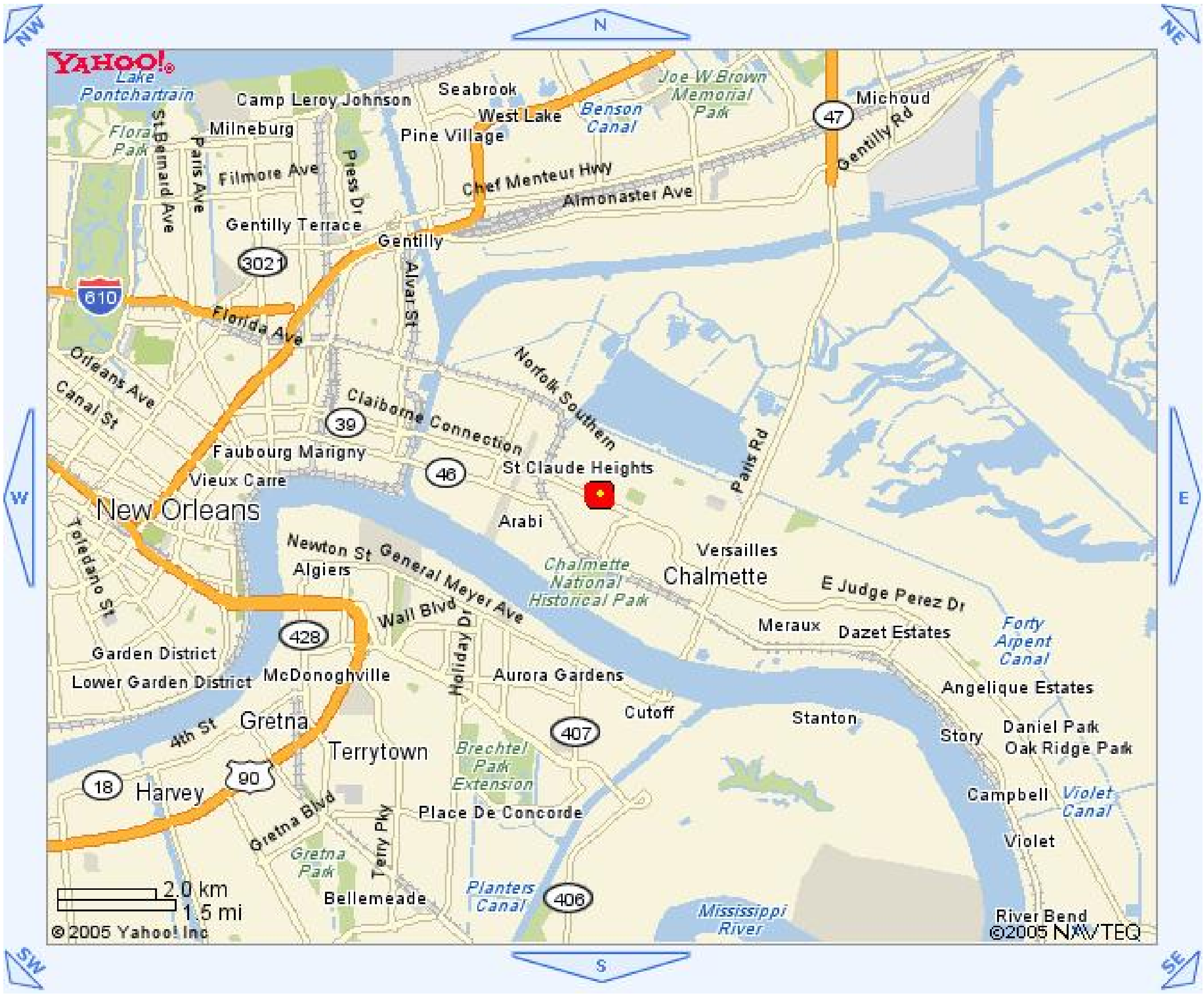

Figure 12. (BaP in Sediment > LDEQ RECAP)

With a level of 0.41 mg/kg, the lone sample that exceeded the sediment RECAP level for benzo(a)pyrene was taken on the west side of Chalmette near West Judge Perez Dr east of Norton Ave (Figure 12). Plumlee, et. al 2006, also reported elevated levels of benzo(a)pyrene in USGS sediment samples taken in Chalmette. No concentrations in water samples tested for BaP were above the detection limit.

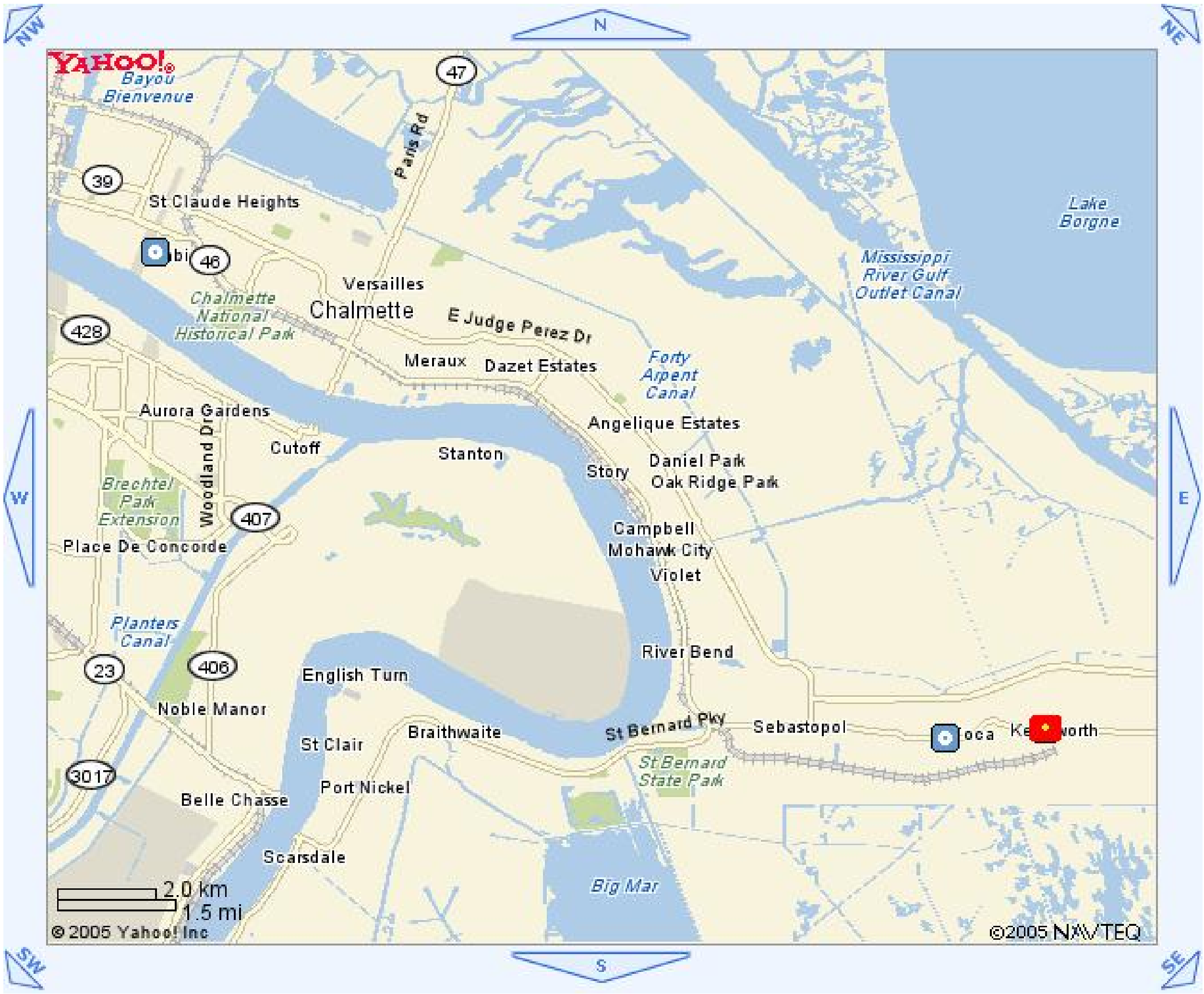

Figure 13. (Lead in Sediment > LDEQ RECAP)

Three of the three hundred four sediment samples in St. Bernard Parish tested for lead exceeded the RECAP level of 400 mg/kg. Like arsenic, the highest lead level detected (1370 mg/kg) was in Kenilworth along Bayou Rd just west of Billot Ln (Figure 13).

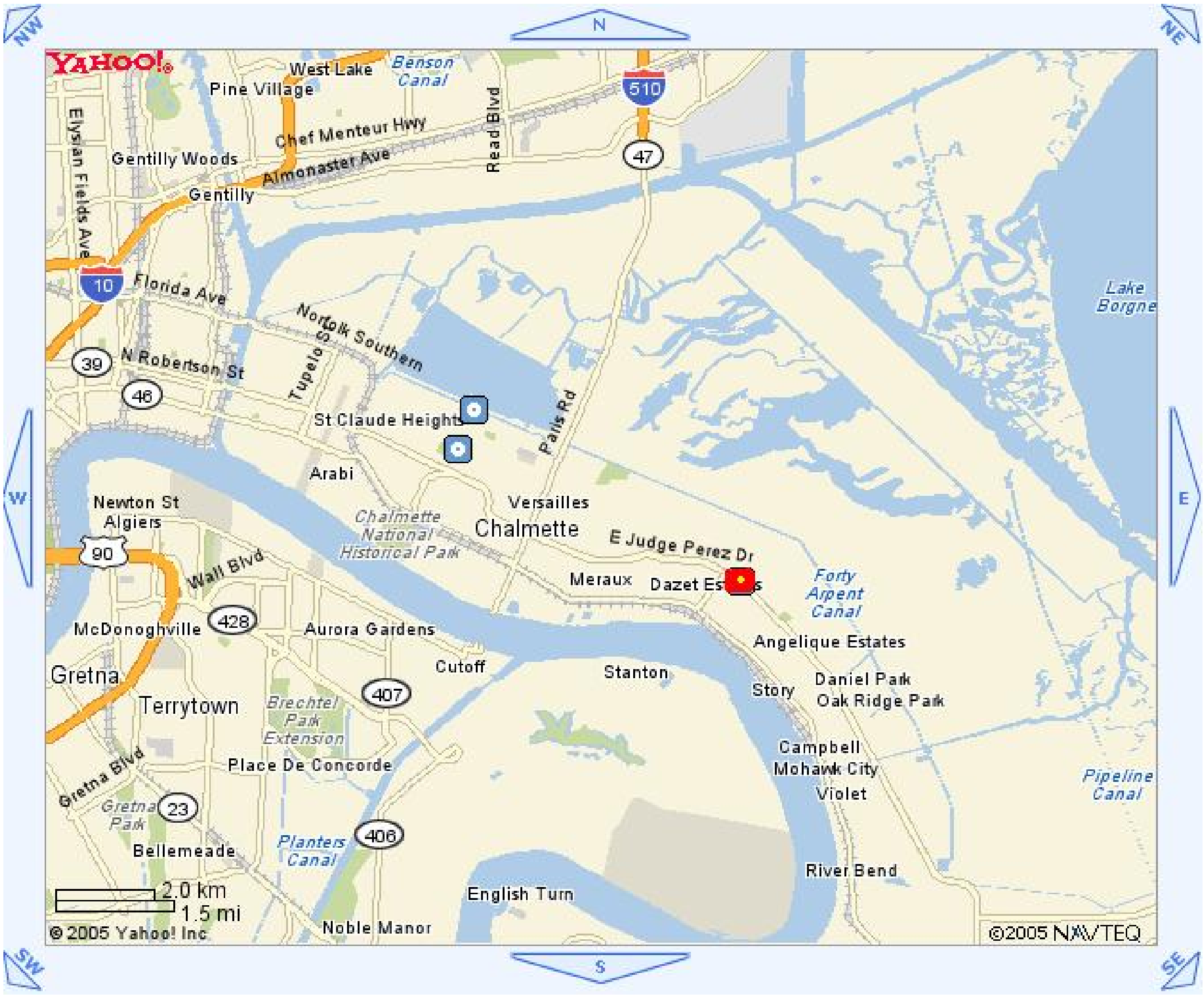

Figure 14. (Lead in Water > LDEQ RECAP)

Figure 14 shows the location of the only three water samples tested for lead that produced a level greater than or equal to the LDEQ RECAP level of 0.015 mg/L. A concentration of 0.022 mg/L was found near Archbishop Hannan High School in Chalmette (shown as red with yellow center marker in Figure 14).

No water or sediment samples in St. Bernard Parish contained a DDE level equal to or greater than the LDEQ RECAP level of 0.0002 mg/L or 1.7 mg/kg respectively.

Table 5 and 6 below present a summary of the sediment and water concentrations from the EPA STORET data set for St. Bernard Parish. The LDEQ RECAP limits and the percent of detections above the LDEQ RECAP limit for the four compounds are listed

Table 5 Summary of EPA STORET Sediment Data in St. Bernard Parish					
Compound	**Samples**	**Average (mg/kg)**	**Maximum (mg/kg)**	**LDEQ RECAP (mg/kg)**	**> LDEQ RECAP (%)**
Arsenic	304	5.7	22.8	12	3%
Lead	304	42	1370	400	1%
BaP	847	0.01	0.41	0.33	0.1%
DDE	308	0.01	0.76	1.7	0%

Table 6 Summary of EPA STORET Water Data in St. Bernard Parish					
Compound	**Samples**	**Average (mg/L)**	**Maximum (mg/L)**	**LDEQ RECAP (mg/L)**	**> LDEQ RECAP (%)**
Arsenic	57	0.003	0.059	0.01	12%
Lead	40	0.001	0.022	0.015	8%
BaP	31	0	0	0.0002	0%
DDE	31	0	0	0.0002	0%

Discussion and Conclusions

An exhaustive evaluation of the available data on the concentrations of organic and inorganic contamination in sediment and water prior to, during, and following the de-watering of New Orleans after the effects of Hurricane Katrina and the subsequent flooding shows no large scale increases in water or sediment levels as a result of the de-watering activity. The four contaminants used in this report were selected based on their presence in the current data set and the fact that they represented important classes of contamination with regards to contaminant behavior: divalent, cationic heavy metals (Pb), anionic heavy metals (As), and hydrophobic organics with various degrees of solubility and sorptive behavior (BaP) and (DDE). None of these four representative contaminants exhibited extensive changes in concentration in or mobility from soils or surface waters as a result of the dewatering effort. Comparisons between data available prior to the flooding events and data obtained both during and following the de-watering process do not show significant differences with regards to sediment and water concentrations. There can be no doubt that the volume of sediment within the city increased significantly and therefore the total mass of both organic and inorganic contaminants within these sediments increased, but this effect was a result of the effects of the hurricane and not the dewatering of the city. However, concentrations of the 4 analytes of interest were detected in sediment and water that sometimes exceeded drinking water and other regulatory levels.

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Appendix 5B
Chemical and Toxic Analysis

Environmental Consequences of the Failure of the New Orleans Levee System During Hurricane Katrina, Chemical and Toxicological Analysis

31 March 2006

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Executive Summary

Introduction

Hurricane Katrina came ashore along the Alabama, Mississippi, and Louisiana coasts on 29 August 2005, resulting in significant physical damage to infrastructure. As a result of the storm, levees were breached or overtopped, resulting in flooding of New Orleans and surrounding areas, including many areas in St. Bernard Parish. Within St. Bernard Parish, floodwaters in Chalmette and Violet, Louisiana were pumped into the adjacent Violet Marsh. There are potential undesirable environmental impacts on the marsh ecosystem resulting from levee breaches and pumping activities. One of the primary environmental concerns is chemical and biological contaminants. Thus, we conducted a study after the storm to compare chemistry and toxicity in sediment samples at sites in the immediate vicinity of active and inoperable pumping stations that discharge into Violet Marsh. The Interagency Performance Evaluation Taskforce (IPET) is investigating environmental impacts originating from the failure of the hurricane protection system to perform as designed around New Orleans, Louisiana during Hurricane Katrina. This study is needed to determine the extent to which Katrina floodwaters in the

New Orleans area may have had impacts to wildlife habitat and other biological resources in surrounding areas.

To assess the potential impacts of pumping water and suspended sediment from urban areas to adjacent ecosystems, the Corps of Engineers collected sediment samples from Violet Marsh, due to its proximity to urban areas, receipt of floodwaters pumped from the adjacent city of Chalmette, and potential importance as a buffer from hurricane-induced storm surges. Sediment samples were collected at four pump stations that could have transported contaminants from urban areas into the marsh. Sediments were also collected from a ditch that ran through portions of the Murphy Oil property and the outfall of a wastewater treatment plant (WWTP) to investigate these two potential contaminant sources. Sediment samples were also collected at various distances from these pumps in Violet Marsh to determine the range of transport of these contaminants into the marsh. Herein we present data regarding the effects of pumped floodwaters on sediment chemistry and benthic invertebrate toxicity near pumping stations that pumped floodwaters into marshes near Chalmette and Violet, Louisiana.

Materials and Methods

Sampling occurred on 14-15 February 2006. Sediment samples were collected using a grab sampler and deployed from the shore or boat. Sediments were thoroughly homogenized and aliquots of the homogenized sediments were partitioned for chemical analyses. Whole sediment acute (10-day) toxicity tests were conducted using the estuarine amphipod, *Leptocheirus plumulosus*. Samples were analyzed for volatile and semivolatile organic compounds, polychlorinated biphenyls (PCBs, as Aroclors), metals (including mercury), pesticides, diesel range organics (DRO), oil range organics (ORO) and total organic carbon (TOC) analyses using USEPA methods, as appropriate.

Results and Discussion

A comparison of sediment chemistry data from this study was made with two other studies that focused on sediment concentrations within the city of New Orleans and surrounding suburbs. The comparison showed that the relative concentrations for four representative chemicals (arsenic, benzo[a]pyrene, DDD [a breakdown product of DDT, a banned pesticide], and lead) with the exception of sediments collected near the WWTP, were lower than the concentrations reported within New Orleans by these other two studies. This suggests that sediments and the associated contaminants present within the levees may not have been pumped into the marsh. Furthermore, there do not appear to be any differences in chemical concentrations in sediments at functioning pump stations #4 and #6 versus inoperable pump stations #2 and #3.

A comparison of the bioassay and chemical analysis results suggest a relationship between the concentrations of several chemicals in the sediment (e.g., Cd, Cu, Pb, Zn, Ag, polycyclic aromatic hydrocarbons, DDD, and dieldrin) and significant mortality of *L. plumulosus* for several sampling stations. Canal stations having a larger percentage of sand and gravel generally had lower chemical concentrations and produced less mortality to *L. plumulosus.*

Spatially, there were trends that suggested that sediments close to the WWTP and pump stations had elevated chemical concentrations and significant mortality to *L. plumulosus*. Generally, sediments further from the levees into Violet Marsh had relatively lower levels of contaminants and resulted in less *L. plumulosus* mortality. Some inconsistencies between sediment chemistry and bioassay results were observed for sample locations BB-3 and BB-4, where significant mortality was observed in the bioassay but very few chemicals exceeded sediment screening values. These observed toxicities may be due to chemicals that were not measured or sensitivity to confounding factors other than chemical contamination (e.g., salinity, sediment grain size, predation).

There were no observable trends in sediment chemistry and toxicity results that suggest pump stations that were functioning following the flood event resulted in transport and deposition of contaminated sediments as compared to inoperable pump stations.

Uncertainty

There are several areas of uncertainty regarding the conclusions that can be drawn from the data collected in this study and what can be concluded regarding the ecological impacts of the dewatering of New Orleans following hurricane Katrina. Firstly, the sediment chemistry and bioassay results are limited due to the scope of the study, limited number of samples, and current tools available to assess toxicity and risk to ecological receptors. These results provide information regarding a single sampling event, with limited spatial coverage, and biological effects using a single test organism. The study was limited to a single wetland (Violet Marsh) so it is difficult to predict that similar impacts would be expected for other wetlands. There are also other risk pathways (bioaccumulation and biomagnification) that were not assessed as part of this study. Food web analysis should be conducted to determine the potential ecological risks posed by the elevated levels of the pesticides DDD and dieldrin, polycyclic aromatic hydrocarbons, and metals.

Introduction

Hurricane Katrina came ashore along the Alabama, Mississippi, and Louisiana coasts on 29 August 2005, resulting in significant physical damage to infrastructure. As a result of the storm, levees were breached or overtopped, leading to flooding of New Orleans and surrounding areas, including many areas in St. Bernard Parish. Within St. Bernard Parish, floodwaters in Chalmette and Violet, Louisiana were pumped into the adjacent Violet Marsh (Figure 1). There are potential undesirable environmental impacts on the marsh ecosystem resulting from levee breaches and pumping activities. The primary environmental concerns are elevated salinity and chemical and biological contaminants. This section focuses on chemical contamination: salinity and biological contamination issues are discussed elsewhere in this report. To address chemical concerns, we conducted a study after the storm to compare chemistry and toxicity in sediment samples at sites in the immediate vicinity of active and inactive (flooded during Katrina) pumping stations that discharge into Violet Marsh (Figure 1). This baseline investigation builds on a pilot study that was conducted in December 2005, which consisted of sampling sediments for chemical analysis and toxicity testing, benthic invertebrates and recording salinity measurements throughout Violet Marsh. Pilot study benthic invertebrate results are addressed in Ray (2006) and salinity results in Lin and Kleiss (2006), respectively; the baseline investigation of benthic invertebrates is presented elsewhere in this report. The pilot study by Suedel et al. (Attachment 2) describing the collection of sediment samples for chemical and toxicological analysis. This section describes a baseline study to discern patterns in chemical contamination and toxicity of sediments at select pumping stations in Violet Marsh.

Purpose

The Interagency Performance Evaluation Taskforce (IPET) is investigating environmental impacts originating from the failure of the hurricane protection system to perform as designed around New Orleans, Louisiana during Hurricane Katrina. This study is needed to determine the extent to which Katrina floodwaters in the New Orleans area may have had impacts to wildlife habitat and other biological resources in surrounding areas. Herein we present data regarding the effects of pumped floodwaters on sediment chemistry and benthic invertebrate toxicity near pumping stations that pumped floodwaters into marshes near Chalmette and Violet, Louisiana.

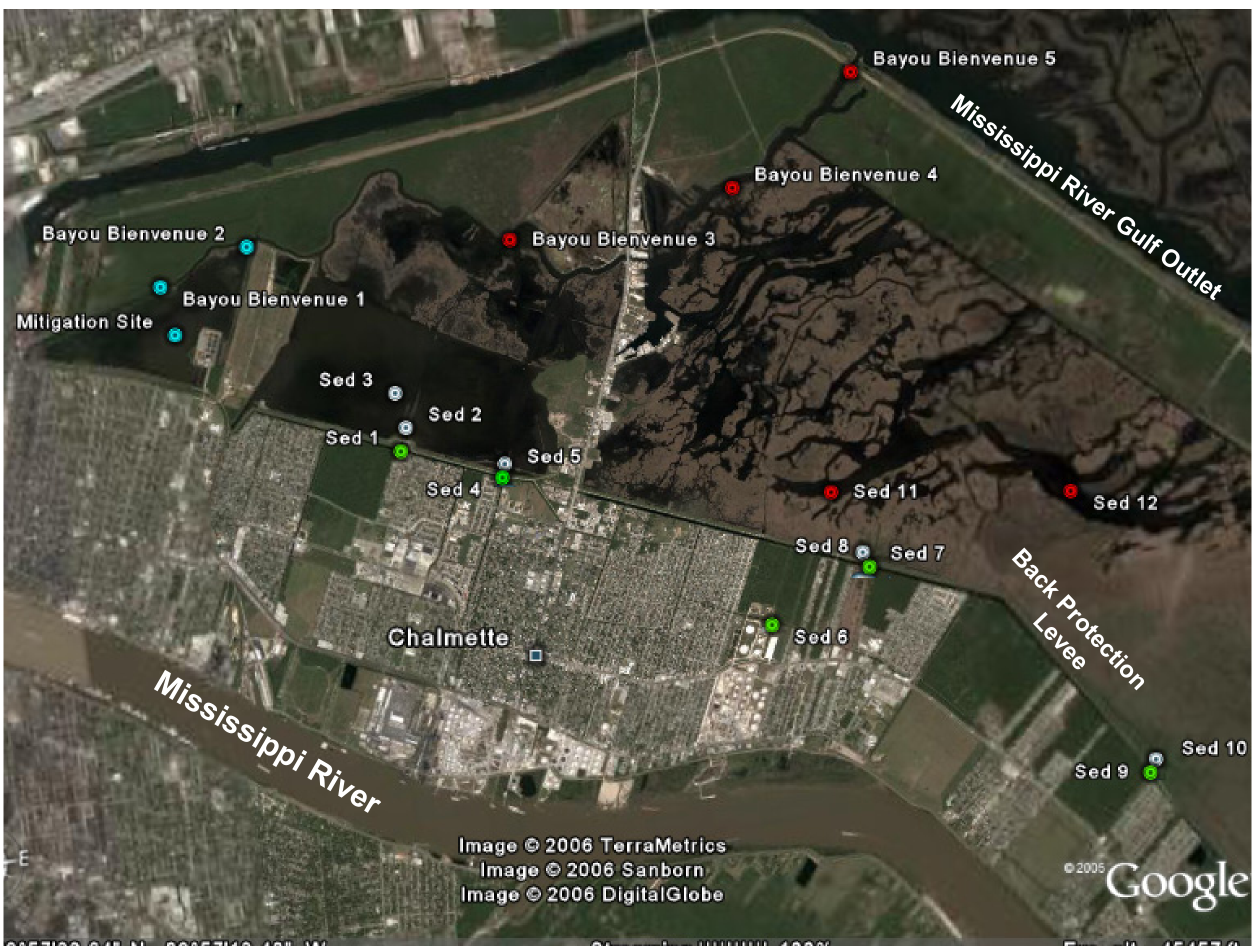

Figure 1. Overview of Violet Marsh and sampling locations.

Background and Rationale

To assess the potential impacts of pumping water and suspended sediment from urban areas to adjacent ecosystems, the Corps of Engineers collected sediment samples from Violet Marsh. Violet Marsh was selected for study because of its 1) proximity to urban areas, 2) receipt of floodwaters pumped from the adjacent city of Chalmette, and 3) potential importance as a buffer from hurricane-induced storm surges.

Violet Marsh covers an area of approximately 81.6 hectares (31.5 sq. miles) between Chalmette, Louisiana and Lake Borgne in St. Bernard Parish, Louisiana (Figure 1). Violet Marsh is bordered to the east by the Mississippi River Gulf Outlet (MRGO), to the north by the Intercoastal Waterway and to the south by the back protection levee. Thus the marsh is connected directly to both the Mississippi River and the MRGO. Bayou Bienvenue winds through the marsh from the west near the municipal waste water treatment plant (WWTP) to the MRGO to the east. The pumps used to remove floodwaters from Chalmette and surrounding suburbs are located along the back protection levee.

To assist in interpretation of the analytical and toxicological data, the 18 sediment sampling locations were divided into four groups depending on their proximity to potential sources of chemical contamination (Table 1). The groups were: (1) Outer Marsh and Bayou, located in the Violet Marsh just south of the MRGO; (2) Canals, located within the canals bordering the back protection levee; (3) Pump Station Outfalls, located in the receiving water basins in the marsh; and (4) Waste Water Treatment Plant (WWTP) Vicinity, located just east of the Mitigation site sampling location. Of the pumps sampled, only Pump Stations Meraux #4 and Jean Lafitte #6 operated in the aftermath of the storm to drain floodwaters from the Chalmette area, pumping over the back protection levee into Violet Marsh. Pump Stations Guichard #2 and Villere #3 were flooded by Katrina and were thus rendered inoperable.

Table 1 List of sediment samples and associated groupings and proximity to potential chemical contamination sources		
Group	**Station**	**Associated Pump Stations/Pump Station Activity**
WWTP Vicinity	Mitigation Site	NA (WWPT)
WWTP Vicinity	BB1	NA (WWTP)
WWTP Vicinity	BB2	NA (WWTP)
Pump Station Outfalls	Sed 2	#6/Active
Pump Station Outfalls	Sed 3	#6/Active
Pump Station Outfalls	Sed 5	#2/Inactive
Pump Station Outfalls	Sed 8	#3/Inactive
Pump Station Outfalls	Sed 10	#4/Active
Canals	Sed 1	#6/Active
Canals	Sed 4	#2/Inactive
Canals	Sed 7	#3/Inactive
Canals	Sed 9	#4/Active
Canals	Sed 6	NA (Murphy Oil refinery)
Outer Marsh and Bayou	BB3	NA
Outer Marsh and Bayou	BB4	NA
Outer Marsh and Bayou	BB5	NA
Outer Marsh and Bayou	Sed 11	#3/Inactive
Outer Marsh and Bayou	Sed 12	#4/Active
Note: WWTP = waste water treatment plant; NA = No association; BB = Bayou Bienvenue.		

Sediment samples were collected both immediately upstream and downstream of these four pump stations that could have transported contaminants from the urban areas and canals over the back protection levee and into Violet Marsh. Sediments were also collected from a ditch that ran through portions of the Murphy Oil property and the outfall of the WWTP to investigate these two potential contaminant sources. Sediment samples were also collected at various distances from these pumps in Violet Marsh to determine the range of transport of these contaminants into the marsh.

Materials and Methods

Sampling Procedures

The sampling event occurred in the New Orleans area, specifically Violet Marsh and Bayou Bienvenue, on 14-15 February 2006. Sediment samples were collected with a standard Ekman grab according to standard guidance (US EPA 2001) attached to a 6 ft aluminum pole deployed from shore or boat. Sediments were thoroughly homogenized to acquire consistent texture and water content. Aliquots of the homogenized sediments were partitioned for chemical analyses. Remaining sediment was archived in plastic bags and kept on wet ice. Several sediments were compromised during shipment to the ERDC Vicksburg, MS, so those samples were not used in this study.

Toxicity Testing

Whole sediment acute (10-day) toxicity tests using the estuarine amphipod, *Leptocheirus plumulosus*, were conducted according to standard guidance (U.S. EPA, 1994). Experimental conditions are outlined in Table 2. Test sediments were stored in the dark at 4 ± 1 °C and used in testing within eight weeks of collection, as recommended (US EPA / ACE, 1998). Sediments were homogenized using a motorized impeller mixer (Lightnin, Rochester, New York) prior to use and approximately 100 mL (1.5 cm depth) of each test sediment was added to each of five replicate test chambers (1-L beakers). Sediment was then overlain with 20 ‰ synthetic seawater (Crystal Sea® Marine Mix; Marine Enterprises International, Inc., Baltimore, MD, U.S.A.) and allowed to equilibrate in test chambers overnight. The test chambers were supplied trickle-flow aeration in a temperature (25.0 ± 1.0 °C) and photoperiod (continuous light) regulated water bath. At test initiation, *L. plumulosus* (500 – 750 µm) were obtained from ERDC in-house cultures and 20 amphipods were gently transferred into each test chamber. Water quality measurements (temperature, dissolved oxygen, pH, salinity, overlying water ammonia) were determined at test initiation and termination. Water quality was measured using a model ABMTC handheld refractometer (Aquafauna Bio-Marine, Hawthorne, California) for salinity, a model 315i meter (WTW; Weilheim, Germany) for pH and a model Oxi 330 meter (WTW; Weilheim, Germany) for D.O. Environmental chamber temperature (min/max) was monitored and recorded daily. Animals were not fed during the test.

The test assessment endpoint was survival. Test sediments were assessed along side a performance control sediment (Sequim, Washington, USA) and a reference sediment (Lake Pontchartrain, Louisiana, USA). For tests to be considered valid, at least 90% survival had to be observed in the performance control and overlying water quality (pH, temperature, dissolved oxygen) within the ranges specified by guidance (U.S. EPA, 1994). In order for test sediment to be considered "toxic," two decision criteria must be met; the survival in the test sediment must be statistically reduced relative to the reference sediment and the reduction must be greater than 20% of the reference survival value (U.S. EPA / U.S. ACE, 1998).

Chemical Analyses

Samples were prepared and analyzed for volatile and semivolatile organic compounds, polychlorinated biphenyls (PCBs, as Aroclors), metals (including mercury) using USEPA methods found in SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical* Methods (1986) and updates. Samples were analyzed for volatile organic compounds (VOCs) using method 8260B (gas chromatography/mass spectrometry (GC/MS)) and for semi-volatile organic compounds (SVOCs) using method 8270C (GC/MS). Metals were analyzed using method 6020B (Inductively Coupled Plasma (ICP) -Atomic Absorption (AA) Spectrometry) and mercury was analyzed using Method 7471A (Cold-Vapor AA). Pesticides and PCBs were analyzed using Method 8081A (GC) and 8082 (GC), respectively. Samples analyzed for diesel range organics (DRO) and oil range organics (ORO) following method 8015 (GC/flame ionization detector (FID)). Total organic carbon (TOC) analyses were quantified using the Lloyd Kahn method.

Statistical Analyses

Data normality (Kolmogorov-Smirnov test), homogeneity (Levene's Test) and treatment differences ($\alpha = 0.05$) compared to the reference sediment were determined at using SigmaStat statistical software (SPSS, Chicago, IL). Survival data were arcsine-square root transformed and a one-way ANOVA (Dunnett's post-hoc comparison) was used to determine if statistical differences existed between individual test sediments and the reference sediment.

Table 2
Conditions for conducting 10-day sediment toxicity tests with the estuarine amphipod, *Leptocheirus plumulosus*

Test type	Static non-renewal
Test duration	10 days
Temperature	25.0 ± 1.0°C
Salinity	20 ± 2 ppt
pH	7.8 ± 0.5
Light quality	Ambient Laboratory
Light intensity	500 – 1000 lux
Photoperiod	24:0 hr (light:dark)
Test chamber size	1 liter
Sediment volume (depth)	100 mL (1.5 cm)
Overlying water volume	Fill to 950 mL
Sediment settling time	Overnight
Water renewal	None
Age of test organisms	Neonates (500 – 750 μm)
Organisms/chamber	20
Replicates/treatment	5
Organisms/treatment	100
Feeding regime	None
Test chamber cleaning	None
Test solution aeration	> 40% O_2 saturation
Dilution water	20 ppt
Dilution series	None
Endpoint(s)	Survival

Results and Discussion

Chemical Analyses

To evaluate potential adverse effects on benthic organisms residing in Violet Marsh sediments, a comparison of sediment concentrations to numerical sediment quality guidelines (SQGs) was performed (see figures in Attachment 1). The SQGs used were the threshold effect levels (TELs) and probable effects levels (PELs) which are the most recently published SQGs for marine and estuarine sediments (MacDonald et al. 1996; Buchman 1999). The TELs are intended to identify chemical concentrations below which harmful effects on sediment-dwelling organisms only rarely occur. The PELs are intended to identify chemical concentrations above which adverse effects frequently occur. Values for TELs and PELs have been developed for 9 metals, 13 PAHs, total PCBs, and 7 pesticides (MacDonald et al. 1996).

An exceedance of a TEL or PEL is not indicative of adverse effects; rather, it signifies that further evaluation of sediments may be necessary. Sediment quality guidelines can be used as a simple first screen of potential hazards to benthos using the chemical analysis of sediments. SQG values can be used to:

- Identify the needs for additional benthic evaluations Determine that a sediment is not likely to cause effects to benthosFocus the scope of additional study (e.g., reduce number of contaminants of concern or pathways to be considered in baseline assessment)
- SQG values may be used in a weight-of-evidence approach with other data (benthic toxicity, biological indices, tissue residues, effects data)

Sediment quality guidelines have several limitations in their use (USACE 1998). The SQG values do not provide estimates of risk. There are many reasons they do not adequately consider risk including:

- Some pathways not considered (bioaccumulation and trophic transfer)
- SQG values do not address more than one chemical or their interactions
- Screening with SQG does not address or quantify exposure
- SQG values are not site specific
- Biological availability is not taken into account

Furthermore, it has been demonstrated the rate of false positives and false negatives in the application of SQG values are high. A study by O'Connor et al. (1998) reported that of 239 samples that exceeded at least one SGQ, the effects range median (ERM), only 38% were toxic to amphipods. In an additional study by Long et al. (1998), the probability of toxicity below the effects range low (ERL) was as high as 10%. Because of these limitations, SQG values should not be used as a remediation goal, to predict biological effects, or to estimate human or ecological risk. The U.S. EPA Superfund Office has the same technical position with regard to the use of SQG values for remediation goals.

Following hurricane Katrina, three studies described chemical concentrations in environmental media around the New Orleans area. Most of these data focused on the concentration of chemicals in the flood waters or sediment associated with settling of suspended material in the flood water. The U.S. Environmental Protection Agency has compiled a significant amount of information regarding the concentration of chemicals in floodwater and sediments in the city (U.S. EPA, 2005). Another study by Pardue et al. (2005) reported concentrations of chemicals in flood water samples collected within the levee walls. The last study by Presley et al. (2006) summarized an assessment of chemical and pathogen concentrations in sediment samples from within the levee walls. To date, there are no studies that have reported concentrations of chemicals in sediments in the wetlands that received the pumped floodwaters. A summary comparing sediment chemistry data from the current study to the U.S. EPA (2006) and Presley et al (2006) study is shown in Table 3. While the other two studies focus on sediment concentrations within the city, the comparison illustrates the relative concentrations for four chemicals; arsenic, benzo[a]pyrene, DDD (dichlorodiphenyldichloroethane), and lead. With the exception of the sediments collected near the outfall of the East Bank Wastewater Treatment Plant (WWTP), concentrations of the four representative chemicals were lower than the concentrations reported within New Orleans by these other two studies. This suggests that sediments and the associated contaminants present within levees may not have been transported by the pumped water to the wetlands. Furthermore, there do not appear to be any differences in chemical levels in sediments at functioning pump stations 4 and 6 that pumped water following the flood event (Sed-1,2,9,10) versus pump stations 2 and 3 that were non-functioning and did not pump water following the flood event (Sed-4,5,7,8). The section on analytical chemistry (IPET Report) goes into additional detail evaluating the other published results, however, analytical chemistry results should be used as an additional line of evidence to understand the impact of pumping on the wetlands.

Table 3
Summary of chemical analysis of sediments following hurricane Katrina. The table summarizes results from the current IPET study, Presley et al., 2005, and U.S. Environmental Protection Agency, 2005

Analyte	IPET Study, Suedel et al. 2006 [2]				Presley et al. 2005[1]	U.S. EPA. 2005		
	Outer Marsh Bayou	Canals	Pump Station Outfalls	WWTP Vacinity	East of Industrial Canal	New Orleans West of Industrial Canal	New Orleans East, N of MRGO	New Orleans South of MRGO
Arsenic (mg/kg)	4.2	6.3	8.7	7.6	24.2	8.65	9.97	4.66
	(4.2-11.1)	(3.6-8.8)	(3.9-10.9)	(6.7-8.4)	(5.7-24.2)	(0.3-78)	(0.82-45.5)	(0.54-29.5)
Benzo[a]pyrene (µg/kg)	ND	35	79	260	810	1745	1762	845
	(<0.59)	(<7.5-46)	(<6.5-200)	(93-670)	(0.00-1260)	(59-31,350)	(103-37,600)	(33-50,100)
DDD (µg/kg)[3]	0.261	5.4	27	52 [4]	NA	110	114	21
	(<0.1-4.4)	(<1.1-5.7)	(<0.2-61)	(<2.2-52)		(10-785)	(20-3,015)	(<2-540)
Lead (mg/kg)	14.6	54.3	84.7	202	642	87.5	43.7	25.4
	(12.1-29.2)	(15.4-83.9)	(32.2-129)	(105-285)	(341.5-642.0)	(1.17-1,160)	(9.21-295)	(14.4-689)
Sample number	5	5	5	3	3 metals, 5 organics	149-153	80-84	209

[1] Presley et al., 2005 reports geometric mean values of 2 measures per site. Reported value is geometric mean at Industrial canal. Range of values is from values reported in the study.
[2] Non-detects in IPET study and synthesis of U.S. EPA data were handled by taking ½ reporting limit.
[3] The DDD values were calculated by taking the geometric mean of detected values.
[4] Single detected value.

Sediment Bioassay

Bioassay results satisfied test acceptability criteria according to the performance control (survival >90%) and water quality parameters (Tables 2 and 4). Several of the sediments collected in Violet Marsh and Bayou Bienvenue caused reduced survival in the 10 d toxicity test (p=0.003), but when compared to the Lake Pontchartrain reference sediment (Control LP), none demonstrated a statistically significant reduction in survival based on Dunnett's Method (Table 5). However, the laboratory control sediment (Control SC) survival was much higher (97.4%) and when used a reference in this test, several of the sites (Sed 2, Sed 8, IHNC-MS, BB3, BB4) had statistically significant reductions in growth ($p<0.001$). Among the sediments that were statistically reduced relative to the control, PEL values were exceeded for Sed 2 (Zn, DDD), Sed 8 (Pb), IHNC – MS (Pb, Hg, Ag, DDD, dieldrin) and BB1 (Pb, Hg, Zn, Acenapthalene, Benzo[a]anthracene, fluroanthene, phenanthrene, DDD, and dieldrin). Sediments BB3 and BB4 did not have analytes that exceeded PEL values and were not particularly high in petroleum hydrocarbons. No sediments that were statistically similar to the control had analytes that exceeded PEL values.

Table 4
Mean physical parameters (ranges in parentheses) measured on Days 0 and 10 of the 10-day sediment toxicity test with the estuarine amphipod, *Leptocheirus plumulosus*.

Sample ID	Temperature (° C)	Salinity (‰)	pH (SU)	D.O. (mg/L)
Control (SC)	24.3 ± 1.9 (24.1 – 24.5)	22 ± 2 (20 – 25)	7.9 ± 0.1 (7.7 – 8.1)	7.3 ± 0.7 (6.3 – 8.0)
Reference (LP)	24.4 ± 0.0 (24.0 – 24.5)	20 ± 0 (20 – 20)	7.7 ± 0.2 (7.5 – 7.9)	7.7 ± 0.4 (7.0 – 8.0)
Sed 2	24.2 ± 2.2 (22.8 – 24.5)	21 ± 2 (20 – 27)	8.0 ± 0.1 (7.8 – 8.1)	7.9 ± 0.3 (7.5 – 8.2)
Sed 3	24.2 ± 1.6 (23.1 – 24.5)	21 ± 2 (20 – 25)	7.9 ± 0.2 (7.5 – 8.1)	7.8 ± 0.3 (7.1 – 8.2)
Sed 8	24.1 ± 1.4 (23.1 – 24.5)	21 ± 1 (20 – 24)	7.9 ± 0.1 (7.6 – 8.1)	7.9 ± 0.2 (7.5 – 8.2)
Sed 7	24.3 ± 1.0 (23.9 – 24.5)	21 ± 1 (20 – 23)	7.9 ± 0.2 (7.5 – 8.1)	7.9 ± 0.3 (7.5 – 8.1)
IHNC MS	24.3 ± 0.7 (24.0 – 24.5)	21 ± 1 (20 – 22)	8.0 ± 0.1 (7.9 – 8.1)	8.0 ± 0.2 (7.8 – 8.2)
BB 1	24.2 ± 1.3 (23.4 – 24.5)	21 ± 1 (20 – 24)	7.8 ± 0.3 (7.1 – 8.1)	7.8 ± 0.2 (7.4 – 8.0)
BB2	24.1 ± 1.8 (23.2 – 24.5)	22 ± 2 (21 – 25)	8.0 ± 0.1 (7.9 – 8.2)	7.4 ± 1.3 (3.8 – 8.2)
BB3	24.1 ± 1.5 (23.1 – 24.5)	24 ± 2 (21 – 25)	8.0 ± 0.1 (7.7 – 8.1)	7.8 ± 0.4 (6.7 – 8.3)
BB4	24.1 ± 1.3 (23.7 – 24.5)	22 ± 1 (21 – 24)	7.9 ± 0.1 (7.7 – 8.1)	7.9 ± 0.3 (7.5 – 8.2)

Table 5
Percent survival reported upon termination of the 10-day sediment toxicity test with the estuarine amphipod, *Leptocheirus plumulosus*

Sample ID	Percent Survival	Min / Max
Control (SC)	97 ± 7	85 – 100
Reference (LP)	81 ± 9	70 – 90
Sed 2	58 ± 37*	0 – 95
Sed 3	78 ± 10	65 – 90
Sed 7	89 ± 11	75 – 100
Sed 8	64 ± 17*	35 – 80
IHNC MS	52 ± 18*	30 – 75
BB 1	48 ± 13*	30 – 65
BB2	88 ± 12	75 – 100
BB3	57 ± 27*	15 – 85
BB4	53 ± 16*	35 – 70

* indicates treatment survival is statistically different (p<0.05) from SC sediment survival when analyzed using one way ANOVA and Dunnett's post-hoc test.

Comparison of the bioassay and chemical analysis results suggest a relationship between the levels of several chemicals in the sediment (PEL exceedances for Cd, Cu, Pb, Zn, Ag, polycyclic aromatic hydrocarbons, DDD, and dieldrin) and significant mortality of *L. plumulosus* (BB-1, 3, 4, Sed-2, 8). The use of sediment quality guideline values can be used to gain a better understanding of the toxicity observed in the bioassay. However, there are several other factors that must be considered when interpreting these results as outlined above (e.g., salinity, total organic carbon). Sediment grain size information (see Attachment 1) can also be used to better understand the chemistry results and bioassay data. Canal sites having a larger percentage of sand and gravel (Sed-4, 7, 9) generally had lower levels of chemicals and did not result in significant toxicity to *L. plumulosus.*

Spatially, there are trends that suggest that sediments close to the East Bank WWTP, and Pump Stations had elevated levels of chemicals and significant mortality to *L. plumulosus*. Generally, sediments further from the levees into the Violet Marsh had relatively lower levels of contaminants and less toxicity observed with *L. plumulosus*. Some inconsistencies between sediment chemistry and bioassay results were observed for sample locations BB-3 and BB-4, where significant mortality was observed in the bioassay but very few chemicals exceeded sediment screening values. The observed mortality may be due to chemicals that were not measured or sensitivity to confounding factors other than chemical contamination (e.g., salinity, sediment grain size, predation).

There were no observable trends in sediment chemistry results that suggest pump stations that were functioning following the flood event resulted in flow and deposition of contaminated sediments as compared to non functioning pump stations. This conclusion is further reinforced by the bioassay results for sites Sed 2 and 8 where toxicity was observed for a functioning pump station and non-functioning pump station, respectively.

Uncertainty of Study Results

Uncertainty is related to either the natural variability of a measurement or from unknown information that cannot be derived from the study. There are several areas of uncertainty regarding the conclusions that can be drawn from the data collected in this study and what can be concluded regarding the ecological impacts of the dewatering of New Orleans following hurricane Katrina. Firstly, the current study summarizes an assessment of sediment chemistry and bioassay results. These data are limited due to the scope of the study, limited number of samples, and current tools available to assess toxicity and risk to ecological receptors. For example, only nine (9) sediments from the Violet Marsh were assessed using the amphipod bioassay to determine the potential ecological impacts due to dewatering of the city. These results provide information regarding a single sampling event, with limited spatial coverage, and biological effects using a single test organism. The study was limited to a single wetland (Violet Marsh) so it is difficult to predict that similar impacts would be expected for other wetlands. While these data were used with chemical analysis data and benthic survey, care should be taken regarding the confidence by which conclusions can be drawn. There are also other risk pathways that were not assessed as part of this study. For example, bioaccumulation and biomagnification of contaminants were not assessed as part of this study. Food web analysis should be conducted to determine the potential ecological risks posed by the elevated levels of the pesticides DDD and dieldrin, polycyclic aromatic hydrocarbons, and metals.

Conclusions

1. Spatial trends were observed for concentrations of chemicals in sediment. The highest to lowest concentrations were reported in sediments within the city of New Orleans, wetlands receiving outfalls from pumps or WWTP, and wetland areas distant from pump stations.

2. Visible trends in sediment chemical concentrations were observed among sample location groups (e.g., outfall locations, WWTP, canals, wetlands); however, these trends were not always consistent with the bioassay results.

3. Pumping during the flood dewatering process did not result in chemical concentrations in marsh sediments greater than what would have occurred under normal (i.e., non-flood impacted) conditions.

4. There are several significant areas of uncertainty in the study. These results may not be representative of other wetland areas impacted by dewatering and ecological effects resulting from food web biomagnification of chemicals, especially pesticides and metals, was not assessed.

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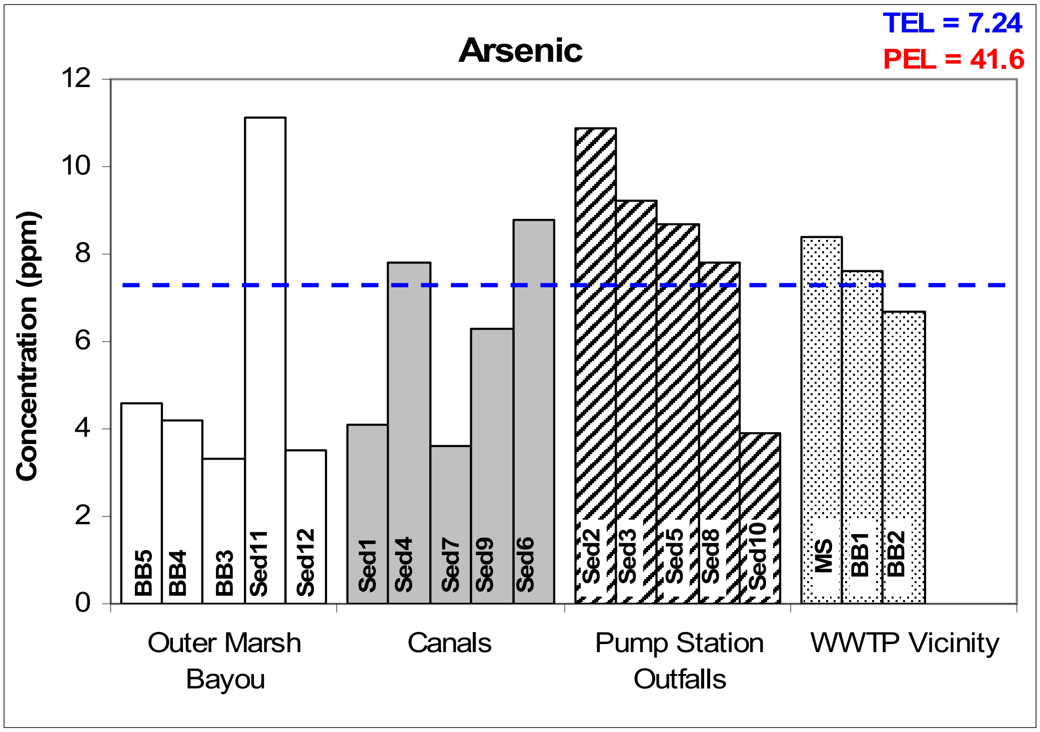
Attachment 1
Tables and Figures Summarizing Sediment Chemistry Data

Table A-1
List of analytes not detected in any samples

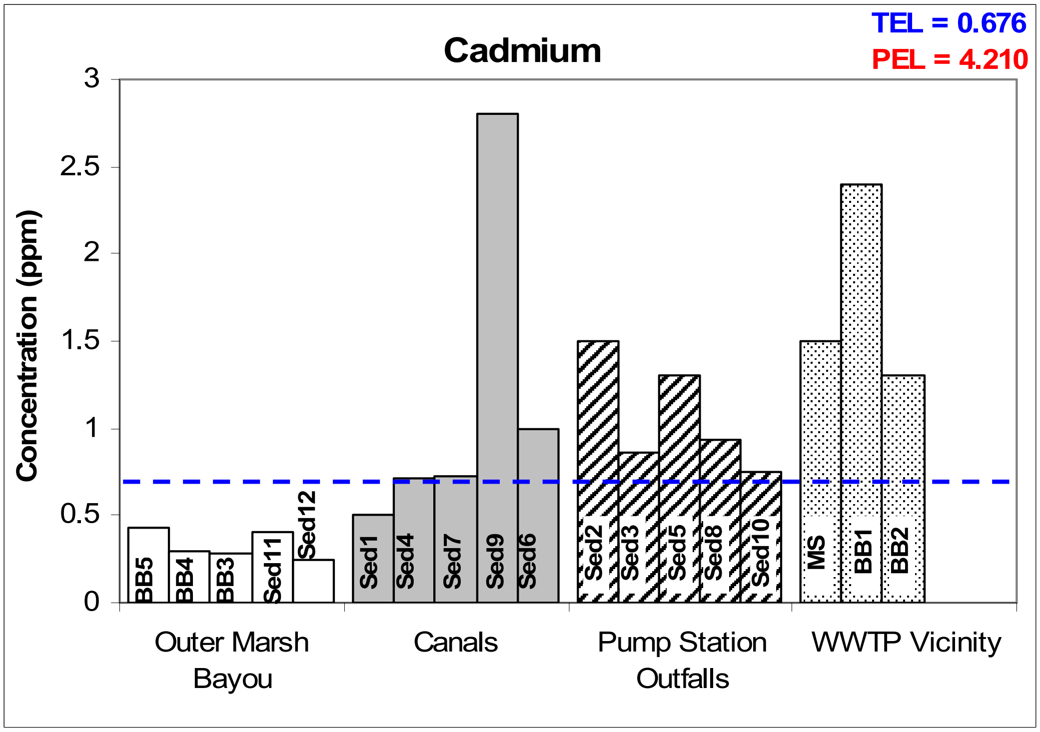
Petroleum Hydrocarbons	**Gasoline**		
Volatile Organics	1,1,1-Trichloroethane	2-Hexanone	Dibromochloromethane
	1,1,2,2-Tetrachloroethane	4-Methyl-2-pentanone	Dichlorodifluoromethane
	1,1,2-Trichloro-1,2,2-trifluoroethane	Benzene	Isopropylbenzene
	1,1,2-Trichloroethane	Bromodichloromethane	Methyl acetate
	1,1-Dichloroethane	Bromoform	Methyl tert-butyl ether
	1,1-Dichloroethene	Bromomethane	Methylcyclohexane
	1,2,4-Trichlorobenzene	Caprolactam	Methylene chloride
	1,2-Dibromo-3-chloropropane	Carbon tetrachloride	Styrene
	1,2-Dibromoethane	Chlorobenzene	Tetrachloroethene
	1,2-Dichlorobenzene	Chloroethane	trans-1,2-Dichloroethene
	1,2-Dichlorobenzene	Chloroform	trans-1,3-Dichloropropene
	1,2-Dichloroethane	Chloromethane	Trichloroethene
	1,2-Dichloropropane	cis-1,2-Dichloroethene	Trichlorofluoromethane
	1,3-Dichlorobenzene	cis-1,3-Dichloropropene	Vinyl chloride
	2-Butanone	Cyclohexane	
Semivolatile Organics (BNA)	1,1'-Biphenyl	3,3'-Dichlorobenzidine	Dimethyl phthalate
	1,4-Dichlorobenzene	3-Nitroaniline	Di-n-butyl phthalate
	2,2'-oxybis(1-Chloropropane)	4,6-Dinitro-2-methylphenol	Hexachlorobenzene
	2,4,6-Trichlorophenol	4-Bromophenyl phenyl ether	Hexachlorobutadiene
	2,4-Dichlorophenol	4-Chloro-3-methylphenol	Hexachlorocyclopentadiene
	2,4-Dimethylphenol	4-Chloroaniline	Hexachloroethane
	2,4-Dinitrophenol	4-Chlorophenyl phenyl ether	Isophorone
	2,4-Dinitrotoluene	4-Nitroaniline	Nitrobenzene
	2,6-Dinitrotoluene	4-Nitrophenol	N-Nitrosodi-n-propylamine
	2-Chloronaphthalene	Acetophenone	N-Nitrosodiphenylamine
	2-Chlorophenol	Benzaldehyde	Pentachlorophenol
	2-Nitroaniline	bis(2-Chloroethoxy)methane	Phenol
	2-Nitrophenol	bis(2-Chloroethyl) ether	
Pesticides	4,4'-DDE	Atrazine	gamma-BHC (Lindane)
	4,4'-DDT	beta-BHC	Heptachlor
	Aldrin	delta-BHC	Heptachlor epoxide
	alpha-BHC	Endosulfan I	Methoxychlor
	alpha-Chlordane	Endosulfan sulfate	Toxaphene
PCBs	Aroclor 1221	Aroclor 1242	
	Aroclor 1232	Aroclor 1248	

Table A-2 List of analytes detected in at least one sample		
Petroleum Hydrocarbons	**Motor Oil**	**Diesel Fuel**
Volatile Organics	Acetone	Toluene
Semivolatile Organics (BNA)	2-Methylnaphthalene	Carbazole
	2-Methylphenol	Carbon disulfide
	4-Methylphenol	Chrysene
	Acenaphthene	Dibenz(a,h)anthracene
	Acenaphthylene	Dibenzofuran
	Anthracene	Diethyl phthalate
	Benzo(a)anthracene	Di-n-octyl phthalate
	Benzo(a)pyrene	Fluoranthene
	Benzo(b)fluoranthene	Fluorene
	Benzo(ghi)perylene	Indeno(1,2,3-cd)pyrene
	Benzo(k)fluoranthene	Naphthalene
	bis(2-Ethylhexyl) phthalate	Phenanthrene
	Butyl benzyl phthalate	Pyrene
Pesticides	4,4'-DDD	Endrin aldehyde
	Dieldrin	Endrin ketone
	Endosulfan II	gamma-Chlordane
	Endrin	
PCBs	Aroclor 1016	Aroclor 1260
	Aroclor 1254	
Metals	Aluminum	Lead
	Arsenic	Magnesium
	Barium	Manganese
	Antimony	Mercury
	Beryllium	Nickel
	Cadmium	Potassium
	Calcium	Selenium
	Chromium	Silver
	Cobalt	Sodium
	Copper	Thallium
	Iron	

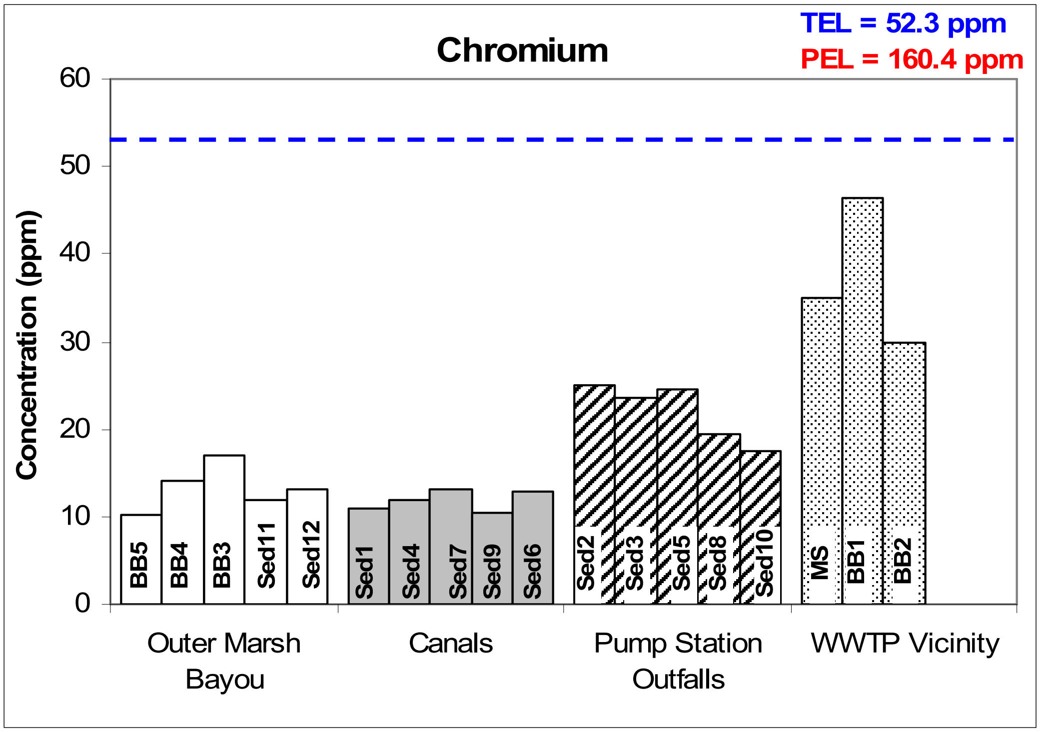
Note: Sediment quality benchmarks for individual chemicals are expressed in the following figures as threshold effects levels (TEL; dashed blue line) and probable effects levels (PEL; solid red line). Bars representing non-detected values have dashed borders and are marked with an asterisk.

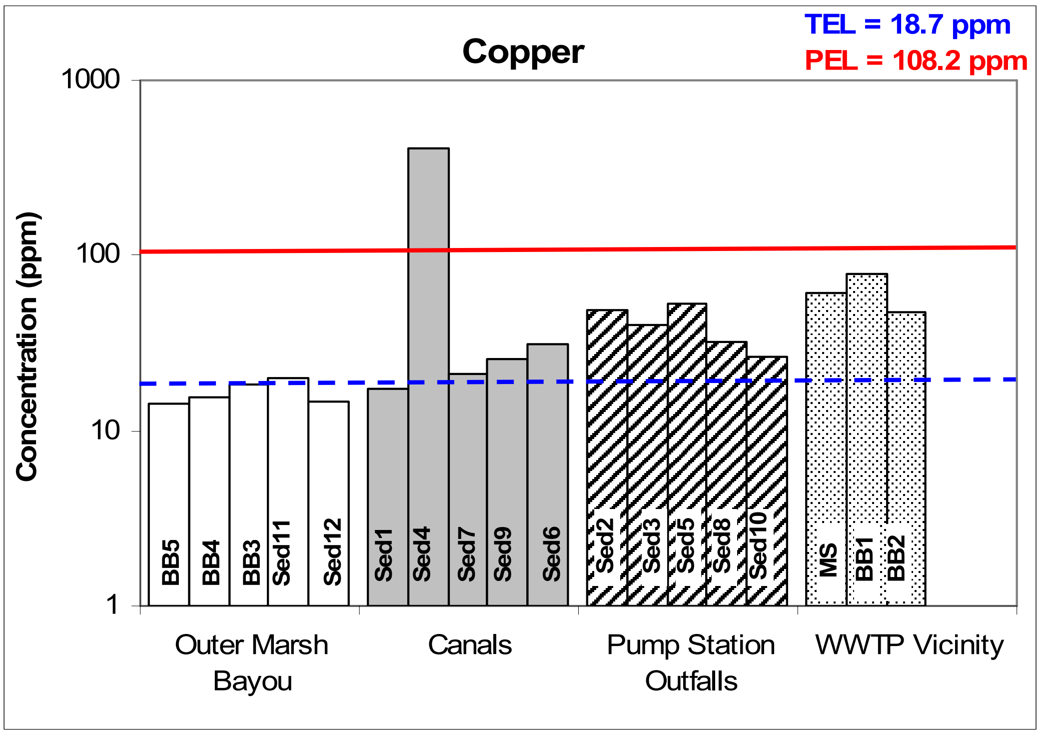


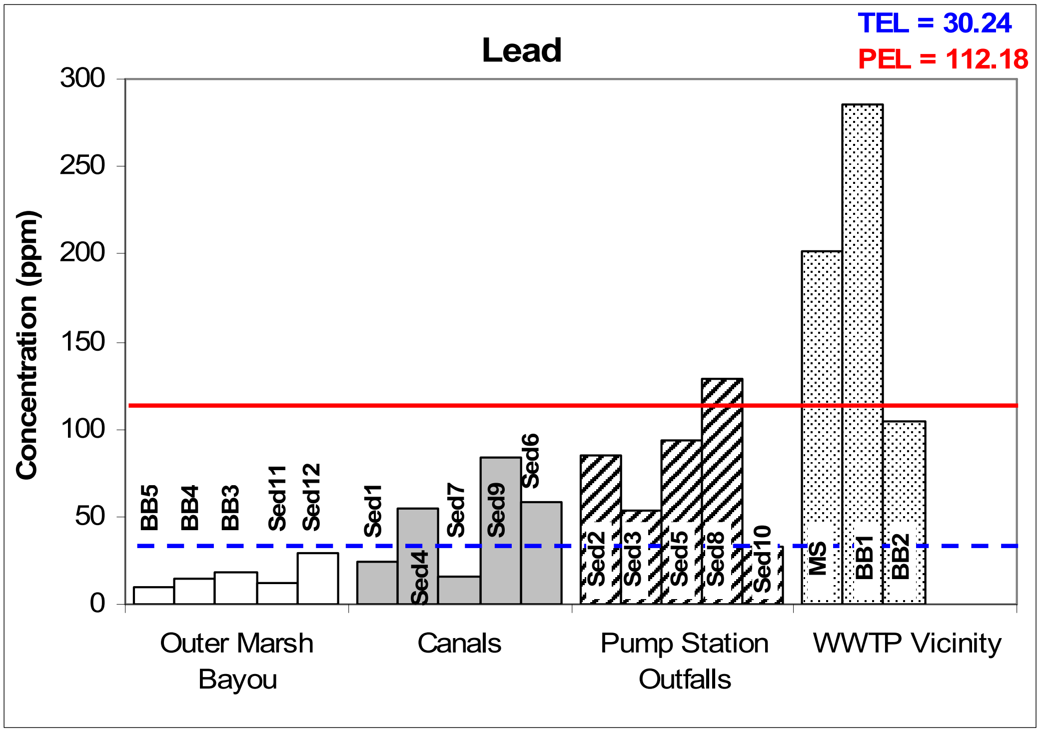
Arsenic
TEL = 7.24
PEL = 41.6
Concentration (ppm)
12
10
8
6
4
2
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

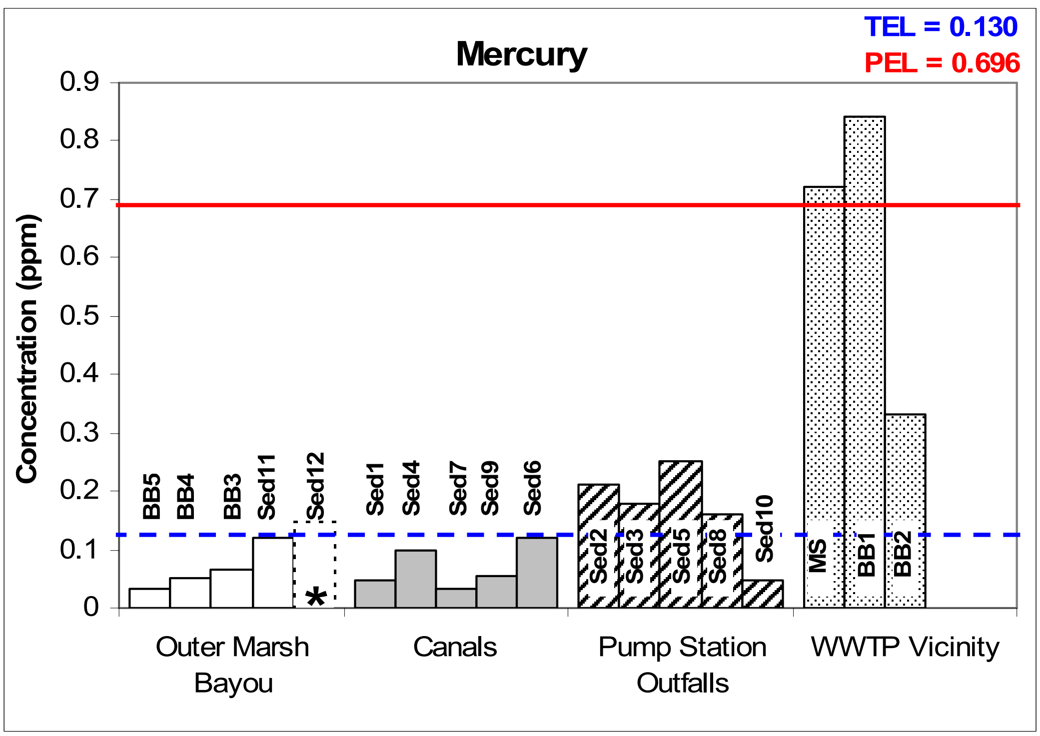


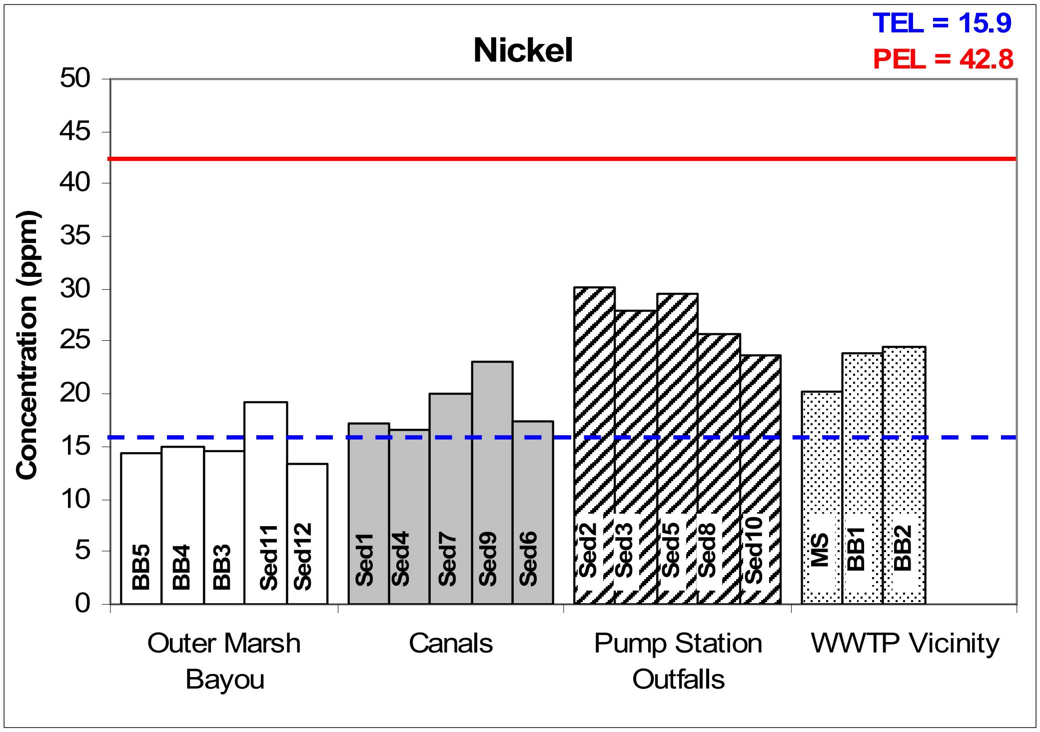
Cadmium
TEL = 0.676
PEL = 4.210
Concentration (ppm)
3
2.5
2
1.5
1
0.5
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

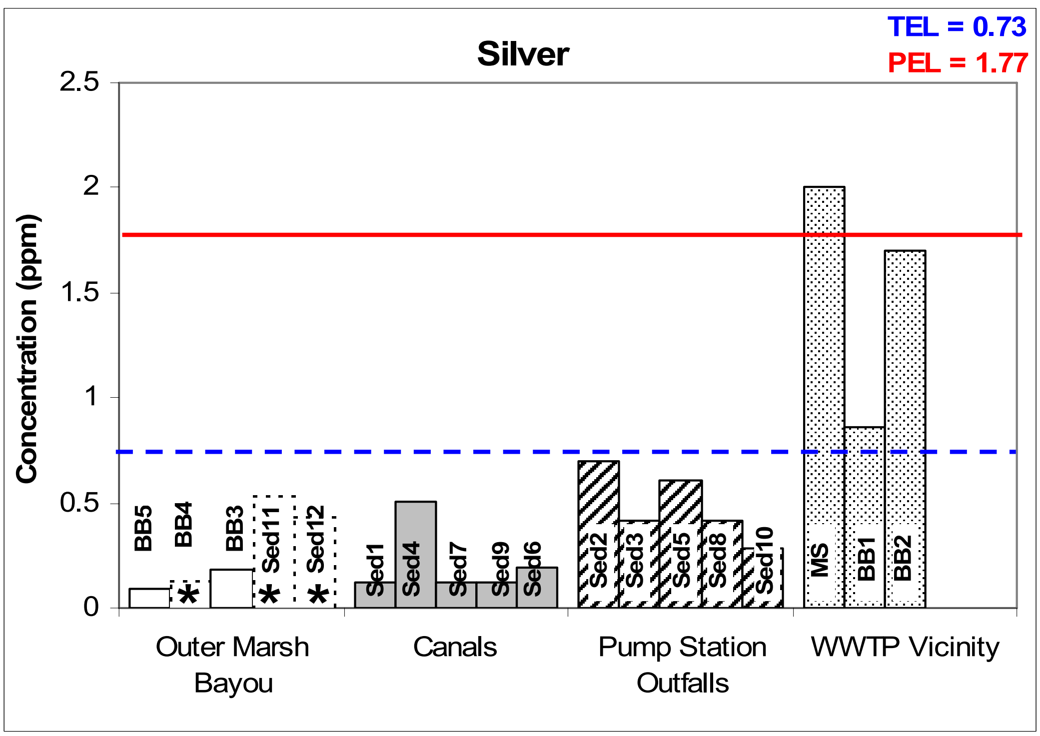

Chromium
TEL = 52.3 ppm
PEL = 160.4 ppm
Concentration (ppm)
60
50
40
30
20
10
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

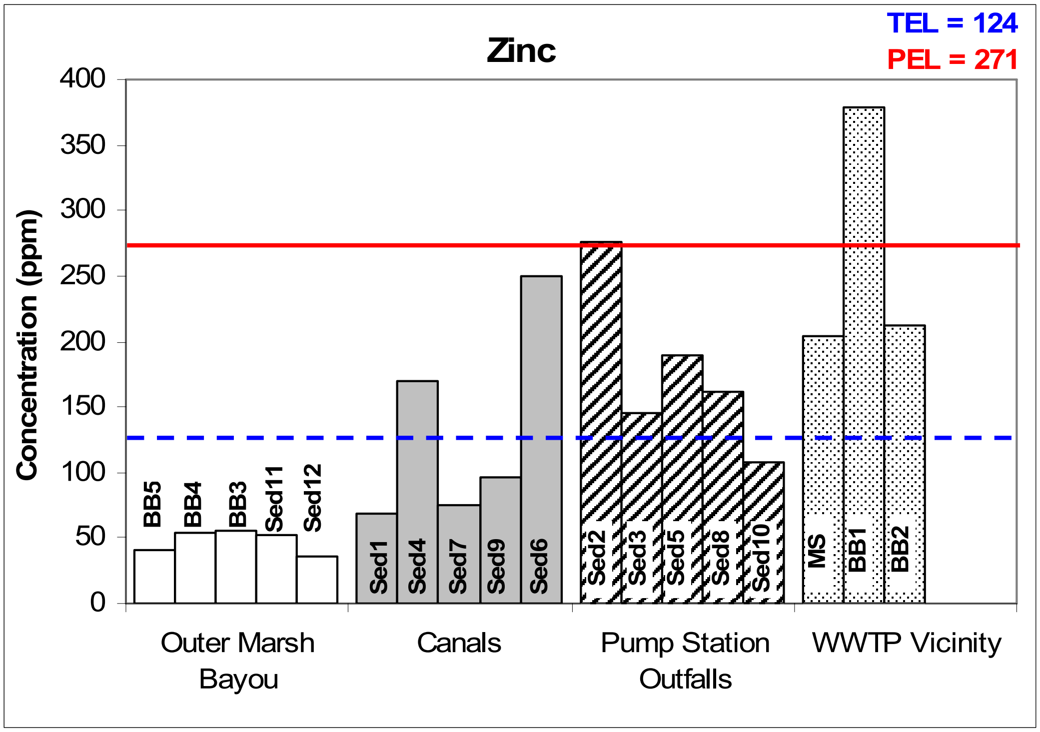

Copper
TEL = 18.7 ppm
PEL = 108.2 ppm
Concentration (ppm)
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

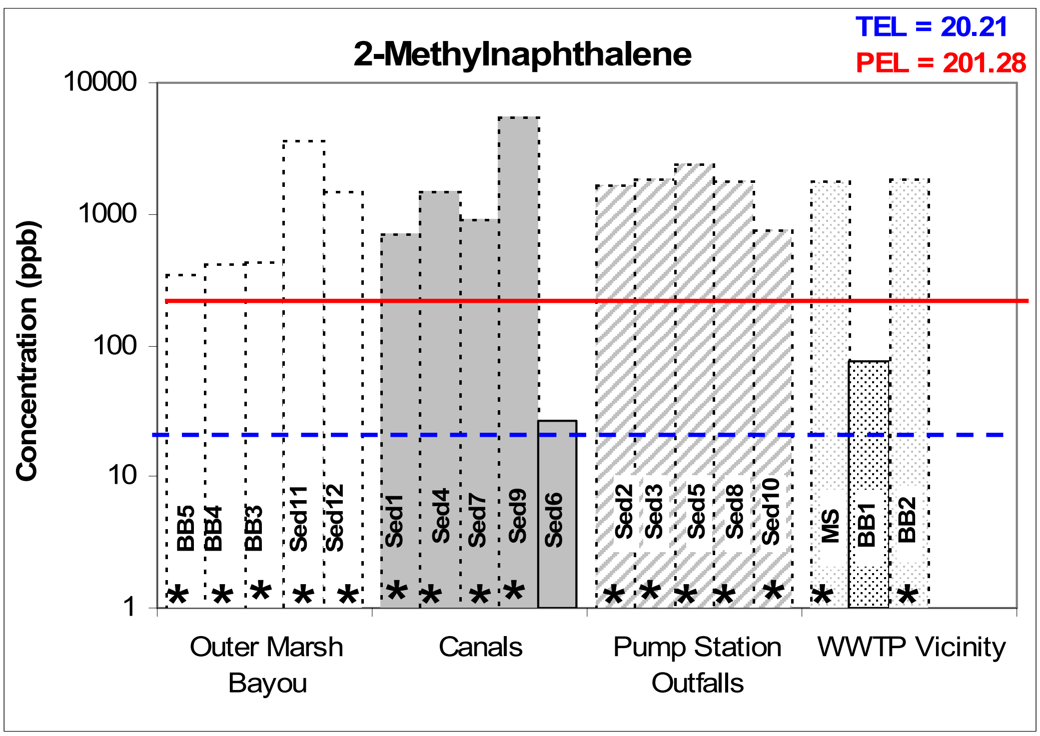

TEL = 30.24
PEL = 112.18
Lead
Concentration (ppm)
300
250
200
150
100
50
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

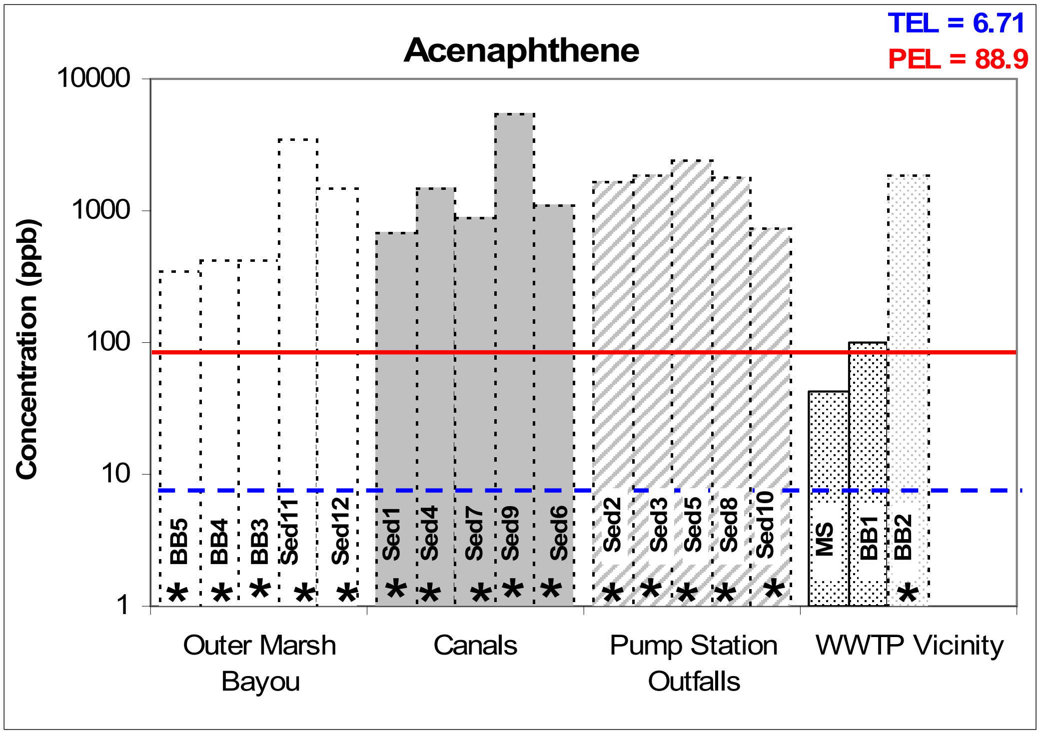

TEL = 0.130
PEL = 0.696
Mercury
Concentration (ppm)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
BB5
BB4
BB3
Sed11
Sed12
*
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

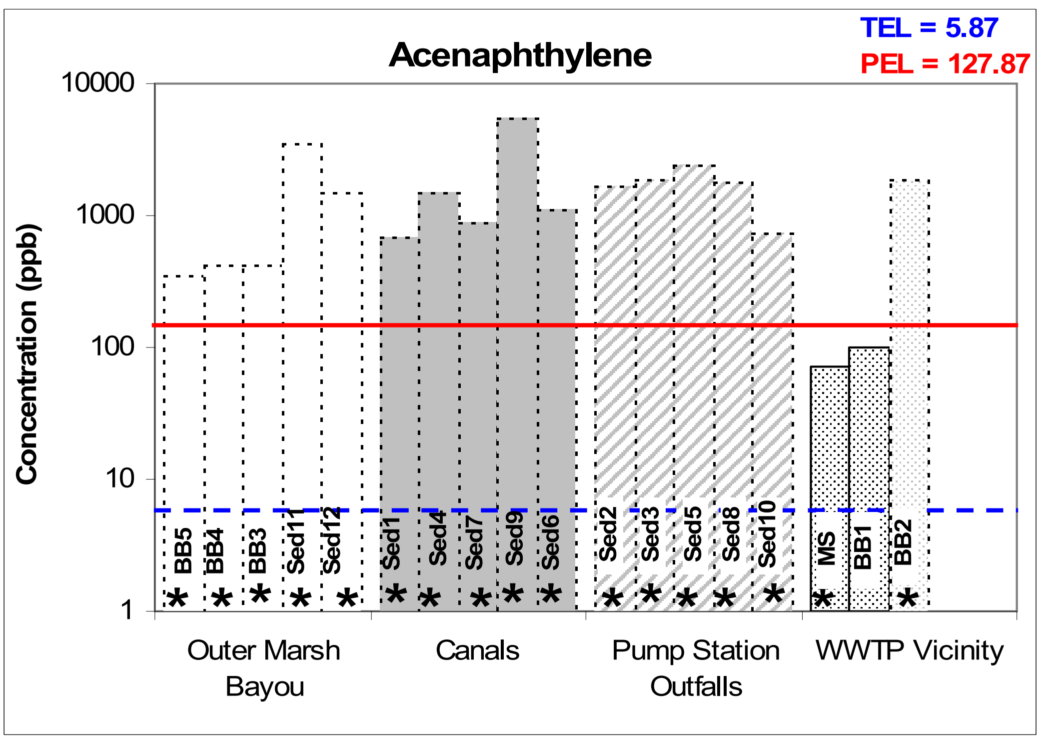

Nickel
TEL = 15.9
PEL = 42.8
Concentration (ppm)
50
45
40
35
30
25
20
15
10
5
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

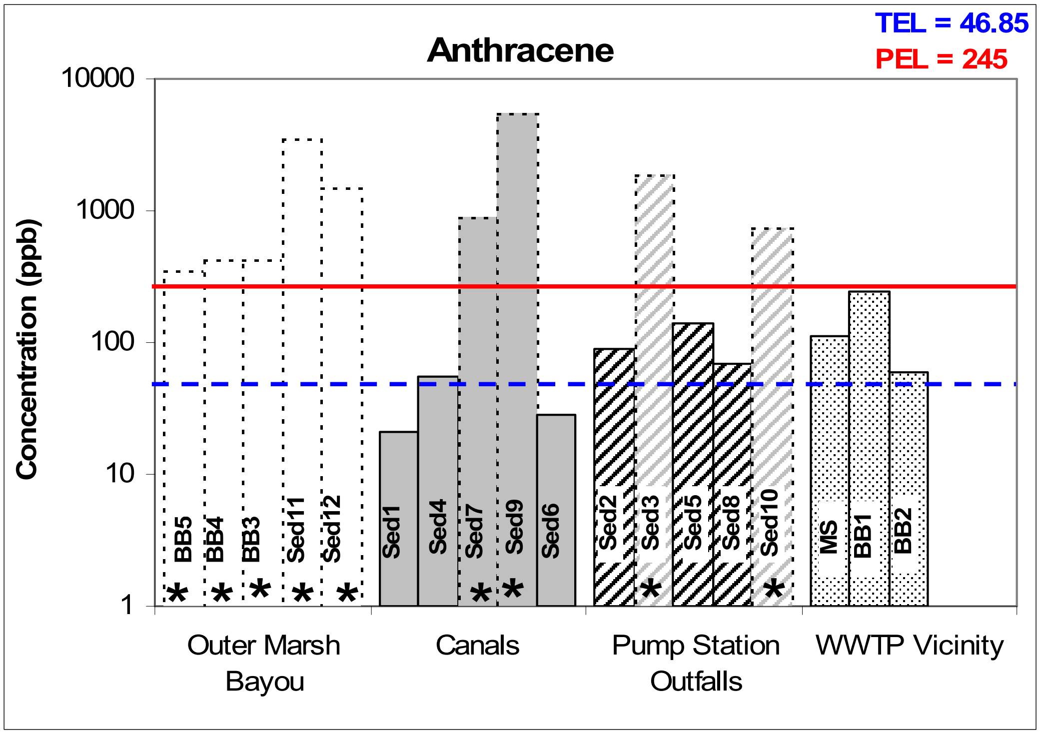

Silver
TEL = 0.73
PEL = 1.77
Concentration (ppm)
2.5
2
1.5
1
0.5
0
BB5
BB4
BB3
Sed11
Sed12
*
*
*
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

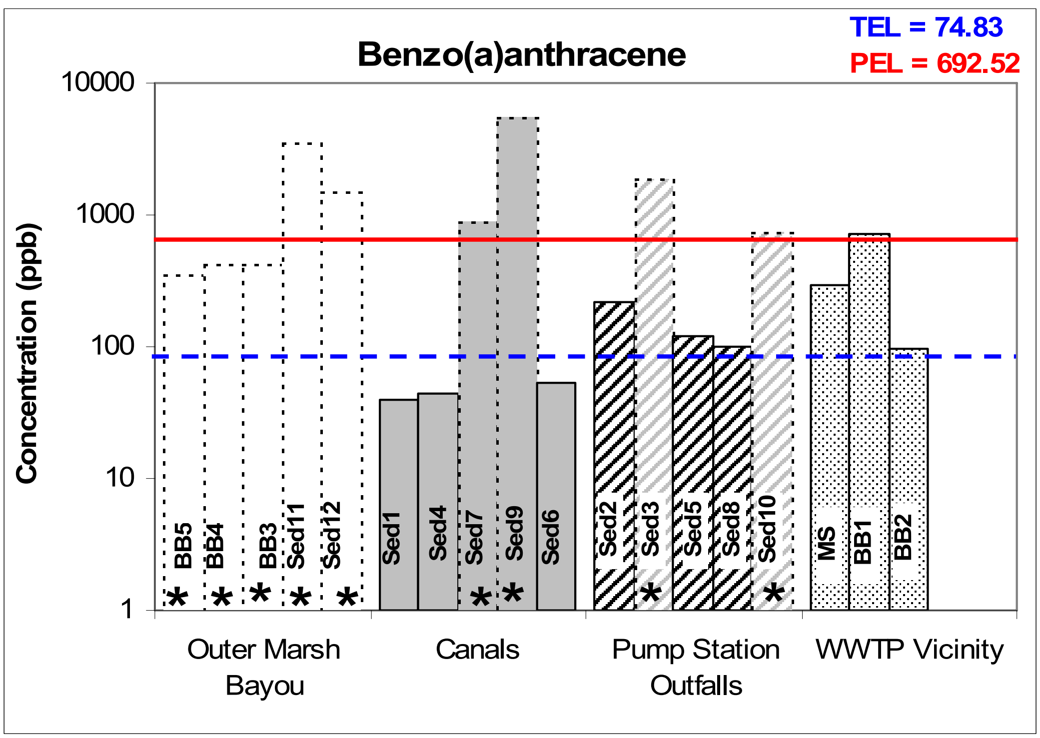

TEL = 124
PEL = 271
Zinc
Concentration (ppm)
400
350
300
250
200
150
100
50
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

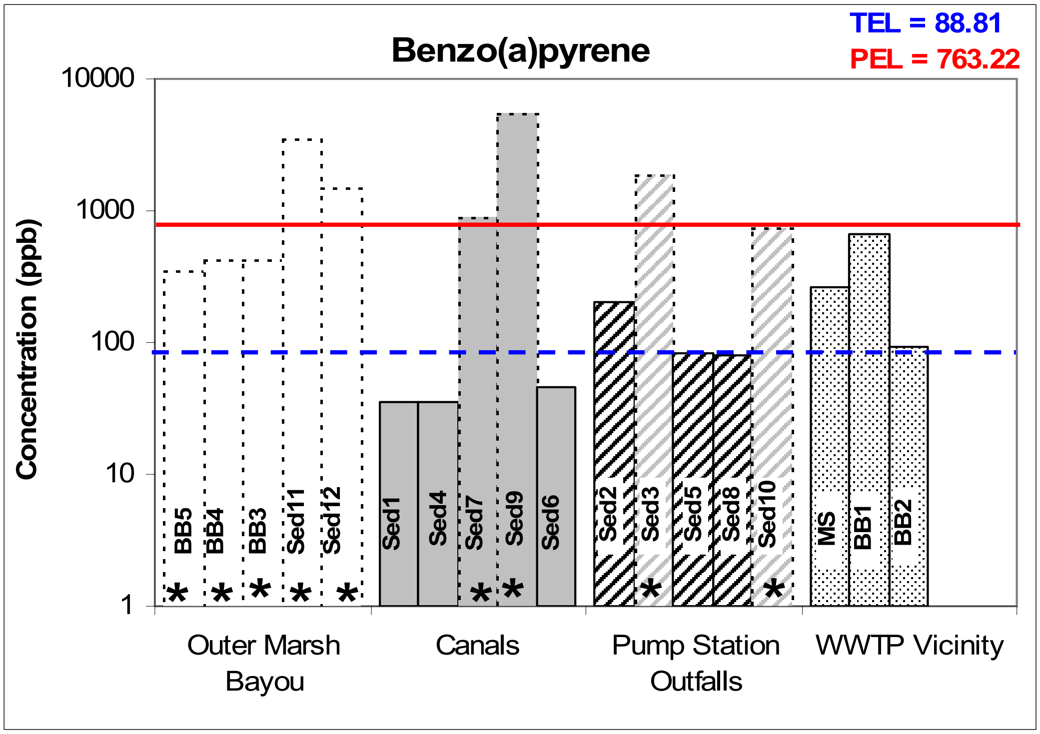

TEL = 20.21
PEL = 201.28
2-Methylnaphthalene
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

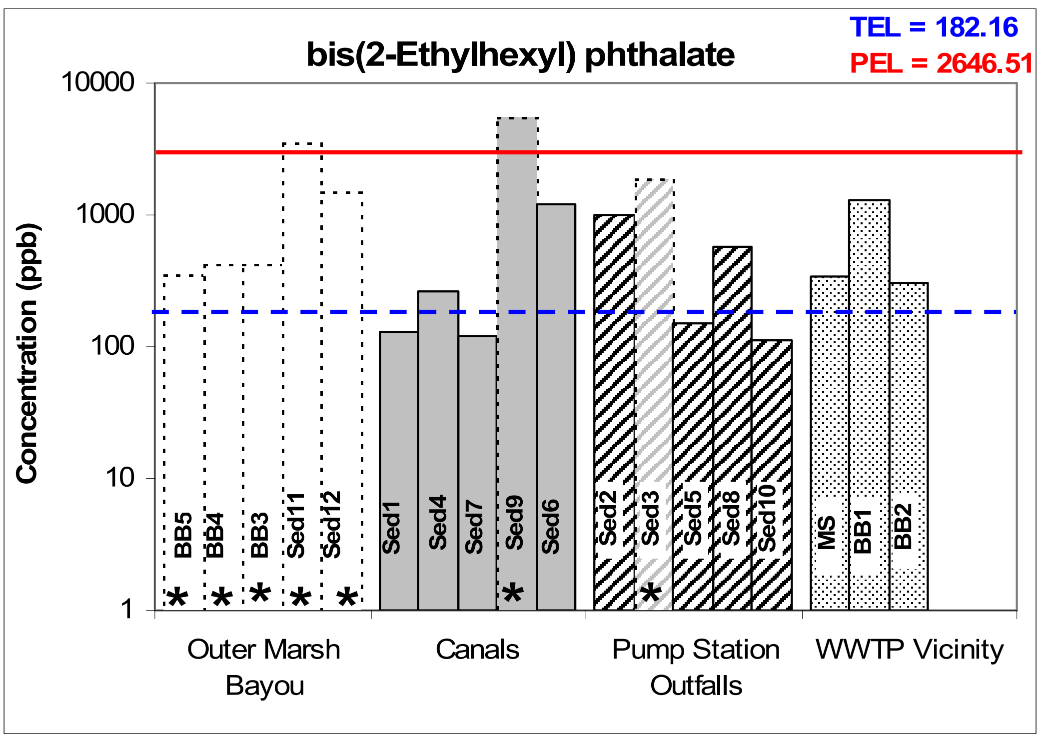

Acenaphthene
TEL = 6.71
PEL = 88.9
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

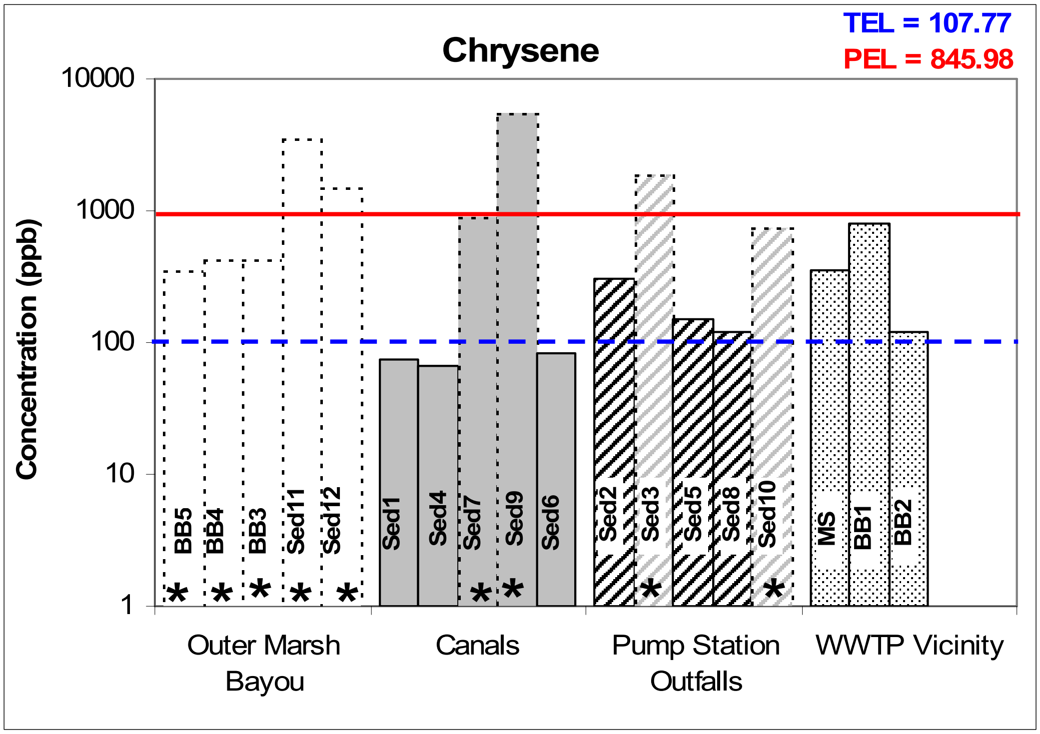

Acenaphthylene
TEL = 5.87
PEL = 127.87
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

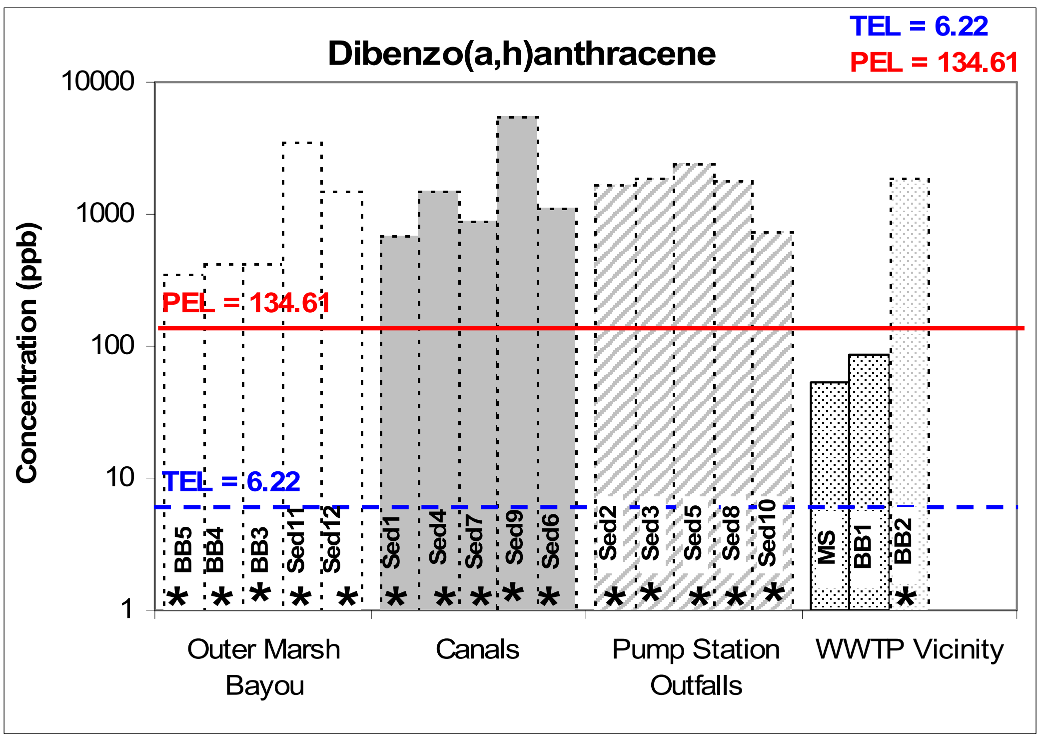

Anthracene
TEL = 46.85
PEL = 245
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity

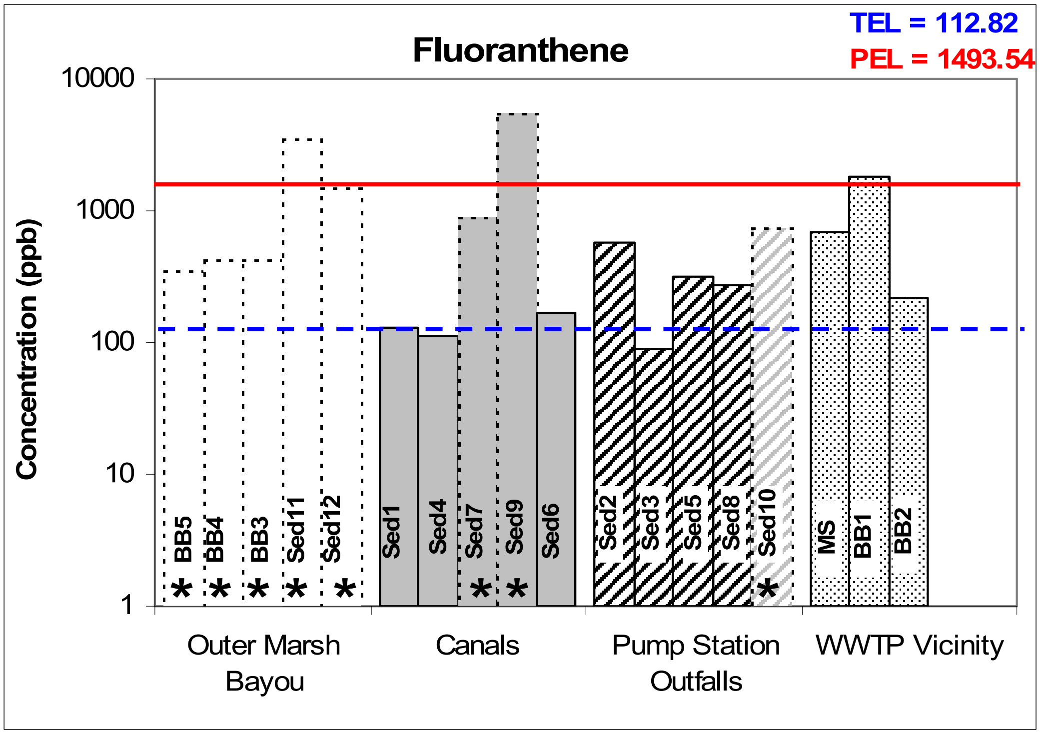

Benzo(a)anthracene
TEL = 74.83
PEL = 692.52
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Benzo(a)pyrene
TEL = 88.81
PEL = 763.22
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


bis(2-Ethylhexyl) phthalate
TEL = 182.16
PEL = 2646.51
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Chrysene
TEL = 107.77
PEL = 845.98
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Dibenzo(a,h)anthracene
TEL = 6.22
PEL = 134.61
Concentration (ppb)
10000
1000
100
10
1
PEL = 134.61
TEL = 6.22
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Fluoranthene
TEL = 112.82
PEL = 1493.54
Concentration (ppb)
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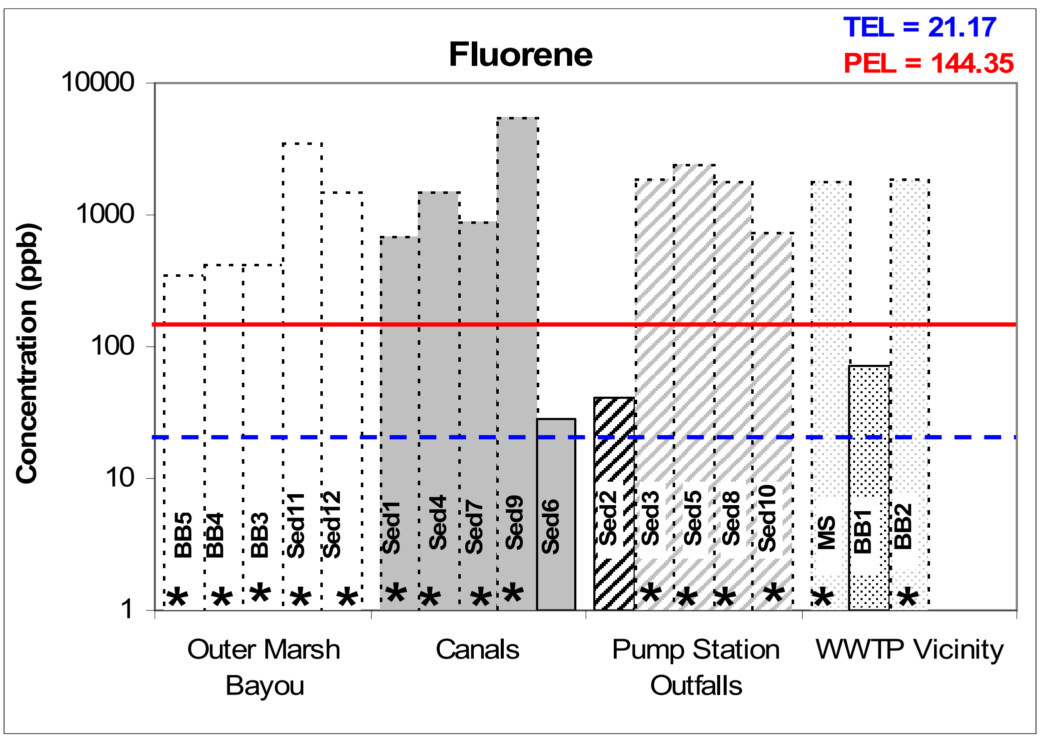
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Fluorene
TEL = 21.17
PEL = 144.35
Concentration (ppb)
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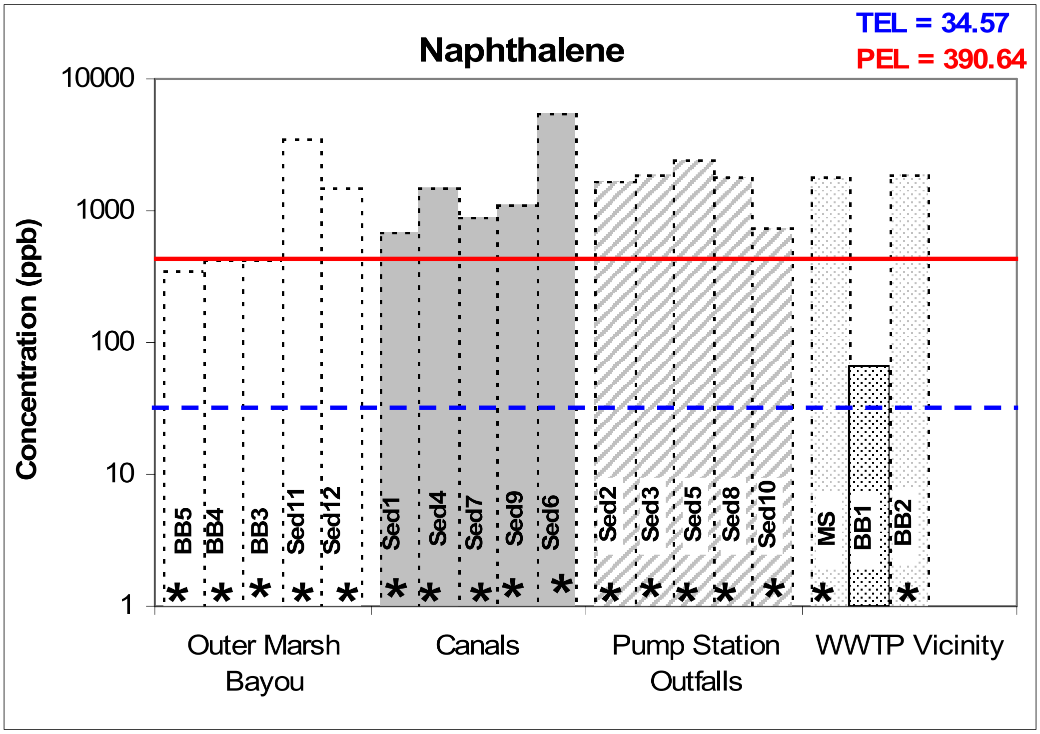
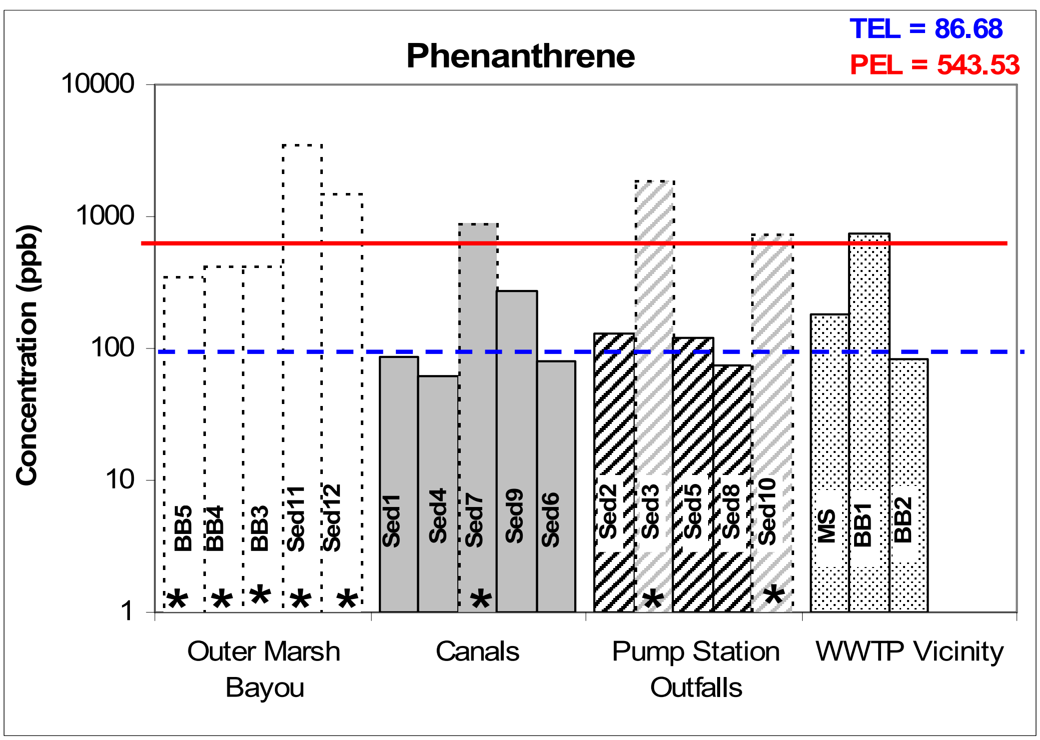
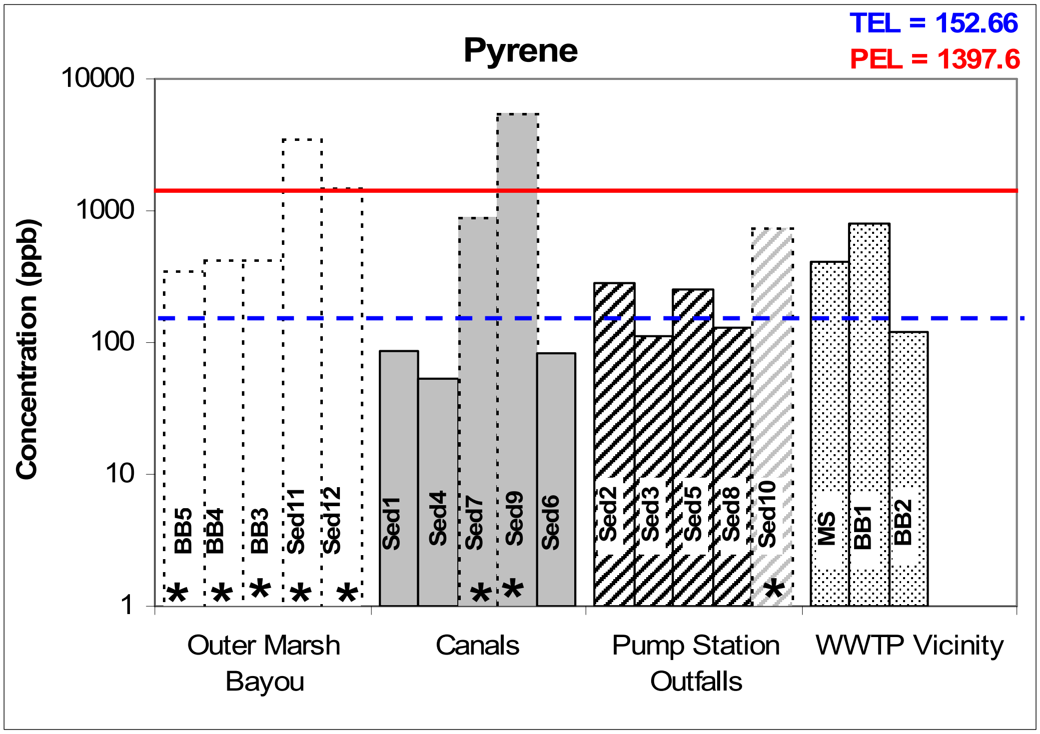
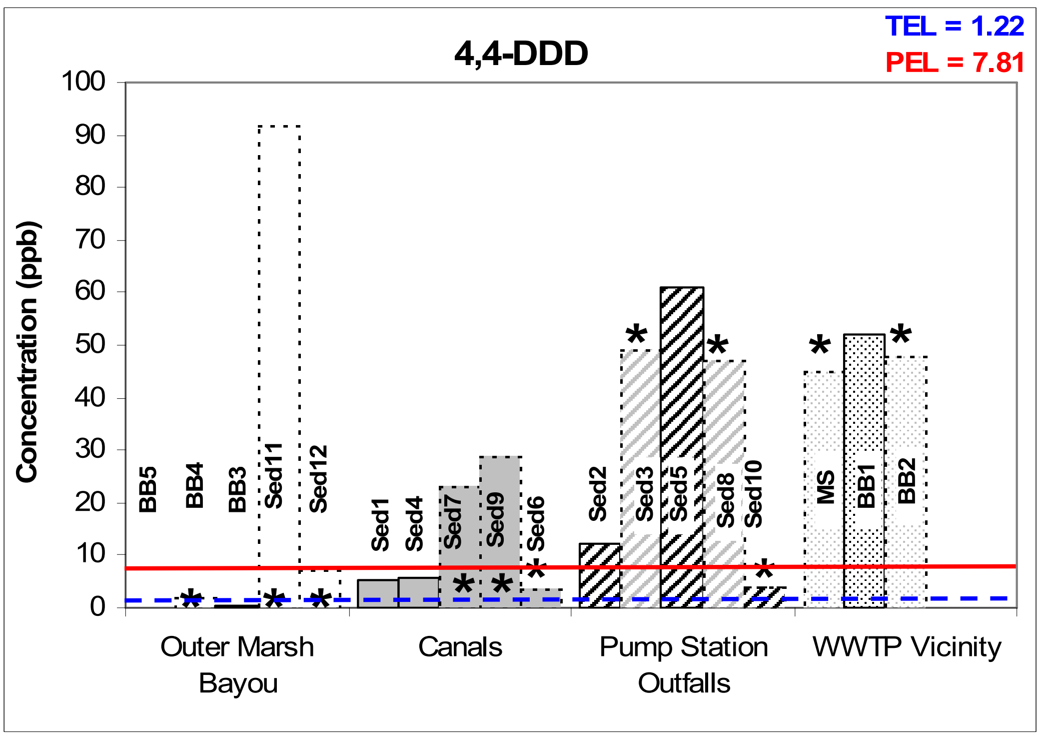
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Naphthalene
TEL = 34.57
PEL = 390.64
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Phenanthrene
TEL = 86.68
PEL = 543.53
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Pyrene
TEL = 152.66
PEL = 1397.6
Concentration (ppb)
10000
1000
100
10
1
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity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PEL = 7.81
Concentration (ppb)
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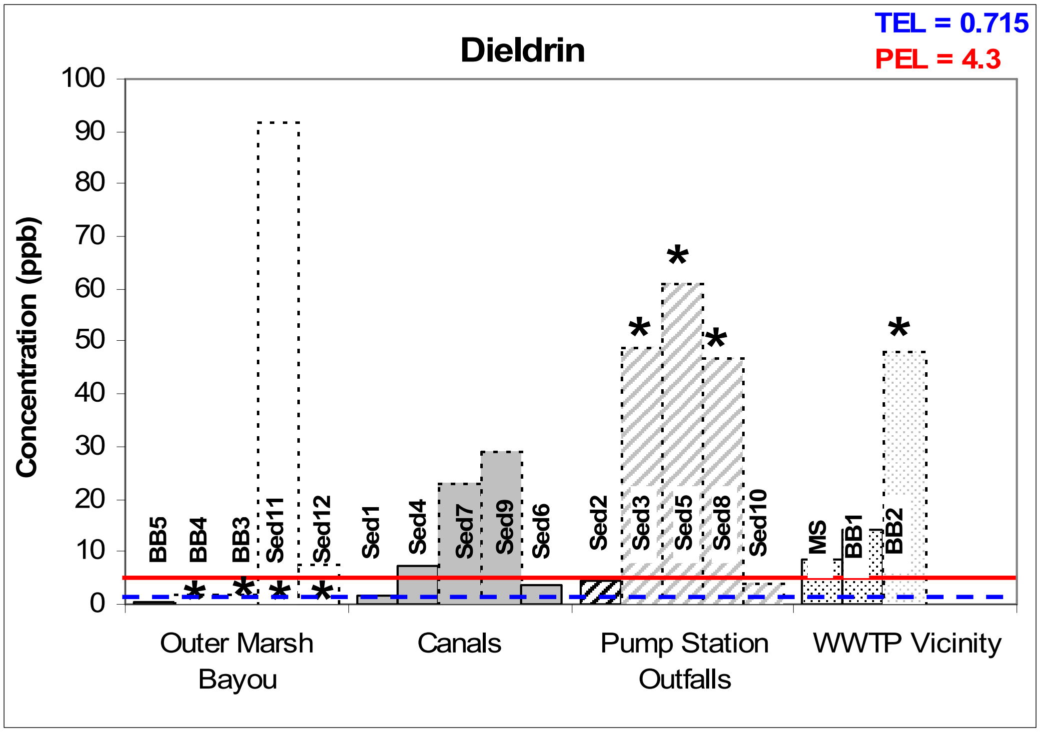
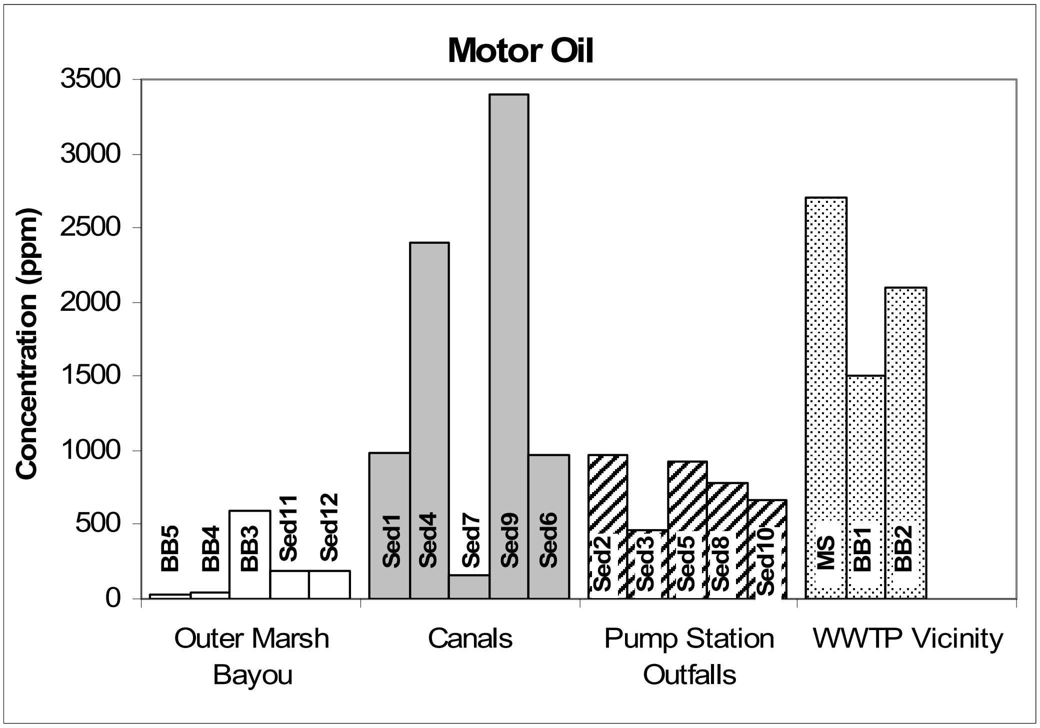
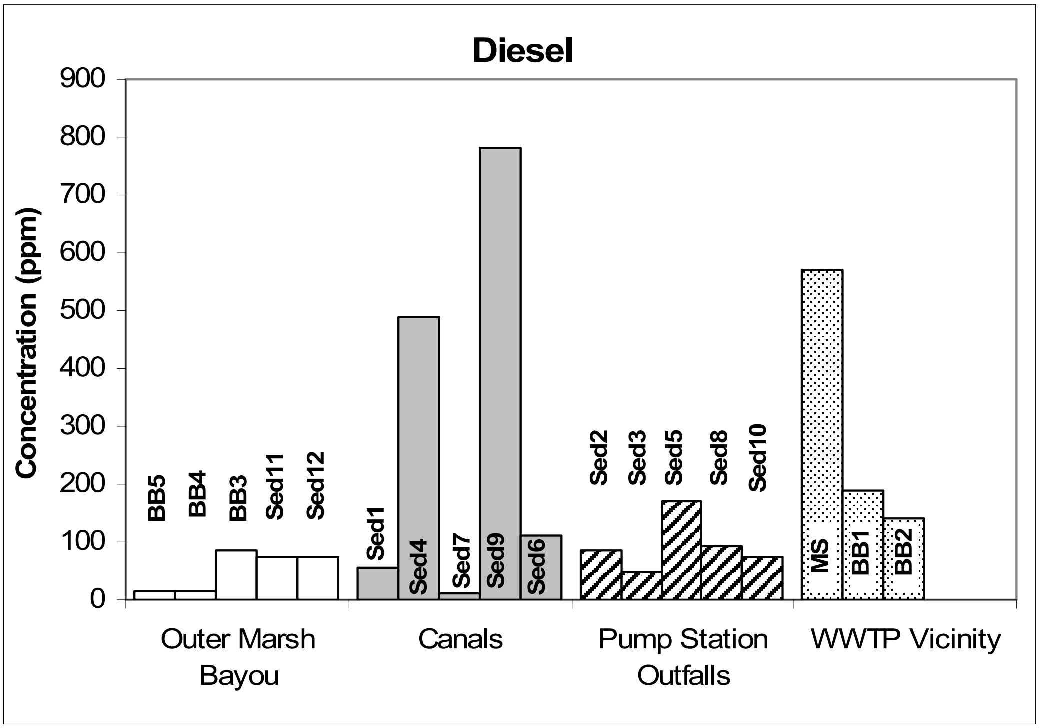
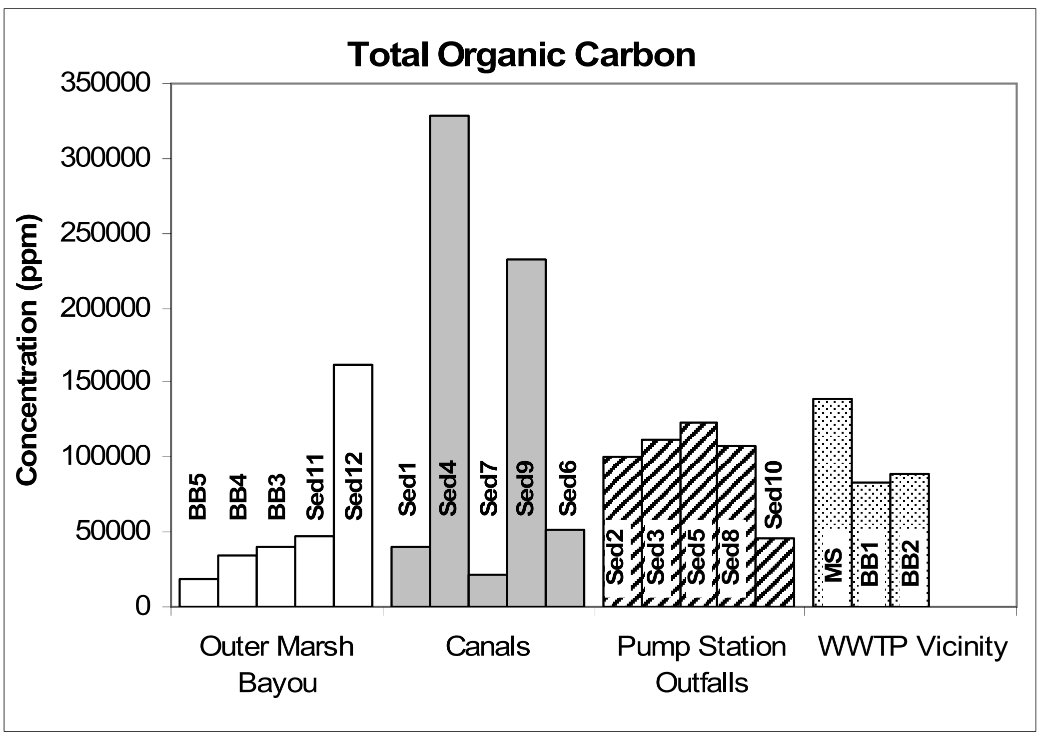
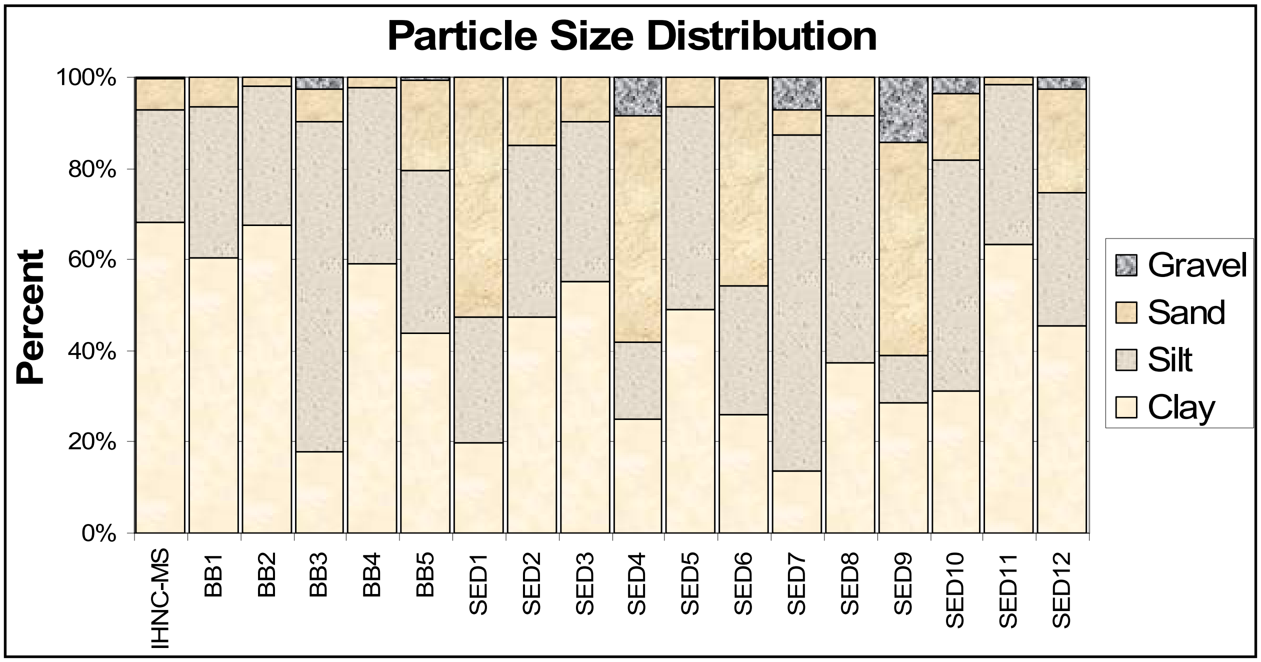
90
80
70
60
50
40
30
20
10
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Dieldrin
TEL = 0.715
PEL = 4.3
Concentration (ppb)
100
90
80
70
60
50
40
30
20
10
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Motor Oil
Concentration (ppm)
3500
3000
2500
2000
1500
1000
500
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Diesel
Concentration (ppm)
900
800
700
600
500
400
300
200
100
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity


Total Organic Carbon
Concentration (ppm)
350000
300000
250000
200000
150000
100000
50000
0
BB5
BB4
BB3
Sed11
Sed12
Sed1
Sed4
Sed7
Sed9
Sed6
Sed2
Sed3
Sed5
Sed8
Sed10
MS
BB1
BB2
Outer Marsh Bayou
Canals
Pump Station Outfalls
WWTP Vicinity



Particle Size Distribution
Percent
100%
80%
60%
40%
20%
0%
IHNC-MS
BB1
BB2
BB3
BB4
BB5
SED1
SED2
SED3
SED4
SED5
SED6
SED7
SED8
SED9
SED10
SED11
SED12
Gravel
Sand
Silt
Clay

Attachment 2
A Pilot Study of the Effects of Post-Hurricane Katrina Floodwater Pumping on the Chemistry and Toxicity of Violet Marsh Sediments (Draft)

Burton C. Suedel, Jeffery A. Steevens and David E. Splichal

PURPOSE: The Interagency Performance Evaluation Taskforce (IPET) is investigating environmental impacts originating from the failure of the hurricane protection system to perform as designed around New Orleans, Louisiana during Hurricane Katrina. The study is needed to determine the extent to which Katrina floodwaters in the New Orleans area may have had impacts to wildlife habitat and other biological resources in surrounding areas. Herein we present preliminary data regarding the effects of pumped floodwaters on sediment chemistry and benthic invertebrate toxicity near pumping stations that pumped floodwaters into marshes near Chalmette and Violet, Louisiana.

BACKGROUND: Hurricane Katrina came ashore along the Alabama, Mississippi, and Louisiana coasts on August 29, 2005, resulting in significant physical damage to infrastructure. As a result of the storm, levees were breached or overtopped, resulting in flooding of New Orleans and surrounding areas, including many areas in St. Bernard Parish. Within St. Bernard Parish, floodwaters in Chalmette and Violet, Louisiana were pumped into the adjacent Violet Marsh. There are potential undesirable environmental impacts on the marsh ecosystem resulting from levee breaches and pumping activities. The primary environmental concerns are elevated salinity and chemical and biological contaminants. To address this concern, we conducted a pilot study after the storm to compare chemistry and toxicity in sediment samples at sites in the immediate vicinity of active and inactive (flooded during Katrina) pumping stations that discharge into Violet Marsh (Figure 1). The pilot study consisted of sampling benthic invertebrates, and recording salinity measurements throughout Violet Marsh, which are addressed in Ray (2006) and Lin and Kleiss (2006), respectively, and collecting sediment samples for chemical and toxicological analysis, which is the subject of the study described herein. This Technical Note describes a pilot study representing an initial effort to discern patterns in chemical contamination and toxicity of sediments at select pumping stations along Violet Marsh and will be used to guide potential future studies in the area.

Figure 2. Aerial view of study area and pump station locations.

STUDY AREA: Sediment samples were collected on 13-14 December 2005, approximately three and a half months after Hurricane Katrina made landfall. Four pumping stations located along the Back Protection Levee along the Forty Arpent Canal in Chalmette, Louisiana were chosen based on pumping activities after Hurricane Katrina (Figure 1). Pump Stations Meraux #4 and Jean Lafitte #6 were fully operational and pumped daily after the storm (Figures 2 and 3) whereas Pump Stations Guichard #2 and Bayou Villere #3 were selected because they were flooded during Katrina and were not operational during this time (Figures 4 and 5). Samples were collected within 50 m of the outfall from each pump station.

METHODS: One sediment sample was collected via aluminum boat or airboat at each pump station in water of approximately one-meter depth using a pole-mounted Ekman dredge (232 cm^3/sample). The top-mounted doors on the sampler were opened and the top 12-15 cm of sediment removed with a pre-cleaned polyethylene spoon. Samples were placed in a pre-cleaned 2-liter polyethylene container and held on wet ice until transport. Samples were transported to laboratory facilities at the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS where the samples were held at 4ºC until analysis.

Figure 2. Pump Station Meraux #4 sampling station (pumped).

Figure 3. Pump Station Jean Lafitte #6 sampling station (pumped).

Figure 4. Pump Station Guichard #2 sampling station (did not pump).

Figure 5. Pump Station Bayou Villere #3 sampling station (did not pump).

Chemistry

Samples were prepared and analyzed for volatile organics, total petroleum hydrocarbons, polycyclic aromatic hydrocarbons, and metals using EPA methods found in SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical* Methods (1986) and updates. Each pump station sample was prepared and analyzed for the following parameters using the referenced methods or a slight modification. Samples were analyzed for volatile organic compounds (benzene, toluene, ethylbenzene, total xylenes and gasoline range organics (GRO)) using methods 5035 (Purge-and-Trap) and 8260B (Gas Chromatography/Mass Spectrometry (GC/MS)). These methods were modified to include the GRO GC/MS fingerprint by analyzing an unleaded gasoline standard. Samples analyzed for semi-volatile organic compounds (including diesel range organics (DRO) and oil range organics (ORO)) were prepared following method 3540C (Soxhlet Extraction) and analyzed using method 8270C (Gas Chromatography/Mass Spectrometry (GC/MS)). These methods were modified to include the DRO and ORO GC/MS fingerprints by analyzing diesel fuel and motor oil standards. Samples analyzed for metals were prepared using method 3050B (Acid Digestion) and quantified using method 6010B (Inductively Coupled Plasma-Atomic Emission Spectrometry). Samples for total organic carbon (TOC) analysis were prepared and quantified following a modification of method 9060A for sediment samples.

Toxicity

Whole sediment acute toxicity tests using the estuarine amphipod, *Leptocheirus plumulosus*, were conducted according to standard guidance (U.S. EPA, 1994). Experimental conditions are outlined in Table 1. Test sediments were stored in the dark at 4 ± 1 °C and used in testing within eight days of collection. Sediments were thoroughly homogenized with a laboratory impeller mixer for five minutes prior to use and approximately 175 mL (2 cm depth) of each test sediment was added to each of five replicate test chambers (1-L beakers). Overlying water, 20 ‰ synthetic seawater (Crystal Sea® Marine Mix; Marine Enterprises International, Inc., Baltimore, MD, U.S.A.), was added and test chambers were allowed to equilibrate overnight. Test chambers were held under ambient light (16 h light: 8 h dark) and supplied trickle-flow aeration in a temperature (25.0 ± 1.0 °C) regulated water bath. At test initiation, *L. plumulosus* (500 – 750 µm) were obtained from ERDC in-house cultures and 20 amphipods were gently transferred randomly into each test chamber. Water quality measurements (temperature, dissolved oxygen, pH and salinity) were determined at test initiation and termination. Environmental chamber temperature (min/max) was monitored and recorded daily. Pore water ammonia was also measured in the bulk sediment using an ISE meter (Thermo Orion Electron Corp., Beverly, MA), equipped with a model 95-12 ammonia sensitive electrode (Thermo Orion Electron Corp., Beverly, MA). Animals were not fed during the test.

Table 1 Leptocheirus plumulosus Test Conditions	
Parameter	
Test duration	10 d
Test type	Static non-renewal
Temperature	20-25°C
Salinity	20°/oo (range 2-32)
Light quality (quantity)	Ambient laboratory (16 h light : 8 h dark)
Test chamber	1 L glass beaker
Sediment depth	2 cm
Age of test organisms	Mature 3-5 mm
Organisms per chamber	20
Replicates per treatment	5
Feeding regime	None
Test aeration	Trickle flow (< 100 bubbles / min)
Test acceptability criterion	$\geq$ 90% survival in controls

The test assessment endpoint was survival. Test sediments were assessed along side of a performance control sediment (Sequim, Washington, USA Lat. 48.0587 Long. -123.0235 and a reference sediment (Lake Pontchartrain, Louisiana, USA; Lat. -89.826389, Long. 30.220556; collected prior to Hurricane Katrina). Both performance control and reference sediments were collected from relatively pristine uncontaminated areas and have undergone rigorous biological and chemical analysis. For tests to be considered valid, at least 90% survival had to be observed in the performance control and overlying water quality (pH, temperature, dissolved oxygen) within the ranges specified by guidance (U.S. EPA, 1994). In order for a test sediment to be considered “toxic,” two criteria must be met; the survival in the test sediment must be statistically reduced compared to the reference sediment and the reduction must be greater than 20% of the reference survival value (U.S. EPA / U.S. ACE, 1998). Data normality (Kolmogorov-Smirnov test), homogeneity (Levene’s Test) and treatment differences (α = 0.05) compared to the reference sediment were determined at using SigmaStat statistical software (SPSS, Chicago, IL). Survival data were arcsine-square root transformed and a simple t-test was used to determine if statistical differences existed between individual test sediments and the reference sediment.

Results

Chemical Analysis

Visual analysis of samples upon collection indicated that all four sediments were composed of primarily fine, unconsolidated material with substantial amounts of decaying vegetative matter. Grain size analysis of sediments confirmed our visual analysis (Table 2). Water quality measurements were taken at the water surface using a YSI Model 85 meter. Salinity at the sampling sites ranged between 11 and 12 ‰ and temperatures ranged from 12°C to 15°C. Dissolved oxygen concentrations at the surface were all at or above 100% saturation. A distinct petroleum odor was detected in sediment and an oily sheen was observed at the water surface during sediment sampling at Pump Station #4.

Table 2
Test sediment grain size analysis

Treatment	Gravel (%)	Sand (%)	Fines (%)
SC (control)	0	6.2	93.8
LP (reference)	NT	NT	NT
PS-2	0	9.3	90.7
PS-3	0	6.5	93.5
PS-4	0	17.9	82.1
PS-6	0	2.3	97.7

NT = Not tested.

Volatile organic compounds and GRO were below detection limits for these compounds, 15 to 40 ug/kg and 250 to 730 ug/kg, respectively. Results from semi-volatile organics analyses show detectable levels of ORO in all samples. Trace levels of DRO were detected in Pump Station #4. Concentrations in the µg/kg range of four to six PAHs were detected in Pump Station #2 and #4 sediments. Bis(2-ethylhexyl)phthalate was detected in all four samples, as well as the method blank. Results from metals analyses show detectable levels, except for antimony and thallium, in all pump station samples. Slightly higher levels of lead were detected in Pump Stations #2 and #6 than in Pump Stations #3 and #4. Results from TOC analyses showed the highest levels in Pump Stations #2 and #6 with lesser values in Pump Stations #3 and #4.

Table 3
Summary Table of Hits at each Pump Station

		Pumping Station #2	Pumping Station #3	Pumping Station #4	Pumping Station #6
		Result	Result	Result	Result
Oil Range Organics		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
ORO	(dry)	1300	1200	830	340 J
	(wet)	160	230	290	46 J
		Result	Result	Result	Result
Diesel Range Organics		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
DRO	(dry)	<790	<530	220 J	<720
	(wet)	<100	<98	78 J	<99
		Result	Result	Result	Result
Semivolatile Organics (BNA)		(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Fluoranthene		1600 J	<5300	500 J	<7200
Pyrene		1300 J	<5300	500 J	<7200
Benzo(a)anthracene		<7900	<5300	300 J	<7200
Chrysene		<7900	<5300	400 J	<7200
Bis(2-ethylhexyl) phthalate		1400 J,B	1700 J,B	1500 J,B	1700 J,B
Benzo(b)fluoranthene		1000 J,I	<5300	600 J,I	<7200
Benzo(k)fluoranthene		I	<5300	I	<7200
Benzo(a)pyrene		<7900	<5300	300 J	<7200
		Result	Result	Result	Result
Metals		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Aluminum		20900	20800	15100	23400
Arsenic		12 B	9.6 B	9.1 B	12 B
Barium		119	120	180	118
Beryllium		0.99	1	1.2	1.1
Cadmium		2.1	1.7	1.7	2.1
Calcium		5080	4400	6150	5410
Chromium		34.2 B	53.2 B	21.4 B	32.1 B
Cobalt		9.2	11	14	10
Copper		59.2	58.7	31	42.9
Iron		26100	26200	20900	25800
Lead		89.7	181	27.2	52
Magnesium		9130	7700	6090	9540
Manganese		409	460	463	741
Nickel		32.2	46.1	32.9	30.5
Potassium		4960	4470	3160	5330
Selenium		2 J	1 J	1 J	2 J
Silver		0.6 J	<1	<1	0.2 J
Sodium		21700	12700	6410	21000
Vanadium		49.8	43.7	36	51.3
Zinc		287	165	139	325
		Result	Result	Result	Result
Total Organic Carbon		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
TOC		100000	58000	35000	94000
J: Estimated concentration above method detection limit but below LRL.					
B: Compound also present in the method blank.					
I: Analytes reported as an isomeric pair due to insufficient baseline resolution.					

Toxicity Analysis

Leptocheirus plumulosus in test vessels were sieved from sediment at the termination of the 10-day exposure period. Test sediment was evaluated for total and unionized ammonia and determined to be suitable for testing without manipulations. Survival of amphipods in the control sediment from Sequim Bay, WA was above the 90% level required for test acceptability. Sediments from Pump Station #4 resulted in significant reductions in amphipod survival as compared to the reference Lake Pontchartrain sediment. Sediment from Pump Stations #2, #3, and #6 did not result in significant toxicity to *L. plumulosus*.

Table 4
Test Sediment Parameters

Sample Treatment	Sediment Moisture Content (%)	Pore Water			
		pH (SU)	Salinity (‰)	Total Ammonia (mg/L)	Unionized Ammonia (mg/L at 25°C)
SC (control)	54.3	7.18	6	17.5	0.15
LP (reference)	21.2	6.97	34	38.6	0.20
PS-2	76.1	7.00	15	19.2	0.11
PS-3	64.9	7.12	12	15.1	0.11
PS-4	35.9	7.28	12	15.1	0.16
PS-6	74.4	7.20	14	9.62	0.09

Table 5
Results from 10-day whole sediment toxicity test using *Leptocheirus plumulosus*. Statistically significant reductions (asterisks) compared to the reference sediment (Lake Pontchartrain, LA) are indicated for each treatment

Treatment	Mean Percent Survival	Coefficient of Variation (%)
Negative Control (Sequim Bay, WA)	90 ± 4	3.9
Reference (Lake Pontchartrain, LA)	95 ± 7	7.4
PS-2	89 ± 4	4.7
PS-3	91 ± 7	7.2
PS-4	76 ± 8 *	10.8
PS-6	97 ± 4	4.6

* Sediment PS-4 was statistically significantly reduced compared to both the control and reference sediments using Dunnett's Method (one-way ANOVA) and a t-test. Guidance recommends using a t-test, comparing each test sediment individually to the reference.

Discussion

Chemical Analysis

Although the results from volatile organics analysis suggested the absence of most volatile compounds and GRO, GC/MS results from Pump Station #4 showed a rise in the chromatogram after the GRO fingerprint (hydrocarbons with carbon number greater than approximately C9) indicating higher molecular weight compounds were present in this sample. This observation is essentially *qualitative* since GRO compounds are not calibrated past C9, but when used in conjunction with the semi-volatile chemical data, confirmed field observations that petroleum contaminants were present.

A low level of DRO (estimated concentration between the laboratory reporting limit and the method detection limit) was detected in sediments from Pump Station #4 but not detected in the other samples. Results show detectable levels of ORO in each sample with Pump Stations #2 and #3 containing the greatest amount. Since three of the four samples had comparable moisture content (Table 1) whereas the moisture content of Pump Station #4 was substantially lower, results for ORO were also calculated on a "wet-weight" basis. Results calculated on the "wet-weight" bases show Pump Station #4 as having the highest concentration of ORO. The detectable levels of the PAHs found in sediments from Pump Stations #2 and #4 also indicated petroleum contamination. Low levels of bis(2-ethylhexyl) phthalate, a plasticizer, were found in field collected sediments and quality control samples. It is likely that these are artifacts of the sampling, preparation, and analysis due to the ubiquitous use of plastics for containers. Results from metals analyses show similar concentrations of metals between the four samples. The results for TOC show the highest levels in Pump Stations #2 and #6 (10.0 and 9.4%, respectively) with lower concentrations in sediments from Pump Stations #3 and #4 (5.8 and 3.5%, respectively).

Toxicity Analysis

Toxicity and analytical chemistry results can be used together to determine the potential impact of chemical contaminants in the floodwaters on benthic organisms in Violet Marsh. While the effects assessed using benthic toxicity tests and sediment chemistry are not predictive of all ecological impacts on a wetland, they can be used as sentinel indicators of adverse effects. Analytical chemistry results indicated elevated levels of petroleum-based organics (e.g., motor oil, diesel fuel, and polycyclic aromatic hydrocarbons) and some metals (e.g., lead). Coupled with toxicity results these data indicate the potential for adverse effects through direct toxicity to benthic organisms and potential adverse impacts from bioaccumulation of organics and metals into the food-chain, especially in sediments in the vicinity of Pump Station #4.

Conclusions

The results of the current pilot study indicate a potential for adverse effects of chemicals present in Violet Marsh on benthic organisms. Further studies will be required to describe the potential for these effects with more certitude. As part of these studies, an assessment of marsh sediments receiving discharge from dewatering activities and assessment of bioaccumulation potential of chemical contaminants in these sediments should be completed.

POINTS OF CONTACT: For additional information contact Dr. Burton C. Suedel (601-634-4578, Burton.Suedel@erdc.usace.army.mil). This technical note should be cited as follows:

> Suedel, B.C., J.A. Steevens and D.E. Splichal. (2006). "A Pilot Study of the Effects of Post-Hurricane Katrina Floodwater Pumping on the Chemistry and Toxicity of Violet Marsh Sediments." Environmental Lab Technical Notes (ERDC/TN EL-06-XX). U.S. Army Engineer Research and Development Center, Vicksburg, MS. ***http://el.erdc.usace.army.mil/*** .

REFERENCES:

Lin, J.P. and Kleiss, B.A. (2006). Salinity Measurements and General Condition of Violet Marsh, Post Hurricane Katrina. EL Technical Notes Collection, *Environmental Lab Technical Note* (ERDC TN-06-??). U.S. Army Engineer Research and Development Center, Vicksburg, MS. ***http://el.erdc.usace.army.mil/*** .

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Appendix Table. Summary of Non-Detected Analytes in Violet Marsh Sediments

		Pump Station #2	Pump Station #3	Pump Station #4	Pump Station #6
Volatile Organics		Result (ug/kg)	Result (ug/kg)	Result (ug/kg)	Result (ug/kg)
Benzene		<40	<25	<15	<30
Toluene		<40	<25	<15	<30
Ethylbenzene		<40	<25	<15	<30
Xylenes		<40	<25	<15	<30
Gasoline Range Organics		Result (ug/kg)	Result (ug/kg)	Result (ug/kg)	Result (ug/kg)
GRO		<730	<470	<250	<620
Oil Range Organics		Result (mg/kg)	Result (mg/kg)	Result (mg/kg)	Result (mg/kg)
ORO	(dry)	1300	1200	830	340 J
	(wet)	160	230	290	46 J
Diesel Range Organics		Result (mg/kg)	Result (mg/kg)	Result (mg/kg)	Result (mg/kg)
DRO	(dry)	<790	<530	220 J	<720
	(wet)	<100	<98	78 J	<99

	Pump Station #2	Pump Station #3	Pump Station #4	Pump Station #6
Semivolatile Organics (BNA)	Result (ug/kg)	Result (ug/kg)	Result (ug/kg)	Result (ug/kg)
Phenol	<7900	<5300	<2800	<7200
Bis(2-chloroethyl) ether	<7900	<5300	<2800	<7200
2-Chlorophenol	<7900	<5300	<2800	<7200
1,3-Dichlorobenzene	<7900	<5300	<2800	<7200
1,4-Dichlorobenzene	<7900	<5300	<2800	<7200
1,2-Dichlorobenzene	<7900	<5300	<2800	<7200
Benzyl alcohol	<79000	<53000	28000	<72000
2-Methylphenol	<7900	<5300	<2800	<7200
2,2'-Oxybis(1-chloropropane)	<7900	<5300	<2800	<7200
N-Nitrosodi-n-propylamine	<7900	<5300	<2800	<7200
Hexachloroethane	<7900	<5300	<2800	<7200
4-Methylphenol	<7900	<5300	<2800	<7200
Nitrobenzene	<7900	<5300	<2800	<7200
Isophorone	<7900	<5300	<2800	<7200
2-Nitrophenol	<16000	<11000	<5600	<14000
2,4-Dimethylphenol	<16000	<11000	<5600	<14000
Bis(2-chloroethoxy)methane	<7900	<5300	<2800	<7200
2,4-Dichlorophenol	<7900	<5300	<2800	<7200

Semivolatile Organics (BNA)	Pump Station #2 Result (ug/kg)	Pump Station #3 Result (ug/kg)	Pump Station #4 Result (ug/kg)	Pump Station #6 Result (ug/kg)
Benzoic acid	<79000	<53000	<28000	<72000
1,2,4-Trichlorobenzene	<7900	<5300	<2800	<7200
Naphthalene	<7900	<5300	<2800	<7200
4-Chloroaniline	<16000	<11000	<5600	<14000
Hexachlorobutadiene	<7900	<5300	<2800	<7200
4-Chloro-3-methylphenol	<16000	<11000	5600	<14000
2-Methylnaphthalene	<7900	<5300	<2800	<7200
Hexachlorocyclopentadiene	<32000	<21000	<11000	<29000
2,4,6-Trichlorophenol	<7900	<5300	<2800	<7200
2,4,5-Trichlorophenol	<7900	<5300	<2800	<7200
2-Chloronaphthalene	<7900	<5300	<2800	<7200
2-Nitroaniline	<79000	<53000	<28000	<72000
Acenaphthylene	<7900	<5300	<2800	<7200
Dimethyl phthalate	<7900	<5300	<2800	<7200
2,6-Dinitrotoluene	<7900	<5300	<2800	<7200
3-Nitroaniline	<79000	<53000	<28000	<72000
Acenaphthene	<7900	<5300	<2800	<7200
2,4-Dinitrophenol	<79000	<53000	<28000	<72000
Dibenzofuran	<7900	<5300	<2800	<7200
4-Nitrophenol	<79000	<53000	<28000	<72000
2,4-Dinitrotoluene	<7900	<5300	<2800	<7200
Fluorene	<7900	<5300	<2800	<7200
Diethyl phthalate	<7900	<5300	<2800	<7200
4-Chorophenyl phenyl ether	<7900	<5300	<2800	<7200
4-Nitroaniline	<79000	<53000	<28000	<72000
4,6-Dinitro-2-methylphenol	<79000	<53000	<28000	<72000
N-Nitrosodiphenylamine	<7900	<5300	<2800	<7200
Hexachlorobenzene	<7900	<5300	<2800	<7200
4-Bromophenyl phenyl ether	<7900	<5300	<2800	<7200
Pentachlorophenol	<79000	<53000	<28000	<72000
Phenanthrene	<7900	<5300	<2800	<7200
Anthracene	<7900	<5300	<2800	<7200
Di-n-butyl phthalate	<7900	<5300	<2800	<7200
Fluoranthene	1600 J	<5300	500 J	<7200
Pyrene	1300 J	<5300	500 J	<7200
Butyl benzyl phthalate	<7900	<5300	<2800	<7200
Benzo(a)anthracene	<7900	<5300	300 J	<7200
3,3'-Dichlorobenzidine	<32000	<21000	<11000	<29000
Chrysene	<7900	<5300	400 J	<7200
Bis(2-ethylhexyl) phthalate	1400 J,B	1700 J,B	1500 J,B	1700 J,B
Di-n-octyl phthalate	<7900	<5300	<2800	<7200
Benzo(b)fluoranthene	1000 J,I	<5300	600 J,I	<7200
Benzo(k)fluoranthene	I	<5300	I	<7200
Benzo(a)pyrene	<7900	<5300	300 J	<7200
Indeno(1,2,3-cd)pyrene	<7900	<5300	<2800	<7200
Dibenzo(a,h)anthracene	<7900	<5300	<2800	<7200
Benzo(g,h,i)perylene	<7900	<5300	<2800	<7200

Metals	Pump Station #2 Result (mg/kg)	Pump Station #3 Result (mg/kg)	Pump Station #4 Result (mg/kg)	Pump Station #6 Result (mg/kg)
Aluminum	20900	20800	15100	23400
Antimony	<4	<4	<4	<4
Arsenic	12 B	9.6 B	9.1 B	12 B
Barium	119	120	180	118
Beryllium	0.99	1	1.2	1.1
Cadmium	2.1	1.7	1.7	2.1
Calcium	5080	4400	6150	5410
Chromium	34.2 B	53.2 B	21.4 B	32.1 B
Cobalt	9.2	11	14	10
Copper	59.2	58.7	31	42.9
Iron	26100	26200	20900	25800
Lead	89.7	181	27.2	52
Magnesium	9130	7700	6090	9540
Manganese	409	460	463	741
Nickel	32.2	46.1	32.9	30.5
Potassium	4960	4470	3160	5330
Selenium	2 J	1 J	1 J	2 J
Silver	0.6 J	<1	<1	0.2 J
Sodium	21700	12700	6410	21000
Thallium	<6	<6	<6	<6
Vanadium	49.8	43.7	36	51.3
Zinc	287	165	139	325

Total Organic Carbon	Result (mg/kg)	Result (mg/kg)	Result (mg/kg)	Result (mg/kg)
TOC	100000	58000	35000	94000

J: Estimated concentration above method detection limit but below LRL.

B: Compound also present in the method blank.

I: Analytes reported as an isomeric pair due to insufficient baseline resolution.

Appendix 5C
Microbiological Analysis

Environmental Consequences of the Failure of the New Orleans Levee System During Hurricane Katrina, Microbiological Analysis

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Executive Summary

Multiple failures of the levee system protection for the City of New Orleans in the aftermath of Hurricane Katrina August 2005 led to the flooding of the metropolitan area. The flood waters and sediments contained some dissolved and entrained chemical and microbial contaminants. Subsequent pumping of flood water from the city to the adjacent environment and the ongoing removal of sediment and sediment-coated debris are potential mechanisms to distribute these contaminants to the local environment. For this report we focused on the analysis of several specific contaminants that, due to the frequency and levels that they were reported to be present in the flooded city and their ability to cause environmental harm, provided the opportunity to evaluate the environmental distribution of contaminants that resulted from the failure of the New Orleans levee systems.

Data on the recalcitrant hydrocarbon benzo[a]pyrene (BaP) and indicators of potentially infectious sewage waste were gathered and analyzed. We first determined the levels of these contaminants in three different drainage areas (polders) in the flooded city and the trends in changes in their levels as the city was pumped out. The reduced data were provided to the U.S. Army Engineer Research and Development Center (ERDC) environmental modeling group for use as source terms in their corresponding analyses of the distributions and potential impacts

of these contaminants of the environment surrounding New Orleans. This environmental modeling information is presented in a separate report in this volume (Dortch et al., 2006). Further analyses of the chemical contaminants were presented in a separate chemical analyses report in this volume (Bednar et al., 2006). In this report we also present data on these contaminants produced from our own sampling and analysis of the Violet Marsh outside the levee from the Lower Ninth Ward of New Orleans and from the Chalmette area of St. Bernard parish, and discuss potential environmental impacts.

Due to the strategy used to pump out the flooded city and the hydraulic flows resulting from this operation and the levee systems, the flooded city of New Orleans was divided into three separate drainage areas or polders: New Orleans proper, New Orleans East, and St. Bernard Parish and the Lower Ninth Ward. The unified Katrina database of the U.S. Environmental Protection Agency (EPA) and the Louisiana Department of Environmental Quality (LADEQ) database was used to determine the levels of fecal coliforms and BaP in the waters and sediments in each of theses three polders, and changes in their levels as the city was pumped dry. Water fecal coliform counts (colony forming units (cfu) per 100 mL of water) ranged from 100 to 490,000 (mean=21,381, standard deviation=74,541, median=2,200) in New Orleans proper, 10 to 30,000 (mean=3,308, SD=8,093, median=200) in New Orleans East, and 17 to 25,000 (mean=1,287, SD=4,381, median= 100) in St. Bernard Parish and the Lower Ninth Ward polders. The LADEQ primary contact recreational water quality criterion for fecal coliforms is 400 cfu/100 mL. The flood water in all three polders frequently exceeded this standard, and no trend (increasing or decreasing cfu/100 mL) was evident with time as the water was pumped out.

Health advisories were issued during the flood and effects were seen. Of the 10,047 New Orleans patient visits during and immediately after the flooding for which information was available to the Center for Disease Control and Prevention the most common were due to gastrointestinal, acute respiratory and skin infections. Our analysis of the EPA/LADEQ database showed BaP levels in water (µg/L) were all non-detect except one data point at 0.42 µg/L in New Orleans proper. BaP is a hydrophobic organic contaminant that would tend to sorb to sediment particles and settle from the water standing in the city. The EPA Region 6 water quality criterion MCL for BaP is 0.20 which was exceeded by the 1 sample. As a result of our analyses of the EPA/DEQ data we provided the medians and protective 95% upper confidence level values of 70,000, 33,000 and 1,700 cfu/100 mL to the environmental modelers to be used as source term load values for water pumped from New Orleans proper, New Orleans East, and St. Bernard Parish and the Lower Ninth Ward polders, respectively, and non-detects for the medians and 95% upper confidence levels of BaP in each polder.

In order to assess the potential impacts of pumping contaminated water and sediment from the city on local ecosystems the ERDC collected sediment core samples from Violet Marsh, analyzed them for markers of infectious waste and BaP, and attempted to identify sources of these contaminants in the Lower Ninth Ward and the Chalmette area. Undisturbed sediment cores were collected from ditches draining the Murphy Oil Corporation property in Chalmette and the outfall of the New Orleans metropolitan sewage treatment plant over the levee from the Lower Ninth Ward to profile these two potential contaminant sources. Core samples were collected from both the immediate influent and immediate effluent of the pumps that could have transported contaminants from these two sources into Violet Marsh. Sediment core samples were also collected at various distances from these pumps out into Violet Marsh to determine the range of transport of these contaminants into the Marsh. Contaminants in sediments in the top of the cores were used to indicate the most recently deposited contaminants. Sediments in the bottom of the cores were used to indicate contaminants deposited before the failure of the levees.

BaP levels (µg/gm dry weight) in sediments taken from the bottoms of the sediment cores ranged from non-detectable to 11.8 (mean=1.5, SD=3.6, median=0.0). Nine of the 18 sediments from the bottom of the cores exceed the EPA sediment quality criterion (0.062 µg/gdw), and 6 of these 18 exceeded the LADEQ criterion (0.33). BaP levels in top sediments ranged from non-detect to 31.2 (mean=2.8, SD=7.1, median=1.1). The most recently deposited sediment exceed the EPA criterion in 16 of the 18 sediment samples and the DEQ criterion in 14 of the 18 sediment samples. Violet Marsh apparently has had a history of BaP contamination that could have been made worse by the failure of the levees. This BaP contamination appeared to have entered Violet Marsh through Bayou Bienvenue and not through the pumps (e.g., pump #6) that would have removed water contaminated from the Murphy Oil spill.

The potential for the presence of infectious waste was indicated using two different approaches, viable indicator bacteria (total coliform, fecal coliform and fecal streptococci) and fecal sterols. Fecal streptococci exceed the detection limits in only one surface sediment sample (Murphy Oil). All the Bayou Bienvenue surface sediment samples were below the detection levels for all viable bacterial indicators measured. Total coliform and fecal coliform measurements indicated a current input of potentially infectious waste from Chalmette into Violet Marsh. None of the 5 surface sediment samples from Bayou Bienvenue exceeded the 40 CFR 503 Biosolids criterion of 1,000 cfu fecal coliform/gdw. All 12 of the remaining surface sediment samples from the Violet Marsh and Chalmette exceeded this 1,000 cfu fecal coliform criterion.

Fecal sterols provided an alternative means of assessing the impacts of infectious waste derived from fecal material. Coprostanol is formed from cholesterol in the human gut track and is the most abundant sterol (40-60%) in human feces (averaging 3,430 µg/gdw). Environmental scientists have suggested environmental quality criteria ranging from 0.1 – 1.0 nmole coprostanol/gdw. The sedimentary coprostanol levels measured in this study were comparable to those of other sewage impacted wetlands. The coprostanol levels in sediments from the bottom of the cores ranged from non-detect to 61.2 nmol/gdw (mean= 16.9, SD= 23.1, median= 8.0). Fifteen of the 18 sediment samples from the bottom of the cores were greater that the most lenient criterion suggested as 1.0 nmol/dgw. Historically, the Bayou Bienvenue (sewage treatment plant) has been the major contributor of fecal material to the Marsh with the Chalmette pump stations playing a lesser role. The coprostanol levels in sediments from the tops of the cores ranged from 3.0 to 61.3 nmol/gdw (mean= 20.2, SD= 14.4, median= 20.7). All 18 sediment samples from the top of the cores were greater than that of the suggested criterion of 1.0 nmol/gdw. The coprostanol levels in the upper sediment indicated that the operating pumps may have recently contributed relatively more fecal material to the Marsh.

The work presented here starts to provide an objective framework and first impression of some of the most obvious environmental consequences of the failure of the levee system around New Orleans and the subsequent pump out operations. Although the levels of fecal coliform bacteria were frequently high above the regulatory concern level for recreational, these levels are expected abate with distance and time. However, fecal coliform bacteria are not a good predictor of human disease in estuarine water, and we are only beginning to understand the environmental parts of the life cycles of microbial pathogens of humans. The absence of environmental impacts shown from the fecal coliform bacteria data should not be interpreted as an absence of environmental impact. Using our own data we show that Violet Marsh has had a history of fecal and BaP contamination, much presumably coming primarily from the sewage treatment plant that drains into Bayou Bienvenue. The flooding of New Orleans and the subsequent pump out resulted in higher levels of fecal material and BaP in the surface sediments of the Marsh and a wider distribution of these contaminants throughout the Marsh. While the data supported these general conclusions, time and financial constraints required us to make major assumptions, precluded sufficient replicate analyses and minimized the number of Violet Marsh locations sampled and the number of different analyzes performed on each sample. Inclusion of analyses of recalcitrant hydrophobic compounds in addition to BaP would enable more accurate sediment source tracking. Additional analyses are required to remove the uncertainty due to assumptions we made and the minimal statistical design of our Violet Marsh survey, and to better quantify these impacts.

Introduction

IPET Relevance - During the period when New Orleans was flooded and during the period when the flood waters were being pumped out the U.S. Environmental Protection Agency (EPA) and the Louisiana Department of Environmental Quality (LADEQ) collected hundreds of samples of water and sediment and analyzed these samples for a long list of potential contaminants. The flooded area under consideration is the urbanized area on the east side of the Mississippi River, seen north of the River in Figure 1.

Figure 1. Map showing the New Orleans area

Of all the water quality parameters measured only a few stood out as a cause for concern for people coming into contact with water and sediment in the city, or to areas receiving the water as it was pumped out of the city. Elevated levels of bacterial indicators of pathogens derived from sewage were well above the concern levels in many areas of the city, which resulted in special warnings from the EPA and posted on EPA's Katrina website. Petroleum hydrocarbons were also frequently detected. Benzo[a]pyrene (BaP) is a particularly mutagenic polycyclic hydrocarbon (PAH) that was frequently detected in these samples. A major oil spill occurred at the Murphy Oil Corporation in Chalmette when a storage tank slid from its foundation during the flood.

To address our charge of determining the environmental effects of the failure of the New Orleans levee system we focused on several indicators of infectious waste derived from sewage, and BaP. These contaminants were chosen because 1) they were frequently detected above regulatory concern levels in flooded New Orleans; 2) some of these analytes were targeted by EPA and LADEQ in their water and sediment analyses so the data coverage with respect to space (inner regions, near regions and far regions) and time (pre-Katrina and after Katrina) were some of the best available; 3) some of the analytes retain fingerprint type identifying information on sources and processes; and 4) they are contaminants that affect both human and environmental health.

Scope and structure of report - The microbiology portion of the IPET Task 9 Consequences Assessment was included in the Section 3.4 Environmental Subtask. Indicators of changes and levels of selected pathogens and other contaminants in sediment were identified.

Existing data were consolidated. Suggested values and statistics were provided to environmental modelers, and corroborative data was collected to help determine the potential for impacts indicated by microbiological considerations in the environmental consequences of levee failure.

The most urbanized portions of the metropolitan area of New Orleans are protected within the innermost of a complex system of levees. As indicated in Figure 2, the levees radiating from the turning basin in the Inner Harbor Navigation Canal (IHNC) provided a consistent basis to consider the urbanized portions divided into three main polders. This inner ecosystem has historically high levels of urban soil contamination, including metals and PAHs (Mielke et al. 2004). New Orleans proper is considered to be that portion of Orleans Parish west of the IHNC, while New Orleans East is the urbanized area of Orleans Parish east of the IHNC and north of the Intracoastal Waterway leading to the Mississippi River Gulf Outlet (MRGO). The urbanized areas east of the IHNC and south of the Intracoastal Waterway are primarily the Lower Ninth Ward of Orleans Parish and the Chalmette area of St. Bernard Parish. Many of the normal pumps that operate to drain the New Orleans area failed due to the effects of Katrina and the aftermath. The normal operating pumps and the emergency pumps that pumped out flooded New Orleans proper and New Orleans East drain into Lake Pontchartrain. This nearby ecosystem was impacted as discussed in the environmental modeling report in this volume (Dortch et al., 2006).

Figure 2. Map illustrating the drainage areas

Only Pump Stations #3 and #6 operated in the aftermath to drain the flood from the Lower Ninth Ward and Chalmette polder, pumping over the levee into the marsh beyond. Bayou Bienvenue winds through the marsh from the north near the municipal sewage treatment plant. The marshy area east of the levee and west of the MRGO is often accessed primarily by the Violet canal to the south, and is referred to uniformly as the Violet Marsh in this report. This nearby ecosystem was impacted as discussed in the environmental modeling report in this volume (Dortch et al., 2006).

Several further outlying areas, including the Mississippi Sound and the Mississippi River Delta, are likely to have environmental impacts from the levee failures that are more dilute than the nearby ecosystems. These more remote ecosystems are not modeled in this report, and samples were not collected from the remote areas.

Conditions to be considered by task - The Task 9 Consequences Assessment Team envisioned three conditions to comparatively assess: The pre-Katrina conditions, the actual Katrina conditions with levee failure, and the hypothetical Katrina conditions without levee failure. However, this subtask only has data to analyze from pre-Katrina conditions and actual

Katrina conditions. Modeling may predict some of the hypothetical conditions without levee failure.

Regarding the pre-Katrina conditions the soil of the inner ecosystems has been well studied, particularly in a series of studies by Prof. Howard Mielke of Tulane University. The surface waters in the inner ecosystems have been less reported, although the measured concentrations in the Katrina storm water pump-out were reported to be similar to normal rainfall pump-out (Pardue et al., 2005). The Lake Pontchartrain Basin Foundation provided historical water quality data to be used for validating the environmental modeling that established pre-Katrina conditions in Lake Pontchartrain. There was a lack of corresponding published data from Violet Marsh. The sediment data collected for this report was intended to provide a partial remedy for that void. The topmost portion of the collected sediment cores was expected to be the most recently deposited. Sediments in the bottom of the cores were used to indicate levels of contaminants that may have been historically deposited before the failure of the levees. However, to this point the collection and analyses of these sediments have been limited by constraints in funding and reporting time. The data interpretations in this report serve mainly to develop hypotheses which, when warranted, should be tested with more detailed studies using appropriate experimental and statistical designs.

Bacterial indicators of infectious wastes - Prior to 1986 EPA recommended the use of fecal coliform as a water quality indicator to help protect prevent bathers from contracting gastr-ointestinal illness from recreational waters. These bacteria often did not cause illness directly, but demonstrated characteristics that made them useful as indicators of the presence of microorganisms that did cause these illnesses. In 1986 EPA published “Ambient Water Quality Criteria for Bacteria” where they revised their recommendations of indicator bacteria. In this document EPA recommended the use of *Escherichia coil* as an indicator in fresh water and enterococci for both fresh and marine recreational waters. These revisions were based on epidemiological studies conducted by EPA which evaluated the use of several indicator microorganisms. Accidental ingestion of recreational water was the most prevalent exposure pathway. The most common bacterial infections contracted in this way included cholera, salmonellosis, shigellosis, and gastroenteritis. Common viral infections included infectious hepatitis, gastroenteritis, and intestinal disease caused by enterovirus. Protozoan infections included cryptosporidiosis, amoebic dysentery, and giardiasis.

Many federal state, local and tribal organizations were slow to adopt EPA’s 1986 guidance so EPA published an “Implementation Guidance for Ambient Water Quality Criteria for Bacteria” in 2002 (Draft) (EPA 2002) to assist these organizations in implementing the 1986 recommendations. The amendment to the Clean Water Act known as the Beaches Environment Assessment and Coastal Health (BEACH) Act required coastal and Great Lake states to have adopted EPA recommended water quality criteria by April 2004. The National Academy of Science’s National Research Council (NRC 2004) recommended that the current use of indicator microorganisms be supplemented with the use of a tool box of microbiological, molecular biology and analytical chemistry techniques to better enable the protection of public health as mandated by the Clean Water Act and the Safe Drinking Water Act. Regulatory criteria are expected to transition from earlier indicator-based measurement to more direct and defensible criteria. This shift is reflected in the EPA document “Standardized Analytical Methods for use

During Homeland Security Events" (EPA 2004) where microbial indicators are used in the early stages (Triage and Screening) of a response, and methods that can provide more quantitative information with respect to microbial risk assessment (ILSI, 2000) are to be used in the Determination stage of the response.

Use of fecal sterols as indicators - In many circumstances microbial indicators are not suitable for determining fecal pollution. The use of fecal coliform as indicators in tropical waters was shown to be particularly problematic because some indicators may grow in such waters (Isobe et al., 2004). Studies of runoff from New Orleans into Lake Pontchartrain have shown that many indicator bacteria are associated with particles in the water column and quickly settle to the sediment where resuspension of the shallow waters serves as a secondary source (Jin et al., 2004). Logistical constraints are imposed by the fact that samples can not be stored for long periods of time before culture and analysis. Live bacterial indicators do not persist over long periods of time in the environment so it is not possible to reconstruct historic records of previous impact using this approach. Because many animals produce fecal bacterial markers in addition to humans and contribute them to the environment, it can be difficult to distinguish different sources of environmental fecal contamination using these markers.

Biochemical markers such as fecal sterols offer important advantages in selected applications. The average human excretes 0.2 – 1.0 g coprostanol per day (Walker et al., 1982). Coprostanol comprises 4-60% of excreted fecal sterols and averages 3.43 mg/gram dry weight of feces (Nichols et al., 1996). Coprostanol is produced from the hydrogenation of cholesterol by bacteria in the digestive system (Eneroth et al., 1964; Murtaugh and Bunch, 1967). In aerobic water columns coprostanol is microbially degraded and half-lives of <10 days at 20^{o} C have been reported (Ogura, 1983). However, coprostanol like other fecal sterols is hydrophobic and associated with particulate matter in sewage and water columns (Takada et al., 1994). Coprostanol is readily incorporated into bottom sediments, where it has been shown to persist under anaerobic conditions without significant degradation for over 450 days at 15^{o} C (Nishimura and Koyama, 1983). Coprostanol can serve as a useful biochemical marker for determining current and long term inputs of fecal matter to aquatic systems (Arscott et al., 2004). Based on surveys of rivers in the United States and Canada, environmental scientists have recommended three different environmental quality criteria for coprostanol; 40 ppb (1.0 nmol/gdw; Kirchmer, 1971), 20 ppb (0.52 nmol/gdw; Murtaugh and Bunch, 1967), and 0.5 ppb (0.13 nmol/gdw; Dutka et al., 1974).

The same GC/MS analysis used to determine levels of coprostanol can produce data on other fecal sterols and non-fecal sterols. The resulting sterol profile can provide additional useful information on the nature of the fecal pollution (Leeming et al., 1996). Ratios of coprostanol to cholesterol that are greater than one have been used as an indicator of fecal contamination in aquatic systems. Figure 3 illustrates the formation processes and transformations of several fecal sterols. The formation of epicoprostanol is favored in sewage treatment plants and the ratio of epicoprostanol to coprostanol has been suggested for use as an indicator of input of treated sewage relative to untreated sewage. Although coprostanol is directly formed in the human gut by the bacterial reduction of cholesterol, it can also be formed under environmental conditions in a multi-step process where cholestenone is an intermediate. The $5\beta/(5\beta+5\alpha)$ cholestan-3-one ratio has been recommended for use in highly productive aquatic systems with relatively low levels of coprostanol (Grimalt et al., 1990).

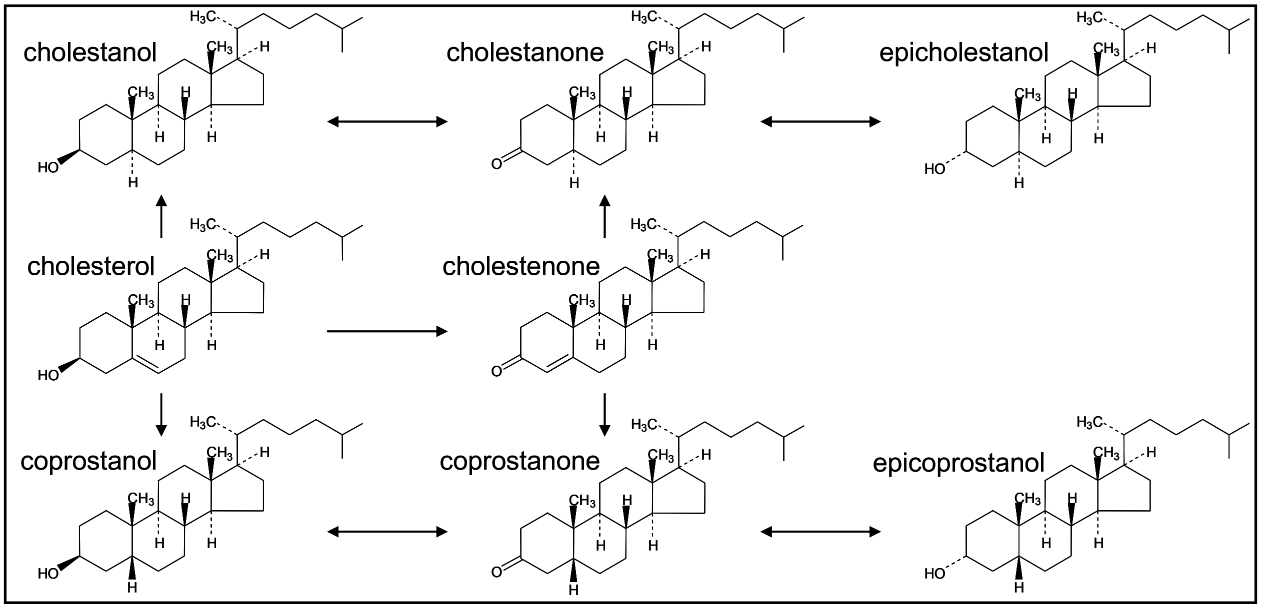

Figure 3. Structures and transformation pathways of some fecal sterols

Benzo[a]pyrene as hydrocarbon tracer - BaP is one of the 16 EPA designated priority pollutant polycyclic aromatic hydrocarbons (PAH; EPA Method 8310). It is a 5-ring PAH with a molecular weight of 252 u. and, due to transformation products formed during liver metabolism, it is the most carcinogenic known of the 16 (Irwin et al., 1997). Depending on the relative levels, much of the regulatory concern from total PAH contamination often devolves upon the BaP. Usually the other PAHs are assigned BaP equivalency factors for the purposes of toxicity assessments. There over 100 PAHs commonly found in environmental samples. These PAHs are all hydrophobic and recalcitrant, with heavier PAHs being more hydrophobic and recalcitrant.

Many other hydrocarbons are found along with PAHs. Usually the most common petroleum hydrocarbons are gasoline range alkanes with 6 to 12 carbons, diesel range alkanes with 12 - 28 carbons, and lubrication oil range with 28 - 36 carbons. Many of the lower molecular weight alkanes are volatile, and most are amenable to microbial degradation in various environmental media. Thus, recalcitrant hydrocarbons such as PAHs can serve as longer term indicators of petroleum hydrocarbons, or more generally, industrial activity.

BaP occurs with several other 5-ring PAHs with a molecular weight of 252. Figure 4 shows a portion of the raw GC/MS data, selected ion 252, from a Violet Marsh sediment sample with a relatively low BaP value of 0.76 µg/gdw. Of the six 5-ring PAHs with molecular weight 252 shown, BaP is the fifth one, near retention time 33.1 minutes. These PAHs all have simple mass spectra with strong molecular weight base peaks.

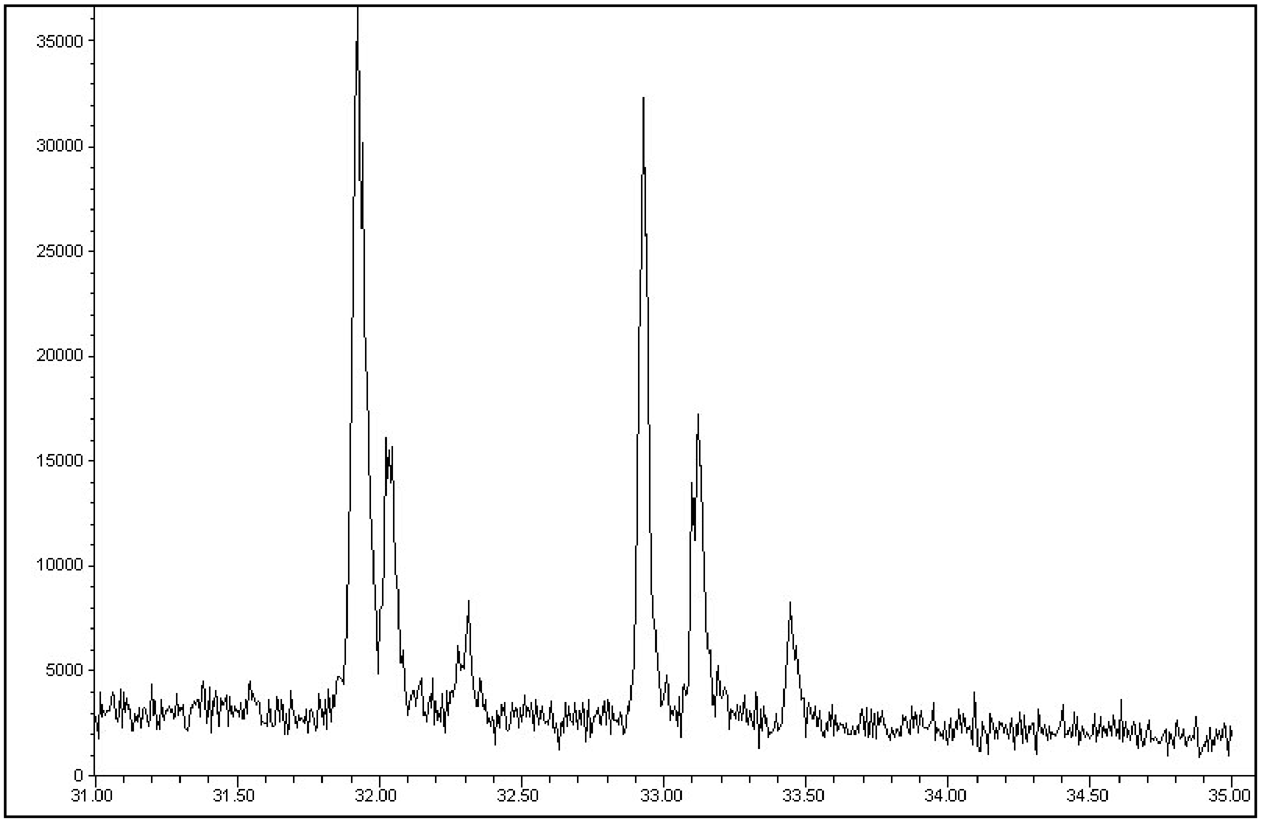

Figure 4. Selected ion (m/z=252) chromatogram of Violet Marsh sediment extract.

The proper aromatic Simplified Molecular Input Line Entry System (SMILES) description of the linked BaP molecule is c1\cc2\cc/cc3ccc4cc5ccccc5c1c4c23. The BaP structure is shown in Figure 5. The environmental recalcitrance and the lack of daughter ions in the mass spectra are due to the visibly highly aromatic structure.

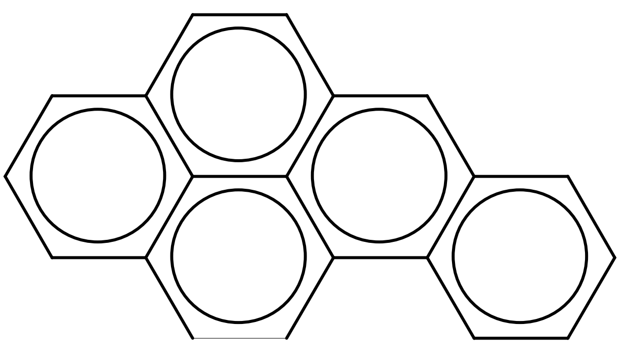

Figure 5. Aromatic structure of benzo[a]pyrene

Like all PAHs, BaP is seldom of concern for acute exposure. The chronic effects of long term exposure to metabolic products are the toxicological problem. Specifically, the cytochrome P450 system produces the ultimate carcinogen (+)-7R,8S-dihydroxy-9S,10R-epoxy-7,8,9,10-tetrahydro-benzo[a]pyrene (Chang et al. 2006). This product intercalates with DNA and causes errors in transcription (Kang et al. 2005).

Due to the hydrophobicity of BaP (log $K_{OW} > 6$), very little is ever present in water. The EPA Region 6 water quality criterion MCL for BaP is 0.20 µg/L. BaP preferentially binds to the organic carbon in solids such as sediments. The EPA Region 6 residential soil screening level for BaP is 62 µg/kg. The applicable LADEQ criterion is 0.33 µg/g.

BaP New Orleans data - Mielke et al. 2001 found that pre-Katrina levels of BaP in New Orleans city soil ranged from 52 to 6102 µg/kg, and found in agreement with other studies that PAHs in runoff sediments were higher than in the soils. In this context the flooded city of New Orleans acted as a BaP source to the local environment as the water was pumped out of the city.

Because the levees failed in multiple areas, all three polders were deeply flooded at about the same time with brackish storm surge water, Lake Pontchartrain water, and Mississippi River water. The depth of flooding can be envisioned from the U.S. Army Corps of Engineers map from the New Orleans District Figure 6 and was up to 20 feet in isolated spots. The flood water remained for weeks. The three polders behind their levees, after they were patched, became three separate contaminant sources for nearby ecosystems. New Orleans proper and New Orleans East were pumped into Lake Pontchartrain, and the Lower Ninth Ward and Chalmette area were pumped into Violet Marsh. Some of the sediment was entrained and pumped out with the water, and more was flushed out with other runoff.

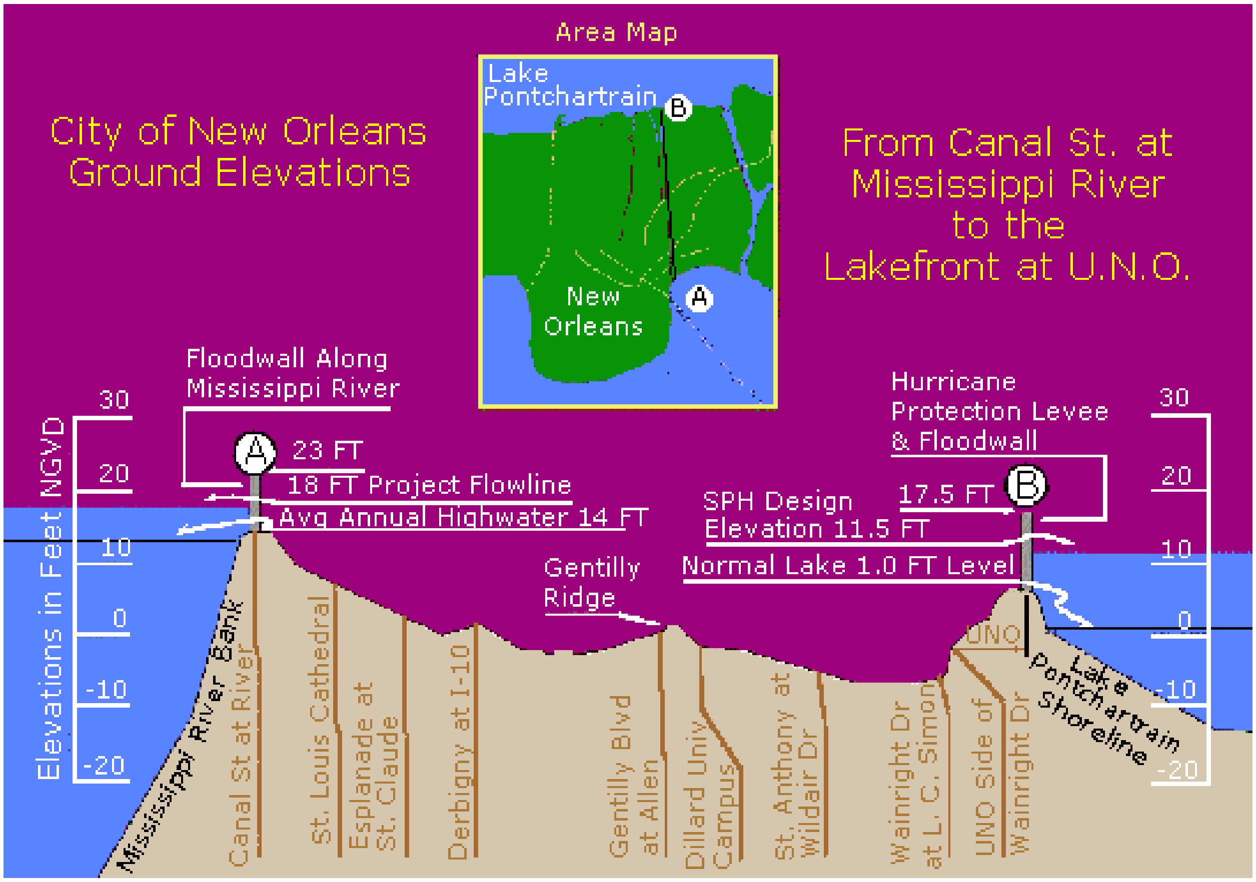

Figure 6. Cross section of New Orleans proper showing elevations

It is thought the storm surge up the Mississippi River Gulf Outlet (MRGO) and the elevated Lake levels provided the hydrological force for most of the levee breaches. The subsided New Orleans area quickly flooded. Many of the details of the flooding and flows have been modeled in Corps of Engineers reports.

Some of the major sources of contamination in New Orleans proper included the contaminated urban soil and structures (Mielke et al. 2004). The flooded New Orleans East area is heavily industrialized. In Chalmette at least one entire oil storage tank at the Murphy Oil Corporation site was breached and completely failed, and the entire site was flooded. Near the Lower Ninth Ward, over the levee by Bayou Bienvenue, the main New Orleans area sewage treatment plant was flooded, damaged, and inoperable for weeks. The Corps of Engineers began to pump out the flood water, and the final flood water was declared pumped out on October 11, 2005. This flood water provided a nearly steady state source of contamination to nearby ecosystems. The hydrological flows and transport processes of the pumping out are treated in detail in the environmental modeling report in this volume.

The U.S. EPA and the LADEQ conducted extensive measurement operations throughout the flooded urbanized New Orleans area from September through December 2005. Louisiana State University (Pardue et al., 2005) and Texas Tech University (Presley et al., 2006) led independent sampling expeditions in flooded New Orleans, principally in limited parts of New Orleans proper. They reported on a greater variety of contaminants over a more limited area than the EPA data. The data sources used in this report are summarized in Table 1.

Table 1
Sources of information used for chemical microbiological analyses

	Inner Region		Nearby Regions			
Region:	Urban		Violet Marsh		Lake Pontchartrain	
	Infectious	Chemical	Infectious	Chemical	Infectious	Chemical
Condition:						
Pre-Katrina	Inferred and anecdotal Fecal sterols-core bottoms	Mielke, 1999 BaP from core bottoms	Fecal sterols-core bottoms	BaP from core bottoms	LPBF - coliform	LPBF-WQ data
Actual Post-Katrina	EPA database Tot. Colif. -core tops Fec. Coilf. -core tops Fec. Strep. -core tops Fecal sterols-core tops	EPA database BaP-core tops	Tot. Colif. -core tops Fec. Coilf. -core tops Fec. Strep. -core tops Fecal sterols-core tops	BaP-core tops	LPBF - coliform	LPBF-WQ data

Experimental Methods

ERDC Sediment Sampling - As part of the Environmental Subtask the ERDC conducted a sampling trip 14-16 February 2006 to Violet Marsh outside the polder of the Lower Ninth Ward and the Chalmette area, using an airboat to access the Marsh. The ERDC metals fabrication shop modified a commercially available stainless steel (SS) soil coring device for the purpose of retrieving undisturbed sediment cores from wetlands (Figure 7). The SS coring device consisted of three SS parts: the main part was the cylindrical coring tube with dimensions of 4.25” outside diameter (o.d.) and 4.00” inside diameter (i.d.), and 11.625” length. Attached to the bottom of the coring tube was a fitted, lock-in-place, stainless steel ring with protruding cutting teeth with dimensions of 4.25” o.d., 4.00” i.d., and 1.5” in length. This piece acted both as the cutting part of the tube and as the securing ring for holding an autoclaved acrylic coring sleeve in place within the SS coring tube. The third component of the coring tube was a SS disk that measured 0.35” in thickness and 3.87” in diameter that rested on top of the acrylic core sleeve within the coring tube. This disk was held in place by two screws set into the rim of the top of the coring tube that protruded approx 0.125” into the interior of the coring tube.

Figure 7.Sediment coring device

The coring tube was gently pushed down into the sediment over the course of a minute using the ratcheting “T-bar” handle. The teeth cut in the direction of ratcheting. The coring continued until the sediment reached the disk, and then the coring tube was brought up into the airboat, or up onto dry land where the cutting ring was removed and the acrylic core containing the sample was allowed to slide partway out of the coring tube (Figure 8). Immediately a plastic cap was secured onto the bottom of the acrylic core sleeve to cover and protect the core sample material inside. Once the bottom cap was secure, the acrylic core sleeve was then allowed to slide fully out of the SS coring tube and was sat upright onto a flat surface. The SS disk was then removed from the top of the acrylic core sleeve where it had acted as a temporary cap to prevent the loss of material, and a second plastic cap was placed on top of the core sleeve to enclose the sediment sample. The secured sample was then placed on ice into a cooler and transported to ERDC after all samples had been collected.

Figure 8. ERDC Team in Violet Marsh

The coring tube, cutting ring, and SS disk were then scrubbed in water with a brush to free them of any remaining sediment, and the insides and outsides were sprayed with a 99% Isopropyl alcohol solution for disinfection and allowed to air dry for a minute after there was no visible liquid alcohol residue. Then a fresh autoclaved acrylic sleeve was placed into the interior of the coring tube, the SS disk was positioned on top of the sleeve within the inside of the coring tube, and the cutting ring was secured to the bottom of the coring tube in preparation for the next core sample to be taken.

In the ERDC Environmental Microbiology laboratory ice cold cores were placed in chemical fume hoods and the top caps were removed from the acrylic cores. The first 5 cm were aseptically removed from the top of each core (Figure 9) and thoroughly mixed with a sterile spatula. Separately the lowest 5 cm were aseptically removed from the bottom of each core and mixed. Portions of this homogenized sediment were frozen and aliquots set aside for the various physical, chemical and microbiological analyses. Dry weights were determined by drying an aliquot in the hood in ambient air for a day.

Figure 9. Removing and weighing sediment

Bacterial indicators of pathogens in sewage - Microbiological analyses for total coliform (SM 9222-D), fecal coliform (SM 9222-D) and fecal streptococci (SM 9230-C) were performed on sediment samples using standard microbiological methods (Standard Methods, 2005).

Benzo[a]pyrene and fecal sterol analyses - Fecal sterols and polycyclic aromatic hydrocarbons were extracted from sediment samples using the methods described in Ringelberg et al. 2001. All glassware was solvent washed and treated in a muffle furnace before use. Sterol standards were purchased from Sigma-Aldrich, Co. (coprostanol, 5ß-cholestan-3ß-ol; epicoprostanol, 5ß-cholestan-3α-ol; ß-sitosterol, 24-ethylcholest-5-en-3ß-ol; stigmastanol, 24-ethyl-5α-cholestan-3ß-ol) and Applied Science Labs, State College, Pa. (coprostanone, 5ß-cholestanone; cholesterol, cholest-5-en-3ß-ol; campesterol, 24-methylcholest-5-en-3ß-ol). An 11g aliquot (wet weight) of sediment was weighed out, and a known amount of deuterated pyrene was mixed into the wet sediment to serve as a recovery standard. A mixture of dichloromethane:methanol:water (1:2:0.8, v:v:v) was added to the sample. The sediment sample was then extracted for 1 hour in an ultrasonic water bath at 10 ^{o}C , and then allowed to stand overnight. Equal volumes of dichloromethane (DCM) and water were added to break the liquid phases and the entire volume was centrifuged at 5000 rpm for 10 minutes. The DCM phase containing the total extractable lipids was recovered using a glass pipette. The DCM was reduced in volume under a stream of dry nitrogen to approximately 100 µL and then brought to a final volume of 2 mL with clean DCM. A subsample (100 µL) of this total lipid extract was derivatized using trimethylchlorosilane for fecal sterol analysis.

Fecal sterols and BaP by GC/MS were determined using slight modifications to the standard method proposed by the Florida Department of Natural Resource Protection (1998). After TMS derivatization fecal sterol samples were analyzed using a gas chromatograph equipped with a 60 m x 0.25 mm (ID) DB-5MS capillary column (0.1 µm film thickness, J&W Scientific, Folsom, CA) and a Mass Selective Detector (Hewlett Packard GC6890-5973). Peak identities were confirmed by comparing retention times and fragment ion masses (with electron impact ionization at 70 eV) to standards and the NIST MS database. Areas under the peaks were converted to concentrations, corrected to the efficiency of recovery of the deuterated pyrene and then normalized to the gram dry weight of the wet aliquot extracted. Ion mass patterns were used to confirm the identities of the benzo[a]pyrene and sterol GC peaks.

The recovery efficiency of the deuterated pyrene was very consistent and low ~30%. All BaP and fecal sterols levels were corrected to each sample's deuterated pyrene recovery. The lower limit for quantization (LLQ) of BaP was determined by adding an extra 0.1 µg/gdw of BaP to three different sediment samples. The LLQ was measured as 3 times the standard deviation of these matrix spikes. The lower limit of detection (LLD) was determined as 3 times the standard deviation of the noise in blanks. The BaP LLQ for these samples and this analysis system was 0.067 µg/gdw and the LLD was 0.009 µg/gdw. Both the LLQ and LLD for the fecal sterols were 0.1 nmol/gdw.

Results

Mining the EPA/LADEQ data - The microbiological raw data downloaded from EPA's STORET Katrina Central Data Warehouse (http://oaspub.epa.gov/storetkp/dw) for Orleans and St. Bernard parishes are in Appendix A. These data included 139 water and 569 sediment sampling results in Orleans and St. Bernard parishes, with sampling dates from 10 September 2005 to 20 November 2005. Some of the samples were taken outside the polder areas. Values were reported as non-detects or present non-quantitated for 19 water and 406 sediment samples in the polders. There were several analytical procedures reportedly used. The sample quantitation limits (SQL) were not reported. The sediment fecal coliform units were erroneously reported in cfu per 100 mL, as for water, instead of the correct cfu/g (EPA 2004b).

All of the EPA/LADEQ Katrina flood water and sediment sampling sites in Orleans and St. Bernard parishes are marked in Figure 10 by green stars. This figure was produced by EPA's EnviroMapper utility.

These sampling points were distributed into three main drainage areas or polders, as defined by the system of levees radiating from the turning basin in the Inner Harbor Navigation Canal, illustrated in Figure 11. New Orleans proper was considered to be that portion of Orleans Parish west of the IHNC, while New Orleans East was the urbanized area of Orleans Parish east of the IHNC and north of the Intracoastal Waterway leading to the Mississippi River Gulf Outlet. The urbanized areas east of the IHNC and south of the Intracoastal Waterway were primarily the Lower Ninth Ward of Orleans Parish and the Chalmette area of St. Bernard Parish. The EPA/LADEQ sampling points which correspond to each polder are given in Appendix B.

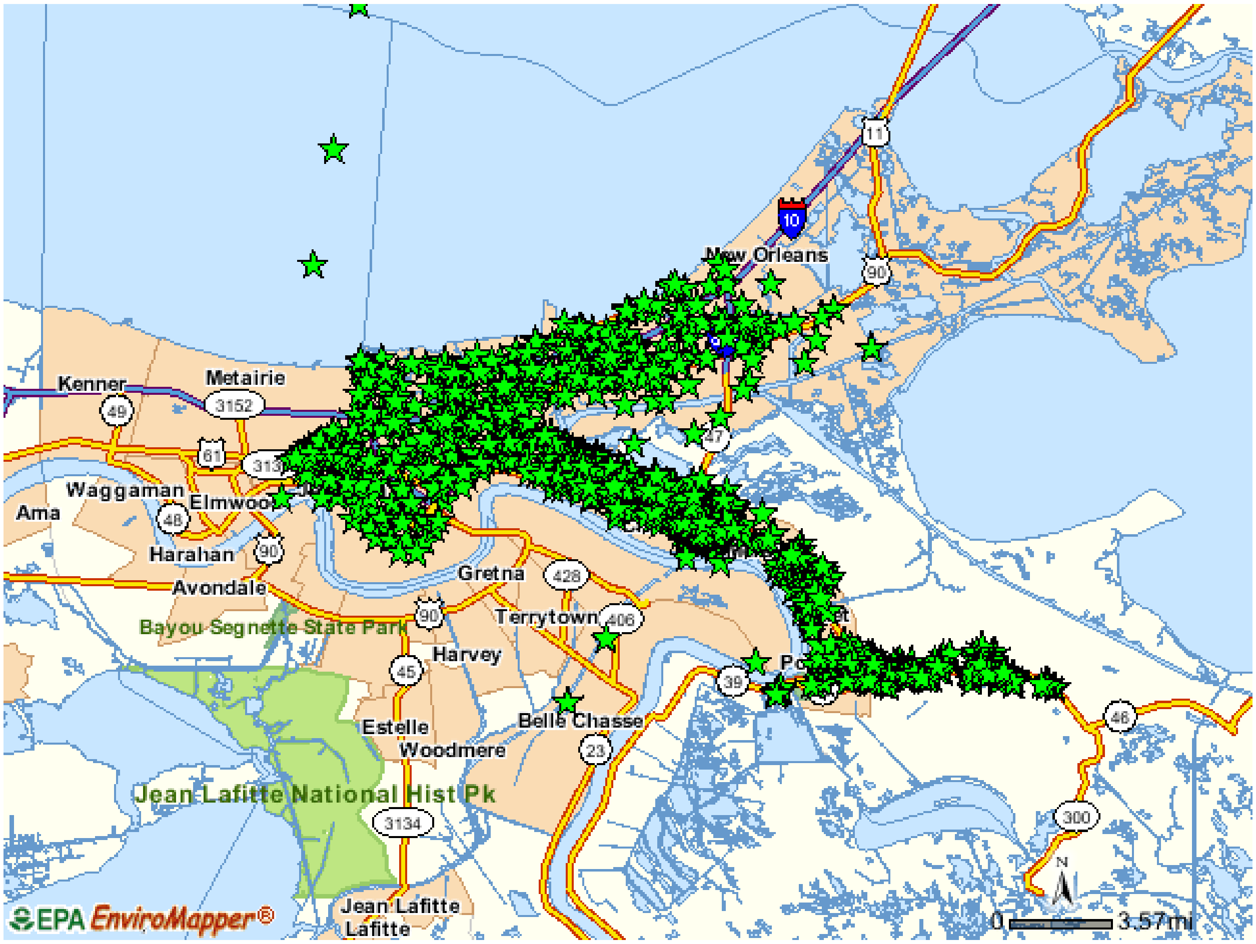

Figure 10. Map showing location of EPA samples in Orleans and St. Bernard Parishes

EPA/LADEQ summary statistics - EPA/LADEQ water fecal coliform counts (colony forming units per 100 mL of water) ranged from non-detect to 490,000 (mean 21,381, median 2,200, standard deviation 74,541) in New Orleans proper, non-detect to 30,000 (mean 3,308, median 200, SD 8,093) in New Orleans East, and non-detect to 25,000 (mean 1,287, median 100, SD 4,381) in St. Bernard and the Lower Ninth Ward polders. EPA/LADEQ sediment fecal coliform (cfu per gram dry weight of sediment) ranged from non-detect to 996,260 (mean 31,645, median non-detect, SD 116,783) in New Orleans proper, non-detect to 416,250 (mean 9,980, median non-detect, SD 47,327) in New Orleans East, and non-detect to 1,115,800 (mean 30,196, median non-detect, SD 119,808) in St. Bernard and the Lower Ninth Ward polders. The polders had different values which could be described statistically.

EPA's STORET Katrina Central Data Warehouse yielded 295 flood water measurements of BaP, with 294 non-detects. The sole detect was 0.42 µg/L. There were 1,110 sediment samples tested for BaP, ranging from non-detect to 35,500 µg/kg, with 894 non-detects. 152 samples exceed the EPA screening standard. The flood sediment in all three polders frequently exceeded the standard. Further analyses of the chemical contaminants in the EPA/LADEQ database is presented in a separate report in this volume (Bednar et al., 2006).

Statistical distribution parameter estimation - For randomly diluted samples a lognormal distribution was expected, in the same way that a normal distribution was expected for randomly additive samples. To develop a lognormal fit to the data, the natural logarithm of each data point, plus an irrelevant small constant offset if there were to be zero or negative data, was calculated and these logarithms were binned. The size of the bins was judiciously chosen to have sufficient data points as well as sufficient resolution. The resulting histogram of the logarithms was then fit by a Gaussian curve. The parameters for curve height, width and location (and offset) were chosen by a global least squares minimization for goodness of fit.

As illustrated in Figure 11 for sediments, the data without the non-detects was indeed roughly lognormal ($r^2 = 0.70$). For a lognormal distribution the 95% UCL is defined (EPA 1992) as

$$95\% \ \ \text{UCL} \equiv e^{\left(\frac{s^2}{2} + l + \frac{h \cdot s}{\sqrt{n-1}}\right)}$$

where n is the number of data points, *l* is the average of the logarithms of the data (with offset), s is the standard deviation of the logarithms, and h is Land's h statistic. Tables of the h statistic have been compiled (Gilbert 1987) and values are also available through commercial software packages.

For further analyses and inclusion into a lognormal distribution, the non-detects cannot be taken to be zero, and in practice were assumed to be on average at half the SQL (EPA 1992). As seen in Figure 11 for the sediments, the large number of non-detects cause another histogram peak at half the SQL. This bimodal distribution could not in general be well fit by any unimodal distribution such as the lognormal, and thus the calculations of distribution-based parameters such as the 95% UCL were much less meaningful for the bimodality reflected in the data. Even simpler parameters such as mode, standard deviation and median are much less useful in describing nonunimodal distributions.

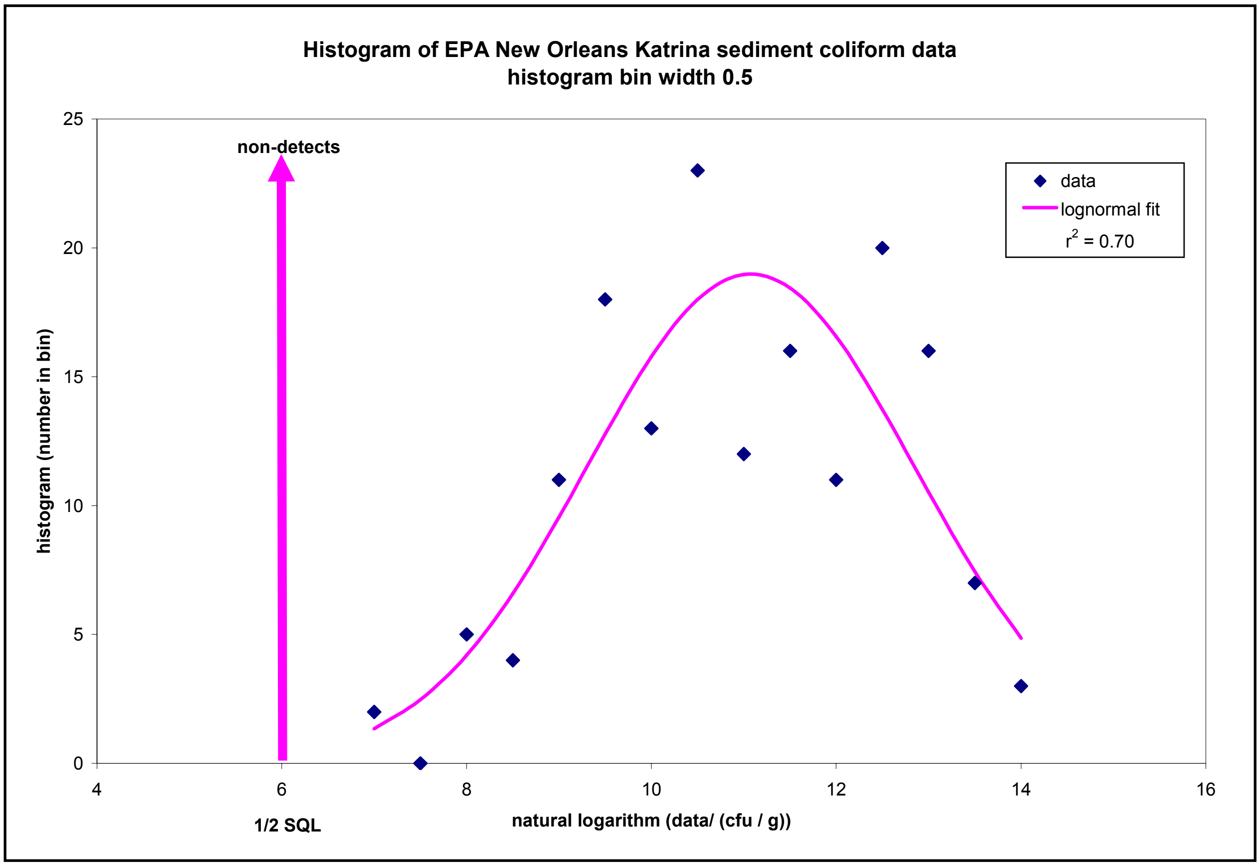

Figure 11. Bimodal historgram of EPA Katrina sediment data

Temporal trend analyses - No trend (neither increasing nor decreasing) was evident with time for the EPA/LADEQ microbiological water data as the flood water was pumped out and then after flood pumping ceased on October 11. As seen in Figure 12, the fecal coliform data were uncorrelated (r^2 = 0.012) with time. The data in neither of other polders were correlated with time. In particular they did not decrease.

The half lives of fecal coliform in New Orleans surface waters are of the order of a couple of days at most (Davies et al. 1995). Thus, that the fecal coliform did not decrease suggested that the post-flood sewage system was not properly operational throughout the time the data was collected. Many of the data frequently exceeded the primary recreational water standard of 400 cfu/100 mL; 53 of the 139 data points exceeded the standard.

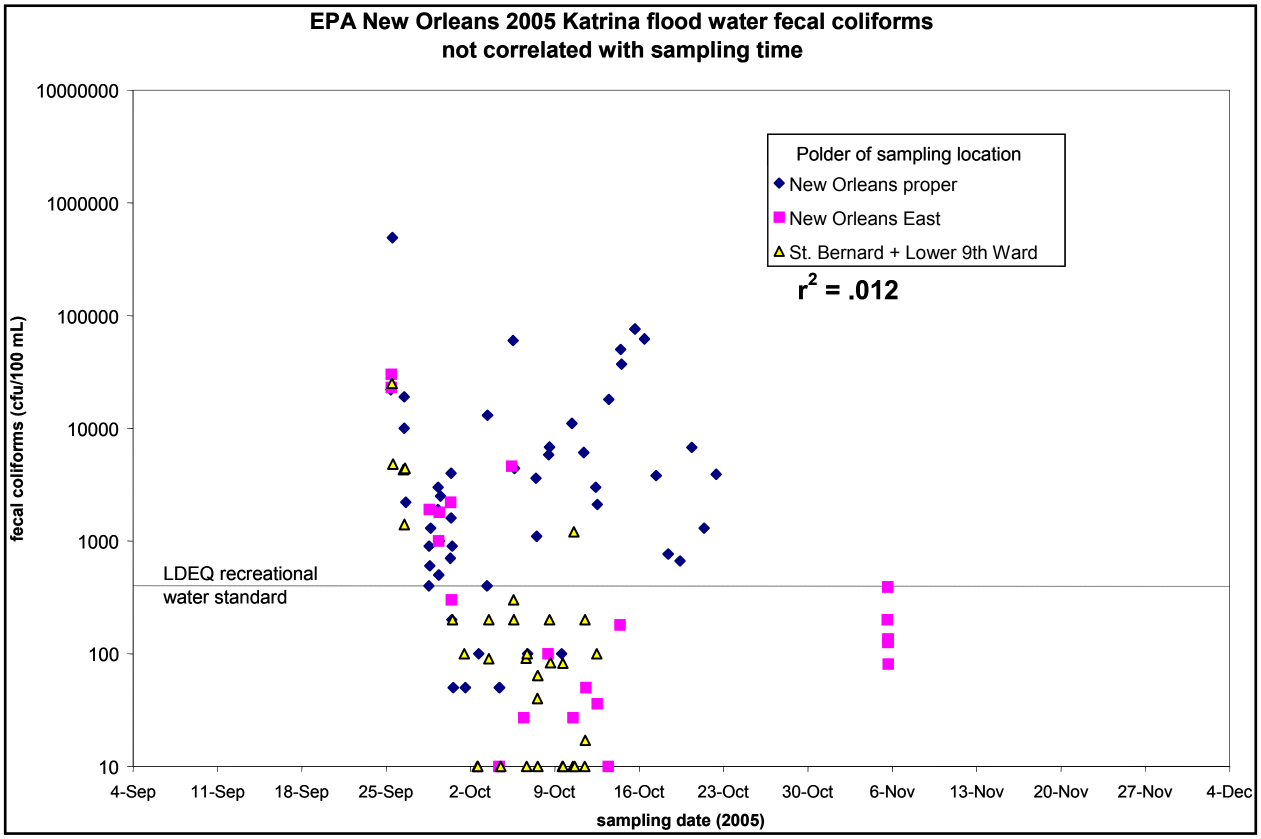

Figure12. EPA New Orleans 2005 Katrina flood water fecal coliforms vs sampling time

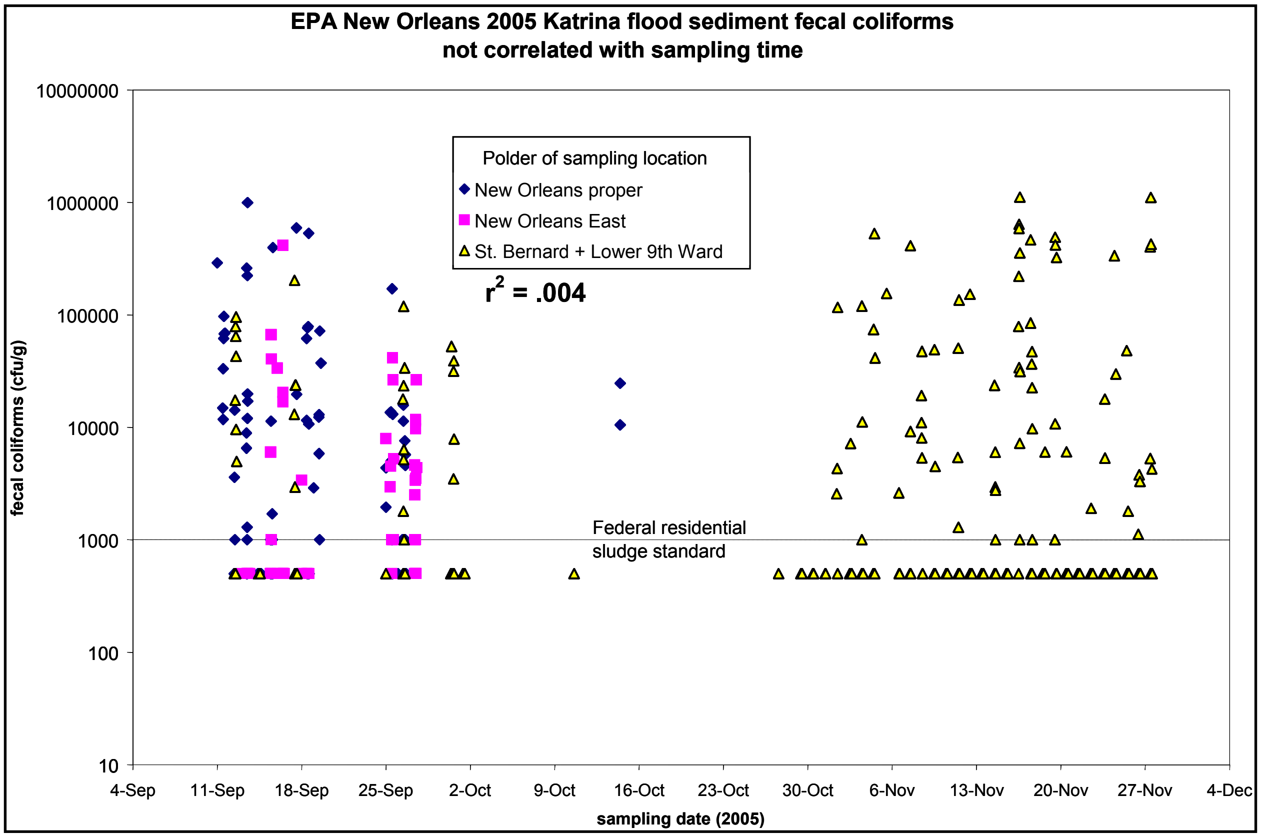

Figure 13. EPA New Orleans 2005 Katrina sediment fecal coliforms vs sampling time

Similarly no trend (neither increasing nor decreasing) was evident with time for the EPA/LADEQ microbiological sediment data as the flood water was pumped out and then after flood pumping ceased on October 11. As seen in Figure 13, the fecal coliform data were uncorrelated ($r^2 = 0.004$) with time. The data in neither of the other polders were correlated with time. In particular they did not decrease.

The half lives of fecal coliform in New Orleans surface sediments are of the order of a couple weeks at most (Burton et al. 1987). Thus, that the fecal coliform did not decrease suggests that the post-flood sewage system was not properly operational throughout the time the data was collected. Many of the data again frequently exceeded the federal residential biosolids standard of 1000 cfu/g; this standard was exceeded by 162 of the 569 EPA Katrina sediment samples from Orleans and St. Bernard parishes.

Data reduction for environmental modeling - As part of the microbiological data mining products, suggested values and statistics were provided to the environmental modeling team. The lack of temporal trend meant that single characteristic values could be used for the entire modeled time. The selected statistics were the medians and the 95% UCL as presented in Table 2.

Table 2
Microbiological values for environmental modeling

all values in cfu / 100 mL	New Orleans Proper	New Orleans East	St. Bernard + Lower 9th Ward
sediment median, neglecting nondetects	**14200**	**9700**	**23800**
sediment median, 1/2 SQL = 500	**500**	**500**	**500**
sediment 95% UCL, neglecting nondetects	**164000**	**55000**	**244000**
sediment 95% UCL, 1/2 SQL = 500	**87000**	**7200**	**334000**
water median, neglecting nondetects	**3600**	**200**	**200**
water median, 1/2 SQL = 50	**2200**	**200**	**100**
water 95% UCL, neglecting nondetects	**41000**	**43000**	**7200**
water 95% UCL, 1/2 SQL = 50	**70000**	**33000**	**1700**

ERDC Sediment Core Locations - Sediment core sample locations were selected to capture potentially major primary contaminant sources located at Murphy Oil Corporation, and the municipal sewage treatment plant. Some samples were collected as close to these sources as possible. Canals drain the Murphy Oil property and conduct water to the large stationary pumps that pumped the water over the levees. Core samples were collected from both the immediate influent and immediate effluent of the pumps that could have transported contaminants from these two sources into Violet Marsh. Sediment core samples were also collected at various distances from these pumps out into Violet Marsh to determine the range of transport of these contaminants into the Marsh. All locations from which ERDC collected core samples were are shown in as yellow circles in Figures 14 and 15 and the GPS coordinates of these sites are given in Table 3. Almost all the ERDC sites are outside the inner urban levees. A few of the nearby EPA sampling sites are shown in red circles for visual comparison. Almost all the EPA sites are inside the inner urban levees.

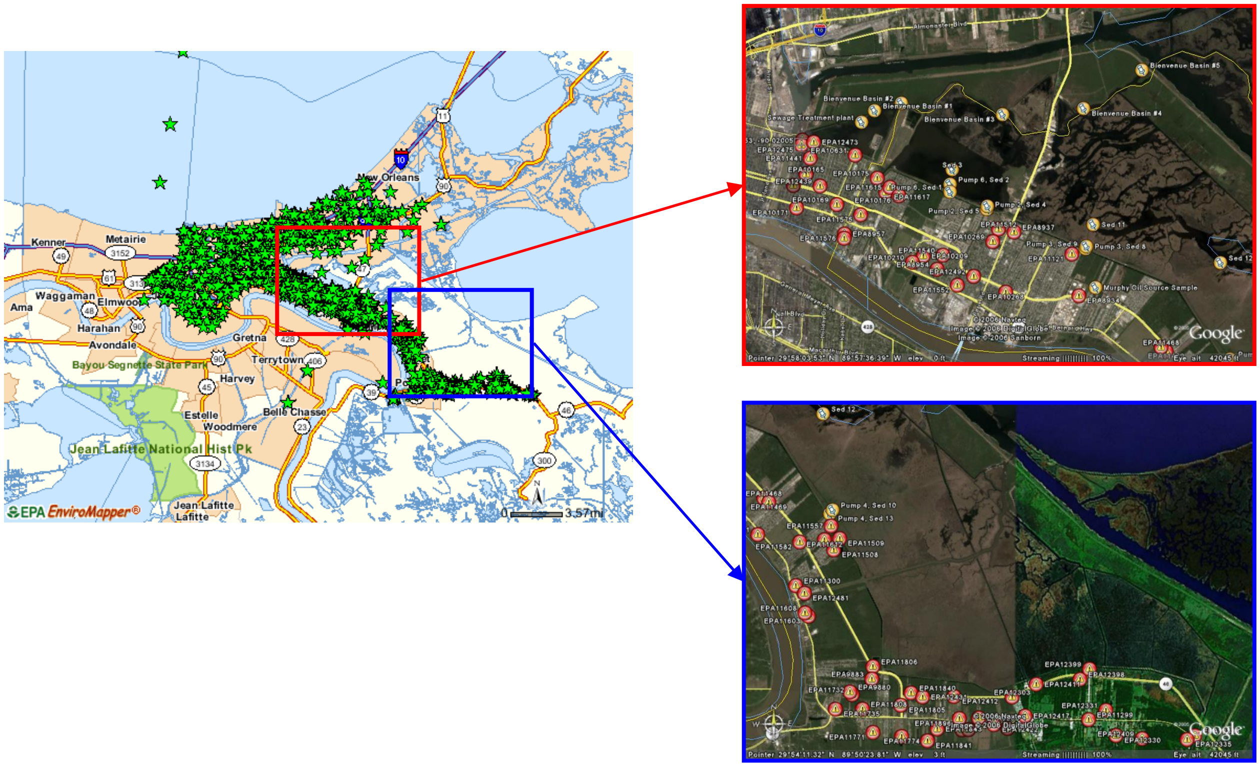

Figure 14. Locations of ERDC core samples and relation to EPA samples

Figure 15. The ERDC locations in more resolution

Table 3
The ERDC sampling locations descriptions

Sample Name	Latitude	Longitude	Description
Sewage Plant	29.984166	-90.001866	Northwest of treatment plant in marsh
Murphy Oil Site	29.940866	-89.931083	Munster Ln, North of Judge Perez, intersection of drainage canal running N.W.
Pump 2 Sed 4	29.961400	-89.963983	Before pump #2
Pump 2 Sed 5	29.962183	-89.963783	After pump #2
Pump 3 Sed 8	29.951633	-89.933833	After pump #3
Pump 3 Sed 9	29.951050	-89.934100	Before pump #3
Pump 4 Sed 10	29.922100	-89.890416	After pump #4
Pump 4 Sed 13	29.921133	-89.891266	Before pump #4
Pump 6 Sed 1	29.965925	-89.975072	Before pump #6
Pump 6 Sed 2	29.967916	-89.975088	After pump #6
Sed 3	29.971766	-89.974433	Due north of pump #6, middle of marsh
Sed 11	29.957350	-89.931783	NNE of pump #3, middle of marsh
Sed 12	29.947333	-89.893266	Due north of pump #4 middle of marsh
Bienvenue Basin 1	29.987200	-89.997950	adjacent to treatment plant areator within discharge canal
Bienvenue Basin 2	29.989166	-89.989816	beginning of treatment plant discharge canal
Bienvenue Basin 3	29.986166	-89.959183	towards the end of treatment plant discharge canal
Bienvenue Basin 4	29.987733	-89.934683	north shore of marsh between discharge canal and intracoastal waterway lock
Bienvenue Basin 5	29.997783	-89.917000	adjacent to intracoastal waterway canal lock

Fecal Bacteria Indicator Culture Data – Sediment cores were transported back to the Vicksburg laboratory on ice and samples from the top 5 cm from each were taken as previously described and analyzed using the Standard Methods Most Probable Number Analyses for total coliform, fecal coliform and fecal streptococci (Table 5). Samples from the bottoms of these cores were not analyzed because these fecal bacteria were not thought to be able to survive for extended periods of time in sediments. Fecal streptococci are the indicators currently recommended by the EPA for estuarine and marine systems, but no sediment quality standards were currently recommended. Only one fecal strep sample from the top of the Murphy Oil drainage canal produced a reading that was above the lower detection limit of the analysis. In contrast, all the total coliform analyses except those from the two outermost samples of Bayou Bienvenue produced moderate to high counts. The highest coliform values were not at the sewage treatment plant outfall but from the Murphy Oil drainage canal and locations indicating input from Chalmette into Violet Marsh. Fecal coliform counts exceeded the standard for biosolids set by 40 CFR 503 (1000 cfu/gdw) for all sample locations except the sewage treatment plant and all samples from the Bayou Bienvenue. The reason for relatively low total and fecal coliform bacteria in these locations was not clear but may be biological (i.e. not just due housing location or dilution) via inhibition of bacterial growth by co-occurring chemical contaminants and/or active coliphage (not measured) activity in these chronically polluted areas.

Fecal sterol data – Coprostanol levels in the tops and bottoms of almost all cores collected indicated significant historic and recent fecal impacts on Violet Marsh (Table 6). These levels are comparable to those in heavily sewage impacted marshes in Barcelona, Spain and Havana, Cuba (Table 7). Analysis of the sterol content from the bottom of the cores provided some insights into the input of fecal matter into Violet Marsh before Katrina struck (Table 6). In these earlier deposited sediments the levels of coprostanol were highest in the two most western sampling stations in the Bayou Bienvenue; BB1 (61.2 nmol/gdw) and BB2 (87.8 nmol/gdw). Coprostanol levels rapidly decreased with distance to the east (BB3-5; 3.4-6.0 nmol/gdw). Together, these data suggested the sewage treatment plant (or other source in this area) constituted a major long-term source of fecal contamination but the distribution of this fecal material into Violet Marsh was rather limited. High to moderate levels of coprostanol were found in the bottom of the core taken closest to the sewage plant outfall (20.3 nmol/gdw) and pump stations #2 (32.8 nmol/gdw), #3 (12.6 nmol/gdw) and #6 (8.0 nmol/gdw), indicating a long-term source of fecal contamination from these sources. It is important to note that almost all of the sediments analyzed exceeded the most lenient coprostanol sediment quality standard suggested of 1 nmol/gdw indicating that Violet Marsh has been chronically impacted by fecal material.

The coprostanol levels in sediment from the top of the cores also showed significant impacts from fecal contamination (Table 6). The average level of coprostanol in the most recent sediment was higher (20.2 nmol/gdw) than that of the bottom sediment (16.9 nmol/gdw), which suggested increasing fecal input. Additionally, the relative coprostanol distribution pattern in the most recent sediments was different from that observed from the analysis of core bottoms. The levels of coprostanol in the surface sediments of the eastern location in the Bayou Bienvenue (BB1=28.3 nmol/gdw; BB2=28.5 nmol/gdw) were approximately half of those found in the sediments of the bottoms of these cores. This may reflect the lack of input due to the failure of the sewage treatment system that resulted from the flooding. In contrast, the surface sediments associated with pump stations #2, #3, #4 and #6 all contained higher levels of coprostanol than their respective core bottoms. This suggested that the flooding resulted in a greater fecal load to Violet Marsh than originated from Chalmette along the northern levee.

Ratios of the levels of various other sterols recovered from wetland sediment cores have been used as aids to data interpretation, particularly in highly productive systems where coprostanol levels were below 2 nmol/gdw and other sources of sterols had become significant. We did not find any of these sterol ratios particularly helpful in the context of gaining additional information from our data (Table 6). The ratio of coprostanol / coprostanol+cholestanol did not change much with location or sediment depth suggesting the relative importance of the different cholesterol reduction pathways did not change very much with time or location in the Marsh. The ratio of epicoprostanol (formed from coprostanol in activated sludge) to coprostanol has been used as an indication of treated *vs* non-treated sewage. Although this ratio fluctuated it was difficult to rationalize these differences in terms of extent of sewage treatment.

Benzo[a]pyrene data - The Violet Marsh has had a history of BaP contamination and the recent flooding has made this contamination more pervasive through the Marsh. BaP levels in the bottom sediments from 9 of the 18 core samples collected exceeded the EPA sediment criterion of 0.062 µg/gdw. The sediments that chronically exceeded this criterion came from Bayou Bienvenue, the sewage treatment plant, and around pump stations #2 and #3. This historic BaP contamination did not extend far into the Marsh (e.g., sediment 12 = 0.0 µg/gdw). When considering the most recently deposited sediments, the number of cores showing measurable BaP levels and the levels of BaP in these sediments indicated that the flooding resulted in the addition of BaP to the marsh in excess of the historically deposited levels. The EPA BaP sediment criterion was exceeded in the sediments most recently deposited in 16 of the 18 cores collected. The averaged level of BaP in the most recent sediments was 2.8 µg/gdw compared to 1.5 µg/gdw in the historic sediments. The highest levels in both the top and bottom sediments were detected in the eastern Bayou Bienvenue.

Discussion

During the Category 3-4 hurricane Katrina, on 28-29 August 2005, 6 - 10 inches of rain fell in the New Orleans area. This amount was not significantly greater than many other storms. The Katrina storm surge on the Mississippi coast exceeded 20 feet in some areas, but ranged from 10-15 feet on the Louisiana coast east of New Orleans. Lake Pontchartrain was elevated a few feet for an extended time. By 29 August New Orleans levees were breached in several locations, and by 30 August 80% of New Orleans was flooded with up to 20 feet of brackish water.

For several days the flood water remained high in the urbanized areas, and began to slowly recede as the levee breaches were patched and pumps were brought in or became operational. Tens of thousands of people who remained in the area were without basic necessities, and without a working sewage system. The main sewage treatment plant was submerged, damaged, and completely out of operation for several weeks. The smaller plant on the west bank received extensive storm damage and was also not operational.

The effects of several inches of rain and wind from the Category 3 hurricane Rita caused several refailures of the levees in New Orleans on 23-24 September, and reflooding up to 10 feet. The operational pumps pumped huge volumes of flood water and sediment continuously for 4-5 weeks. The last of the flood waters was declared pumped out on October 11. The flooding and flows are detailed in the modeling report in the volume (Dortch et al., 2006). The pump out of the flooded city and the hydraulic flows resulting from this operation and the levee systems was accomplished with three separate drainage areas or polders: New Orleans proper, New Orleans East, and St. Bernard Parish and the Lower Ninth Ward. Lake Pontchartrain received the bulk of the pumped flood water, from New Orleans proper and New Orleans East. The Violet Marsh received the pumped flood water from the Lower Ninth Ward and Chalmette area.

The U.S. EPA and the LADEQ conducted extensive measurement operations throughout the urbanized New Orleans area from September through December. The only EPA and LADEQ flood water and sediment microbiology data available is for fecal coliform bacteria. LSU (Pardue et al., 2005) and Texas Tech (Presley et al., 2006) led independent sampling expeditions in flooded New Orleans, principally in limited parts of New Orleans proper. They reported on a greater variety of contaminants over a more limited area than the EPA data. Much of the sewerage system was antiquated and permanently damaged from the flooding. Even during normal storms without flooding, the sewers cross flow into storm drainage (Pardue et al., 2005). The main EPA warning concerning contaminants in the flood water was to avoid contact due to elevated sewage levels. http://www.epa.gov/katrina/precautions.html. Much raw sewage, particularly in the Lower Ninth Ward and Chalmette area polder, was still evident in surface waters when we sampled (February 2006).

The recreational (swimming) water criteria for bodily contact and accidental or incidental ingestion are developed in terms of other groups of organisms. The applicable standard is the primary contact recreational water quality criterion which is 400 cfu/100 mL for fecal coliform bacteria (EPA 2003, LADEQ 2004). This standard was exceeded in 53 of the 139 EPA Katrina water samples from Orleans and St. Bernard parishes. The averages of the fecal coliform bacteria in cfu/100 mL reported in the EPA Katrina water samples from the three polders were 21,381 in

New Orleans proper, 3,308 in New Orleans East and 1,287 in St. Bernard Parish and the Lower Ninth Ward. There are very few bacteriological sediment standards. The large National Sediment Quality Survey (EPA 2004b) contains no bacteriological data. The federal Biosolids rules are applicable to transported sediments which have been impacted by sewage sludge. The Biosolids residential standard (40 CFR 503.32) for fecal coliform bacteria is 1000 cfu/g. This standard was exceeded by 162 of the 569 EPA Katrina sediment samples from Orleans and St. Bernard parishes. The averages of the fecal coliform bacteria in cfu/g reported in the EPA Katrina sediment samples from the three polders were 31,645 in New Orleans proper, 9,980 in New Orleans East, and 30,196 in St. Bernard Parish and the Lower Ninth Ward.

The potential for infections from pathogens in sewage waste was the primary Katrina-related health concern of the EPA and CDC. Air-borne molds are another microbial concern in New Orleans. The EPA issued flood-related mold warnings, especially concerning the black molds related to *Stachybotrys chartarum*. (http://www.epa.gov/katrina/healthissues.html#floodmold). This report does not cover air borne pathogens, only the pathogens reported in the flood waters and sediment.

The ERDC Environmental Microbiology Team supported the environmental modeling effort required for the IPET Task 9 by obtaining and reducing data on fecal contamination and providing it to ERDC environmental modelers (Table 2). The fecal coliform data as a whole do not appear to result from random dilutions of a fecal source or sources because of the large number of non-detects reported. Once the non-detect values are removed the remaining numerical values do tend to follow an expected unimodal lognormal distribution characteristic of random dilutions of a fecal source or sources. The reported non-detects appear to result from a separate source or sources of more dilute material, resulting in a bimodal distribution for the fecal coliform data as a whole. Several further outlying areas, including the Mississippi Sound and the Mississippi River Delta, are likely to have environmental impacts from the levee failures that are more dilute than the nearby ecosystems. These remote ecosystems are not modeled in this report, and samples were not collected from the remote areas.

Screening of New Orleans water and sediment samples for the coliform bacteria found in fecal material and correlated to infectious human disease frequently showed fecal coliform bacterial levels high above the regulatory levels of concern. As a result health advisories due to infectious material in the flooded New Orleans were issued. The advisories were warranted. Assessment of the actual human health impacts due to infectious agents as a result of the flood is an ongoing process. Of the 10,047 New Orleans patient visits during and immediately after the flooding for which information was available to the Center for Disease Control and Prevention (CDC, 2006) the most common were gastrointestinal, acute respiratory and skin infections. However, it will probably not be possible to capture all the data on illness of New Orleans residents who left the area and received medical treatments for infections. In the context of this report it is important to point out that the high levels of fecal coliform bacterial revealed by the screening procedures did detect a human health risk due to infectious agents, health advisories were issued and some summaries of impacts of human infections have been recently published. This series of events identifies a potential source of infectious materials that constitute a real environmental risk of unknown magnitude and duration on the environment around New Orleans as the city was pumped out and debris is removed.

Extending the fecal coliform indicator screening level analysis to areas adjacent to New Orleans is one of the few options open to use the data that is currently available. Simple water dilution calculations and coliform bacteria die-off rates in estuarine water indicate that fecal coliform counts would be below levels of concern for the majority of Lake Pontchartrain. This is indeed observed in the most recent data from the Lake Pontchartrain Basin Foundation. While this is good news these data should not be equated to the lack of an environmental problem. According to EPA guidance and federal law (BEACH Act) fecal streptococci should have been used as the fecal indicator in estuarine water and not fecal coliform bacteria. The very high levels of fecal coliform bacteria in the flood water indicated an obvious health risk. However, the interpretation of low fecal coliform counts in estuarine water in terms of risk to human health is problematic. Lack of correlation between low fecal coliform counts and human illness is one of the reasons EPA in 1986 changed its guidance in estuarine waters to the use of fecal streptococci. Additionally, recent literature has revealed that we are only beginning to understand the part of the life cycle of microbial pathogens of humans that occurs outside the human host. Taken together the message here is that the current lack of an indicator of fecal waste problem in New Orleans and Lake Pontchartrain should not be interpreted as the absence of an environmental problem. On the other hand, Lake Pontchartrain itself is a recovering ecosystem with a long history of fecal and chemical pollution. It is not possible with the data we currently have available to evaluate the impact of the pump out on the already impacted Lake.

In contrast, much of the Violet Marsh is confined by levees and this small confined area received a great volume of material that was pumped out of the urbanized area of New Orleans. We were able to select our own tests and sample sites, and perform our own quick survey of this system. As a result we were able to show a probable environmental impact of BaP and fecal contamination that resulted from the pump out of the Lower Ninth Ward of New Orleans and the Chalmette area that exceeded the historic level of BaP and fecal contamination that this system normally receives. The Violet Marsh was shown to have levels of contamination and ranges of indicators similar to other sewage impacted wetlands areas (Grimalt et al. 1990) that are well above suggested sediment quality criteria (Kirchmer 1971; Murtaugh and Bunch 1967; Dutka et al. 1974). Other chemical tracers of anthropogenic contamination were also evident in our GC/MS analyses, but time did not permit a more detailed environmental forensics analysis of the data. Additional analyses are required to remove uncertainty due to assumptions we made and the minimal statistical design of our Violet Marsh survey, and to quantify these impacts.

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List of Abbreviations

IPET	Inter-agency Performance Evaluation Team
BaP	benzo[a]pyrene
ERDC	Engineer Research and Development Center
US EPA	United States Environmental Protection Agency
SD	standard deviation
LADEQ	Louisiana Department of Environmental Quality
ng	nanogram
L	liter
cfu	colony forming unit
mL	milliliter
µg	microgram
g	gram
DEQ	Department of Environmental Quality
CFR	Code of Federal Regulations
gdw	gram dry weight
ILSI	International Life Sciences Institute
pmol	pico-mol
nmol	nano-mol
ppb	parts per billion
GC/MS	gas chromatography mass spectrometer
TPH	total petroleum hydrocarbons

NO	New Orleans
COE	Corps of Engineers
SS	stainless steel
v.v.v.v	volume to volume to volume to volume
DCM	dichloromethane
LLQ	lower limit for quantization
LLD	lower limit of detection
TMS	trimethylchlorosilane
µm	micro-meter
eV	electron volts
USGS	United States Geological Survey
LSU	Louisiana State University
STORET	EPA/LADEQ Katrina Central Data Warehouse (http://oaspub.epa.gov/storetkp/dw)
SQL	Sample quantization level
UCL	Upper confidence level
MPN	Most probable number

Table 4
Benzo[a]pyrene levels in Violet Marsh sediments.

Table Concentration of Benzo(A)Pyrene in Top and Bottom of Cores

Sample		BaP ug/g *dw*	EPA criteria	LDEQ criteria
Location			0.062	0.33
Bienvenue Basin 1	TOP	31.2	>	>
Bienvenue Basin 2	TOP	2.8	>	>
Bienvenue Basin 3	TOP	1.0	>	>
Bienvenue Basin 4	TOP	0.0	-	-
Bienvenue Basin 5	TOP	0.4	>	>
Sewage Plant	TOP	3.1	>	>
Murphy Oil Site	TOP	1.6	>	>
Pump 2 Sed 4	TOP	1.4	>	>
Pump 2 Sed 5	TOP	1.4	>	>
Pump 3 Sed 8	TOP	0.9	>	>
Pump 3 Sed 9	TOP	1.3	>	>
Pump 4 Sed 10	TOP	1.5	>	>
Pump 4 Sed 13	TOP	0.2	>	-
Pump 6 Sed 1	TOP	1.1	>	>
Pump 6 Sed 2	TOP	1.2	>	>
Sed 11	TOP	0.0	-	-
Sed 12	TOP	0.1	>	-
Sed 3	TOP	1.1	>	>
Mean		2.8		
Standard Deviation		7.1		
Median		1.1		
Bienvenue Basin 1	Bottom	11.8	>	>
Bienvenue Basin 2	Bottom	11.0	>	>
Bienvenue Basin 3	Bottom	0.1	>	-
Bienvenue Basin 4	Bottom	0.0	-	-
Bienvenue Basin 5	Bottom	0.1	>	-
Sewage Plant	Bottom	0.5	>	>
Murphy Oil Site	Bottom	0.8	>	>
Pump 2 Sed 4	Bottom	0.8	>	>
Pump 2 Sed 5	Bottom	2.5	>	>
Pump 3 Sed 8	Bottom	0.0	-	-
Pump 3 Sed 9	Bottom	0.3	>	-
Pump 4 Sed 10	Bottom	0.0	-	-
Pump 4 Sed 13	Bottom	0.0	-	-
Pump 6 Sed 1	Bottom	0.0	-	-
Pump 6 Sed 2	Bottom	0.0	-	-
Sed 11	Bottom	0.0	-	-
Sed 12	Bottom	0.0	-	-
Sed 3	Bottom	0.0	-	-
Mean		1.5		
Standard Deviation		3.6		
Median		0.0		

Table 5
Fecal indicator bacteria levels in Violet Marsh sediments

Table Plate count results from Top of Soil Core					
		Total	Fecal	Fecal	40 CFR 503
Sample		Coliforms	Coliforms	Streptococci	BioSolid Res Std FecColif
Location		CFU/gm	CFU/gm	CFU/gm	1000
Bienvenue Basin 1	TOP	17,000	< 1,000	<1,000	–
Bienvenue Basin 2	TOP	12,000	< 1,000	<1,000	–
Bienvenue Basin 3	TOP	<1000	< 1,000	<1,000	–
Bienvenue Basin 4	TOP	<1000	< 1,000	<1,000	–
Bienvenue Basin 5	TOP	3,000	< 1,000	<1,000	–
Sewage Plant	TOP	10,000	< 1,000	<1,000	–
Murphy Oil Site	TOP	1,600,000	630,000	100	>
Pump 2 Sed 4	TOP	57,000	14,000	<100	>
Pump 2 Sed 5	TOP	133,000	25,000	<100	>
Pump 3 Sed 8	TOP	84,000	5,000	<100	>
Pump 3 Sed 9	TOP	630,000	70,000	<100	>
Pump 4 Sed 10	TOP	77,000	10,000	<100	>
Pump 4 Sed 13	TOP	128,000	15,000	<100	>
Pump 6 Sed 1	TOP	30,000	8,000	<100	>
Pump 6 Sed 2	TOP	65,000	2,000	<100	>
Sed 11	TOP	33,000	3,000	<100	>
Sed 12	TOP	>200000	4,000	<1,000	>
Sed 3	TOP	2,100	3,000	<100	>
Mean		192,073	65,750		
Standard Deviation		419,233	178,681		
Median		57,000	9,000		

Table 6
Fecal Sterol levels in Violet Marsh sediments

Table X. Fecal sterol content of sediment from the tops and bottoms of cores.									
		A	B	C	D	Ratio	Ratio	Ratio	Ratio
Sample		coprostanol	epicoprostanol	cholesterol	cholestanol	A/D	B/A	A/C	A/A+D
Location		nmol/gm dw	nmol/gm dw	nmol/gm dw	nmol/gm dw				
Bienvenue Basin 1	Top	28.3	1.6	43.5	3.8	7.37	0.06	0.65	0.88
Bienvenue Basin 2	Top	28.5	41.4	355.2	41.0	0.70	1.45	0.08	0.41
Bienvenue Basin 3	Top	9.2	0.8	43.6	7.9	1.16	0.08	0.21	0.54
Bienvenue Basin 4	Top	9.1	2.6	42.7	5.0	1.81	0.29	0.21	0.64
Bienvenue Basin 5	Top	4.2	0.4	110.9	5.1	0.82	0.10	0.04	0.45
Sewage Plant	Top	27.3	18.1	29.2	6.5	4.20	0.66	0.93	0.81
Murphy Oil Site	Top	20.8	0.6	17.2	1.3	15.58	0.03	1.21	0.94
Pump 2 Sed 4	Top	3.0	3.7	67.7	3.8	0.79	1.24	0.04	0.44
Pump 2 Sed 5	Top	61.3	4.6	344.7	30.3	2.02	0.07	0.18	0.67
Pump 3 Sed 8	Top	20.6	1.8	145.8	10.0	2.06	0.09	0.14	0.67
Pump 3 Sed 9	Top	39.1	2.2	90.0	9.1	4.31	0.06	0.44	0.81
Pump 4 Sed 10	Top	28.1	2.0	32.4	5.9	4.72	0.07	0.87	0.83
Pump 4 Sed 13	Top	13.4	1.0	68.6	6.3	2.11	0.08	0.20	0.68
Pump 6 Sed 1	Top	22.0	1.7	117.4	10.5	2.09	0.08	0.19	0.68
Pump 6 Sed 2	Top	9.5	0.8	44.3	6.8	1.39	0.08	0.21	0.58
Sed 11	Top	21.5	6.0	90.3	7.0	3.06	0.28	0.24	0.75
Sed 12	Top	4.3	0.7	40.6	7.3	0.58	0.17	0.10	0.37
Sed 3	Top	14.3	1.1	67.5	11.0	1.31	0.07	0.21	0.57
Mean		20.2	5.1	97.3	9.9	3.1	0.3	0.3	0.7
Standard Deviation		14.4	10.0	98.0	9.8	3.6	0.4	0.3	0.2
Median		20.7	1.8	67.6	6.9	2.0	0.1	0.2	0.7
Bienvenue Basin 1	Bottom	61.2	2.5	80.2	6.5	9.38	0.04	0.76	0.90
Bienvenue Basin 2	Bottom	87.8	4.6	115.4	11.3	7.78	0.05	0.76	0.89
Bienvenue Basin 3	Bottom	3.4	0.5	23.4	3.0	1.15	0.14	0.15	0.53
Bienvenue Basin 4	Bottom	6.0	0.5	33.2	7.0	0.86	0.09	0.18	0.46
Bienvenue Basin 5	Bottom	3.4	0.5	22.0	5.0	0.68	0.14	0.15	0.40
Sewage Plant	Bottom	20.3	2.7	91.8	19.8	1.02	0.13	0.22	0.51
Murphy Oil Site	Bottom	23.9	1.2	15.3	4.6	5.18	0.05	1.56	0.84
Pump 2 Sed 4	Bottom	8.1	0.7	84.5	4.8	1.67	0.09	0.10	0.63
Pump 2 Sed 5	Bottom	32.8	3.2	99.2	19.1	1.72	0.10	0.33	0.63
Pump 3 Sed 8	Bottom	0.9	0.1	4.9	0.4	2.16	0.08	0.19	0.68
Pump 3 Sed 9	Bottom	12.6	0.5	20.3	5.1	2.50	0.04	0.62	0.71
Pump 4 Sed 10	Bottom	0.0	0.0	2.7	0.9	0.00	-	0.00	0.00
Pump 4 Sed 13	Bottom	0.0	0.0	2.1	0.4	0.00	-	0.00	0.00
Pump 6 Sed 1	Bottom	5.0	0.5	24.0	3.5	1.41	0.10	0.21	0.59
Pump 6 Sed 2	Bottom	8.0	1.1	56.5	10.0	0.79	0.13	0.14	0.44
Sed 11	Bottom	14.2	1.4	84.5	12.3	1.15	0.10	0.17	0.54
Sed 12	Bottom	6.0	1.3	55.6	9.8	0.61	0.22	0.11	0.38
Sed 3	Bottom	11.2	1.1	63.3	18.4	0.61	0.10	0.18	0.38
Mean		16.9	1.2	48.8	7.9	2.1	0.1	0.3	0.5
Standard Deviation		23.1	1.2	36.8	6.2	2.6	0.0	0.4	0.3
Median		8.0	0.9	44.4	5.8	1.2	0.1	0.2	0.5

Table 7
Comparison of Fecal Sterols in other Tropical Wetlands

Sample	A Coprostanol nmoles/gdw	B Epicoprostanol nmoles/gdw	C Cholesterol nmoles/gdw	D Cholestanol nmoles/gdw	A/D	B/A	A/C	A/A+D
Human feces[1]	8,824.29		746.08				11.83	
Barcelona S1[2]	1,003.34	12.86	205.81	41.16	24.38	0.01	4.88	0.96
Barcelona S2[2]	115.77	5.15	25.73	18.01	6.43	0.04	4.50	0.87
Barcelona S3[2]	87.47	3.86	23.15	10.29	8.50	0.04	3.78	0.89
Barcelona S4[2]	61.74	2.57	51.45	7.72	8.00	0.04	1.20	0.89
Barcelona S5[2]	38.59	1.29	30.87	7.72	5.00	0.03	1.25	0.83
Barcelona S7[2]	3.34	0.26	2.57	1.03	3.25	0.08	1.30	0.76
Barcelona S7[2]	2.57	0.21	1.29	0.64	4.00	0.08	2.00	0.80
Havana, Cuba S8[2]	2.83	0.26	8.23	1.75	1.62	0.09	0.34	0.62
Havana, Cuba S9[2]	1.05	0.10	2.57	1.41	0.75	0.10	0.41	0.43
Kirchmer criterion[3]	1.03							
Murtaugh criterion[4]	0.51							
Dutka criterion[5]	0.13							

[1]Nichols et al., 1996
[2]Grimalt et al., 1990
[3]Kirchmer, 1971
[4]Murtaugh and Bunch, 1967
[5]Dutka et al., 1974

Appendix A. LPBF data

Lake Pontchartrain Basin Foundation
Basin-Wide Water Quality Monitoring Program

LPBF Master Database 2005									
Site	Date	Water Temp °C	Diss Oxy mg/L	Spec Cond mS/cm	Salinity ppt	Turbidity NTU	pH	Fecal Coliform MPN/100 mL	Enterococci MPN/100 mL
1	1/4/2005	12.1	9.48	9.28	5.2	3.18	7.98	33	
2	1/4/2005	13	9.19	8.02	4.5	1.05	7.78	13	
3	1/4/2005	11.6	8.72	8.91	5	2.88	7.62	23	
4	1/4/2005	11.7	10.06	9.11	5.1	2.48	7.45	79	
5	1/4/2005	13.5	8.97	10.19	5.8	1.16	7.76		
6	1/4/2005	17.5	7.55	0.04	0	5.25	7.29	130	
7	1/4/2005	15.6	8.24	2.63	1.4	6.89	6.97	79	
8	1/4/2005	16.8	10.1	8.95	5	3.53	7.67	170	
9	1/4/2005	18.6	8.58	9.09	5.1	2.67	7.48	4.5	
10	1/4/2005	16.2	10.83	7.15	4	8.02	7.62	49	
1	1/11/2005	15.7	8.6	9.11	5.1	3.17	7.46	49	
2	1/11/2005	15.5	5.31	9.14	5.1	2.03	7.52	110	
3	1/11/2005	15.1	7.1	8.83	4.9	1.65	7.47	11	
4	1/11/2005	14.6	7.41	8.98	5	1.8	7.27	79	
5	1/11/2005	15	6.89	9.64	5.5	0.87	7.62		
6	1/11/2005	16	8.52	0.04	0	13.3	6.65	920	
7	1/11/2005	16.2	6.15	1.5	0.8	18.1	6.48	920	
8	1/11/2005	16.9	7.43	6.19	3.4	5.61	6.69	1600	
9	1/11/2005	17.3	8.97	9.12	5.1	2.95	7		
10	1/11/2005	17.7	9.74	9.27	5.2	6.01	7.44	49	
1	1/12/2005	15.8	7.76	9.37	5.3	1.5	7.46	49	
2	1/12/2005	15.4	6.28	9.37	5.3	2.08	7.12	33	
3	1/12/2005	15.5	7.12	9.17	5.2	2.54	7.11	33	
4	1/12/2005	15.2	6.87	9.28	5.2	1.75	7.09	70	
5	1/12/2005	16.3	7.09	9.71	5.5	0.91	7.45	23	
6	1/12/2005	17	7.9	0.04	0	12.4	6.76	540	
7	1/12/2005	16.7	6.37	1.26	0.6	16	6.26	920	
8	1/12/2005	17	8.57	8.24	4.6	4.68	6.73	920	
9	1/12/2005	18.2	8.18	9.09	5.1	12.9	6.88	79	
10	1/12/2005	18.2	9.36	9.26	5.2	4.21	7.54	350	
1	1/18/2005	9.6	10.13	8.45	4.7	52.5	7.61	240	75
2	1/18/2005	9.2	10.08	8.4	4.6	37	7.6	79	20
3	1/18/2005	10.4		9.34	5.2	28.6	7.59	49	10
4	1/18/2005	9.8		9.67	5.4	33.8	7.53	130	10
5	1/18/2005	6.2		9.42	5.2	24.5	7.66	70	42
6	1/18/2005	8.7				11.6	7.68	240	164
7	1/18/2005	11				22.7	6.6	1600	42
8	1/18/2005	10.1				4.63	6.82	130	75
9	1/18/2005	7.4				1.18	7.16	7.8	5
10	1/18/2005	6.8				4.67	7.48	33	5
1	1/25/2005	10	8.92	7.25	4	13.6	8.2	22	10

LPBF Master Database 2005									
Site	Date	Water Temp °C	Diss Oxy mg/L	Spec Cond mS/cm	Salinity ppt	Turbidity NTU	pH	Fecal Coliform MPN/100 mL	Enterococci MPN/100 mL
2	1/25/2005	10.3	7.48	8.43	4.7	16.9	7.83	46	10
3	1/25/2005	10.5	8.63	8.72	4.9	21.6	7.64	79	20
4	1/25/2005	10.6	8.79	10.17	5.8	6.82	7.6	13	5
5	1/25/2005	8	9.68	10.35	5.8	12.3	7.66	17	5
6	1/25/2005	9.3	9.9	0.04	0	6.3	7.6	27	137
7	1/25/2005	9.7	8.85	3.69	2	9.52	6.94	49	20
8	1/25/2005	9.9	9.37	8.23	4.6	5.65	7.05	170	10
9	1/25/2005	8.8	10.53	8.96	5	14.3	7.05	7.8	5
10	1/25/2005	10.1	10.18	9.18	5.1	33.5	7.29	130	5
1	2/1/2005	11.9	9.51	6.31	3.5	59.3	7.73	540	453
2	2/1/2005	12.1	9.67	5.45	2.9	56.7	7.78	350	1091
3	2/1/2005	12	9.75	7.12	3.9	25.8	7.64	540	1184
4	2/1/2005	11.9	9.9	7.5	4.2	17.9	7.46	540	738
5	2/1/2005	12	9.42	9.26	5.2	39.2	7.51	350	504
6	2/1/2005	12.1	9.19	0.05	0	19.6	7.6	1700	2100
7	2/1/2005								
8	2/1/2005	11.9	8.2	8.02	4.5	3.91	6.83	1600	1091
9	2/1/2005	11.9	9.8	9.24	5.2	2.06	6.88	21	5
10	2/1/2005	11.8	9.43	11.97	6.9	4.66	6.99	130	192
1	2/2/2005	12.5	9.73	5.02	2.7	58.4	7.68	1700	2100
2	2/2/2005	12.3	8.91	6.53	3.6	29.4	7.72	1600	2100
3	2/2/2005	12.1	9.48	7.35	4.1	24.4	7.51	350	207
4	2/2/2005	12	8.59	7.84	4.4	19	7.53	220	478
5	2/2/2005	12.4	8.95	10.04	5.7	3.48	7.48	49	178
6	2/2/2005	11.5	9.54	0.03	0	52.2	6.41	1700	2100
7	2/2/2005								
8	2/2/2005	12	8.51	3.6	1.9	22.6	6.34	1700	2100
9	2/2/2005	12.2	9.68	9.03	5.1	6.19	6.62	920	406
10	2/2/2005	12.4	9.28	14.09	8.2	8.01	6.85	23	75
1	2/15/2005	13.7	9.33	6.52	3.6	4.84	10.1	1600	254
2	2/15/2005	13.8	6.16	7.04	3.9	4.07	7.8	130	31
3	2/15/2005	13.5	8.68	6.15	3.4	2.72	8.02	49	5
4	2/15/2005	13.7	8.61	7.38	4.1	3.67	7.79	33	10
5	2/15/2005	14.6	6.17	7.41	4.1	1.54	8.24	17	10
6	2/15/2005	14.6	9.7	0.04	0	23.6	7.13	1700	2100
7	2/15/2005	15	7.78	1.62	0.8	13.2	6.53	79	75
8	2/15/2005	14.8	8.49	7.15	4	14.8	6.63	1600	2100
9	2/15/2005	15.3	9.86	8.71	4.9	5.38		4.5	5
10	2/15/2005	15.5	10.17	8.26	4.6	5.63	6.97	110	10
1	2/22/2005	17.5	7.24	5.86	3.2	4.34	7.67	4.5	5
2	2/22/2005	16.7	6.74	7.24	4	2.31	7.38	46	31
3	2/22/2005	16.6	6.48	6.78	3.7	2.68	7.46	130	5
4	2/22/2005	17	5.79	7.35	4.1	3.2	7.48	31	5
5	2/22/2005	18.9	4.48	9.04	5.1	1.19	7.66	7.8	31
6	2/22/2005	18	7.93	0.04	0	6.71	7.2	220	75
7	2/22/2005	17.6	7.63	1.97	1	13.3	6.43	49	20

LPBF Master Database 2005									
Site	Date	Water Temp °C	Diss Oxy mg/L	Spec Cond mS/cm	Salinity ppt	Turbidity NTU	pH	Fecal Coliform MPN/100 mL	Enterococci MPN/100 mL
8	2/22/2005	17.9	7.73	6.89	3.8	7.81	6.64	350	53
9	2/22/2005	19.2	8.06	8.79	4.9	15.4	6.8	4.5	5
10	2/22/2005	17.9	9.12	8.57	4.8	3.45	6.95	33	5
1	2/23/2005	16.2	6.72	6.17	3.4	3.17	10.1	23	10
2	2/23/2005	17.2	6.64	7	3.9	3.46	7.78	49	99
3	2/23/2005	16.9	5.95	7.12	3.9	2.26	7.51	79	64
4	2/23/2005	16.8	5.76	7.12	3.9	3.16	7.16	13	5
5	2/23/2005	17.5	4.34	8.24	4.6	1.22	7.1	1	5
6	2/23/2005	18.9	7.84	0.04	0	8.63	7.04	110	150
7	2/23/2005	18.9	7.45	1.62	0.8	11.9	6.44	17	20
8	2/23/2005	18.7	8.23	8.36	4.7	6.81	6.66	140	20
9	2/23/2005	18.7	8.62	8.65	4.8	3.41	6.86	7.8	5
10	2/23/2005	19.1	8.58	8.53	4.8		6.96	140	31
1	3/1/2005	14.5	9.06	5.69	3.1	26.6	7.66	350	42
2	3/1/2005	14.1	9.5	6.22	3.4	24.3	7.65	280	53
3	3/1/2005	14.1	10.76	6.66	3.9	29.2	7.62	350	53
4	3/1/2005	14.5	9.25	7.21	4.1	30.8	7.48	280	31
5	3/1/2005	13.2	10.22	8.05	4.5	25	7.8	79	10
6	3/1/2005								
7	3/1/2005	14.4	6.93	1.88	1	14.3	7.7	49	87
8	3/1/2005	14.2	6.49	4.15	2.2	20.9	6.88	350	207
9	3/1/2005	11.9	10.17	7.12	3.9	28.1	6.96	49	53
10	3/1/2005	14.6	9.49	7.74	4.3	29.1	7.14	49	31
1	3/8/2005	15.3	9.37	6.29	3.5	46.9	7.55	110	99
2	3/8/2005	14.6	9.04	7.95	4.4	49.4	7.71	920	560
3	3/8/2005	15.2	9.9	8.61	4.8	45.2	7.7	1700	207
4	3/8/2005	15	9.86	8.51	4.6	47.4	7.69	1700	99
5	3/8/2005	14.5	8.96	9.63	5.4	25.2	7.89	130	87
6	3/8/2005	15	8.44	0.4	0	11	8	140	406
7	3/8/2005	15.3	7.85	3.04	1.6	12.2	7.31	49	10
8	3/8/2005	15.5	8.35	6.09	3.3	9.9	7.17	79	10
9	3/8/2005	14.2	9.63	6.64	3.7	32.5	7.27	49	31
10	3/8/2005	16	8.71	7.7	4.3	47.3	7.32	140	75
1	3/15/2005	16.7	8.75	5.33	2.9	50.2	7.73	79	64
2	3/15/2005	15.9	9.13	6.3	3.5	29.7	7.62	240	20
3	3/15/2005	16.5	9.45	6.37	3.6	29.6	7.75	33	42
4	3/15/2005	15.8	8.06	6.72	3.7	18.7	7.64	33	42
5	3/15/2005	15.1	5.05	9.47	5.3	26.9	7.71	130	64
6	3/15/2005	15.7	7.84	0.04	0	5.15	8.07	49	99
7	3/15/2005	16.6	7.88	3.5	1.8	7.91	7.19	6.8	10
8	3/15/2005	16.6	7.77	5.8	3.2	5.29	7.13	33	5
9	3/15/2005	15.5	8.43	6.32	3.5	4.12	7.32	7.8	5
10	3/15/2005	15.4	9.09	8	4.5	18.7	7.62	7.8	10
1	3/22/2005	16.7	8.61	5.71	3.1	16.1	7.73	11	31
2	3/22/2005	16.5	8.03	6.28	3.5	5.67	7.68	23	5
3	3/22/2005	15.9	7.4	7	3.9	5.1	7.58	7.8	10

LPBF Master Database 2005									
Site	Date	Water Temp °C	Diss Oxy mg/L	Spec Cond mS/cm	Salinity ppt	Turbidity NTU	pH	Fecal Coliform MPN/100 mL	Enterococci MPN/100 mL
4	3/22/2005	15.8	7.4	8.2	4.6	4.99	7.45	46	10
5	3/22/2005	17	7.13	10.01	5.7	2.01	7.56	70	5
6	3/22/2005	17.4	8.14	0.04	0	51.6	7.57	49	87
7	3/22/2005	17.6	7.95	2.82	1.5	11.2	6.81	49	20
8	3/22/2005	17.6	8.46	5.99	3.3	14	6.75	240	53
9	3/22/2005	18.9	8.21	6.31	3.4	15.1	6.82	49	31
10	3/22/2005	17.5	9.26	5.94	3.2	5.97	7.1	130	10
1	3/29/2005	18.3	5.14	5.25	2.8	15.9	7.92	33	20
2	3/29/2005	17.9	7.98	5.96	3.3	10.7	7.58	49	5
3	3/29/2005	18.2	9.55	6.11	3.3	13.1	7.91	49	5
4	3/29/2005	18.2	6.91	6.58	3.6	15.5	7.68	110	31
5	3/29/2005	18.5	9.47	7.47	4.1	12.8	7.6	23	5
6	3/29/2005	15.8	7.45	0.04	0	6.07	7.79	350	254
7	3/29/2005	18.9	5.75	3	1.6	8.98	6.86	7.8	10
8	3/29/2005	19.3	6.27	5.95	3.2	9.19	6.86	33	42
9	3/29/2005	17.6	8.36	6.76	3.7	21.2	7.13	11	10
10	3/29/2005	20.4	9.52	6.4	3.5	21.5	8.2	130	10
1	4/5/2005	19.2				10.1	7.45	130	5
2	4/5/2005	18.8				9.25	7.44	23	5
3	4/5/2005	18.9				12.5	7.3	33	453
4	4/5/2005	18.8				6.45	7.48	350	64
5	4/5/2005	19.2				4.37	7.32	33	20
6	4/5/2005	17.4	6.96	0.04	0	14.8	7.4	920	150
7	4/5/2005	19.2	5.84	1.85	0.9	9.79	6.72	110	10
8	4/5/2005	19.4	5.68		2.8	11.6	6.71	49	87
9	4/5/2005	19	7.18	6.59	3.6	49.6	7.01	33	5
10	4/5/2005	20.5	7.51	5.54	3	33.6	7.49	240	42
1	4/11/2005	21.3	7.58	4.62	2.5	23	7.68	49	10
2	4/11/2005	20.9	7.55	5.3	2.9	5.92	7.47	49	5
3	4/11/2005	20.7	7.42	5.71	3.1	7.28	7.39	79	271
4	4/11/2005	20.6	7.33	5.96	3.2	6.51	7.22	79	20
5	4/11/2005	20.8	8.06	7.59	4.2	2.34	7.55	22	10
6	4/11/2005	19.8	7.62	0.04	0	7.99	7.41	130	238
7	4/11/2005	21.1	7.12	2.74	1.4	10.8	6.65	49	5
8	4/11/2005	21.7	7.34	6.49	3.6	10.2	6.84	110	42
9	4/11/2005	21	8.1	6.68	3.7	19.4	7.06	49	20
10	4/11/2005	21.2	8.42	3.06	1.6	35	7.05	240	87
1	4/12/2005	21.1	7.06	4.1	2.2	49.1	7.58	1700	2100
2	4/12/2005	20.5	7.63	5.22	2.8	15.4	7.41	1700	2100
3	4/12/2005	20.4	8.51	5.25	2.8	23.1	7.5	1700	2100
4	4/12/2005	20	7.77	4.24	2.3	31.7	7.28	1700	2100
5	4/12/2005	20.2	7.98	5.18	2.8	40.9	7.55	1700	2100
6	4/12/2005	18.7	7.28	0.03	0	96.1	7.23	1700	2100
7	4/12/2005	21	5.8	4.17	2.2	14.5	6.45	220	406
8	4/12/2005	21.8	4.7	5.15	2.8	9.47	6.42	1600	1652
9	4/12/2005	21.1	7.64	5.75	3.1	32.1	6.96	130	164

LPBF Master Database 2005									
Site	**Date**	**Water Temp °C**	**Diss Oxy mg/L**	**Spec Cond mS/cm**	**Salinity ppt**	**Turbidity NTU**	**pH**	**Fecal Coliform MPN/100 mL**	**Enterococci MPN/100 mL**
10	4/12/2005	21.1	7.82	3.1	1.6	34.9	6.91	240	738
1	4/19/2005	21.3	8.48	6.06	3.3	5.36	7.56	13	31
2	4/19/2005	20.7	8.08	6.4	3.5	3.86	7.26	23	31
3	4/19/2005	20.7	8.39	7.23	4	7.79	7.4	23	20
4	4/19/2005	20.7	7.85	7.63	4.2	5.75	7.15	49	10
5	4/19/2005	20.9	8.38	7.49	4.1	3.07	7.76	13	5
6	4/19/2005	18.1	7.67	0.04	0	8.65	7.68	130	178
7	4/19/2005	20.5	5.2	0.59	0.3	19.2	6.65	46	20
8	4/19/2005	21.6	7.09	6.07	3.3	6.91	6.73	70	10
9	4/19/2005	20.6	7.74	6.32	3.5	23	7.11	13	5
10	4/19/2005	22	8.59	5.66	3.1	15.8	7.87	110	5
1	4/26/2005	20.1	8.79	5.97	3.3	21.8	7.7	70	53
2	4/26/2005	20	8.07	6.65	3.6	15.1	7.46	23	5
3	4/26/2005	20.5	7.91	6.92	3.8	9.42	7.36	13	5
4	4/26/2005	20.6	7.23	6.97	3.8	7.3	7.24	33	31
5	4/26/2005	19.9	8.46	8.03	4.5	4.09	8.03	45	5
6	4/26/2005	16.7	7.65	0.05	0	11.9	8.25	1600	1445
7	4/26/2005	20.2	6.73	2.83	1.5	10.8	6.94	23	31
8	4/26/2005	21	6.68	5.76	3.1	9.11	6.9	170	75
9	4/26/2005	18.9	7.9	5.83	3.2	44.8	7.04	240	99
10	4/26/2005	20.6	7.68	4.16	2.2	37.4	7.04	49	124
1	5/3/2005	21.2	7.51	6.41	3.5	76.5	7.52	350	75
2	5/3/2005	19.8	8.15	7.02	3.9	68.1	7.4	350	150
3	5/3/2005	20.4	8.07	9.15	5.1	21.3	7.53	110	87
4	5/3/2005	20.3	8.01	9.57	5.4	21.1	7.53	79	10
5	5/3/2005	19.4	7.39	7.01	3.9	28.8	7.83	49	42
6	5/3/2005	17.7	7.37	0.04	0	11	7.98	1600	150
7	5/3/2005	20	5.12	0.64	0.3	15	7.45	140	111
8	5/3/2005	20.2	5.89	4.16	2.2	10.1	7.36	240	111
9	5/3/2005	20.1	7.69	5.57	3	2.53	7.34	17	23
10	5/3/2005	20.9	8.25	3.97	2.1	9.5	7.61	33	20
1	5/10/2005	22.4	6.41	6.85	3.8	3.87	7.53	7.8	5
2	5/10/2005	22.6	6.76	7.71	4.3	2.74	7.48	2	5
3	5/10/2005	22.6	6.38	7.66	4.2	4.95	7.95	13	5
4	5/10/2005	22.8	6.11	8.5	4.7	3.14	7.53	4.5	5
5	5/10/2005	22.2	6.26	8.72	4.9	2.1	8.46	2	5
6	5/10/2005	20.1	7.17	0.05	0	7.89	7.91	1600	192
7	5/10/2005	22.3	4.79	1.12	0.6	9.85	6.85	21	111
8	5/10/2005	23.2	6.77	5.59	3	5.12	6.96	23	531
9	5/10/2005	23.2	7.7	6.08	3.3	3.91	7.18	2	5
10	5/10/2005	24.2	7.99	6.01	3.3	7.02	7.35	49	5
1	5/17/2005	24.8	5.78	7.4	4.1	9.68	7.22	7.8	20
2	5/17/2005	24.3	5.75	7.66	4.2	19.1	6.93	130	5
3	5/17/2005	24.3	6.72	7.46	4.1	7.4	7.1	1700	2100
4	5/17/2005	24.4	5.87	7.49	4.1	12.6	7.04	33	31
5	5/17/2005	24.8	6.09	9.17	5.1	11.6	7.31	11	10

LPBF Master Database 2005									
Site	Date	Water Temp °C	Diss Oxy mg/L	Spec Cond mS/cm	Salinity ppt	Turbidity NTU	pH	Fecal Coliform MPN/100 mL	Enterococci MPN/100 mL
6	5/17/2005	21.8	6.46	0.04	0	5.43	7.97	130	124
7	5/17/2005	24.6	5.5	2.46	1.3	8.12	6.98	33	42
8	5/17/2005	25.7	6.62	6.53	3.6	3.81	7.04	33	5
9	5/17/2005	25.3	6.9	6.98	3.8	3.07	7.27	1	5
10	5/17/2005	26.1	7.05	6.28	3.4	8.2	7.39	11	10
1	5/24/2005	28.9	4.44	7.57	4.2	4.35	7.03	33	10
2	5/24/2005	28.6	5.15	8.01	4.4	4.97	7.1	4.5	10
3	5/24/2005	28.7	6.88	7.98	4.6	14.2	7.35	4.5	20
4	5/24/2005	28.3	6.21	8.39	4.6	15.2	7.29	140	406
5	5/24/2005	27.4	7.27	8.88	4.7	16.9	7.68	17	87
6	5/24/2005	25.3	6.15	0.05	0	6.49	7.06	49	222
7	5/24/2005	29.4	5.38	6.16	3.3	4.6	6.88	4.5	10
8	5/24/2005	28.6	5.39	2.52	1.3	14.2	6.78	17	5
9	5/24/2005	27.1	7.75	6.18	3.4	23.8	7.2	11	10
10	5/24/2005	28.4	6.73	6.71	3.6	94.7	7.09	26	254
1	5/31/2005	26.8	5.92	7.48	4.1	10.8	7.51	1600	178
2	5/31/2005	26.6	5.9	8.47	4.7	5.14	7.26	540	64
3	5/31/2005	26.8	6.33	8.66	4.8	3.45	7.15	350	324
4	5/31/2005	26.7	5.59	8.64	4.8	2.97	7.02	540	99
5	5/31/2005	25.7	6.09	9.14	5.1	4.82	7.29	23	164
6	5/31/2005	21.5	6.6	0.03	0	42.1	6.29	1600	2100
7	5/31/2005	24.7	3.87	1.16	0.6	10.8	6.26	920	1298
8	5/31/2005	23.6	4.47	1.67	0.8	14.2	6.16	1700	2100
9	5/31/2005	25.2	6.88	5.16	2.8	6.94	6.39	540	53
10	5/31/2005	25.5	6.78	7.24	4	13.6	6.62	170	164
1	6/7/2005	27.6	5.23	6.74	3.7	4.88	7.26	920	324
2	6/7/2005	27.2	5.51	7.36	4	2.45	7.12	1600	324
3	6/7/2005	27.5	5.46	8.6	4.8	2.24	7.16	140	254
4	6/7/2005	27.4	5.25	8.52	4.7	2.36	7.07	350	137
5	6/7/2005	26.8	5.77	9.47	5.3	4.87	7.64	1	10
6	6/7/2005	23.5	6.43	0.05	0	9.26	7.22	130	137
7	6/7/2005	27.2	3.52	2.59	1.3	6.49	6.01	79	64
8	6/7/2005	27.9	3.74	4.83	2.6	4.37	6.02	170	150
9	6/7/2005	27.6	6.68	6.15	3.3	7.55	6.48	7.8	5
10	6/7/2005	28.1	6.73	6.96	3.8	5.86	6.7	13	10
1	6/14/2005	29.2	5.45	7.38	4	4.15	7.49	13	5
2	6/14/2005	29.3	4.93	8.28	4.6	3.14	7.18	13	20
3	6/14/2005	29.6	6.09	9.19	5.1	2.94	7.72	1	5
4	6/14/2005	29.5	6.3	9.41	5.2	3.24	7.68	6.8	5
5	6/14/2005	28.2	4.37	9.63	5.4	2.9	7.34	2	20
6	6/14/2005	27.1	6.31	0.05	0	6.76	7.09	130	64
7	6/14/2005	29.8	4.33	2.82	1.4	6.12	6.6	13	10
8	6/14/2005	30.2	4.23	4.97	2.6	3.97	6.53	23	75
9	6/14/2005	30.4	6.33	6.07	3.3		6.86	33	10
10	6/14/2005	30.4	6.96	7.42	4.1	7.95	7.18	7.8	5
1	6/15/2005	29.9	5.25	7.45	4.1	3.2	7.11	4.5	5

LPBF Master Database 2005									
Site	Date	Water Temp °C	Diss Oxy mg/L	Spec Cond mS/cm	Salinity ppt	Turbidity NTU	pH	Fecal Coliform MPN/100 mL	Enterococci MPN/100 mL
2	6/15/2005	29.4	4.85	8.59	4.8	2.79	6.97	9.3	5
3	6/15/2005	29.4	6.67	9.37	5.2	3.35	7.1	240	31
4	6/15/2005	29.2	5.72	9.63	5.4	3.79	7.23	23	5
5	6/15/2005	29.3	6.07	9.47	5.3	7.93	7.36	49	31
6	6/15/2005	27.2	5.91	0.05	0	5.58	7.14	540	53
7	6/15/2005	30	3.57	2.15	1.1	5.58	5.06	79	75
8	6/15/2005	30.8	4.7	4.96	2.6	6.02	5.13	46	42
9	6/15/2005	30	6.44	5.83	3.1	32.4	5.28	49	64
10	6/15/2005	30.1	6.03	7.57	4.1	24	5.3	23	10
1	6/21/2005	29.1	4.86	7.98	4.4	5.58	6.78	23	10
2	6/21/2005	29.3	5.66	9.14	5.1	5.68	7.11	4	5
3	6/21/2005	29.1	5.35	9.88	5.5	2.25	7.05	130	5
4	6/21/2005	29.5	6.73	9.95	5.6	3.35	7.41	4.5	10
5	6/21/2005	28.2	6.25	10.07	5.6	3.5	7.63	2	5
6	6/21/2005	25	5.8	0.05	0	8.3	6.57	130	150
7	6/21/2005	28.7	3.78	1.59	0.8	5.57	6.71	79	20
8	6/21/2005	29.2	4.88	4.12	2.2	4.22	6.86	33	5
9	6/21/2005	29.1	6.24	4.46	2.4	1.86	6.89	4	5
10	6/21/2005	29.5	6.53	7.43	4.1	3.45	6.88	23	5
1	6/28/2005	30.9	4.78	58.5	4.7	1.84	6.59	4.5	5
2	6/28/2005	30.3	4.56	9.17	5.1	2.45	6.6	70	5
3	6/28/2005	30.2	4.54	9.77	5.5	2.27	6.97	33	5
4	6/28/2005	30.1	4.16	9.76	5.4	2.39	6.96	33	5
5	6/28/2005	28.6	5.75	9.66	5.4	6.65	7.34	7.8	10
6	6/28/2005	26.3	6.67	0.05	0	8.02		110	99
7	6/28/2005	29.9	5.19	2.66	1.4	4.92		7.8	5
8	6/28/2005	30.3	4.99	4.4	2.3	5.54		4.5	10
9	6/28/2005	29.9	5.91	4.68	2.5	3.19		4.5	5
10	6/28/2005	29.3	6.53	8.03	4.4	4.21		13	5
1	7/5/2005	30	5.23	9.22	4.7	2.02		23	20
2	7/5/2005	29.2	4.1	10.16	5.2	1.95		13	20
3	7/5/2005	29.2	5	9.54	5.3	2.93		23	5
4	7/5/2005	29.5	4.19	9.74	5.4	2.12		33	31
5	7/5/2005	29.2	5.55	10.06	5.6	5.38		6.1	5
6	7/5/2005	27	6.12	0.05	0	7.51	7.33	350	238
7	7/5/2005	29.2	4.62	2.12	1.1	7.25	6.65	11	10
8	7/5/2005								
9	7/5/2005	28.1						79	20
10	7/5/2005	28.5	7.32	7.95	4.4	39.6	7.43	130	42
1	7/12/2005	27.7	4.18	9.53	5.3	11	6.96	22	20
2	7/12/2005	28	3.87	11.88	6.7	11.5	7.09	79	20
3	7/12/2005	28.4	5.02	10.02	5.6	7.36	7.58	14	10
4	7/12/2005	27.7	5.18	9.7	5.4	9.17	7.22	4.5	5
5	7/12/2005	28.4	3.75	9.19	5.1	7.49	7.06	2	10
6	7/12/2005	26.3	5.86	0.04	0	7.54	6.55	110	164
7	7/12/2005	28.1	4.13	0.98	0.5	8.56	6.51	13	20

LPBF Master Database 2005									
Site	Date	Water Temp °C	Diss Oxy mg/L	Spec Cond mS/cm	Salinity ppt	Turbidity NTU	pH	Fecal Coliform MPN/100 mL	Enterococci MPN/100 mL
8	7/12/2005	28.2	3.7	2.73	1.4	7.83	6.07	79	53
9	7/12/2005	28.8	6.7	4.45	2.4	35	6.37	33	20
10	7/12/2005	29.5	6.67	5.87	3.2	8.31	6.88	23	10
1	7/20/2005	29.8	6.2	9.32	5.2	12.8	6.88	4.5	31
2	7/20/2005	29.4	5.95	9.59	5.3	6.15	6.86	17	5
3	7/20/2005	29.5	5.7	9.36	5.2	2.75	6.92	79	5
4	7/20/2005	29.3	5.96	9.3	5.2	2.74	6.95	6.8	10
5	7/20/2005	29.4	6.1	8.59	4.8	4.04	7.27	7.8	5
6	7/18/2005	26	6.47	0.04	0	0	6.64	170	222
7	7/18/2005	28.9	3.46	0.58	0.3	11	6.51	49	42
8	7/18/2005	30	4.33	3.22	1.7	6.04	6.35	33	64
9	7/18/2005	30	6.83	4.13	2.2	13	6.9	33	31
10	7/18/2005	30.1	7.02	6.45	3.5	6.41	7.31	33	10
1	7/19/2005	29.8	5.52	9.46	5.3	13.9	6.91	46	42
2	7/19/2005	5.52	4.9	9.44	5.3	7.82	6.77	7.8	5
3	7/19/2005	4.9	5.46	9.19	5.1	3.29	6.89	33	20
4	7/19/2005	28.9	5.66	9	5	4.33	6.85	23	10
5	7/19/2005	28.9	6.64	8.37	4.6	15.5	7.07	13	5
6	7/19/2005	26	6.35	0.04	0	10.1	6.64	280	99
7	7/19/2005	29.1	3.5	0.75	0.04	10	6.44	23	31
8	7/19/2005	30.4	4.35	3.28	1.7	5.61	6.35	33	20
9	7/19/2005	30.3	6.77	4.58	2.4	2.67	6.34	1	5
10	7/19/2005	30.2	7.09	6.9	3.8	5.03	7.33	14	10
1	7/26/2005	32.4	3.35	9.18	5.1	6.23	6.71	70	20
2	7/26/2005	31.9	3.57	9.6	5.3	3.01	7.08	17	10
3	7/26/2005	31.4	5.01	9.5	5.3	2.34	7.35	1	5
4	7/26/2005	31.4	3.98	9.43	5.2	2.76	6.85	4.5	10
5	7/26/2005	30.3	3.77	8.62	4.8	1.61	7.08	2	10
6	7/26/2005	27.5	5.84	0.05	0	8.67	6.97	240	164
7	7/26/2005	30.6	1.73	1.22	0.6	9.3	6.34	13	10
8	7/26/2005	31.3	3.91	3.43	1.8	6.68	6.33	31	42
9	7/26/2005	31.4	6.1	4.37	2.3	2.74	6.21	1	5
10	7/26/2005	31.6	5.58	6.75	3.7	3.66	6.91	2	10
1	8/2/2005	31.5	5.25	8.43	4.6	11.7	6.67	79	344
2	8/2/2005	30.3	5.73	8.83	4.9	8.85	6.95	350	659
3	8/2/2005	30.2	5.89	8.62	4.8	15.8	7.08	1700	1091
4	8/2/2005	30.5	4.78	8.88	4.8	17.9	7.01	1700	2005
5	8/2/2005	28.8	4.85	9.2	5.1	7.51	6.97	79	42
6	8/2/2005	25	6.56	0.04	0	21.6	6.89	1600	1184
7	8/2/2005	29.4	2.07	1.15	0.6	9.11	6.22	49	64
8	8/2/2005	29.5	3.25	3.41	1.8	9.58	6	49	75
9	8/2/2005	28.4	6.53	4.27	2.3	13.8	6.29	110	10
10	8/2/2005	29	5.9	6.34	3.4	8.31	6.68	33	137
1	8/9/2005	31.8	5.66	5.81	3.1	9.42	6.53	33	31
2	8/9/2005	31.7	5.65	7.22	3.9	4.72	5.86	13	5
3	8/9/2005	31.5	6.55	8.1	4.4	4.66	6.51	14	10

LPBF Master Database 2005									
Site	**Date**	**Water Temp °C**	**Diss Oxy mg/L**	**Spec Cond mS/cm**	**Salinity ppt**	**Turbidity NTU**	**pH**	**Fecal Coliform MPN/100 mL**	**Enterococci MPN/100 mL**
4	8/9/2005	31.1	5.64	8.27	4.5	8.13	6.51	33	5
5	8/9/2005	29.4	6.24	10.12	5.7	14.3	7.5	4.5	5
6	8/9/2005	25.5	5.62	0.05	0	11.1	7.13	240	271
7	8/9/2005	28.6	3.03	0.65	0.3	9.6	6.47	17	31
8	8/9/2005	29	2.9	3.49	1.8	7.08	6.14	79	20
9	8/9/2005	29.2	6	4.8	2.6	7.66	6.4	7.8	5
10	8/9/2005	29.6	5.49	5.95	3.2	8.27	6.87	11	20
1	8/16/2005	30.9	5.23	5.91	3.2	15.9	6.38	130	31
2	8/16/2005	30.6	5.08	6.94	3.8	10.3	6.34	13	10
3	8/16/2005	30.6	5.61	6.39	3.4	5.82	6.75	23	5
4	8/16/2005	31	5.35	7.33	4	4.88	6.5	49	20
5	8/16/2005	30.8	4.8	8.67	4.8	2.6	7.01	2	5
6	8/16/2005	26.7	6.44	0.05	0	11.1	7.42	130	87
7	8/16/2005	30.2	3.81	2.35	1.2	6.28	6.34	4.5	10
8	8/16/2005	31.1	3.45	6.29	3.4	15.8	6.21	79	10
9	8/16/2005	30.5	6.96	7.04	3.8	4.61	6.51	2	5
10	8/16/2005	31.2	7.45	6.73	3.6	4.77	7.1	23	10
1	8/23/2005	31.8	4.92	6.82	3.7	17.4	6.59	140	150
2	8/23/2005	32	4.92	8.93	4.9	10.5	6.63	33	20
3	8/23/2005	32	5.21	9.74	5.4	6.78	7.02	23	10
4	8/23/2005	31.5	4.35	9.91	5.5	4.47	6.98	7.8	10
5	8/23/2005	30.6	5.13	9.41	5.2	7.49	7.54	13	5
6	8/23/2005	26.5	5.97	0.04	0	12.3	7.13	350	192
7	8/23/2005	31	4.79	3.62	1.9	4.97	6.39	7.8	20
8	8/23/2005	31.5	3.11	6.27	3.4	8.87	6.16	33	53
9	8/23/2005	30.5	6.25	6.73	3.7	4.2	6.26	2	5
10	8/23/2005	31.1	6.29	7.54	4.1	4.77	6.94	13	20
1	9/27/2005								
2	9/27/2005								
3	9/27/2005								
4	9/27/2005								
5	9/27/2005								
6	9/27/2005	28.9	4.45	0.05	0	7.43	6.48	130	104
7	9/27/2005	31.9	1.54	4.64	2.5	14.9	6.33	230	184
8	9/27/2005	30	3.99	9.64	5.4	11.8	6.88	80	80
9	9/27/2005								
10	9/27/2005	29.5	5.49	17.73	10.4	7.7	7.21	0	0
1	10/4/2005	27		12.42	7.1	62.3		13	30
2	10/4/2005	26.8	6.21	12.34	7	105		300	200
3	10/4/2005	27.5	6.6	12.7	7.2	20.3		30	30
4	10/4/2005	27.4	5.26	12.65	7.2	8.2		50	5
5									
11	10/4/2005	27.8	5.56	11.98	6.8	21		50	130
6	10/4/2005	25.3	5.67	0.05	0	7.01	6.85	230	30
7	10/4/2005	27.7	2.56	4.26	2.3	7.19	6.68	80	30
8	10/4/2005	28.1	6	10.65	6	7.65	7.01	80	200

LPBF Master Database 2005									
Site	**Date**	**Water Temp °C**	**Diss Oxy mg/L**	**Spec Cond mS/cm**	**Salinity ppt**	**Turbidity NTU**	**pH**	**Fecal Coliform MPN/100 mL**	**Enterococci MPN/100 mL**
9	10/4/2005								
10	10/4/2005	28.4	7.55	14.75	8.5		7.59	23	100
1	10/11/2005	23.8	6.19	10.77	6.1	44.2		50	6
2	10/11/2005	24.1	6.45	10.13	5.7	45.3		23	18
3	10/11/2005	24.7	7.86	11.03	6.3	14.1		7	1
4	10/11/2005	24.5	7.35	11.57	6.6	12.9		4	2
5									
11	10/11/2005	24.4	4.4	12.1	6.9	5.53		17	112
6	10/11/2005	21.6	6.66	0.05	0		7.63	170	110
7	10/11/2005	24.2	3.91	6.19	3.4		6.69	13	20
1	10/4/2005	27		12.42	7.1	62.3		13	30
8	10/11/2005	24.5	6.83	12.81	7.4		7.07	8	8
9	10/11/2005								
10	10/11/2005	24.9	8.03	13.09	7.5		7.54	4	1
1	10/18/2005	23.5	6.47	10.8	6.1	30.3		30	8
2	10/18/2005	23.3	7.09	12.1	6.9	12.8		11	2
3	10/18/2005	24.5	6.69	13.7	7.9	8.17		1	1
4	10/18/2005	23.6	3.92	12.16	7	3.04		2	2
5									
11	10/18/2005	24.6	6.3	14.47	8.4	5.01		17	4
6	10/18/2005	19.7	6.96	0.05	0	7.23	7.85	50	28
7	10/18/2005	23.9	7.46	7.19	4	6.07	7.04	8	6
8	10/18/2005	24.1	5.71	11.78	6.7	8.75	7.06	1	14
9	10/18/2005								
10	10/18/2005	24.6	8.01	13.17	7.6	11.6	7.76	1	4
1	10/25/2005	16.4	8.31	9.97	5.6	50		70	36
2	10/25/2005	17.3	7.88	12.28	7.1	70.9		8	1
3	10/25/2005	17.1	8.74	12.94	7.5	35.9		500	150
4	10/25/2005	18.5	7.62	13.3	7.7	17.5		170	54
5									
11	10/25/2005		6.54	12.45	7.2	3.02		50	1
6	10/25/2005	15.4	7.96	0.05	0	6.03		230	52
7	10/25/2005	14.2	4.53	5.6	3	15.8		510	50
8	10/25/2005	19.6	7.18	10.94	6.2	7.14		300	8
9	10/25/2005								
10	10/25/2005	19	8.79	13.88	8.1	65		30	8
1	11/1/2005	18.4	8.37	12.47	7.2	27.6		80	2
2	11/1/2005	18.6	8.38	14.71	8.6	7.25		7	4
3	11/1/2005	18.5	8.47	15	8.8	11.3		13	0
4	11/1/2005	18.3	7.95	15.13	8.8	6.82		23	26
5									
11	11/1/2005	18.8	7.13	14.04	8.2	3.97		230	28
6	11/1/2005	16.9	7.98	0.05	0	5.6		300	32
7	11/1/2005	18.7	7.65	7.77	4.3	7.25		50	10
8	11/1/2005	18.8	7.99	9.47	5.3	5.13			
9	11/1/2005								

LPBF Master Database 2005									
Site	Date	Water Temp °C	Diss Oxy mg/L	Spec Cond mS/cm	Salinity ppt	Turbidity NTU	pH	Fecal Coliform MPN/100 mL	Enterococci MPN/100 mL
10	11/1/2005	18.9	8.19	13.99	8.1	14.7			
1	11/8/2005	20.3	6.57	11.99	6.9	3.85		30	36
2	11/8/2005	20.8	6.26	11.28	7	4.78		500	30
3	11/8/2005	20.1		12.43	7.1	2.54		14	10
4	11/8/2005	20.4	7.59	12.33	7.1	2.29		4	8
5									
11	11/8/2005	23.3	5.6	14.14	8.2	7.38		80	66
6	11/8/2005	21	6.93	0.06	0	5.25		500	32
7	11/8/2005	21.9	9.63	6.85	4.1	6.36		130	4
8	11/8/2005	21.2	8.11	9.75	5.5	6.4		50	10
9	11/8/2005								
10	11/8/2005	23.1	8.69	14.41	8.4	4.62		9	4
1	11/15/2005	21.4	6.05	11.75	6.7	4.03		50	16
2	11/15/2005	20.5	6.41	13.09	7.6	4.05		80	16
3	11/15/2005	20.7	7.37	14.67	8.5	4.1		11	8
4	11/15/2005	20.4	5.7	14.36	8.3	3.09		0	4
5	11/15/2005	23.1	3.15	13.33	7.7	3.88		500	500
6	11/15/2005	20.9	7.87	0.05	0			1600	72
7	11/15/2005	21.8	8.43	8.52	4.8	4.07		23	10
8	11/15/2005	21.8	7.49	12.01	6.9	5.37		80	50
9	11/15/2005								
10	11/15/2005	23.3	8.21	15.19	8.9			30	16
1	11/22/2005	13.4	8.68	11.48	6.6	55.9		30	8
2	11/22/2005	13.7	8.47	11.97	6.9	36.5		11	6
3	11/22/2005	13.9	9.75	13.39	7.1	46.9		50	6
4	11/22/2005	13.9	9.4	12.75	7.4	20.9		4	10
5	11/22/2005	14.3	6.31	13.46	7.8	1.31		30	54
6	11/22/2005	12.7	8.57	0.05	0	9.43		230	80
7	11/22/2005	15.2	8.67	6.99	3.9	9.85		130	10
8	11/22/2005	14.3	8.97	11.4	6.5	9.95		50	20
9	11/22/2005								
10	11/22/2005	16.1	9.09	14.45	8.4			30	0
1	11/29/2005	16	7.7	11.51	6.6	42.7		30	6
2	11/29/2005	15.7	8.05	12.17	7	18.1		300	82
3	11/29/2005	15.7	8.95	11.15	7.2	22.6		1100	112
4	11/29/2005	15.3	8.35	13.16	7.6	13		700	94
5	11/29/2005	16.7	6.03	13.44	7.8	1.63		50	18
6	11/29/2005	15.9	7.59	0.05	0	22.6		300	300
7	11/29/2005	16.3	8.68	7.58	4.2	5.97		170	190
8	11/29/2005	17.1	6.41	8.11	4.5	8.71		500	150
9	11/29/2005								
10	11/29/2005	16.7	8.56	20.13	12.1	18.5		70	4
1	12/6/2005	12.4	9.35	11.13	6.4	95.3		130	98
2	12/6/2005	12.9	9.28	11.51	6.6	79.5		80	14
3	12/6/2005	12.9	9.22	11.83	6.8	23.2		50	50
4	12/6/2005	12.4	9.48	12.22	7	21.2		80	16

LPBF Master Database 2005									
Site	**Date**	**Water Temp °C**	**Diss Oxy mg/L**	**Spec Cond mS/cm**	**Salinity ppt**	**Turbidity NTU**	**pH**	**Fecal Coliform MPN/100 mL**	**Enterococci MPN/100 mL**
5	12/6/2005								
11	12/6/2005	12.9	5.28	12.76	7.4	1.95		30	12
6	12/6/2005	11.9	8.45	0.05	0			3000	84
7	12/6/2005	12.8	8.82	6.35	3.5	4.79		130	41
8	12/6/2005	14	7.97	10.5	6	5.03		230	128
9	12/6/2005								
10	12/6/2005	13.3	9.69	16.71	9.9	12.5		30	8
1	12/13/2005	11.5	10.44	11.42	6.5	5.71		30	4
2	12/13/2005	11.4	6.64	12.09	6.9	10.9		50	4
3	12/13/2005	11.3	10.26	12.01	6.9	5.66		23	0
4	12/13/2005	11.3	9.36	12.51	7.2	5.08		8	0
5	12/13/2005								
11	12/13/2005	11.4	10.24	13.36	7.7	5.91		14	4
6	12/13/2005	10.9	8.95	0.05	0	4.94		170	12
7	12/13/2005	12.4	7.27	4.82	2.6	10.6		30	2
8	12/13/2005	12.5	9.81	12.01	6.9	3.81		50	4
9	12/13/2005								
10	12/13/2005	15.4	9.48	14.91	8.7	21.9		7	2

Appendix B
EPA data

Fecal Coliform Data from EPA's STORET Katrina Central Data Warehouse (http://oaspub.epa.gov/storetkp/dw)

Orleans Parish water fecal coliforms

Orleans Parish water fecal coliforms, cont.

Station ID	Latitude	Longitude	Horiz. Dat.	Activity ID	Activity Start	Activity Comment	Value Type	Result Value	Units
10813	29.98687	-90.044891	NAD83	1673	10/16/2005 10:25	T0335-051016-01	Estimated	62000	cfu/100ml
10809	29.985965	-90.045428	NAD83	1672	10/15/2005 15:33	T0335-051015-13	Actual	76000	cfu/100ml
10770	30.05868	-89.966296	NAD83	1468	10/14/2005 10:00	T0054-051014-01	Estimated	180	cfu/100ml
10772	29.986761	-90.044891	NAD83	1470	10/14/2005 12:55	T0054-051014-03	Actual	37000	cfu/100ml
10771	29.981681	-90.023403	NAD83	1469	10/14/2005 11:10	T0054-051014-02	Actual	50000	cfu/100ml
10743	29.98593	-90.045446	NAD83	1455	10/13/2005 11:45	T0054-051013-04	Actual	18000	cfu/100ml
10740	30.058483	-89.96645	NAD83	1451	10/13/2005 10:10	T0054-051013-01	Actual	*Non-detect	
10700	29.9869	-90.0449	NAD83	1823	10/12/2005 9:45	T0442-051012-01	Actual	3000	cfu/100ml
10707	30.0355	-90.0113	NAD83	1831	10/12/2005 12:20	T0442-051012-08	Actual	36	cfu/100ml
10699	29.981793	-90.023225	NAD83	1745	10/12/2005 12:50	T0429-051012-03	Actual	2100	cfu/100ml
10698	29.975678	-90.004216	NAD83	1744	10/12/2005 11:45	T0429-051012-02	Actual	100	cfu/100ml
10663	29.98686	-90.044878	NAD83	1447	10/11/2005 9:50	T0054-051011-01	Actual	6100	cfu/100ml
10683	29.97563	-90.00397	NAD83	1820	10/11/2005 13:00	T0442-051011-10	Actual	17	cfu/100ml
10682	29.9738	-90.00539	NAD83	1819	10/11/2005 12:00	T0442-051011-09	Actual	*Non-detect	
10665	29.98008	-90.02015	NAD83	1449	10/11/2005 12:10	T0054-051011-03	Actual	200	cfu/100ml
10666	30.058643	-89.966211	NAD83	1450	10/11/2005 14:00	T0054-051011-04	Actual	50	cfu/100ml
10628	29.97556	-90.004003	NAD83	1805	10/10/2005 12:05	T0442-051010-01	Actual	*Non-detect	
10614	30.058661	-89.966468	NAD83	1434	10/10/2005 12:40	T0054-051010-02	Actual	27	cfu/100ml
10632	29.98075	-90.02011	NAD83	1810	10/10/2005 15:29	T0442-051010-05	Actual	*Present >QL	
10630	29.975536	-90.003793	NAD83	1808	10/10/2005 14:15	T0442-051010-03	Actual	1200	cfu/100ml
10613	29.985866	-90.045421	NAD83	1433	10/10/2005 10:15	T0054-051010-01	Actual	11000	cfu/100ml
10611	29.97992	-90.018781	NAD83	1432	10/9/2005 16:05	T0054-051009-15	Actual	82	cfu/100ml
10610	29.974616	-90.00432	NAD83	1431	10/9/2005 15:05	T0054-051009-14	Actual	*Non-detect	
10594	29.977231	-90.011651	NAD83	1804	10/9/2005 16:30	T0442-051009-03	Actual	*Non-detect	
10609	29.986921	-90.04482	NAD83	1430	10/9/2005 13:55	T0054-051009-13	Actual	*Present >QL	
10587	29.976736	-90.016516	NAD83	1417	10/8/2005 15:15	T0054-051008-05	Actual	83	cfu/100ml
10573	29.976721	-90.010841	NAD83	1802	10/8/2005 13:45	T0442-051008-08	Actual	200	cfu/100ml
10586	29.98587	-90.045426	NAD83	1416	10/8/2005 13:30	T0054-051008-04	Actual	6800	cfu/100ml
10585	29.986513	-90.125111	NAD83	1415	10/8/2005 12:00	T0054-051008-03	Actual	5800	cfu/100ml
10566	30.035626	-90.011516	NAD83	1795	10/8/2005 10:15	T0442-051008-01	Actual	100	cfu/100ml
10563	29.978071	-90.01587	NAD83	1793	10/7/2005 13:05	T0442-051007-11	Actual	40	cfu/100ml
10552	29.977188	-90.013405	NAD83	1412	10/7/2005 14:10	T0054-051007-03	Actual	*Present >QL	
10564	29.980166	-90.019358	NAD83	1794	10/7/2005 14:20	T0442-051007-12	Actual	64	cfu/100ml
10550	29.986878	-90.044878	NAD83	1410	10/7/2005 10:20	T0054-051007-01	Actual	3600	cfu/100ml
10551	29.994541	-90.100673	NAD83	1411	10/7/2005 11:50	T0054-051007-02	Actual	1100	cfu/100ml
10546	29.985766	-90.045418	NAD83	1409	10/6/2005 17:45	T0054-051006-05	Actual	*Present >QL	
10542	30.058823	-89.966333	NAD83	1400	10/6/2005 10:05	T0054-051006-01	Actual	27	cfu/100ml

10514	29.362626	-89.562276	NAD83	1781	10/6/2005 14:50	T0442-051006-03	Actual	91	cfu/100ml
10545	29.973066	-90.006506	NAD83	1407	10/6/2005 16:45	T0054-051006-04	Actual	100	cfu/100ml
10544	29.975601	-90.011406	NAD83	1405	10/6/2005 15:50	T0054-051006-03	Actual	*Non-detect	
10432	29.974161	-90.01439	NAD83	18584	10/5/2005 14:00	T0442-051005-06	Actual	300	cfu/100ml
10425	29.973415	-90.011876	NAD83	18553	10/5/2005 14:13	T0219-051005-08	Actual	200	cfu/100ml
10431	29.986895	-90.044888	NAD83	18583	10/5/2005 12:55	T0442-051005-05	Actual	60000	cfu/100ml
10433	29.98198	-90.02393	NAD83	18585	10/5/2005 15:45	T0442-051005-07	Actual	4400	cfu/100ml
10418	30.046516	-89.988681	NAD83	18546	10/5/2005 10:20	T0219-051005-01	Actual	4600	cfu/100ml
10331	29.973688	-90.012878	NAD83	18369	10/4/2005 11:40	T0219-051004-03	Actual	*Non-detect	

Orleans Parish water fecal coliforms, cont.

Station ID	Latitude	Longitude	Horiz. Dat.	Activity ID	Activity Start	Activity Comment	Value Type	Result Value	Units
10348	30.04668	-89.988356	NAD83	18394	10/4/2005 9:00	T0335-051004-01	Actual	10	cfu/100ml
10329	29.984216	-90.037473	NAD83	18367	10/4/2005 9:30	T0219-051004-01	Actual	*Non-detect	
10332	29.974683	-90.017273	NAD83	18370	10/4/2005 12:30	T0219-051004-04	Actual	*Non-detect	
10330	29.981563	-90.02374	NAD83	18368	10/4/2005 10:00	T0219-051004-02	Actual	*Non-detect	
10301	29.986793	-90.044983	NAD83	18250	10/3/2005 10:15	T0219-051003-02	Estimated	13000	cfu/100ml
10300	29.988338	-90.067525	NAD83	18248	10/3/2005 9:00	T0219-051003-01	Actual	400	cfu/100ml
10303	29.97369	-90.01772	NAD83	18253	10/3/2005 12:50	T0219-051003-04	Actual	200	cfu/100ml
10303	29.97369	-90.01772	NAD83	18252	10/3/2005 12:50	T0219-051003-04	Actual	90	cfu/100ml
10246	29.969131	-90.005483	NAD83	18108	10/2/2005 13:45	T0335-051002-13	Actual	*Non-detect	
10246	29.969131	-90.005483	NAD83	18107	10/2/2005 13:45	T0335-051002-13	Actual	*Non-detect	
10248	29.984215	-90.037448	NAD83	18110	10/2/2005 16:15	T0335-051002-15	Actual	100	cfu/100ml
10247	29.97261	-90.017935	NAD83	18109	10/2/2005 14:50	T0335-051002-14	Actual	*Non-detect	
10214	29.986978	-90.044828	NAD83	18003	10/1/2005 13:50	T0335-051001-02	Actual	*Non-detect	
10213	29.967838	-90.008003	NAD83	18002	10/1/2005 11:30	T0335-051001-01	Actual	100	cfu/100ml
10152	29.988548	-90.068003	NAD83	17865	9/30/2005 11:00	T0335-050930-03	Estimated	200	cfu/100ml
10151	29.981826	-90.023351	NAD83	17864	9/30/2005 9:30	T0335-050930-02	Estimated	1600	cfu/100ml
10148	29.967111	-90.018495	NAD83	17860	9/30/2005 12:01	T0442-050930-02	Estimated	200	cfu/100ml
10149	30.011501	-90.119301	NAD83	17861	9/30/2005 14:00	T0442-050930-03	Actual	*Non-detect	
10141	30.058218	-89.966783	NAD83	17849	9/30/2005 9:50	T0219-050930-02	Estimated	300	cfu/100ml
10140	30.03472	-90.010603	NAD83	17848	9/30/2005 8:30	T0219-050930-01	Estimated	2200	cfu/100ml
10143	29.994503	-90.100611	NAD83	17852	9/30/2005 11:40	T0219-050930-04	Estimated	900	cfu/100ml
10150	30.01618	-90.06955	NAD83	17862	9/30/2005 8:04	T0335-050930-01	Estimated	700	cfu/100ml
10147	29.984208	-90.037536	NAD83	17858	9/30/2005 9:28	T0442-050930-01	Estimated	4000	cfu/100ml
10061	30.05809	-89.96681	NAD83	17541	9/29/2005 10:00	T0219-050929-03	Actual	1800	cfu/100ml
10059	29.99424	-90.101263	NAD83	17539	9/29/2005 7:15	T0219-050929-01	Actual	1900	cfu/100ml
10085	29.981686	-90.023468	NAD83	17695	9/29/2005 9:15	T0335-050929-02	Actual	500	cfu/100ml
10086	29.988305	-90.067593	NAD83	17696	9/29/2005 10:35	T0335-050929-03	Actual	1000	cfu/100ml
10062	29.986948	-90.044831	NAD83	17542	9/29/2005 12:10	T0219-050929-04	Actual	2500	cfu/100ml
10060	30.046786	-89.988471	NAD83	17540	9/29/2005 8:50	T0219-050929-02	Actual	1000	cfu/100ml
10085	29.981686	-90.023468	NAD83	17694	9/29/2005 9:15	T0335-050929-02	Actual	500	cfu/100ml
10084	30.01621	-90.069575	NAD83	17693	9/29/2005 7:50	T0335-050929-01	Actual	3000	cfu/100ml
10045	29.994175	-90.10086	NAD83	17502	9/28/2005 16:45	T0219-050928-03	Actual	1300	cfu/100ml
10040	30.016148	-90.069373	NAD83	17467	9/28/2005 15:00	T0441-050928-03	Actual	600	cfu/100ml
10044	30.058215	-89.96674	NAD83	17501	9/28/2005 14:00	T0219-050928-02	Actual	1900	cfu/100ml

10041	29.981465	-90.025366	NAD83	17468	9/28/2005 13:55	T0335-050928-01	Actual	900	cfu/100ml
10039	29.982128	-90.02787	NAD83	17466	9/28/2005 13:05	T0441-050928-02	Actual	400	cfu/100ml
10028	29.9815	-90.02625	NAD83	17422	9/26/2005 15:30	SW593-GB-G-N-09	Actual	2200	cfu/100ml
9864	29.988133	-90.067735	WGS84	17232	9/26/2005 12:10	SW202-KN-G-D-09	Actual	19000	cfu/100ml
9864	29.988133	-90.067735	WGS84	17231	9/26/2005 12:10	SW202-KN-G-N-09	Actual	10000	cfu/100ml
9854	29.986885	-90.044821	WGS84	17215	9/25/2005 9:00	SW600-gb-G-N-09	Actual	22000	cfu/100ml
9810	30.046608	-89.98866	WGS84	17193	9/25/2005 9:50	SW200-KN-G-D-09	Actual	30000	cfu/100ml
9857	29.967326	-90.020568	WGS84	17218	9/25/2005 13:30	SW598-gb-G-N-09	Actual	4800	cfu/100ml
9811	30.008701	-90.10819	WGS84	17194	9/25/2005 12:40	SW201-KN-G-N-09	Actual	490000	cfu/100ml
9856	29.963453	-90.021036	WGS84	17217	9/25/2005 12:00	SW599-gb-G-N-09	Actual	25000	cfu/100ml
9810	30.046608	-89.98866	WGS84	17192	9/25/2005 9:50	SW200-KN-G-N-09	Actual	23000	cfu/100ml

Orleans Parish water fecal coliforms

Station ID	Latitude	Longitude	Horiz. Dat.	Activity ID	Activity Start	Activity Comment	Value Type	Result Value	Units
10025	29.966392	-89.99893	NAD83	17419	9/26/2005 11:00	SW590-GB-G-N-09	Actual	4300	cfu/100ml
10027	29.961883	-90.00083	NAD83	17421	9/26/2005 14:00	SW592-GB-G-N-09	Actual	4400	cfu/100ml
10026	29.96792	-89.99893	NAD83	17420	9/26/2005 12:30	SW591-GB-G-N-09	Actual	1400	cfu/100ml

Appendix 5D
Fate and Transport Modeling

Contaminant Fate/Transport Modeling for Environmental Consequences of IPET Task 9

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Background

Mathematic models are useful for filling data gaps and providing information for relating impacts for different operational scenarios. One of the primary environmental concerns associated with Hurricane Katrina was the impacts to ecological resources stemming from contaminants that were released into the flood waters and subsequently pumped into surrounding water bodies outside the levee system. Models were used within Task 9 to provide information with which to more fully evaluate such environmental consequences. This chapter describes these model studies and the results obtained from them.

Objective

The objective of the Task 9 environmental modeling was to compute contaminant concentrations within the water column and sediment bed for two environmentally important water bodies, Lake Pontchartrain and Violet Marsh, which received pumped flood water effluents following Hurricane Katrina. These two systems were selected for study since they were primary recipients of pumped flood waters, they contain valuable ecological resources, and they are representative of natural ecosystems that are adjacent to New Orleans. The goal was to provide more complete information on contaminant concentrations in these two systems so that more definitive conclusions regarding environmental consequences resulting from contaminant releases could be drawn.

Approach

Two different mathematical models were used to simulate contaminant concentrations within the lake and marsh. Each model and how it was applied are described below. Contaminant concentrations were modeled for two conditions: 1) dewatering of flood waters for the "*actual*" conditions that occurred with levee breaches; and 2) dewatering for conditions of the system performing as designed ("*baseline*" conditions). The *baseline* conditions serve as a basis for comparison with the *actual* conditions.

Lake Pontchartrain Model

The three-dimensional (3D) hydrodynamic model CH3D and the 3D water quality model CE-QUAL-ICM (ICM) were used to model conditions in Lake Pontchartrain for a period of 90 days starting on September 1, 2005. Thus, both the *actua*l and *baseline* conditions include the period during which pumps were operating to remove flood and rain water from the city following Hurricanes Katrina and Rita.

The z-plane version of CH3D was used (Johnson et al. 1991 and 1993). This version has a varying number of layers with the total number along a water column depending on the depth. A plan view of the model computational grid is shown in Figure 1. The grid contains 6038 computational cells in the surface layer and 21018 cells in total over all layers. Each layer thickness was 5 ft except the surface layer which varied depending on the water surface elevation. The maximum number of layers was 6 for a maximum depth of about 30 ft. A typical cell size in plan form is on the order of 300 m by 700 m.

Although the CH3D model includes baroclinic terms (i.e., it can simulate stratified flows resulting from water density differences caused by temperature and salinity), this feature was not activated for this study since the flood waters had about the same salinity as the lake water in the vicinity of the pumped discharges. Turning on this feature would have increased the input data and modeling requirements substantially, so it did not seem warranted given the paucity of data. Also, given the fact that the pumped discharges following Katrina dominated the lake currents and thus the salinity along the south shore, ignoring salinity differences is a reasonable approach. Salinity measurements taken in the lake at Station 4 (south shore at Pontchartrain Beach) by the Lake Pontchartrain Basin Foundation averaged 7.4 parts per thousand (ppt) in the fall of 2005, whereas salinity across the lake near Slidell at Station 10 (North Shore Beach) were higher, averaging 14 ppt. Salinity measurements taken throughout October 2005 in the New Orleans floodwaters averaged 5.6 ppt, where floodwater salinity was higher near the lake shore (ranging from approximately 7 to 9 ppt) and decreased moving south towards downtown away from the shore (ranging from approximately 2 to 6 ppt). These data indicate that the pumped water near the shore was nearly the same salinity as the lake water near the shore. Therefore, model output from the surface layer should be representative of expected lake concentrations resulting from pumping since pumped water enters along the surface of the lake, and with about the same salinity, it would remain near the water surface.

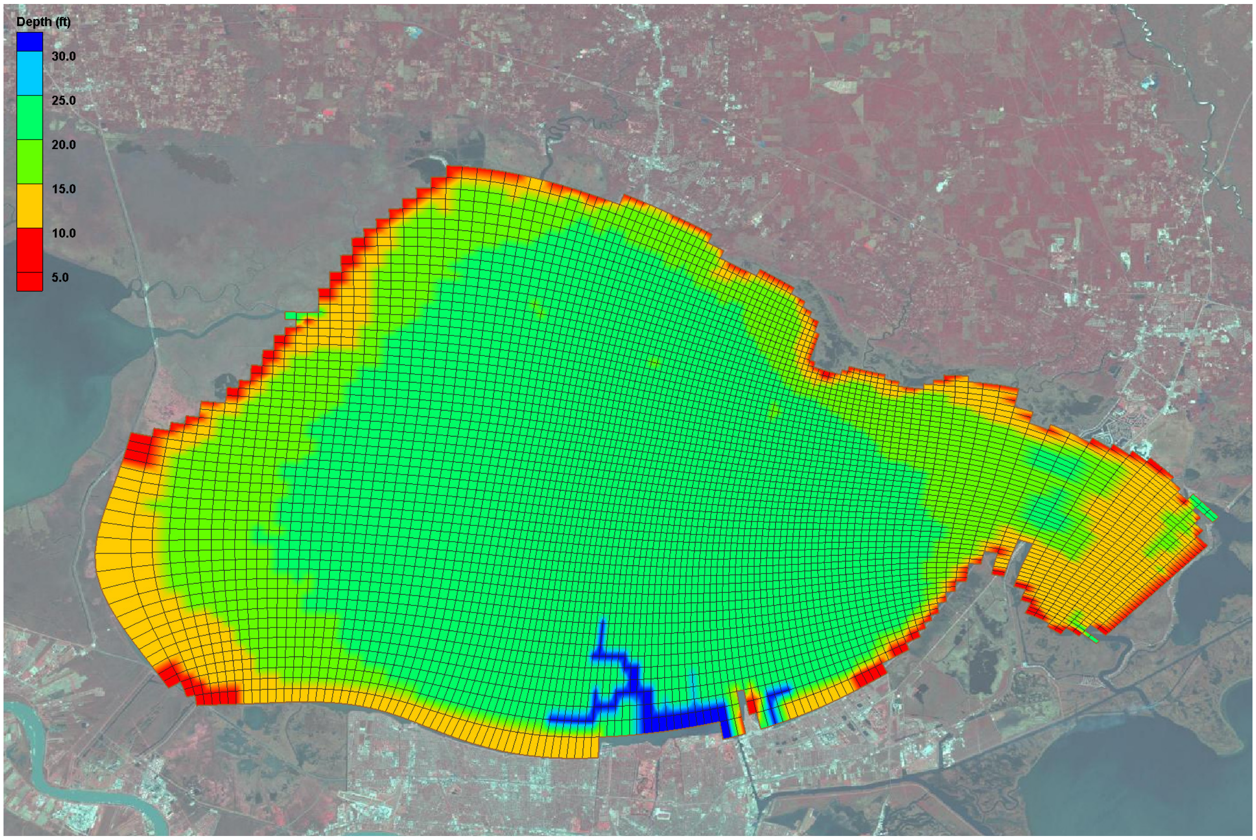

Figure 1. Model grid for Lake Pontchartrain with depth contours

The hydrodynamic model was run for both the *actual* and *baseline* conditions. Wind speed and direction from the New Orleans International Airport was applied to the model. NOAA tide records were used as boundary conditions at the open sea boundary, which was located at the Rigolets inlet to the lake. Additionally, the pumped flows were applied as boundary conditions along the south shore and were the major forcing function for the lake hydrodynamics during *actual* dewatering. Freshwater stream flows entering the lake were not included in the model since such flows are small with respect to wind and tidal forcing except when Mississippi River flood waters are diverted through the Bonne Care Spillway.

The hydrodynamic model used the estimating pumping rates obtained from IPET Task 8 for *actual* conditions of post Katrina, including the pumping during and following Hurricane Rita. These data show that the pumps starting operating on September 11, 2005, and ended on October 20. Obtaining pumping rates for the *baseline* conditions was more problematic. IPET Tasks 2 and 3 will estimate the pumping rates for conditions of the levees performing as designed, but this information was not available in time for the Task 9 study. In the absence of these data, assumptions were used to establish a *baseline* condition. The rainfall amounts recorded for Katrina and Rita were multiplied by the approximate rainfall collection area to produce rainfall volumes. The known pump flow capacities were divided into the rainfall volumes to estimate the time required to pump out the rainfall. The capacity of each pump was used with the duration required to dewater the rainfall to establish the *baseline* pumped flows. The biggest problem with this approach is that it does not include water that would overtop the levees. Thus, this approach assumes that a levee system was in place that fully protected New Orleans from any flooding by these two hurricanes.

The water quality model was originally developed during a study of Chesapeake Bay (Cerco and Cole 1993), but has subsequently been applied to a variety of systems throughout the U.S. and the San Juan Bay System in Puerto Rico. The version of the model used for Lake Pontchartrain is based on a recent version used on Lake Washington, WA (Cerco et al. 2004). The water quality model used the same grid resolution as the hydrodynamic model of Lake Pontchartrain. The hydrodynamic model was executed, flow fields and cell volumes were saved, and these data were subsequently used to run the water quality model.

The water quality model was applied for five constituents, arsenic (As), lead (Pb), benzo(a)pyrene (BaP), DDE, and fecal coliform bacteria (FCB). The model state variable for each contaminant is treated as total concentration (i.e., dissolved and particulate) with fractions of dissolved and particulate calculated from equilibrium partitioning to suspended solids or sediment bed solids. Fate processes of sorption to solids, settling of particulate contaminant, volatilization of dissolved contaminant, and die-off of FCB were modeled. Degradation of the organic chemicals was ignored given the relatively short simulation period. These constituents provide a wide range in adsorption behavior with arsenic having a relatively low sorption distribution coefficient and DDE having a high value. Fecal coliform bacteria can serve as a tracer if die-off is set to 0.0.

The water quality model requires constituent loading (mass/time) for each effluent location. Loading is the product of discharge rate (volume/time) and concentration (mass/volume) of the effluent. With pumping rates given, the concentrations of the effluent had to be determined for both scenarios. Fortunately, for the *actual* scenario, many flood water and flood sediment samples were collected and analyzed for a host of contaminants. These data were collected by the U.S. Environmental Protection Agency (EPA), Louisiana State University (LSU), and Louisiana Department of Environmental Quality (DEQ) and were assembled into an EPA database. Data for the constituents assessed in this study were extracted from the database and analyzed. This analysis produced concentrations to use for calculating the model pumped loadings and resulted in a median concentration and a 95% upper confidence limit (95UCL) concentration for each constituent for 3 different areas of interest, Orleans Parish Proper, Orleans Parish East, and St. Bernard Parish. The first two areas involve flood waters that were pumped into the lake, and the latter represents flood waters that were pumped into the marsh. Given the extensive difficulty in trying to sort out which specific sub-areas of flood water (and associated sample concentrations) to assign to each pump, the decision was made to process all measured values within each of the 3 broad areas to produce a single median and 95UCL concentration to use for the pumped effluents of that area. In summary, measured concentrations were used to establish the pumped loadings discharged into the lake for the *actual* conditions for Orleans Proper and Orleans East, and the concentrations were held constant for the duration of the pumping to establish those loadings.

Estimating pumped concentrations for the *baseline* conditions was problematic. The plan was to use data from a previous pumping event that endured rainfall of the amount that fell during Katrina. However, no such data could be found for the constituents being studied. The paper by

Pardue et al. (2006) states that the metal concentrations in the Katrina flood waters of New Orleans were generally typical of storm water with a few exceptions of elevated concentrations of lead. Jin et al. (2004) reported FCB concentrations of 40,000 MPN/100 ml measured during 1998 in pumped storm water in drainage canals that into the lake. This concentration is within the range of values measured in the Katrina flood waters. Given the lack of any better information, the assumption was made that the pumped concentrations for the *baseline* conditions are the same as those for the *actual* conditions. However, the total constituent loading for the *baseline* conditions are much less since the pumps operate for a much shorter period of time to remove far less water.

Output from the 3D lake water quality model consists of time-varying concentrations in the water column for each computational cell and time-varying sediment concentrations of the benthic sediments beneath each bottom water cell. Such a large amount of data requires reduction to render presentations that are useful for interpretation. Two-dimensional surface layer and sediment contour plots of maximum concentrations were used to collapse data down for manageable interpretation.

Given the observational data limitations, it was not possible to calibrate and validate the lake hydrodynamic and water quality models to the extent normally desired. However, some water surface elevation and fecal coliform bacteria measurements were available for the lake during the fall of 2005 which were used as discussed in the Calibration/Validation section. The flow fields and transport computed with these models have been found to be relatively accurate in other studies if sufficient boundary conditions for inflows, water levels, winds, and constituent loadings are provided.

Violet Marsh Model

The upper portion of Violet Marsh was selected for the model study since this area directly received pumped discharges and is a well defined as a system geometrically, bounded on all 4 sides by a bayou, a highway, a levee, and a wastewater treatment facility. This simplified the modeling approach while focusing on an area of environmental interest that received significant pumped water. Given the simplicity of this water body and the rapid flushing rate, which was on the order of half a day during Katrina dewatering, it was possible to use a much simpler model than for the lake, thus, the RECOVERY model (Ruiz and Gerald 2001) was used. RECOVERY was first developed in 1994 (Boyer et al. 1994) but has been modified and improved over the years; the most recent version (4.3) was used for this study. RECOVERY is a time-varying model that treats the water column as a single, fully mixed cell of known area, depth, and flushing rate and represents the bottom sediments as a series of layers over the vertical dimension. Thus, this model, like the lake model, produces time-varying concentrations for the water column and bottom sediments. The model assumes a constant flushing rate or flow through the system; however, it can accept time-varying loadings. The surface area of upper Violet Marsh is 9.76E6 m^2, and the mean depth is about 0.175 m, which results in a very short residence time of less than a day for typical pumped discharges.

The same assumptions made for the lake model were used for the marsh model. Thus, the *baseline* pump flows were based on rainfall volume and pump capacity, and the *baseline* pumped concentrations were set equal to the concentrations obtained for the *actual* conditions. Pumped flows for *actual* conditions were based on the Task 8 estimates, and the associated pumped concentrations were based on the analysis of sample measurements taken in St. Bernard Parish flood waters.

The same five constituent selected for the lake model were modeled for the marsh. The marsh model simulated a year for each run with the loading starting on day 1 and ending on day 2 for *baseline* conditions and starting on day 1 and ending on day 37 for *actual* conditions. The RECOVERY model assumes a constant background flushing flow rate, but allows a time-varying loading of constituents. During pumping, the flushing flow should be equal to the pumped flow. However, when pumping and loading ceases, the flushing flow should drop to an unknown, but much lower background flow. The background flow was assumed to be 0.1 m^3/sec for this small isolated wetland system. In order to account for 2 different flushing flows (during pumping and after pumping ceases), two separate runs were required. The computed peak water and sediment concentrations, which occurred when pumping ceased, were taken from the first model run (i.e., flushing flow equal to pumping flow) and used as initial conditions for a second run with the flushing flow set to a nominal background flow of 0.1 m^3/sec. This two-step flushing conditions should yield a much more reasonable prediction of peak sediment concentrations, which should be slightly higher than those computed from the first model run since the water column concentrations are flushed out much more slowly after pumping ceases, thus raising sediment concentrations.

Model Inputs

Parameters

In addition to boundary conditions and model control variables, several other parameters and basic data are required to apply the lake and marsh models. These include:

- Total suspended solids (TSS), mg/L
- TSS settling rate, (m/day)
- Fecal coliform bacterial die-off rate, day^{-1}
- fraction of total organic carbon (TOC) to total sediment by dry weight, f_{oc}, for the water column and sediment bed
- Sedimentation variables, either burial rate or resuspension rate (m/day)
- Benthic surficial layer porosity
- Sediment-water sorption distribution coefficient, K_d, L/kg

TSS was calculated from turbidity using a regression developed from data collected from the Inner Harbor Navigation Channel (IHNC) for studies of the Corps Dredged Material Management Units (DMMU). Abundant turbidity data existed for both the flood waters and the lake. There was not any turbidity data for the marsh, thus, values for the floodwater were used. TSS settling rate was set to 1 m/day based on experience in modeling similar systems and particle settling studies conducted for the DMMUs of the IHNC. The total coliform bacterial die-off rate is typically around 1.0 day^{-1} (Thomann and Mueller 1987) for freshwater and 1.4 for seawater. Jin et al. (2004) measured FCB die rates of approximately 2.8 day^{-1} in the lake. A relatively conservative value of 1.0 day^{-1} was used in the model. Data from Corps DMMU studies indicated f_{oc} values of about 0.02 (2%), which were used for the lake and marsh. Resuspension was assumed to be zero, and using the settling rate, TSS, and sediment porosity (thus bulk density), a burial rate of 0.026 m/yr was calculated based on a steady-state solids balance. Benthic surficial layer porosity was assumed to be 0.9, which is a value typical of most surficial sediments that are not consolidated. Estimates of K_d for arsenic and lead were obtained from the literature and consisted of values of 300 and 4,000 L/kg, respectively. The organic carbon-water partition coefficient, K_{oc}, was computed for the organic constituents BaP and DDE using the relationship

$$K_{oc} = 0.6 K_{ow} \tag{1}$$

where K_{ow} is the octonol to water partition coefficient for organic chemicals. Databases of chemical properties were searched to obtain values of K_{ow} for BaP and DDE of 1.0E6 and 3.24E6, respectively. The K_d for organic chemicals is usually the product of K_{oc} and f_{oc} when total solids are used to partition, but in the case of the ICM model, inorganic suspended solids and particulate organic suspended solids are used for inorganic and organic contaminants, respectively, thus, care must be taken in defining K_d for use in ICM as explained in the next section. The TOC concentration is the product of f_{oc} and TSS for the water column or the product of f_{oc} and sediment bulk density for the sediment bed.

Since K_d is an important parameter that can be affected by other ambient conditions and can vary from system to system for the same chemical, testing was conducted with the RECOVERY model to validate the literature values for K_d and K_{ow}. RECOVERY was run to steady state assuming no flushing, settling, resuspension, degradation, or volatilization; only equilibrium sediment-water partitioning was included. Sediment concentrations measured from the flood waters were input to the model, and overlying equilibrium water concentrations were computed by the model and compared with measured water values taken concurrent with the sediment measurements. The model indicated that the value of 4,000 L/kg for lead K_d was representative of conditions in the New Orleans flood waters. However, the value of K_d for arsenic had to be adjusted slightly to 500 L/kg to match observed water concentration. The K_{ow} for BaP and DDE also had to be decreased to 0.5E6 and 1.0E6 L/kg, respectively, to match observations. Since Equation 1 is programmed into the RECOVERY model code, and f_{oc} is a measured variable, it was easier and more rational to adjust K_{ow} for BaP and DDE. More than likely, adsorption to dissolved organic carbon (DOC), which is manifested as partitioning to water but is not included in the model, is the reason that K_{ow} had to be decreased to match observations. In reality, K_{ow} is a chemical property that should not require adjustment if DOC partitioning is included. These tests resulted in relatively minor model adjustments that gave increased confidence in the modeled sorption process.

Lake Model

As discussed in the approach section, the hydrodynamic model of the lake was driven with winds, tides at the Rigolets Inlet, and pumped discharges from New Orleans. The hydrodynamic model was started with quiescent conditions on September 1, 2005, and run for 90 days.

Observed wind data from the New Orleans airport was used as input. However, wind data was not available until September 7 due to Katrina, so the wind vectors applied to the model between September 1 and 7 were linearly ramped from 0.0 to the values observed on September 7. Thus, the period between September 1 and 7 are considered a model spin-up period and were not be used for model analysis and comparisons.

The water level boundary conditions at the entrance of the Lake Pontchartrain (Rigolets Inlet) included both meteorological and astronomical tide. For the astronomical tide, hourly predictions from NOAA at Waveland (station number 8747766) were used. There is a predicted tide station at Long Point, LA, in Lake Borgne which is closer to the Rigolets entrance, but only high and low tides are available for that location. Measured water levels were available for the Waveland gage prior to Hurricane Katrina, but the gage was destroyed during the hurricane. Thus, predicted hourly tides were used for this location. The sub-tidal signal was obtained from water level recordings at East Bank 1 gage, Norco, Bayou LaBranche, LA (gage number 8762372) by using a 48 hour moving average to filter out higher frequency signals. The sub-tidal signal was transposed for about 24 hours and added to the astronomical tidal signal for Waveland to form the boundary condition at the Rigolets Inlet.

The pumped discharges and loadings to the lake were separated into Orleans Proper and Orleans East. Orleans Proper includes all the pump stations in Orleans Parish that are west of the IHNC that pump water into the lake or into canals that empty into the lake, whereas, Orleans East includes all the pump stations in Orleans Parish east of the IHNC that pump into the lake. Records indicate that Jefferson Parish pumps that discharge into the lake were not operated. Figure 2 shows time series plots of the combined, estimated pumping rates into waterways emptying into the lake for Orleans Proper and Orleans East following Katrina (*actual* conditions). The flows for each pump station have been combined for the two areas for report presentation, but the flow for each pump constituted a separate discharge input for the model. The pump stations included in the lake model are shown in Figure 3 with the exception of 2 temporary pumps in Orleans East that pumped into the lake. Since the lake model grid did not include canals that are connected to the lake, the discharges of any pump stations that are not located on the shoreline were assumed to be located at the confluence of the lake and the canal they are pumped into. Pumped discharges were used for inflows to the hydrodynamic model and for calculating loading inputs for the water quality model.

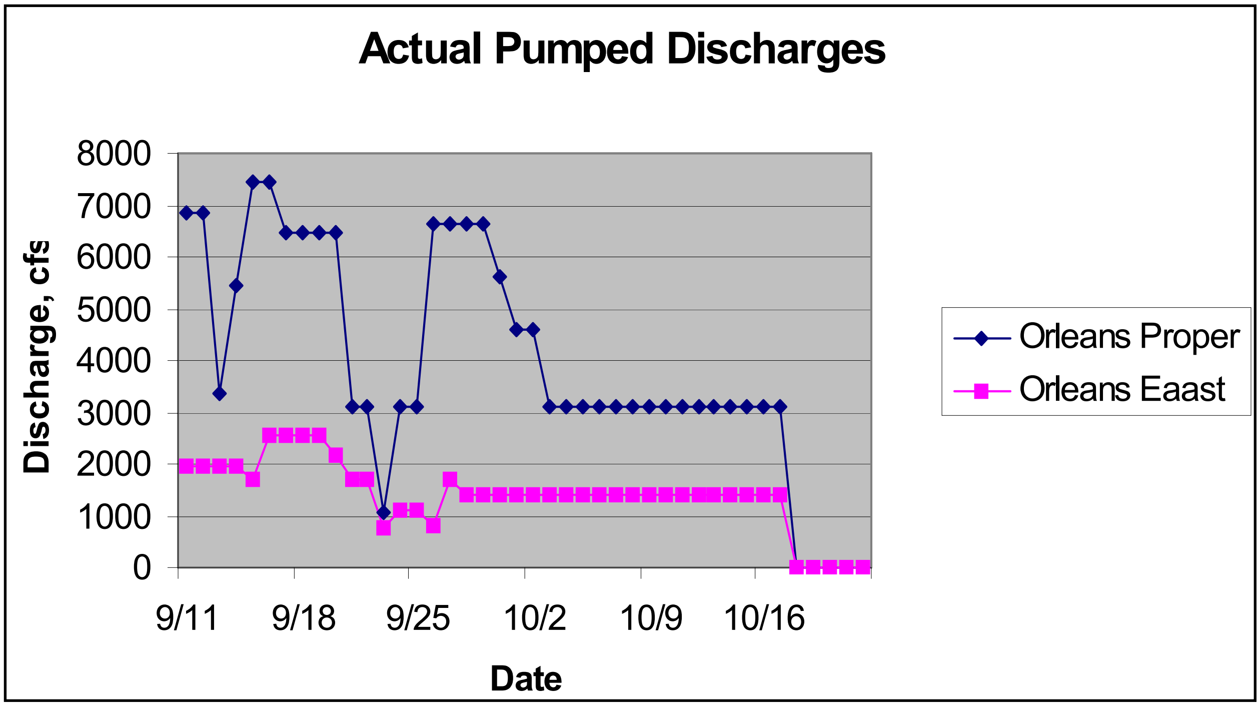

Figure 2. Time series of combined *actual* pump discharges for Orleans Proper and Orleans East that pump into the lake

Figure 3. Locations of pump stations for Orleans Parish included in the model that pump into the lake

As explained in the Approach section, rainfall and pump capacities were used to establish the *baseline* pumping conditions. The rainfall reported at Slidell (other gages in the area did not report) was approximately 8” for Katrina, and the rainfall reported at the New Orleans International Airport for Rita was 2.3”. Given the approximate, combined collection basin area for Orleans Proper and Orleans East of 3E9 ft^2, the rainfall volumes for Katrina and Rita were about 2E9 ft^3 and 0.6E9 ft^3, respectively. With the Orleans Parish pump-to-lake total discharge capacity of approximately 38,000 ft^3/sec (cfs), rain water could have been pumped out in less than a day following each hurricane. Of course, this pumping period assumes no overtopping of the levees. The pump-out time for Katrina under these assumptions is about 0.6 days. The capacity of each pump is known, and it was assumed that each pump would have been run at capacity for the *baseline* condition. Examination of pump records during tropical storm Isadora during September 2002 indicated this was a reasonable assumption. However, the model can accept only daily inputs for flows and loads (i.e., flow and load is assumed constant over each day, but can change from day to day). Therefore, the pump capacities were adjusted to provide a daily flow equal to the amount of rain water to be emptied. For example, if a pump capacity is 1,000 cfs, then the flow used for the model pump was 600 cfs based on the Katrina pump-out time of 0.6 days.

The ICM model includes inorganic suspended solids (ISS) and suspended particulate organic carbon (POC) as modeled state variables, rather than TSS. The model allows simulation of one inorganic contaminant that sorbs to ISS and one organic contaminant that sorbs to POC. As discussed earlier, TSS was estimated based on turbidity measurements, but there were no data for ISS and POC that are needed by the model for simulating the fate of particulate contaminants. POC constitutes about 40% of the volatile suspended solids (VSS), where VSS represents suspended particulate organic matter. It was possible to estimate ISS using TSS and f_{oc} data and recognizing that TOC is primarily made up of POC, thus,

$$TSS = ISS + VSS = ISS + 2.5 f_{oc} TSS \tag{2}$$

Rearranging Equation 2 yields

$$ISS = TSS\left(1 - 2.5 f_{oc}\right) \tag{3}$$

POC is calculated from

$$POC = f_{oc}\, TSS \tag{4}$$

Concentrations of ISS and POC were held constant as background values throughout the lake by setting the initial conditions and all boundary conditions to the same constant values.

The fraction of particulate inorganic contaminant concentration to total inorganic contaminant concentration can be determined through reversible equilibrium partitioning from

$$F_{pi} = \frac{K_d\, ISS}{1 + K_d\, ISS} \tag{5}$$

Likewise, the fraction of particulate organic contaminant concentration to total organic contaminant concentration can be determined from

$$F_{po} = \frac{K_d\, POC}{1 + K_d\, POC} \qquad (6)$$

The units for K_d in ICM are m^3/g, thus, the values presented in the previous section were converted from L/kg to m^3/g by multiplying by 1.0E-6. The K_d values input for lead (Pb) and arsenic (As) were 0.5E-3 and 4.0E-3 m^3/g, respectively. For ICM, K_d and K_{oc} are operationally the same since f_{oc} is taken into account by using POC instead of TSS to compute F_{po}. Thus, the K_d values for BaP and DDE (after applying Equation 1 to get K_{oc}) used in ICM were 0.3 and 0.6 m^3/g, respectively.

The ICM model requires input of the volatilization rate (K_{vol}, m/day) rather than computing it from chemical properties, wind, and hydrodynamic flow conditions. Wind is the predominant forcing factor over flow for lakes, thus, volatilization rate was computed based on wind speed, using an average speed of 5 miles per hour (3 m/sec). This wind speed, Henry's law constants for BaP and DDE of 4.5E-7 and 4.0E-5 atm-m^3/mole, respectively, and respective molecular weights of 252 and 318 g/mole were used to compute K_{vol} using the algorithm within the RECOVERY model. Volatilization within RECOVERY is based on the Whitman two-film theory where the gas and liquid side mass transfer rates are computed from wind speed. The resulting values of K_{vol} for BaP and DDE were 0.005 and 0.19 m/day, respectively. The ICM model multiplies K_{vol} by the dissolved organic chemical concentration in the surface layer of the water column to calculate the volatilization flux (g/m^2/day). The dissolved organic chemical concentration is the product of the total organic chemical concentration times the quantity (1-F_{po}). Table 1 summarizes values for the various parameters for partitioning and volatilization.

Table 1
Summary of partitioning and volatilization parameters used for the lake model

Chemical	K_{ow} (L/kg)	K_d (L/kg)	K_d (m^3/g)	K_{vol} (m/day)
As	NA	500	0.5E-3	NA
Pb	NA	4000	4.0E-3	NA
BaP	0.5E6	0.3E6	0.3	0.005
DDE	1.0E6	0.6E6	0.6	0.19

The concentrations used to establish the lake water quality model loadings are shown in Table 2. The loadings were categorized by median and 95UCL concentrations, which were determined from statistical analysis of the flood water measurements taken in the two areas (Orleans Proper and Orleans East).

Table 2 **Lake loading concentrations (total) by region for *baseline* and *actual* conditions**		
Constituent	**Median, µg/L**	**95UCL, µg/L**
Orleans Proper		
Arsenic	20	20
BaP	5	5
DDE	0.05	0.05
Lead	5	44
Fecal coliform bacteria	2,200*	70,041*
Orleans East		
Arsenic	20	26
BaP	5	5
DDE	0.05	0.38
Lead	2.5	12
Fecal coliform bacteria	200*	32,869*
* Units are cfu/100ml or MPN/100ml		

Turbidity measurements for Lake Pontchartrain are routinely measured. Lake turbidity values obtained during the fall of 2005 following Katrina were analyzed over time and for all recording stations to obtain a lake-wide median value. The lake median turbidity was converted to a median TSS value of 19.2 mg/L for use in the lake model for background suspended sediment. Although the ICM model transports sediment, it was possible to hold the value constant by setting initial conditions and all boundary conditions to the background value. Resuspension rate was set to zero in the lake model, and the surficial sediment bed layer thickness was set to 0.2 m. The burial rate was set to 0.026 m/yr, which was computed by the from a steady-state solids balance in the bed and a settling rate of 365 m/yr. Degradation rates were set to zero for all constituents except FCB.

Marsh Model

Using an 8" rainfall for the New Orleans area during Katrina and an approximate collection area of 3.4E8 ft^2, the approximate rainfall volume for the area of St. Bernard Parish that was pumped into the marsh was estimated to be 6.4E6 m^3. Using the combined pump capacities for pumps 1 and 6 of 70 m^3/sec, the estimated dewatering time without levee failures or overtopping is about 26 hours, or about a day. Thus, a pump flow of 70 m^3/sec over one day was used for the pump operations to establish the loading and background flushing during dewatering for *baseline* conditions. It was assumed that pump 4 would not be used as it was not used following Katrina. Also, rainfall from Rita was not considered for the marsh modeling for either condition.

The estimated *actual* pump flows for pumps 1 and 6 and concentration measurements taken from St. Bernard Parish were used for the *actual* conditions. The estimated flows through pumps 1 and 6 were combined and averaged over the 37 day pumping period yielding an average pump flow rate of 31 m^3/sec for 37 days. This flow was used to establish the loading and to set the modeled system background flushing flow rate during dewatering for *actual* conditions.

The RECOVERY model was run for all 5 constituents, for *actual* and *baseline* conditions, and for 2 loadings based on median and 95UCL concentrations for each of the 2 conditions. These combinations constituted 4 runs since all 5 constituents could be included in a run. These runs are referred to as Actual and Base and Actual95 and Base95 for the *actual* and *baseline* conditions with median and 95UCL loading concentrations, respectively. As described in the Approach Section, the results from these runs were used as initial conditions for subsequent runs with a low level background flushing flow following pumped flow cessation. The loading concentrations for *baseline* and *actual* conditions are shown in Table 3.

Table 3
Marsh loading concentrations (total) for *baseline* and *actual* conditions

Constituent	Median, µg/L	95UCL, µg/L
Arsenic	12.0	14.0
BaP	5.0	5.0
DDE	0.05	0.1
Lead	2.5	4.9
Fecal coliform bacteria	90*	1708*

* Units are cfu/100ml or MPN/100ml

The RECOVERY model required TSS as an input parameter for calculating water column particulate contaminant concentrations. Turbidity measurements obtained from the flood waters following Katrina were analyzed for median concentration, which was converted to a TSS concentration of 19.8 mg/L. This value was used in the model since the short flushing time of the marsh will result in marsh TSS concentrations equal to that of the flood water pumped into it.

The RECOVERY model uses K_{ow} and Equation 1 to compute K_{oc} and the product of K_{oc} and f_{oc} to compute K_d for organic chemicals. Then TSS is used in place of POC in Equation 6 to calculate the fraction of particulate organic chemical to total organic chemical concentration. For inorganic chemicals, K_d values are input directly into the model. The K_{ow} and K_d values shown in Table 1 (L/kg) were used for model input.

RECOVERY requires several other inputs, including the sediment dry density, which was 2.65 g/ml, and surficial layer thickness, which was set to 0.2 m. Sediments are typically found to be fairly well mixed over a depth of 0.2 m. The surficial sediment layer thickness does affect computed sediment concentrations. The average wind speed of 3.0 m/sec was applied to the marsh model. Sediment resuspension rate was set to 0.0. A burial rate 0.026 m/yr was computed by the model from a steady-state solids balance in the bed and a settling rate of 365 m/yr. Degradation rates were set to 0.0 for all constituents except FCB which had a die-off rate of 1.0 day^{-1}.

Calibration/Validation

A limited level of model calibration and validation was undertaken for the lake model, but due to lack of data, calibration and validation were not conducted for the marsh model. Model calibration/validation was less important for the marsh given the simplicity of the marsh system and its modeling approach. The preferred approach is to adjust model parameters (i.e., calibrate) to match observations as well as possible for one set of conditions, then validate how well the model can reproduce observations using a different, independent set of conditions. Given the data limitations and short time available to conduct this study, it was not possible to adhere to the usual protocol for model calibration/validation. Observational data collected during September and October 2005 was used to conduct concurrent model calibration and validation. The hydrodynamic model was executed for *actual* conditions following Katrina. Model parameters were adjusted to bring the model into agreement with observed water surface elevations in the lake. The water quality model was applied for FCB during *actua*l conditions following Katrina to validate the model against observed FCB in the lake using the calibrated hydrodynamic model output.

The computed and observed water surface elevations during September and early October 2005 at the Norco gage of Lake Pontchartrain are shown in Figure 4. This was the only water level observation gage available in Lake Pontchartrain for model comparison. This gage was not operational between October 10 and December 2, 2005. The model compares closely with the observations throughout the observation period with the exception of the first 4 days, which was the model spin-up period when the model was started with quiescent conditions at mean sea level elevation. The large spike in water level around September 24 was due to Hurricane Rita. The model performs exceptionally well given that the boundary conditions at the open sea boundary were synthesized from the combination of predicted astronomical tides and filtered sub-tidal meteorological forcing. Measured water levels at the seaward boundary are usually available for most estuarine and coastal hydrodynamic model applications. As stated previously, this model has been found to perform quite well if boundary conditions are adequately prescribed. Such was the case here as it was not necessary to make any adjustments in model parameters, such as bottom roughness and wind drag coefficients.

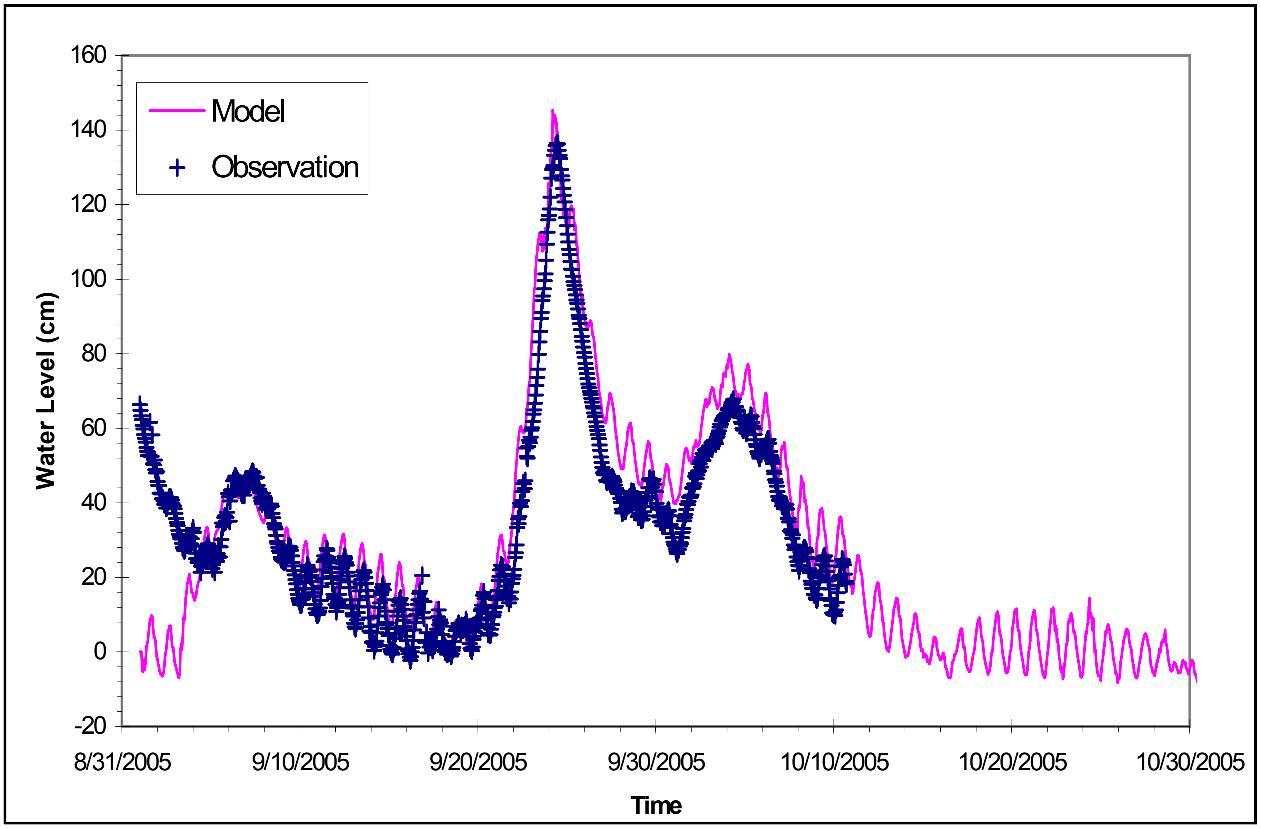

Figure 4. Computed and observed water level in Lake Pontchartrain for tide gage 8762372 East Bank 1, Norco, Bayou LaBranche, LA

Pumped flows were a dominant factor in the lake currents under the *actual* conditions as can be seen in Figure 5, which shows the surface layer velocity vectors computed for September 12, 2005, near the end of the day. Animation of the currents shows that the speeds increase and decrease dramatically near the south shore when pumping begins and ends.

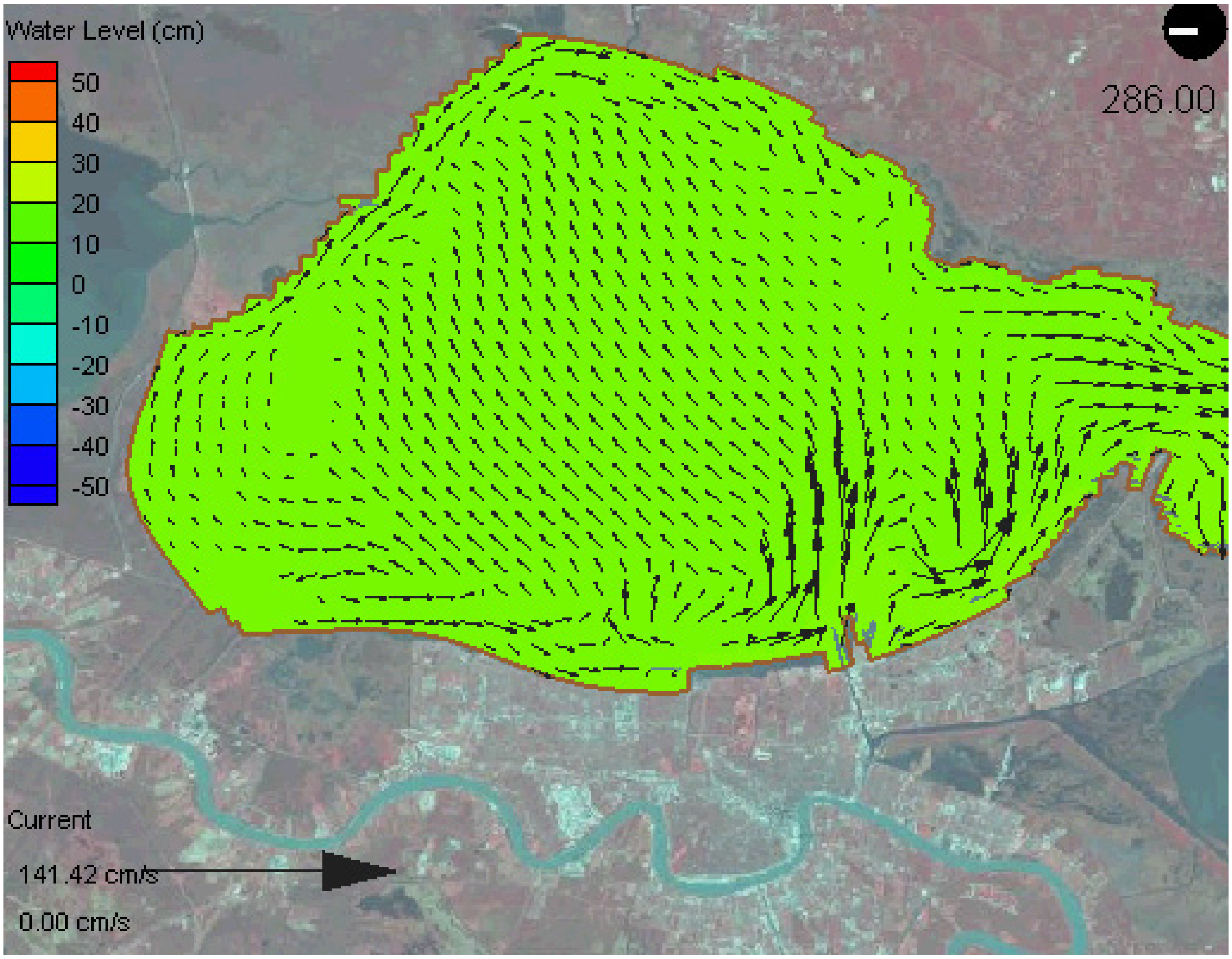

Figure 5. Computed surface layer currents at the end of September 12, 2005, *actual* conditions

The lake water quality model output for FCB and *actual* conditions were compared to lake measurements of FCB obtained by the Lake Pontchartrain Basin Foundation following Katrina. The Foundation's water sampling station locations are shown in Figure 6. Comparison of model and observed data are shown in Figure 7 for stations 1-4 where data were available during September and October along the south shore. Data for station 5 was not available during those months, and data at stations along the north shore were not compared since the model did not include any FCB loadings from the north shore. Model loadings end on October 18 when pump-out was completed, but observations indicate that there must have been other source loadings into the lake after that date. It is difficult to make any statements regarding water quality model validation based upon Figure 7. The model is in close agreement with a few of the observed values, and model and observations have the same order of magnitude, but few other conclusions can be drawn. It should be noted that the model loading concentration was constant over time and equal to the median concentrations in the flood waters, whereas the actual loading concentrations probably varied due to variations in pumped flood water concentration over time and space. There may have been sources of FCB released into the lake that are not accounted for in the model in addition to the pumped flood waters. Further work would be required to find data adequate for use in model validation and to conduct the model validation applications.

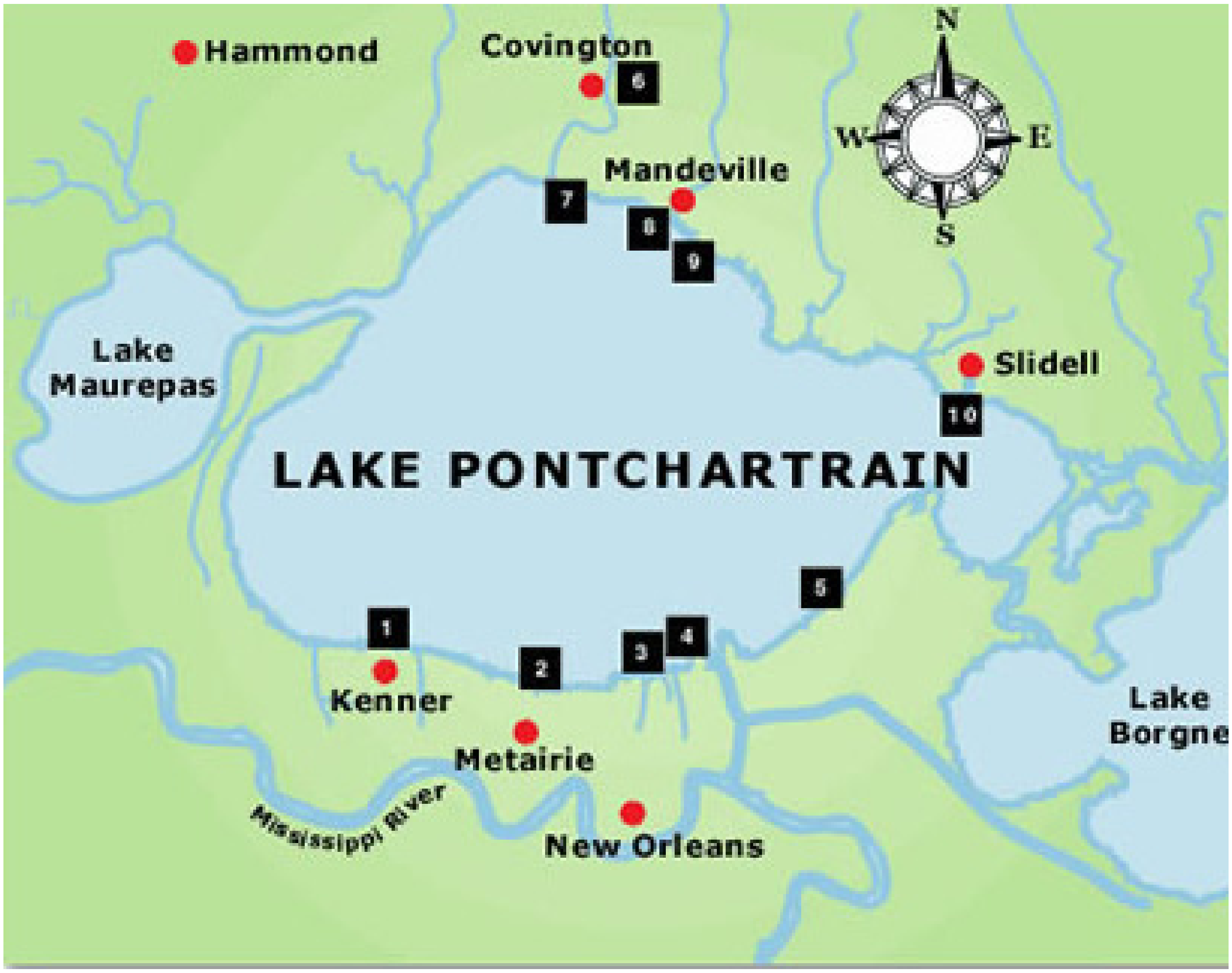

Figure 6. Lake Pontchartrain Basin Foundation water quality sampling station locations

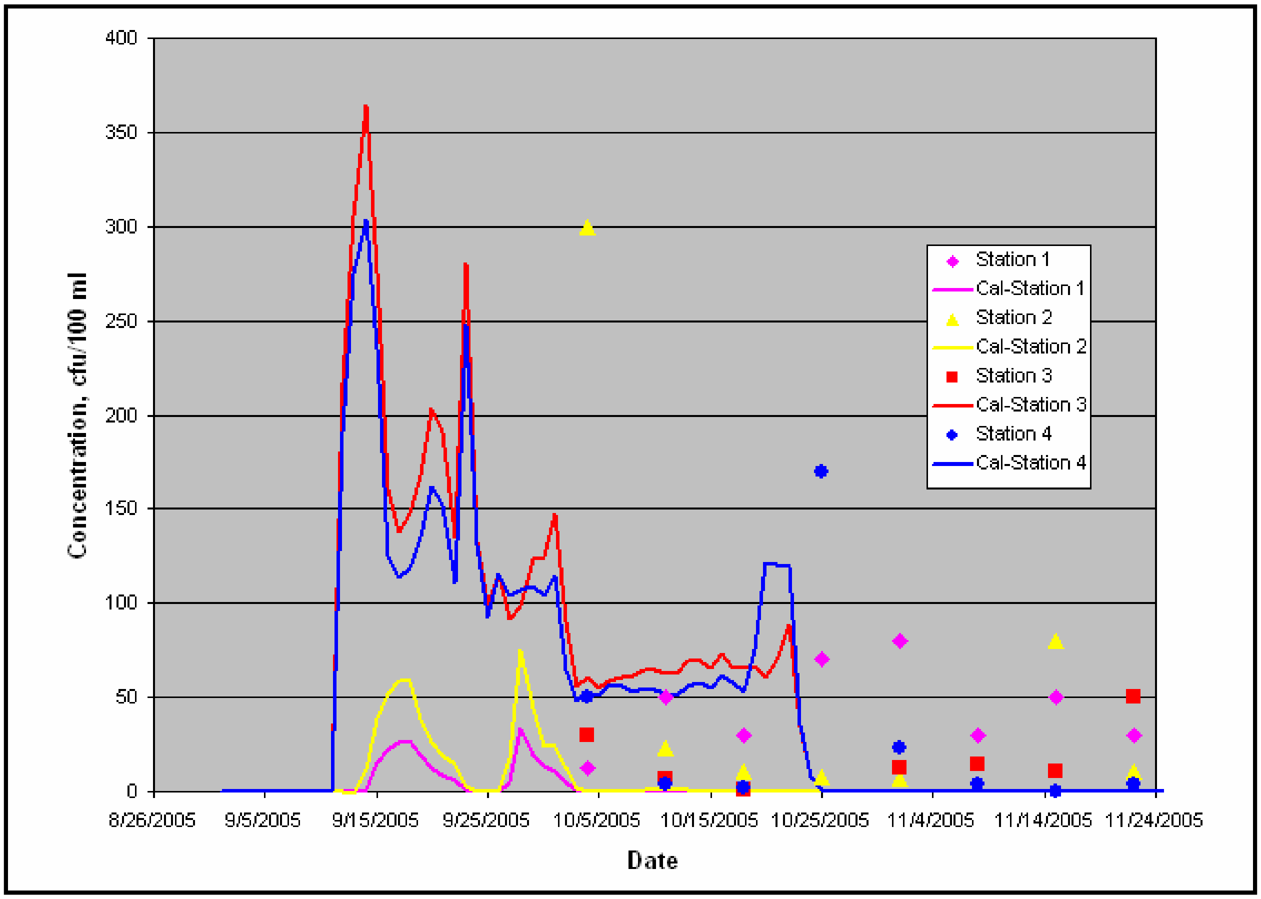

Figure 7. Model-computed (Cal-Station and solid lines) FCB concentrations for *actual* conditions and median loading concentration and measured (symbols) FCB concentrations following Katrina at 4 stations along the south shore of Lake Pontchartrain

Scenario Results

Lake Model

Three-dimensional models can generate voluminous output that can be viewed in a wide variety of formats, but two-dimensional concentration contour plots are one good way to view results. An example of this type of plot is illustrated in Figure 8, where maximum concentrations for the 90 day simulation are stored for every cell of the lake surface layer, then plotted as concentration contours. The results in Figure 8 are for arsenic with *actual* conditions and a median loading concentration of 20 μg/L. The third contour line from the top is 4 μg/L, which is a 5 fold reduction in effluent concentration. The red color shading along the south shore is 12 μg/L or about half the effluent concentration.

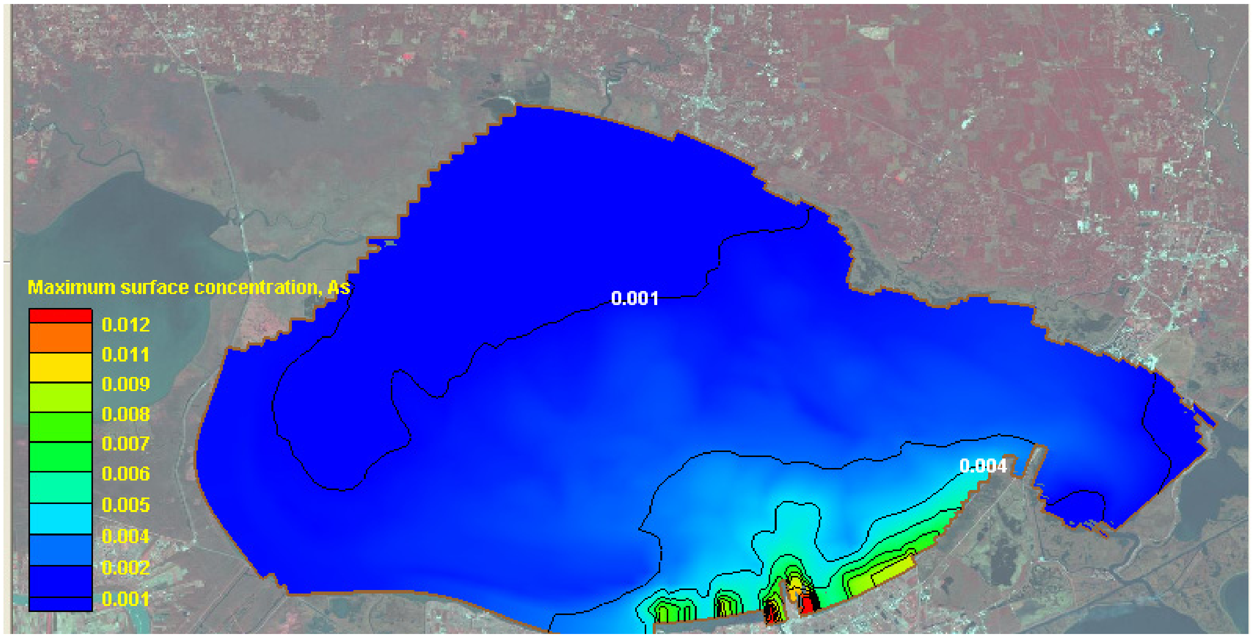

Figure 8. Maximum Arsenic concentrations (mg/L total) in the surface layer of the Lake Pontchartrain model for *actual* conditions and median loading concentration

The lake water quality model was executed for each scenario (*baseline* and *actual*) and for median and 95UCL loading concentration. All five constituents were modeled, but not all could be included in the same model run since the model can presently handle only 2 contaminant constituents at a time. Maximum concentrations in the model surface layer for the median loading concentrations were plotted and are provided in Appendix A for all five constituents and for both *baseline* and *actual* conditions. Similarly, maximum concentrations in surficial benthic sediments as computed by the model for the median loading concentrations are provided in Appendix A for all five constituents and both scenario conditions.

Results for the 95UCL loading concentrations are not plotted since these plots would look similar to the median loading concentration results except that the concentration values along each contour would be increased in proportion to the product of the ratio of the 95UCL to median concentrations. However, the ratio of median and 95UCL loading concentrations are different for Orleans Proper and Orleans East for all constituents except BaP. Thus, the amount of change in the contour concentration depends on how close the contour is to each loading source and the source's change in loading concentration. The results can be used to estimate receiving water concentrations resulting from other loading concentrations if all source loading concentrations are adjusted by the same factor. For example, suppose someone wanted to know what would be the maximum lake concentration at a point of interest for 10 times the concentration used in the model for all sources? All they would need to do is multiply the computed model concentration at that location times 10. Normally the same could be said for scaling the loading rate, but since the loading flow into the lake is a major component of the hydrodynamics, a linear scaling is not appropriate.

One can relate the effects of the levee failures on the lake environment by comparing the figures in Appendix A for *actual* and *baseline* conditions. In general, the outermost extent of the maximum concentration contours for *actual* conditions extend further out from the shore and cover a larger area, whereas the *baseline* contours are more compact. Also, the outermost contours have higher concentrations for the *actual* conditions. The greater spread is due to the longer duration of pumping and the overall larger total mass loadings of the *actual* conditions associated with the greater water volumes pumped. However, the pump discharge rates of the *baseline* conditions are at pump capacity, which results in a larger flow rate and mass loading rate, but for a much shorter duration. The short-term bursts of higher loading rates of the *baseline* conditions result in slightly higher overall maximum concentrations near the shore (see Table 4) and even a larger impacted area for FCB; but as soon as pumping stops, the concentrations in the impacted area rapidly dissipate. This behavior occurs for the other constituents as well as evident by comparing the As results in Appendix A plotted for September 12 (Figures A19 and A20). The behavior is more apparent for FCB because of the higher concentrations.

The highest maximum sediment concentrations tend to be concentrated along the southeast shore of the lake, out from Orleans East, for both conditions (see Figures A11-A18). This is believed to be due to the currents and the shallow water in this area. More material can settle to the bottom in shallow water than in deep water. It should be noted that resuspension was set to zero, and resuspension can reduce sediment concentrations over time. However, it is doubtful that much resuspension and transport would occur during the 90 day simulation.

Table 4
Computed maximum water (µg/L) and sediment (mg/kg) concentrations (total) for Lake Pontchartrain for *actual and baseline* conditions and median loading concentrations

Condition	As water	As sed	BaP water	BaP sed	DDE water	DDE sed	Pb water	Pb sed	FCB water*
Actual	13	0.048	3.7	0.173	0.036	0.0024	3.7	0.053	1,055
Actual95	16	0.066	3.7	0.173	0.209	0.0171	25.4	0.384	42,214
Base	14	0.0052	3.7	0.014	0.037	0.000172	3.7	0.0062	1,413
Base95	14	0.0054	3.7	0.014	0.053	0.000598	32.1	0.051	44,780

*Units for FCB are cfu/100ml or MPN/100ml
Note: Actual and Base are median loading concentrations, and Actual95 and Base95 are 95UCL loading concentrations

From study of Table 4, it is apparent that the maximum water concentrations for the *actual* conditions are about the same or a little less than those for the *baseline* conditions. The reason for this is that the *baseline* condition has a higher flow rate (due to more pumps operating at capacity) during pumping which results in less time for settling of particulate matter and die-off for FCB, thus slightly greater water column concentrations. However, the maximum sediment concentrations for the *baseline* condition are roughly an order of magnitude less than those of the corresponding *actual* condition for all constituents, which is due to the fact that the sediment for the *baseline* condition has a much shorter exposure duration to constituents in the water column because the pumping and loading period is much shorter.

Responses are not all linear with respect to loading concentrations as expected. Linear response means that if the loading concentration doubles, then the corresponding water column and sediment concentrations also double, as long as the flow conditions do not change. However, if the loading flow doubles, then the corresponding concentrations due not necessarily double since this system is flow dominated. The results in Table 4 do have a linear response for some constituents and conditions, such as for As with *actual* and *actual95* conditions/loadings, but others do not, especially for sediment concentrations. The non-linear response may be due to the differences in median and 95UCL loading concentrations that differ by loading location (i.e., Orleans Proper and Orleans East) and the effects of the shallow waters along the shore of Orleans East.

Marsh Results

The marsh is dominated by the loadings, thus, the water concentrations rapidly reach a constant value and remain constant over the loading period, then rapidly drop when pumping and loading ceases as shown in Figure 9 for arsenic with a loading concentration of 1,000 µg/L. The sediment concentrations increase more gradually during loading, but then drop off gradually after loading ceases as shown in Figure 10. However, the results in Figure 10 are for a flushing rate equal to the pumping rate that continues after pumping ceases. Figure 11 shows results for the same conditions but using a flushing rate of 0.1 m^3/sec after pumping ceases and with peak concentrations of Figures 9 and 10 as initial conditions for the run that produced Figure 11. It can be seen by comparing Figures 10 and 11 that the two-step flushing procedure extends concentrations over time with higher peak sediment concentrations, which are considered to be more representative of what is expected to occur.

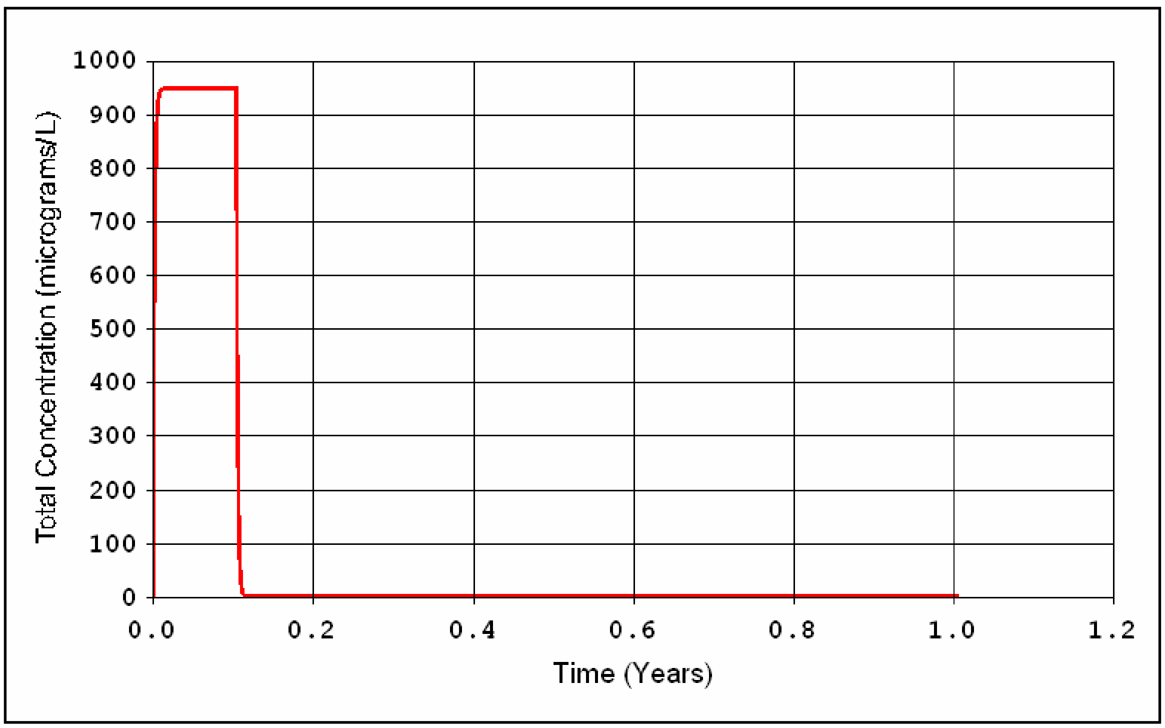

Figure 9. Computed arsenic concentrations (total) for water column of upper Violet Marsh for *actual* conditions using a pumped effluent concentration of 1000 µg/L

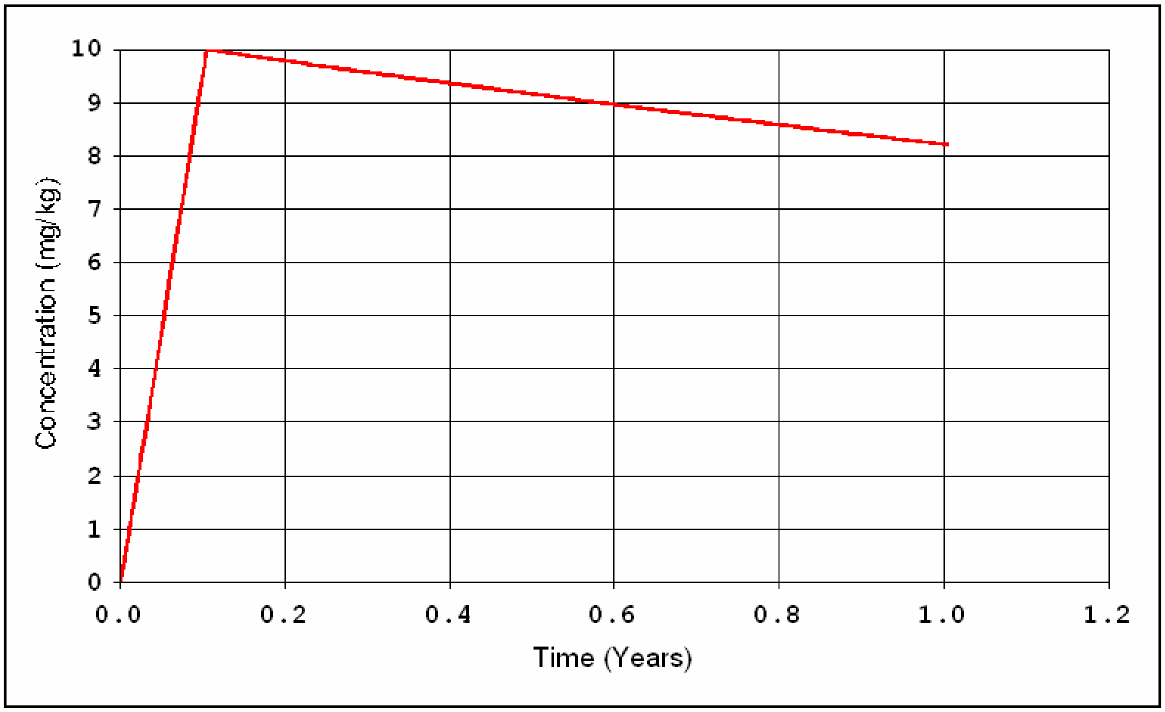

Figure 10. Computed arsenic concentrations (total) for benthic sediment of upper Violet Marsh for *actual* conditions using a pumped effluent concentration of 1,000 µg/L and with background flushing equal to the pumped discharge flow

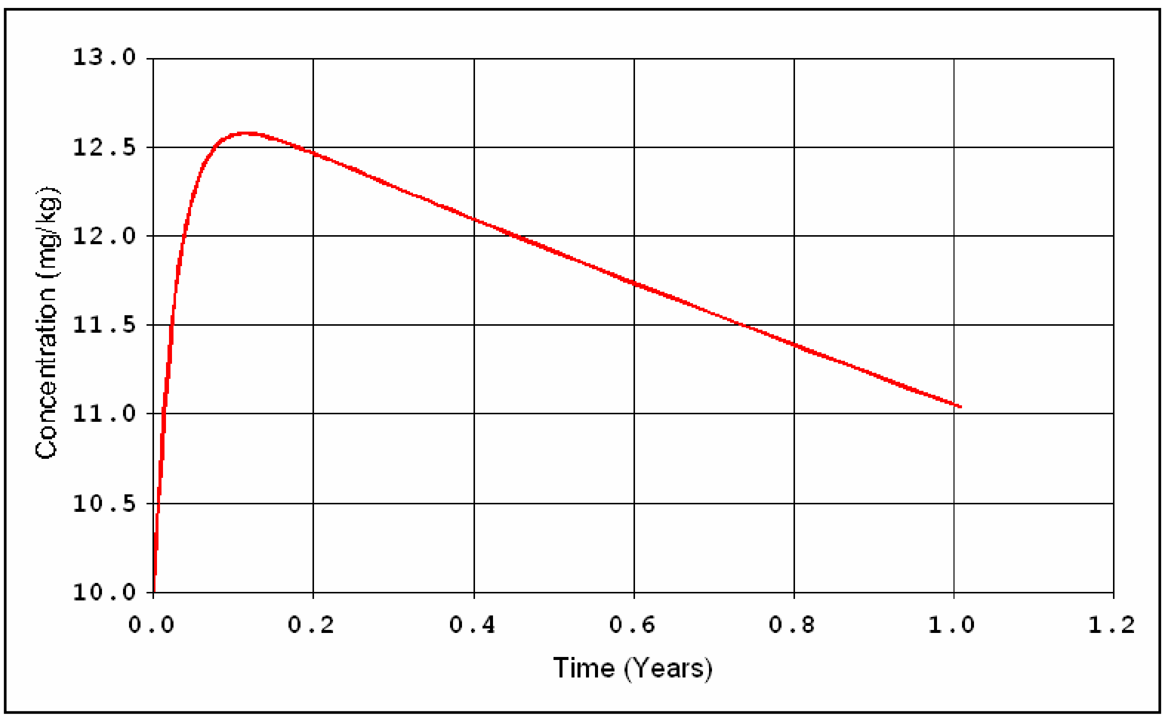

Figure 11. Computed arsenic concentrations (total) for benthic sediment of upper Violet Marsh for *actual* conditions using a pumped effluent concentration of 1,000 µg/L and with background flushing flow of 0.1 cms following pumping cessation

Marsh model results for peak water and sediment concentrations (total) are presented in Table 5 for both conditions and for loading concentrations shown in Table 3. The peak sediment concentrations were obtained from the runs with the low background flushing rate after pump cessation.

Table 5
Computed maximum water (µg/L) and sediment (mg/kg) concentrations (total) for upper Violet Marsh for *actual and baseline* conditions and median and 95UCL loading concentrations

Condition	As water	As sed	BaP water	BaP sed	DDE water	DDE sed	Pb water	Pb sed	FCB water*
Actual	11.5	0.15	3.5	0.28	0.022	0.003	1.95	0.111	55.0
Actual95	13.4	0.18	3.5	0.28	0.044	0.006	3.82	0.22	1040
Base	11.5	0.038	4.2	0.026	0.032	0.00024	2.2	0.012	69
Base95	13.4	0.044	4.2	0.026	0.065	0.00048	4.3	0.023	1310

* Units for FCB are cfu/100ml or MPN/100ml
Note: Actual and Base are median loading concentrations, and Actual95 and Base95 are 95UCL loading concentrations

Several interesting features can be observed from Table 5. One feature is that the *baseline* condition results in maximum water concentrations that are either equal to or slightly greater than those for the corresponding *actual* condition. The reason for this is that the *baseline* condition has a higher flow rate through the system (due to more pumps operating at capacity) during pumping which results in less time for settling of particulate matter and die-off for FCB, thus slightly greater water column concentrations. However, the maximum sediment concentrations for the *baseline* condition are roughly an order of magnitude less than those of the corresponding *actual* condition for all constituents, which is due to the fact that the sediment for the *baseline* condition has a much shorter exposure duration to constituents in the water column because the pumping and loading period is much shorter.

The maximum sediment concentrations at the end of the initial runs (i.e., background flushing flow equal to pumped flow) are close to the maximum sediment concentrations for the subsequent runs (i.e., background flushing flow set to 0.1 m^3/sec) for the *actual* conditions; however, for the *baseline* condition, the sediment concentrations increased substantially above the initial concentrations during the subsequent runs. This is due to the short duration of initial loading relative to the follow-on settling period associated with the *baseline* condition.

Responses are linear for all conditions and loadings; for example, if the median loading concentration doubles, then the corresponding water column and sediment concentrations also double. However, if the loading flow doubles, then the corresponding concentrations due not necessarily double since the system is flow dominated. Thus, the results in Tables 5 can be easily extended to other loading conditions (i.e., loading concentrations) as long as the loading discharges and durations and background flows do not change.

Comparisons to Protective Benchmarks

Dissolved water concentrations were needed for comparison to water quality criteria, which are stated as dissolved. Dissolved concentrations were obtained by multiplying the fraction of dissolved to total contaminant concentrations in the water column (F_{dw}) times the total concentrations in water in Tables 4 and 5. The dissolved concentrations are reported in Table 6 for each constituent in Table 6 along with the dissolved fractions.

Table 6
Dissolved fractions in the water column (F_{dw}) for each constituent and computed maximum water (µg/L) concentrations (dissolved) for *actual and baseline* conditions and median and 95UCL loading concentrations

Condition	As	BaP	DDE	Pb
F_{dw}	0.99	0.89	0.80	0.93
		Lake		
Actual	12.9	3.3	0.029	3.4
Actual95	15.8	3.3	0.167	23.6
Base	13.9	3.3	0.030	3.4
Base95	13.9	3.3	0.042	29.8
		Marsh		
Actual	11.4	3.11	0.018	1.81
Actual95	13.3	3.11	0.035	3.55
Base	11.4	3.74	0.026	2.05
Base95	13.3	3.74	0.052	4.0

The lake and marsh model results were compared with screening protective benchmarks for sediment and water. The maximum dissolved water column concentrations and maximum sediment concentrations were compared with the chronic marine water quality criteria and sediment screening values shown in Table 7. U.S. EPA (1986) recommended primary contact protective limits for FCB of 400 MPN/100ml for a single sample.

Table 7
Screening protective benchmarks

Criteria	As	BaP	DDE	Pb
EPA, marine waters (µg/L dissolved)	36	300	14	4.0[1]
LA, marine waters (µg/L dissolved)	36	NA	0.14	1.2
Sediment[2] (µg/kg dry)	5.9	0.0319	0.00142	35.0

[1] Adjusted for hardness
[2] Freshwater TEL

Lake. The computed maximum water concentrations for As and BaP were less than the EPA and LA water quality criteria for both conditions and both loading concentrations. The computed maximum water column concentrations for Pb exceeded the LA criteria for both conditions and both loading concentrations, and the concentrations for DDE exceeded the LA criteria for the both conditions with 95UCL loading concentrations. Maximum concentrations for FCB in water exceed EPA criteria for both conditions and both loading concentrations, but this normally occurs during storm water dewatering (Jin et al. 2004).

The computed maximum sediment concentrations for As and Pb were less than the sediment screening criteria for both conditions and both loading concentrations. The computed maximum sediment concentrations for BaP and DDE were less than the sediment screening criteria for both loading concentrations of the *baseline* conditions, but sediment concentrations for both constituents exceeded the criteria for both loading concentrations under the *actual* conditions.

In summary, the model indicated that only Pb would exceed water quality criteria in the lake for both *baseline* and *actual* conditions with median loading concentrations. DDE was found to exceed LA criteria slightly with 95UCL loading concentrations and *actual* conditions. However, 95UCL loading concentrations represent the extreme high end of flood water concentrations, thus, DDE is not considered to present a concern for water quality as a result of *actual* conditions following Katrina. Based upon the model, both BaP and DDE are expected to exceed sediment criteria for *actual* conditions. The expected consequences of *actual* conditions on Lake Pontchartrain Marsh following Katrina are: 1) sediment concentrations of all constituents are about an order of magnitude or more greater than those normally anticipated under *baseline* conditions; 2) water concentrations of all constituents are about the same or slightly less than those normally anticipated under *baseline* conditions; and 3) concentrations for organic chemicals, such as BaP and DDE, exceed sediment criteria, whereas they normally should not under *baseline* conditions. Maximum water concentrations for Pb in the lake are expected to exceed LA water quality criteria for both conditions and loading concentrations. Maximum lake concentrations of FCB are expected to exceed EPA criteria for almost any dewatering condition, with or without levee failures.

Marsh. The computed maximum water concentrations for As, BaP, and DDE were less than the EPA and LA water quality criteria for both conditions and both loading concentrations. The computed maximum water column concentrations for Pb exceeded the LA standards for both conditions and both loading concentrations and equaled the EPA standard for the Base95 condition. Maximum concentrations for FCB in water exceed EPA criteria for both conditions and the 95UCL loading concentrations, but are below the criteria for both conditions and the median loading concentrations. This result is different from the lake results because the FCB loading concentrations for the lake are considerably higher than for the marsh (see Tables 2 and 3).

The computed maximum sediment concentrations for As and Pb were less than the sediment screening criteria for both conditions and both loading concentrations. The computed maximum sediment concentrations for BaP and DDE were less than the sediment screening criteria for both loading concentrations of the *baseline* conditions, but sediment concentrations for both constituents exceeded the criteria for both loading concentrations under the *actual* conditions.

In summary, the model indicated that only Pb would exceed water quality criteria in the marsh for both *baseline* and *actual* conditions, and BaP and DDE are expected to exceed sediment criteria for *actual* conditions. Therefore, the expected consequences of *actual* conditions on Violet Marsh following Katrina are: 1) sediment concentrations of all constituents are about an order of magnitude greater than those normally anticipated under *baseline* conditions; 2) water concentrations of all constituents are about the same or slightly less than those normally anticipated under *baseline* conditions; and 3) concentrations for organic chemicals, such as BaP and DDE, exceed sediment criteria, whereas they normally should not under *baseline* conditions. Maximum water concentrations for Pb in the marsh are expected to exceed LA water quality criteria for both conditions and loading concentrations. Maximum marsh concentrations for FCB may or may not exceed EPA criteria depending on the loading concentration, with little or no dependency on dewatering conditions with or without levee failures.

Discussion

The lake and marsh respond in a similar manner to loadings. However, the marsh tends to have a greater sediment response to loadings than does the lake due to the marsh being a confined system with the loadings being the only flow in the system. Also, lake and marsh concentrations differ due to differences in loading concentrations for the same conditions, such as for Pb.

The greatest area for improvement in the model would be to obtain a better representation of pump flow rates for the *baseline* scenario. The present *baseline* scenario approach ignores any water entering the city by levee overtopping, whereas, data indicate that overtopping would have occurred even if the levees had functioned fully as designed. The second highest priority for model improvement should focus on obtaining water quality measurements in storm water under normal, *baseline* conditions of the levees functioning as designed. The assumption was made for the modeling that storm water and flood water concentrations were the same under *baseline* and *actual* conditions, an assumption that is highly questionable due to limited measured water quality data for normal dewatering operations. Additionally, given more time and funding, it would be good to conduct additional model calibration/validation for the lake model.

At one point early in this study, there was consideration given to trying to estimate the source terms that resulted in the flood water contamination. Models are much more robust if the source terms can be quantified. However, such an undertaking would have required a tremendous effort with very high uncertainty of the results. Therefore, this idea was dropped from further consideration and is most likely not a viable goal for future studies. Furthermore, Mielke et al. (2004) reported high soil concentrations of PAHs and metals in the urban area of New Orleans, especially near busy city streets. These data are pre-Katrina and represent a common condition in urban areas with heavy traffic. Thus, a substantial portion of flood water contamination may have been caused by flooding of already contaminated soils rather than rupturing or leaking chemical sources. Flooding and the subsequent dewatering resulted in exposing the environment surrounding New Orleans to these contaminants. However, such exposure occurs even during normal (*baseline*) dewatering, but to a less degree due to less storm water and shorter pumping durations.

In retrospect, the use of 95UCL loading concentrations and sampling of the model maximum water and sediment concentrations may have been an excessively conservative approach. A better approach would have been to use a statistical distribution of loading concentrations observed in the flood waters and then process the output distribution to determine the 95UCL water and sediment concentrations. However, this approach would have require many more computer runs and post processing which would have required substantially more time and funding to complete the study. The approach used provides a good indication of the impacts of *actual* conditions following Katrina since it is compared relative to the *baseline* conditions.

Conclusions

The models applied to Lake Pontchartrain and upper Violet Marsh indicate the same consequences of dewatering the flood waters of Hurricane Katrina as a result of levee failures, which are the following.

- The increase in lake and marsh sediment concentrations as a result of dewatering are expected to be about an order of magnitude greater than normally expected for removal of storm water without levee failure.

- Maximum sediment concentrations for organic chemicals, such as BaP and DDE, are expected to exceed sediment quality criteria, whereas they are not expected to following normal removal of storm water without levee failure. However, it should be recognized that the sediment area exceeding sediment quality criteria is relatively small and isolated to areas near the southeast shore of the lake and the upper portion of Violet Marsh.

Other water impacts, such as elevated concentrations of FCB in water, are expected to occur in the lake regardless of dewatering conditions (i.e., levees functioning as designed or not). Elevated FCB concentrations may or may not occur in the marsh, depending on pump effluent concentrations, with little or no dependence on dewatering conditions. In fact, water concentrations of all constituents should be about the same, or even less, with levee failures since fewer pumps may be operating, and those that are may be operating below capacity. Lower pump discharge rates can result in lower water concentrations due to larger residence times in ambient waters with great opportunity for settling and dilution. The reason that sediment concentrations are expected to be higher with levee failures is that more flood water volume must be removed, thus, dewatering takes longer and much more contaminant mass is discharged to receiving waters, which is manifested as higher sediment concentrations.

Other constituents, such as Pb, may present water quality concerns under any dewatering conditions regardless of the levees functioning as designed or not. Maximum water concentrations of Pb computed by the models for the lake and marsh exceeded water quality criteria for both *actual* and *baseline* conditions. Elevated concentrations of metals and PAHs existed in urban New Orleans soils before Katrina. Thus, the presence of these constituents is expected for both urban floodwater and urban storm water runoff and in the subsequent pumped effluents, with or without levee failures.

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Appendix A: Contour Plots of Computed Maximum Water Concentrations in Surface Layer and Maximum Benthic Sediment Concentrations for Lake Pontchartrain

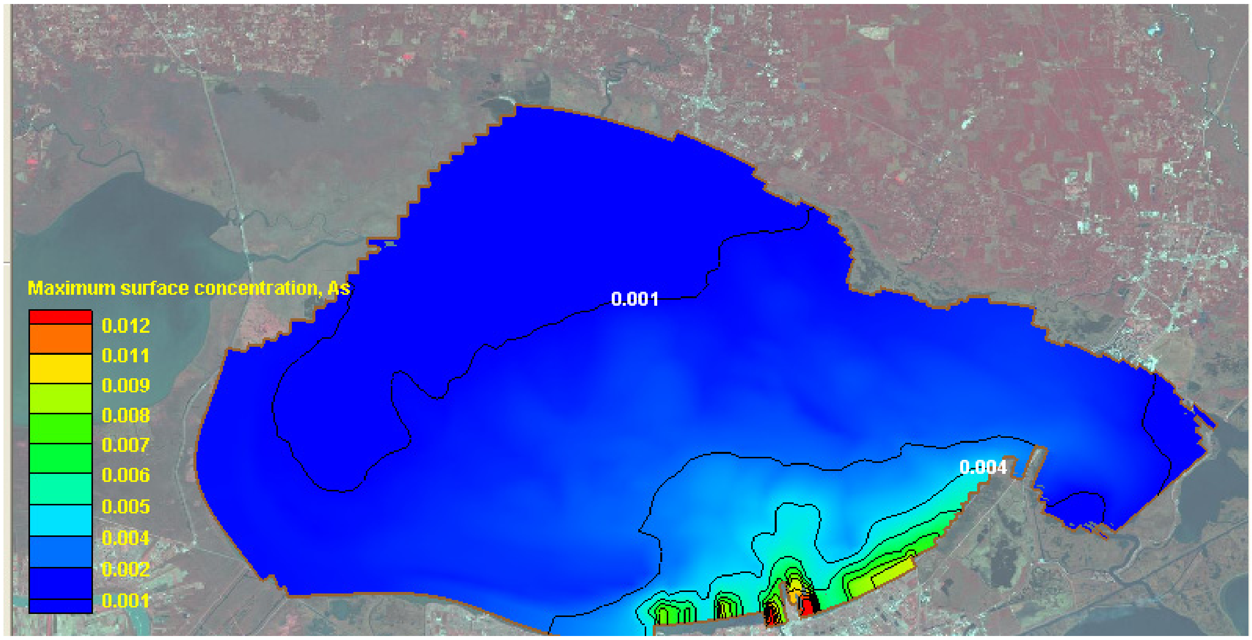

Figure A1. Maximum As water surface concentrations (mg/L total) in Lake Pontchartrain for *actual* conditions, median loading concentrations

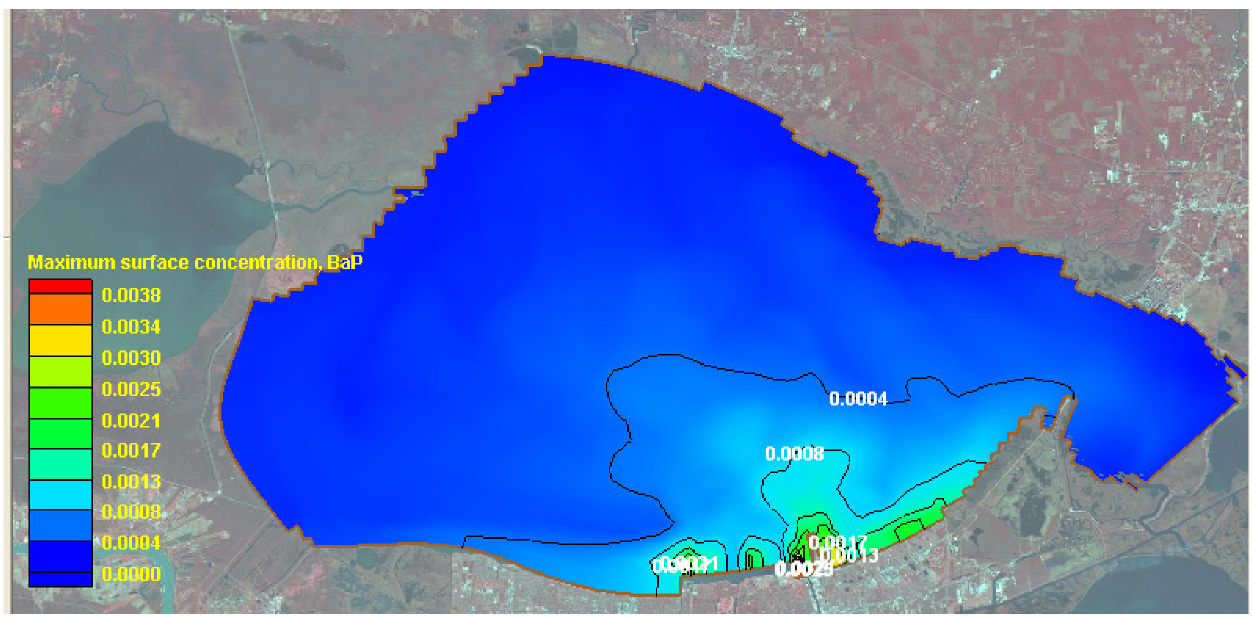

Figure A2. Maximum BaP water surface concentrations (mg/L total) in Lake Pontchartrain for *actual* conditions, median loading concentrations

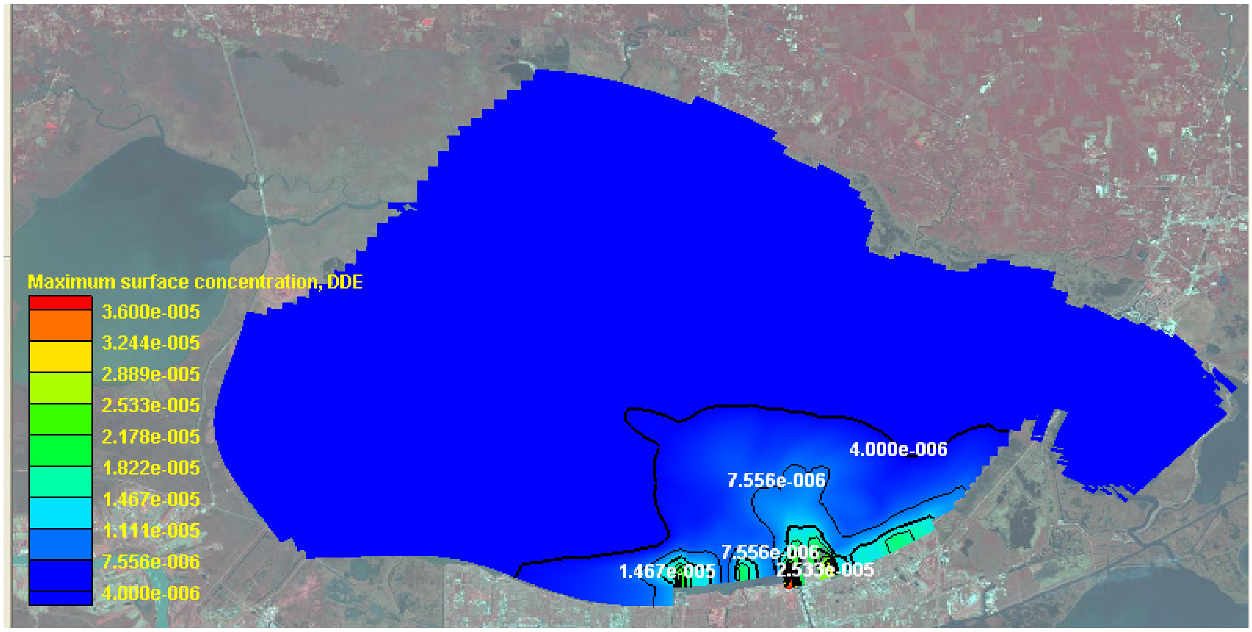

Figure A3. Maximum DDE water surface concentrations (mg/L total) in Lake Pontchartrain for *actual* conditions, median loading concentrations

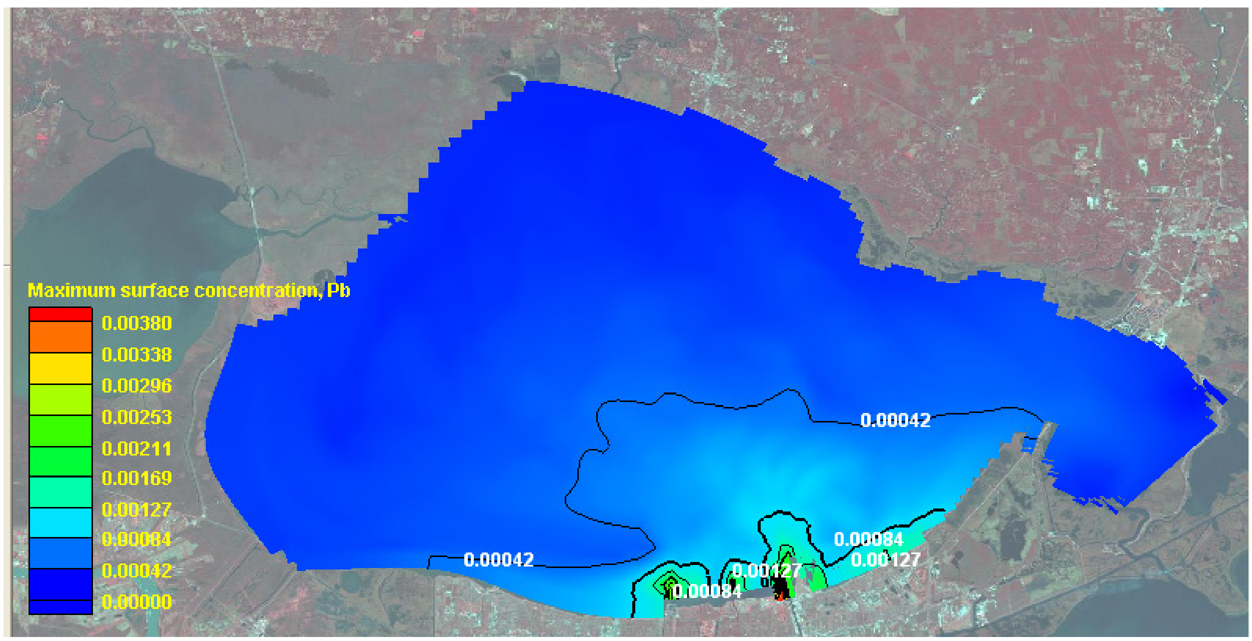

Figure A4. Maximum Pb water surface concentrations (mg/L total) in Lake Pontchartrain for *actual* conditions, median loading concentrations

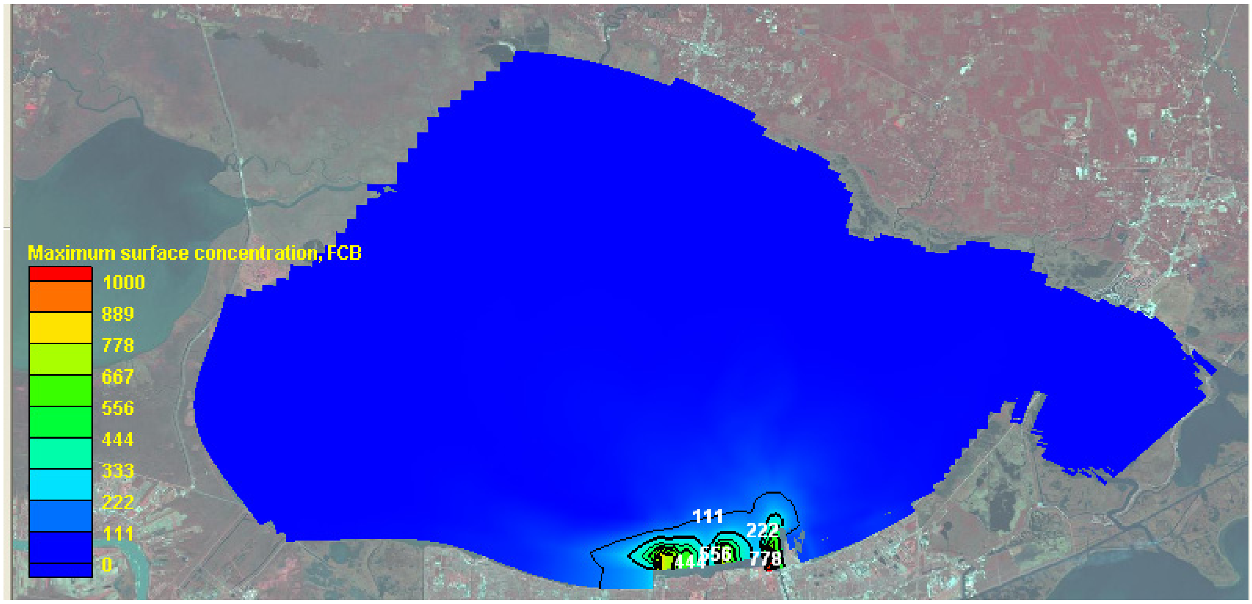

Figure A5. Maximum FCB water surface concentrations (cfu/100ml) in Lake Pontchartrain for *actual* conditions, median loading concentrations

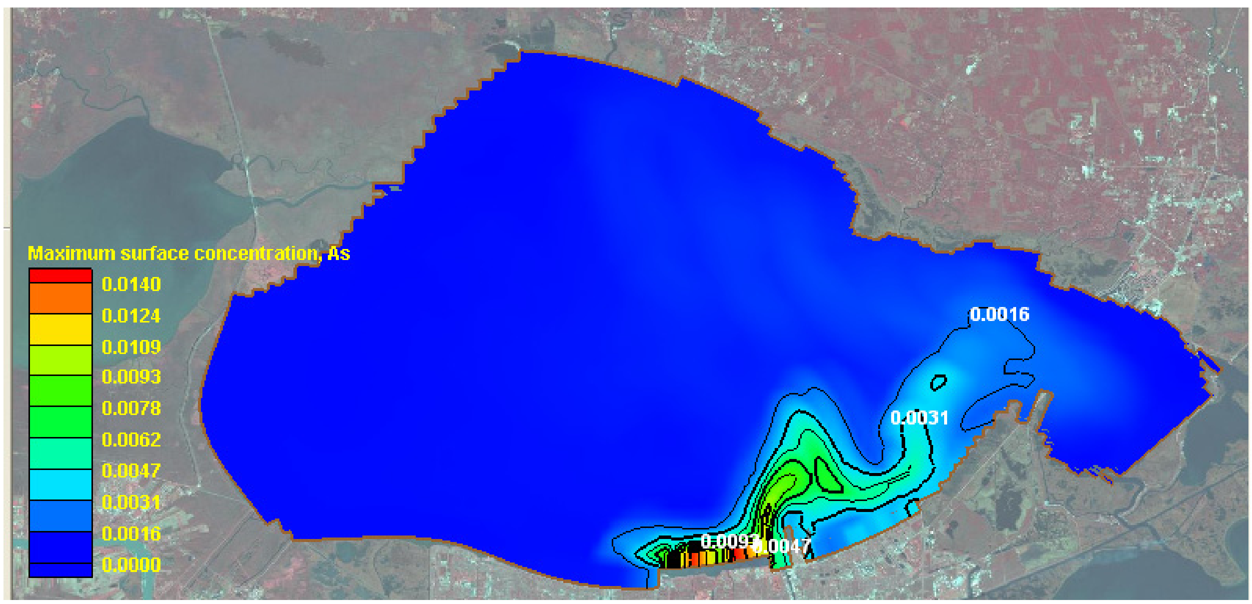

Figure A6. Maximum As water surface concentrations (mg/L total) in Lake Pontchartrain for *actual* conditions, median loading concentrations

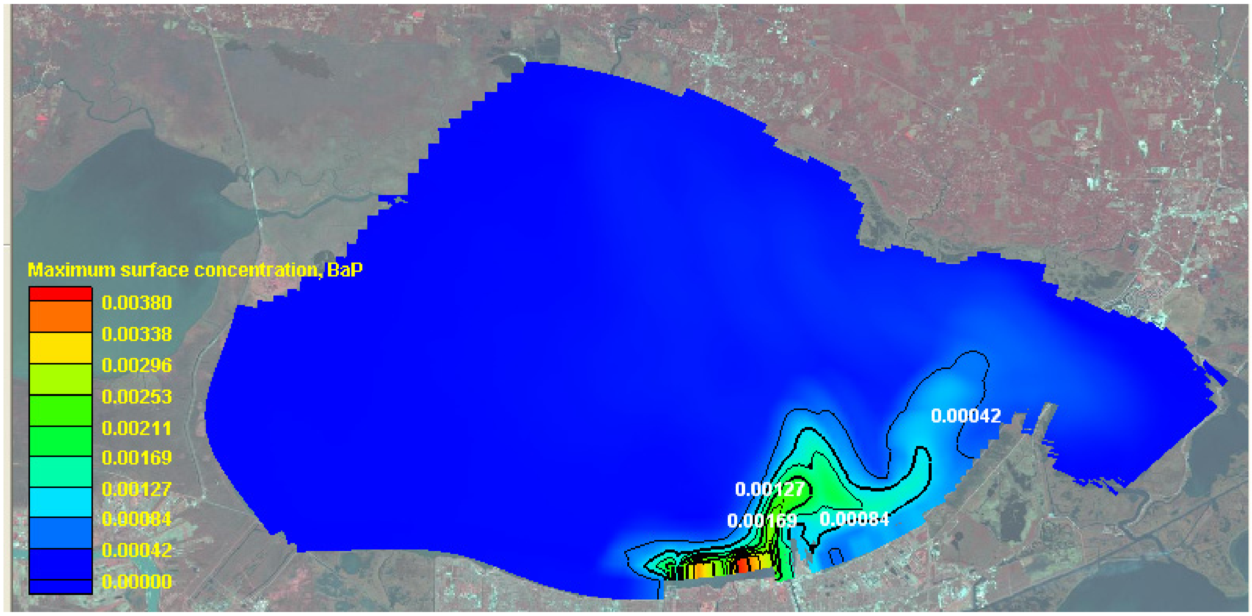

Figure A7. Maximum BaP water surface concentrations (mg/L total) in Lake Pontchartrain for *actual* conditions, median loading concentrations

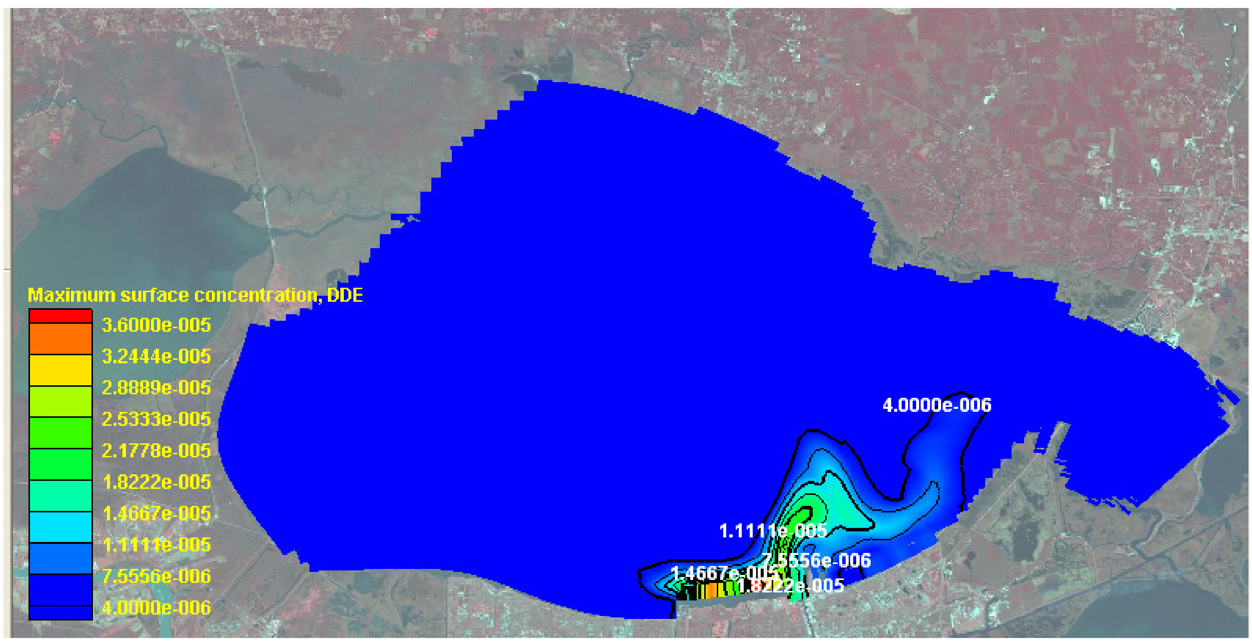

Figure A8. Maximum DDE water surface concentrations (mg/L total) in Lake Pontchartrain for *actual* conditions, median loading concentrations

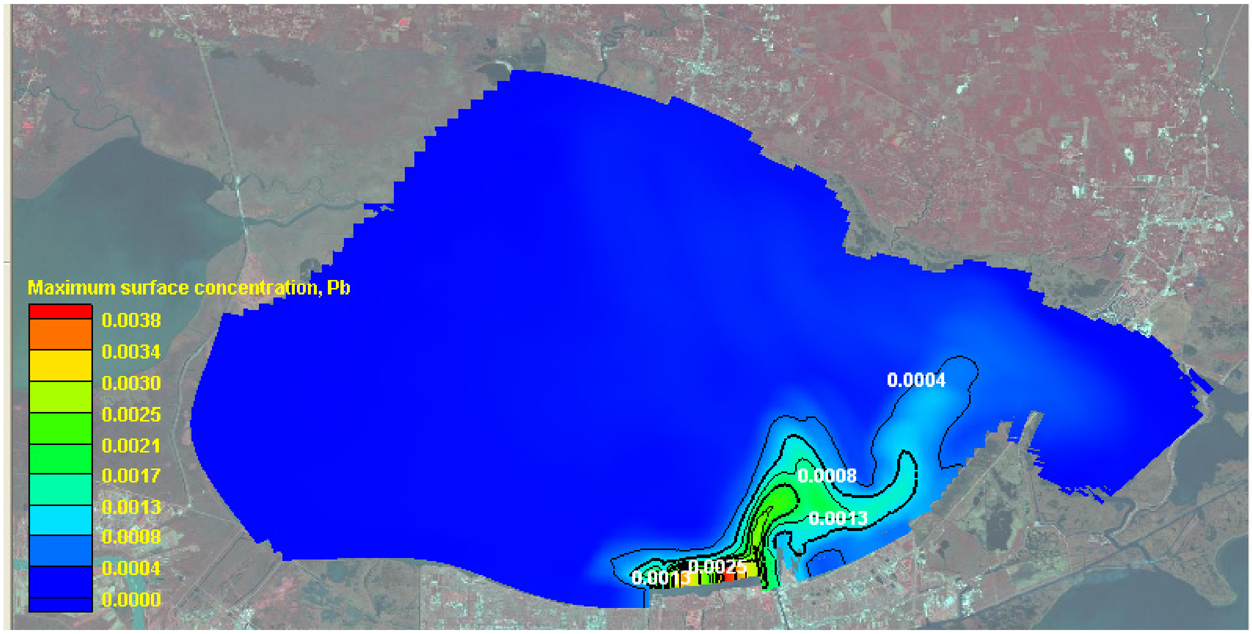

Figure A9. Maximum Pb water surface concentrations (mg/L total) in Lake Pontchartrain for *actual* conditions, median loading concentrations

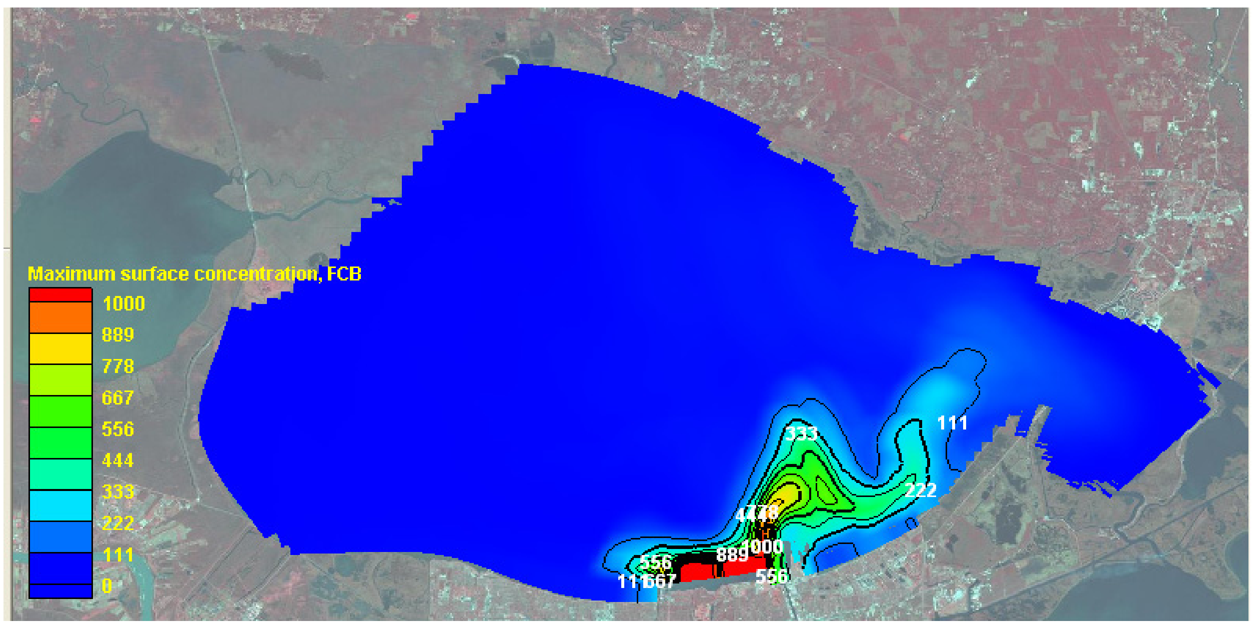

Figure A10. Maximum FCB water surface concentrations (cfu/100ml) in Lake Pontchartrain for *actual* conditions, median loading concentrations

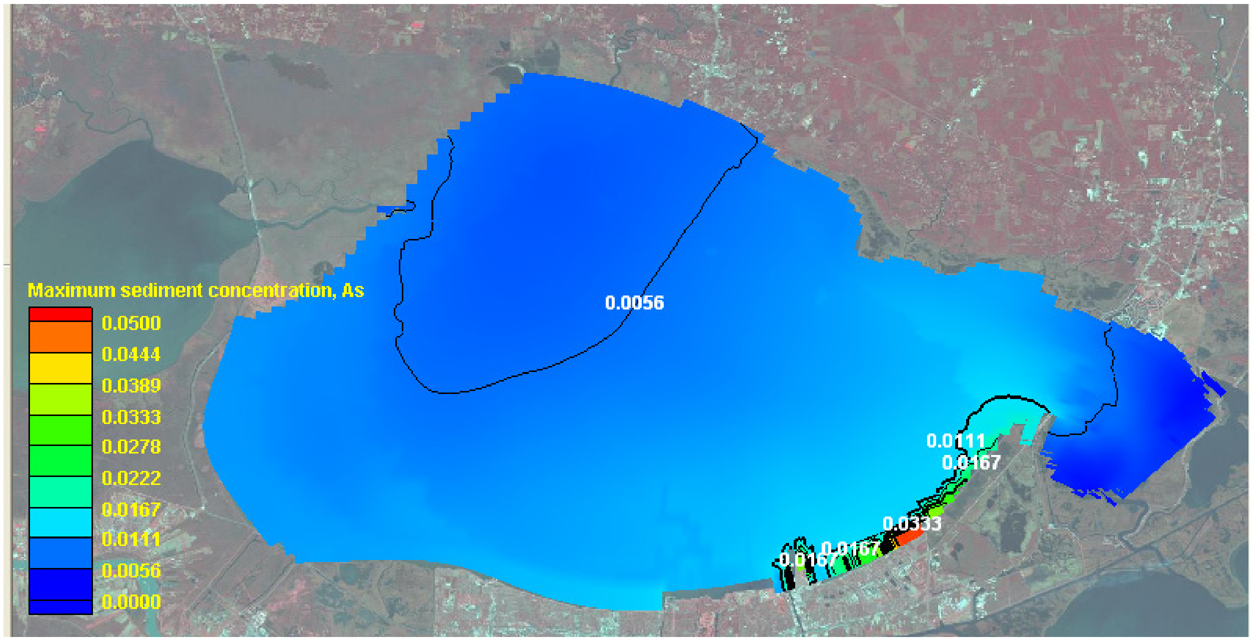

Figure A11. Maximum As sediment concentrations (mg/kg total) in Lake Pontchartrain for *actual* conditions, median loading concentrations

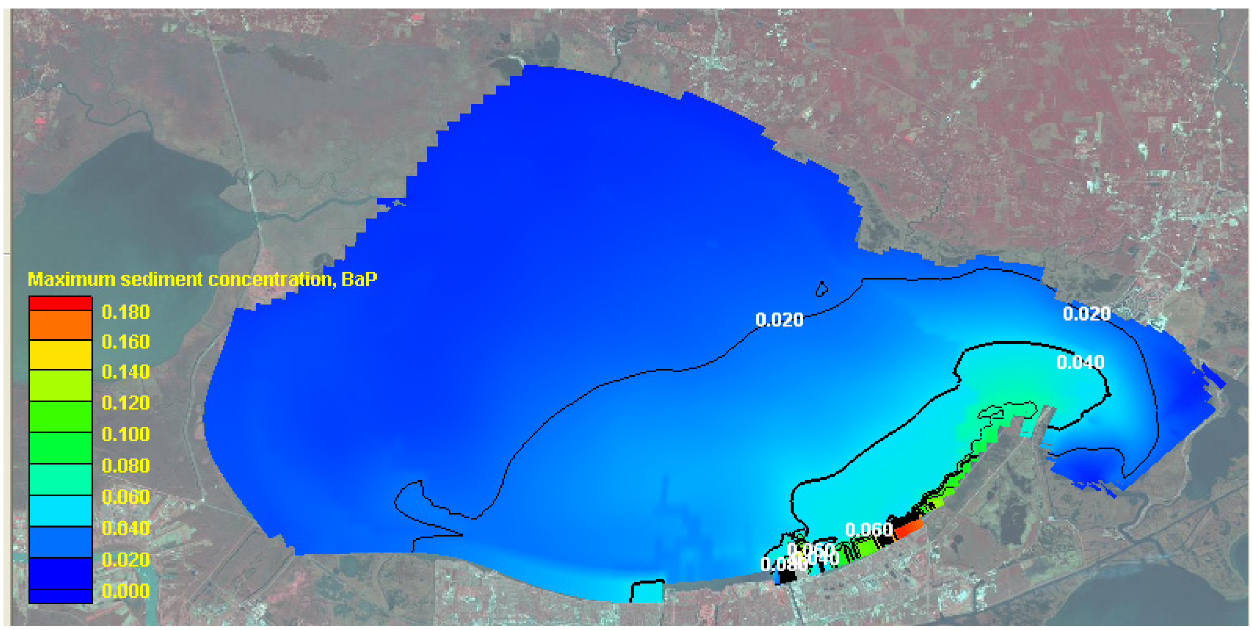

Figure A12. Maximum BaP sediment concentrations (mg/kg total) in Lake Pontchartrain for *actual* conditions, median loading concentrations

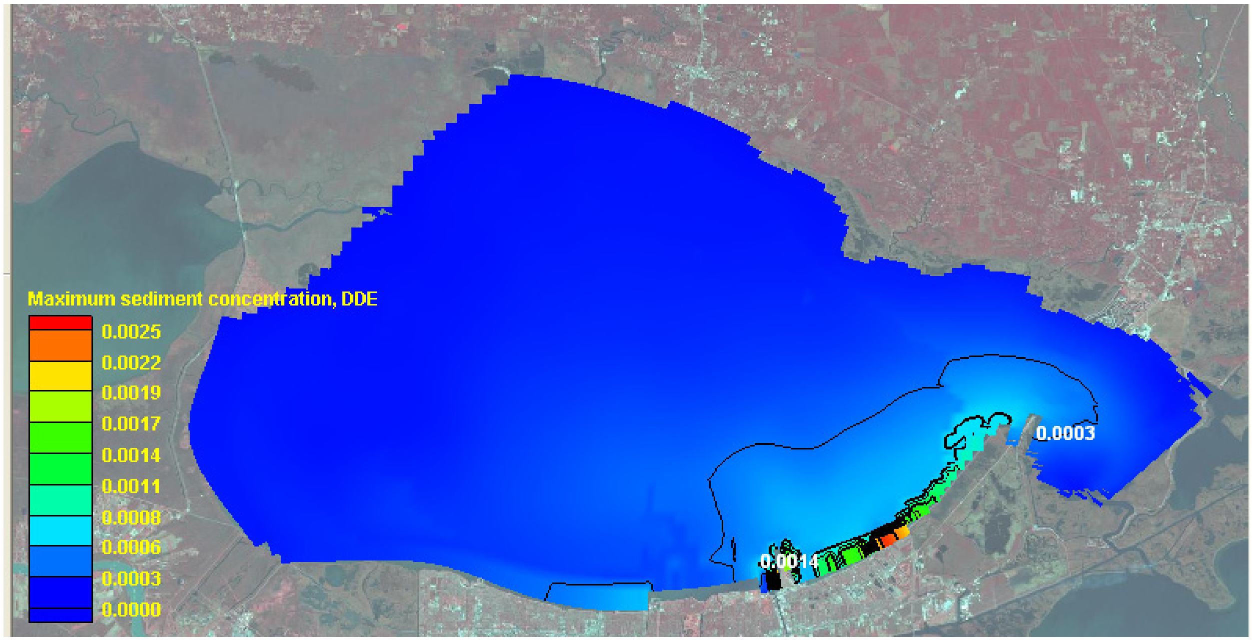

Figure A13. Maximum DDE sediment concentrations (mg/kg total) in Lake Pontchartrain for *actual* conditions, median loading concentrations

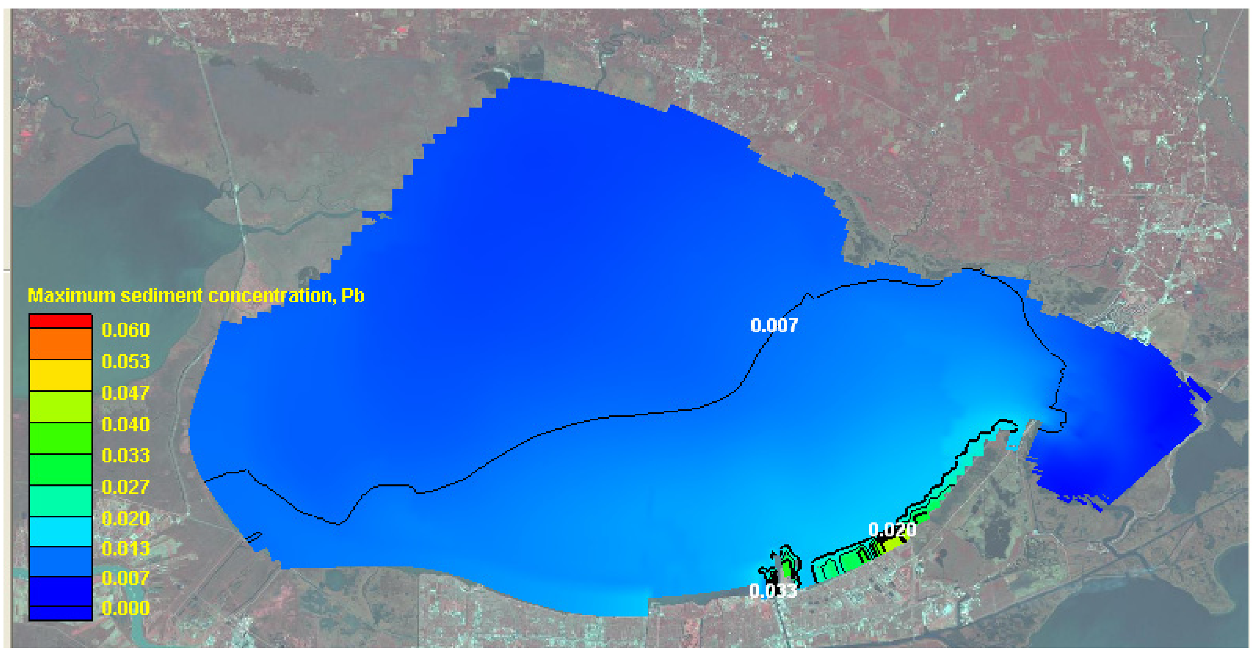

Figure A14. Maximum Pb sediment concentrations (mg/kg total) in Lake Pontchartrain for *actual* conditions, median loading concentrations

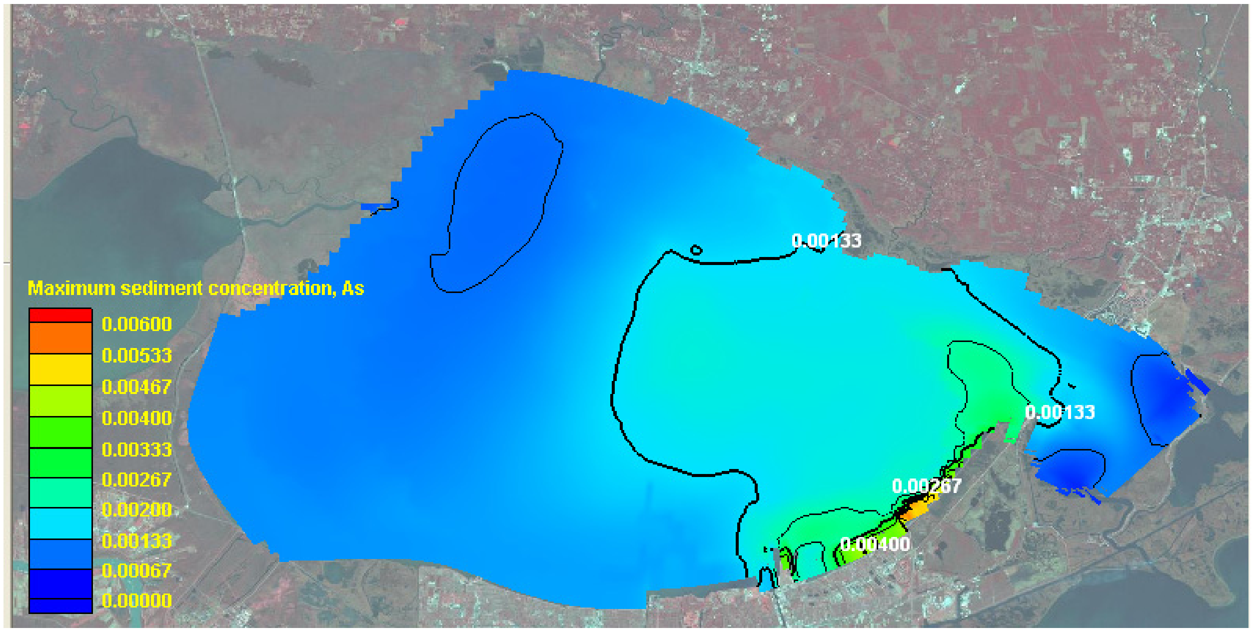

Figure A15. Maximum As sediment concentrations (mg/kg total) in Lake Pontchartrain for *baseline* conditions, median loading concentrations

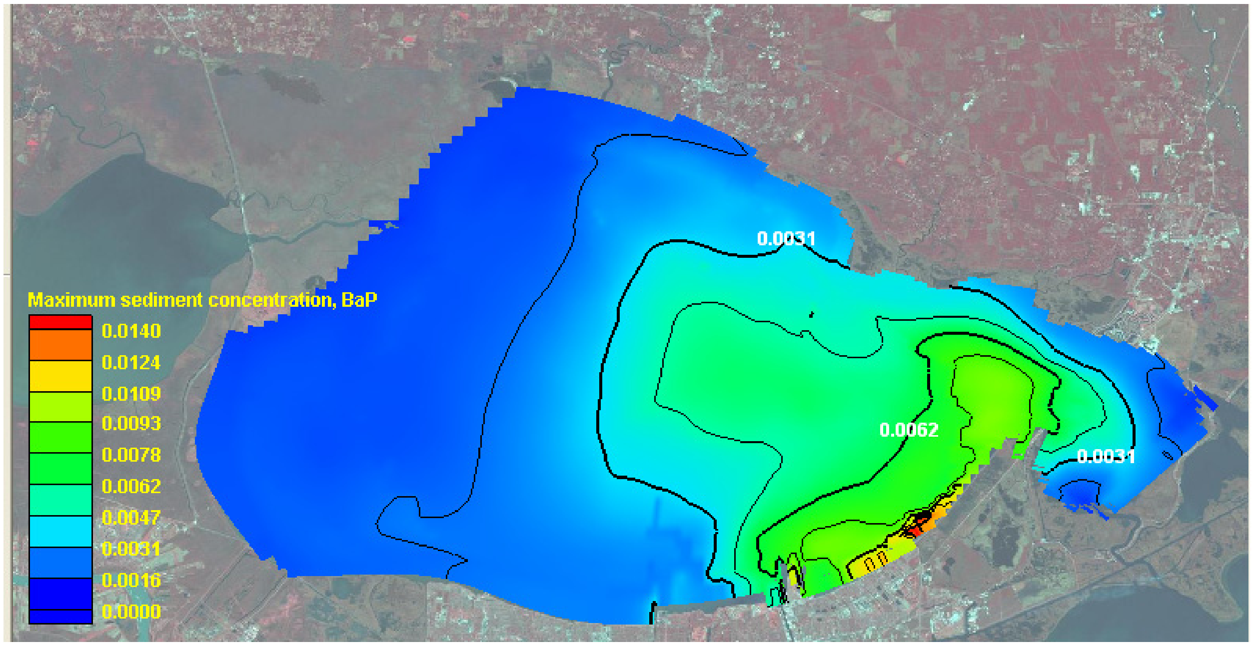

Figure A16. Maximum BaP sediment concentrations (mg/kg total) in Lake Pontchartrain for *baseline* conditions, median loading concentrations

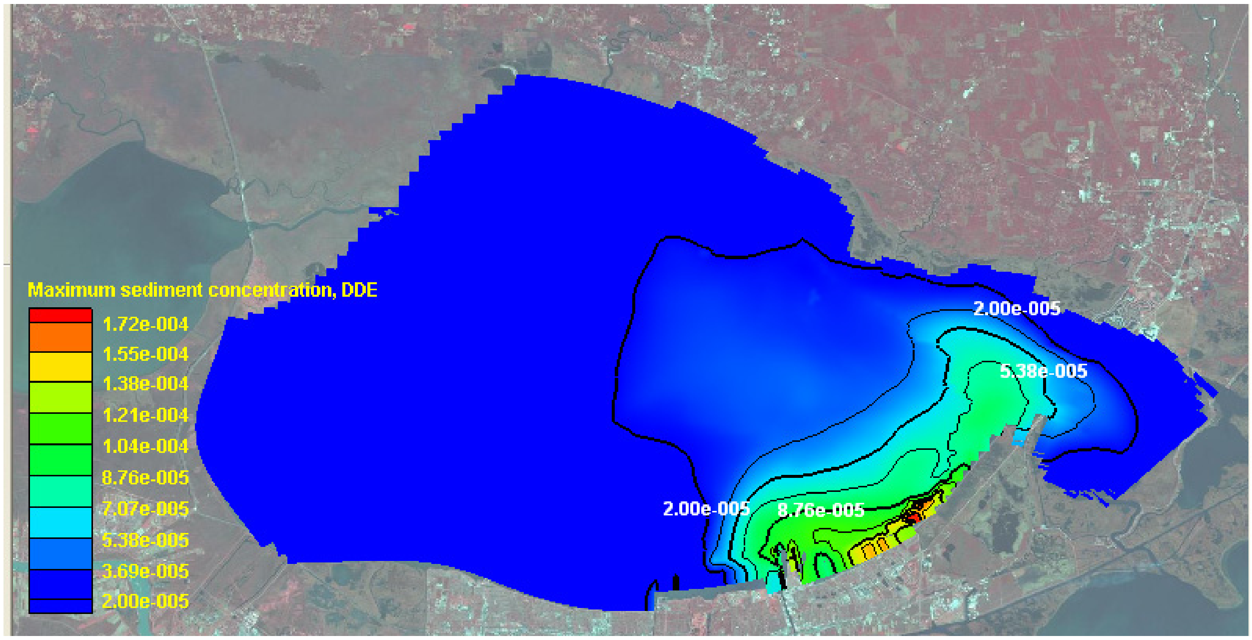

Figure A17. Maximum DDE sediment concentrations (mg/kg total) in Lake Pontchartrain for *baseline* conditions, median loading concentrations

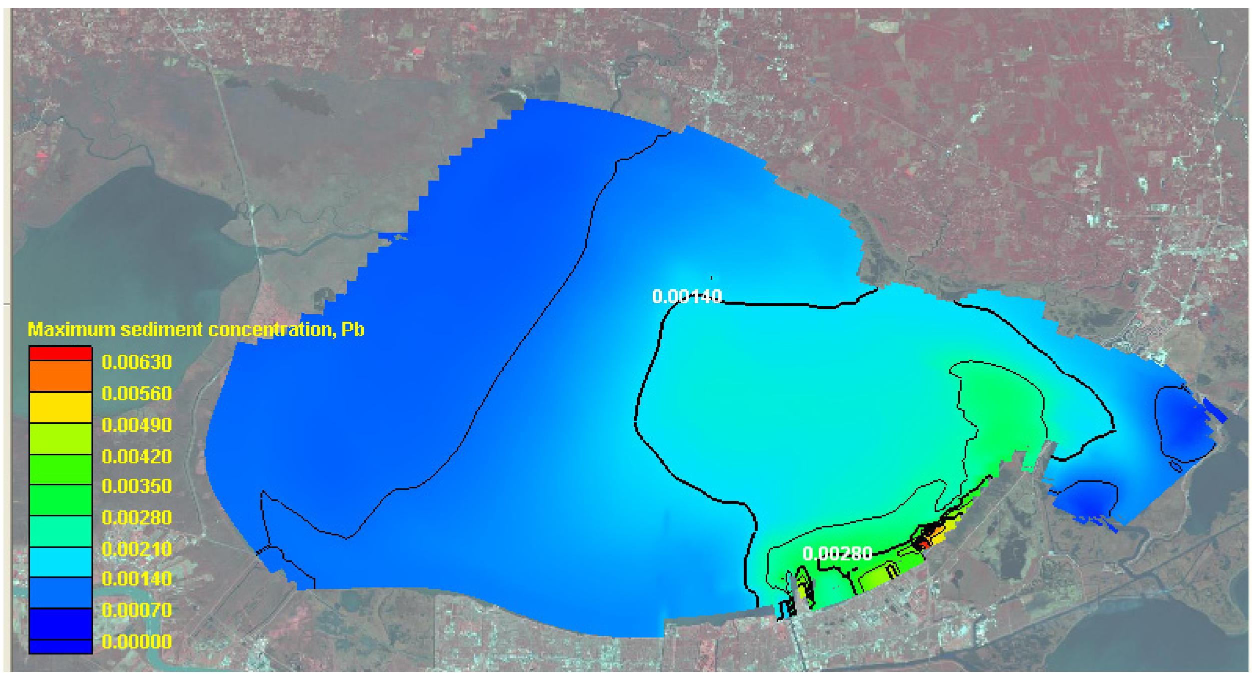

Figure A18. Maximum Pb sediment concentrations (mg/kg total) in Lake Pontchartrain for *baseline* conditions, median loading concentrations

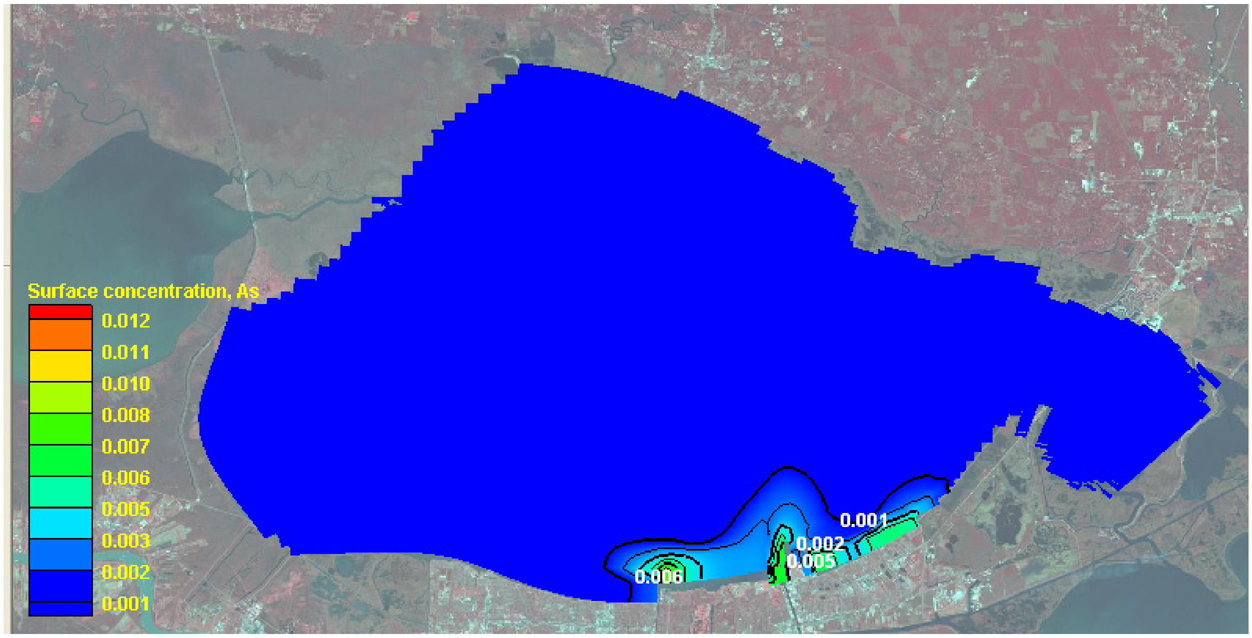

Figure A19. Water surface concentrations (mg/L total) for As in Lake Pontchartrain on September 12 for *actual* conditions, median loading concentrations

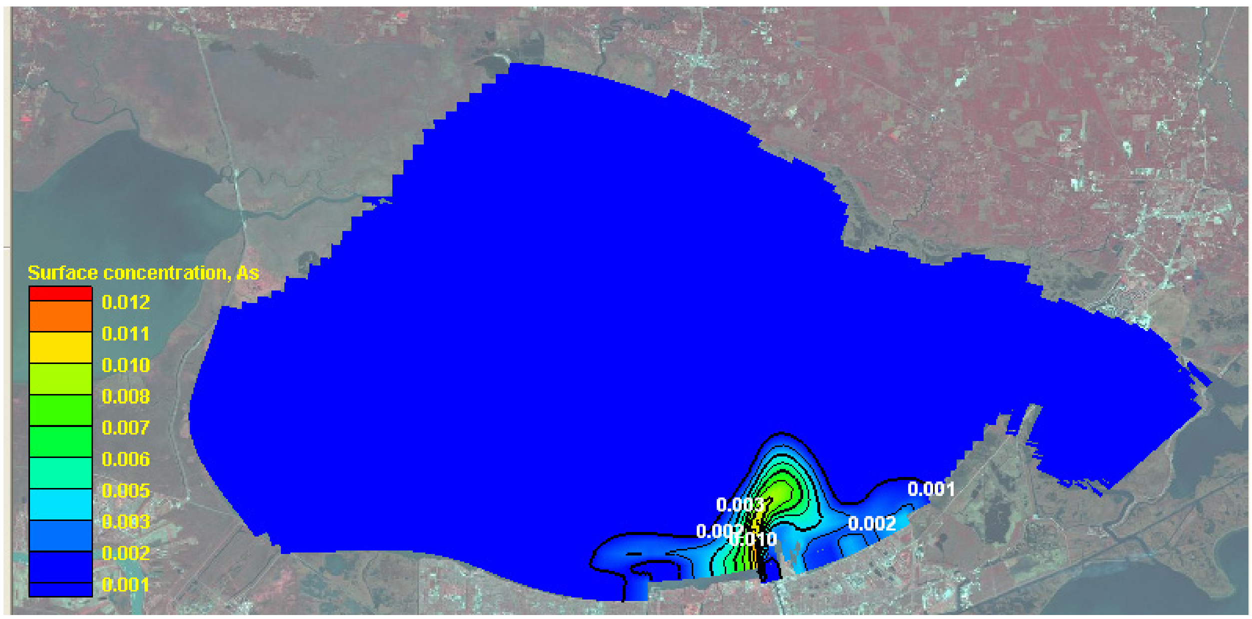

Figure A20. Water surface concentrations (mg/L total) for As in Lake Pontchartrain on September 12 for *actual* conditions, median loading concentrations

Appendix 5E
Fisheries, Wildlife, Pests, and Special-Status Species

Fisheries, Wildlife, Threatened and Endangered Species, and Pest Species

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Executive Summary

The primary focus of this section was to assemble and summarize information relating to biological resources likely to have been affected by pumping of floodwaters in the vicinity of New Orleans following Hurricanes Katrina and Rita. These resources included fisheries (finfish, shellfish, and benthic invertebrate assemblages), wildlife, and threatened and endangered species. Pest species were also examined within this section. Information was gathered by queries of library databases of the peer-reviewed scientific and technical literature, state and federal government reports, and non-governmental organization publications, by web-based searches, and by personal communication with local experts. Much of the information garnered was found in the published results of long-term data collections performed by the Louisiana Department of Wildlife and Fisheries, National Oceanographic and Atmospheric Administration (NOAA), and the U. S. Environmental Protection Agency (EPA). Examples of post-storm data collections are limited, but include information collected during a joint NOAA-EPA sampling effort and two post-storm sampling trips to the Violet Marshes conducted by ERDC-EL.

Introduction

This study was conducted to assess the possibility of losses and damages to fisheries, wildlife, and threatened and endangered species associated with Hurricane Katrina and flooding of greater New Orleans. Possible pest problems were also investigated.

Results

Fisheries

Nearshore and Delta Ecosystems

Fish and Trawlable Invertebrates: Baseline information on nearshore fish and trawlable invertebrate (e.g. shrimp) populations is available from three primary sources: 1) the SEAMAP program, a joint operation of the Gulf States Marine Fisheries Commission and the National Oceanographic and Atmospheric Administration (NOAA), 2) the United States Environmental Protection Agency's (USEPA) EMAP program, and 3) the Louisiana Department of Wildlife and Fisheries (LADWF).

SEAMAP is a fisheries independent monitoring study of fish and invertebrate populations (www.gsmf.org). Samples are taken at several depths in summer and fall throughout the Northern Gulf of Mexico. Although there is no single summary of the results, data from 1998, 1999 and 2000 can be downloaded from the SEAMAP website. As an example, partial results from data collected at 0-30 m (~0-90 ft) on the Louisiana shelf are presented in Appendix Table C1. The dominant invertebrate species in all three years (1998-2000) was the brown shrimp, *Penaeus aztecus* while the dominant fish species was Atlantic croaker (*Micropogonias undulatus*) in 1998 and 1999 and yellowtail (*Chloroscombrus crysurus*) in 2000. In a January 2006 press release, the program reported that fall 2005 trawl surveys found no indication of reductions in fish or shrimp populations (http://www.st.nmfs.gov/hurricane_katrina/press_releases.html). They also reported no evidence of fish kills. A full report is expected by early summer 2006.

The USEPA EMAP program sampled fish, invertebrates, benthic assemblages, sediments, water quality, and contaminants in fish tissues throughout the Gulf coast between 1991 and 1994 (http://www.epa.gov/emap/index.html). Species collected during this program were similar to those reported by SEAMAP (Appendix Table C2). Brown shrimp was the most abundant organism, followed (in order of abundance) by Atlantic croaker, white shrimp (*P. setiferus*), gulf menhaden (*Brevoorita patronus*), and bay anchovy (*Anchoa mitchelli*). As with the SEAMAP data, brown shrimp were generally the most abundant invertebrate species while the most dominant fish species varied among years (1991- yellowtail, 1992-bay anchovy, 1993 and 1994 – Atlantic croaker).

Results from fisheries independent sampling by LADWF has been incorporated into the the Coast 2050 report (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998). Data are reported as general trends in abundance (steady, decreasing, increasing, unknown) of species guilds (marine, estuarine dependent, estuarine resident, and freshwater) for major regions of the Louisiana coast. Region 1, Lake Pontchartrain Drainage, corresponds the most closely to the area of interest in the present study. Summaries of the status of individual by individual mapping units within each region, as well as the text of the report, are available at http://coast2050.gov/2050reports.htm. The status of most marine guilds in Region 1 was either steady or unknown, although the Red drum guild was thought to be increasing at the time of the report near Eloi Bay and the Biloxi marshes (Appendix Table C2). Long-term projections for most marine guilds were for declining populations based on the assumption of continuing losses of coastal marshes on which many of these species rely for juvenile or adult habitat.

Data for pre-storm (1991-1994) levels of contaminants in fish and shrimp tissues from Mississippi Sound are available from EMAP. Representative values for Atlantic croaker and brown shrimp are presented in Appendix Table C3. Post-storm evaluations thus far are limited to a joint project of NOAA, USEPA, United States Geological Survey (USGS) and Dauphin Island Marine Lab launched immediately after Hurricane Katrina to assess potential contamination levels present in inshore and offshore water, sediment, infauna, and fish and shellfish tissues. Results from these analyses indicated that bacterial contamination (*E. coli, Enterococcus*, or *Vibrio cholera* and other *V. spp*.) in water and sediments from Mississippi Sound and offshore areas did not exceed EPA standards for recreational waters (Peterson et al. 2005a, 2005b). Tissues of fish, shrimp, and crabs from these sites showed no indication of contamination by *E. coli, Enterococcus*, or *Vibrio cholera*, however there were concentrations of other *Vibrio* species (Peterson et al. 2005c, 2005d). The authors indicate that where *Vibrio* spp. were encountered, concentrations were not beyond those expected under normal conditions. Krahn et al (20005a, 2005b) examined persistent organic pollutant (PCB's and DDT's) and polycyclic aromatic compounds (PAC's) in fish tissues and report that concentrations did not exceed FDA standards for consumption. The Louisiana Department of Environmental Quality (LADEQ) found high bacterial counts on the northern shore of Lake Pontchartrain; however, concentrations of organic contaminants were generally below water quality standards (LADEQ2005).

Shellfish: Both the Mississippi Department of Marine Resources (MSDMR) and LADWF report significant physical damage to oyster beds due to scouring, sedimentation, and debris deposition (http://www.dmr.state.ms.us and personal communication, Marti Bourgeois, LA DWF). Elevated bacterial concentrations consistent with a storm runoff event have been reported by NOAA's Status and Trends – Mussel Watch program immediately after Hurricane Katrina (http://ccma.nos.noaa.gov/cit/katrina/prelim.html). Subsequent sampling by the USEPA and the Mississippi Department of Environmental Quality (USEPA-MSDEQ 2005) found few instances of elevated bacterial concentrations or priority pollutants in Mississippi waters and the States of Mississippi and Louisiana and the Food and Drug Administration have all issued news releases indicating that seafood, including oysters, now safe to eat (www.fda.gov/bbs/topics/NEWS/2005/NEW01271.html).

Benthic Invertebrates: Benthic invertebrate assemblages of near-shore environments have been described in a number of studies including those of the EMAP program, Vittor and Associates 1982, 2005, and United States Army Corps of Engineers 1999. Representative results from EMAP results for Mississippi Sound are provided in Appendix Table C4. Several assemblages are present in the area associated with specific combinations of sediment and depth. Vittor and Associates (1982) identify seven such assemblages: shallow (coastal margin) mud, lower Mobile Bay mud, deep (open sound) muddy sand, tidal pass/shallow sound clean sand, offshore mud, offshore mixed sediment, and offshore clean sand. At the present time only the joint NOAA, USEPA, USGS and Dauphin Island Marine Lab study is known to have collected post-storm benthic data in Mississippi Sound. A report from that study is expected to be released sometime in summer 2006.

Lakes Pontchartrain and Borgne

Fish and Trawlable Invertebrates: There is a considerable amount of information on the fish assemblages of Lake Pontchartrain; including a recent assessment of fish-habitat relationships (O'Connell et al. 2004) and the University of New Orleans Vertebrate Museum's fish collection database (http://www.nekton.uno.edu/about.htm). O'Connell et al. (2004) summarized information on changes in fish assemblages over the last 50 years. In the late 1950's the lake was dominated by Atlantic croaker, spot (*Leiostomus xanthurus*) and hard head catfish (*Arius felis*) while more recently bay anchovy has been most abundant. Gulf menhaden has been abundant throughout the time period. Changes in the fish assemblage over time are attributed to a combination of factors including altered land use patterns, pollution, eutrophication, and annual differences in precipitation.

Information on fish populations in Lakes Pontchartrain and Borgne is also available from trawl samples taken annually between 1991 and 1994 by the EMAP program (http://www.epa.gov/emap/index.html). As found by O'Connell et al. (2004), the fish community of Lake Pontchartrain was dominated by Atlantic croaker, blue catfish (*Ictalurus furcatus*), bay anchovy and gulf menhaden (Appendix Tale C5). The relative abundance of individual species varied over time with catfish being dominant in 1991, bay anchovy in 1992, and Atlantic croaker in 1993 and 1994.

Coast 2050 assessments of fish and invertebrate guilds for Lake Pontchartrain were steady for both present and projected status (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998). Assessments for Lake Borgne from this same study indicated that all guilds were presently steady but projected to decline based on the assumption of continued wetland losses.

Fish and invertebrate collections from the EMAP study of Lake Borgne had a greater similarity to nearshore fish and invertebrate assemblages than to Lake Pontchartrain (Appendix Table C6). The overall dominant was yellowtail due to high numbers of this fish collected in 1992. Otherwise, Atlantic croaker, hard head catfish, gafftopsail catfish (*Bagre marinus*), and bay anchovy were the most abundant fish species. Brown shrimp were generally the most abundant invertebrate although white shrimp were occasionally abundant. Contaminant levels present in fish from both lakes are available from the EMAP database (see Appendix Table C3 for representative values).

Post-storm data collections of fish and invertebrate data are limited to a few stations sampled in Lake Borgne as part of the SEAMAP program. As previously stated, these data will not be available until early summer 2006. The same is true for post-storm measurements of contaminant levels in fish and invertebrate tissues. Water quality assessments by LADEQ 2005) after Hurricane Katrina found significant low dissolved oxygen conditions and fish kills along the northern shore of Lake Ponchartrain (LADEQ 2005). It was anecdotally noted that "numerous bait fish and mullet" and live crabs were present in the lake (http://www.deq.louisiana.gov/portal/portals/ 0/news/pdf/Post-KatrinaWaterQualityAssessment9-20-05.ppt).

Slack (2005) has reported kills of freshwater fish on the lower and middle Pascagoula River, the Leaf River, and Lake Bogue Homa. An estimated 39,000 fish including sunfish (*Lepomis spp*.) gizzard shad (*Dorosoma cepedianum*), large-mouth bass (*Micropterus salmoides*) golden shiner (*Notemiginus crysoleucas*), channel catfish (*I. punctatus*), and spotted sucker (*Minytrema melanops*) were killed in Lake Bogue Homa.

Shellfish: Results described as part of the Near-shore and Delta Ecosystem include shellfish data from Lake Borgne and the Mississippi Gulf coast. Coast 2050 assessments indicate that oysters and their associated fauna have exhibited steady to declining population levels. As previously dicussed there were substantial losses in oyster populations due to sedimentation and scouring; however, there are presently no quantitative estimates of damage. Mississippi oyster beds remain closed to commercial shellfishing.

Benthic Invertebrates: Pre-storm conditions for benthic invertebrate assemblages in Lake Ponchartrain are limited to those collected by EMAP and Junot et al. (1983). Benthic assemblages in the lake are characterized by low salinity species such as the hydrobid snail *Probythinella louisianae*, the bivalve *Rangia cuneata*, and the polychaete *Hobsonia florida* (Appendix Tale C7). Larvae of the phantom midge (*Chaoborus sp.*) were found in great abundance in 1991. Junot et al. (1983) have described benthic assemblages of the southern end of the lake and related community structure to salinity gradients and low dissolved oxygen conditions. Sikora and Sikora (1982) also associated areas of defaunated sediments in the lake with low oxygen conditions. No post-storm assessments of benthic assemblages appear to have been conducted in Lake Pontchartrain at the time of this report.

Pre-storm benthic assemblages of Lake Borgne have also been reported by EMAP (Appendix Table C8). The assemblage was dominated by low salinity tolerant species such as the polychaete worms *Streblopsio benedicti*, *Mediomastus* sp. *and H. florida*, the snails (*Texadina sphinctostoma* and *P. louisianae*), and the bivalves *Tellina versicolor, Mullinia spp.* and *R. cuneata.* Post-storm assessments include the joint NOAA, USEPA, USGS and Dauphin Island Marine Lab study (data have yet to be reported (http://water.usgs.gov/wicp/acwi/monitoring/ppt/pensacola1105/) and a study by Ray (2006a) performed for the USACE New Orleans District. Sampling in November 2005, this study found that species composition of the benthic assemblage was considerably altered from that reported by EMAP. Many of the species associated with low salinity were either absent or present only in low numbers while more salt-tolerant species such as the polychaetes *Nereis succinea* and *Dipolydora ligni* were dominant (Appendix Table C8).

Inner Ecosystem

Fish, Invertebrates, and Shellfish: No fish, trawlable invertebrate or shellfish data have been found describing either pre- or post-Katrina conditions in the inner ecosystem.

Benthic Invertebrates: Post-storm data have been collected for benthic invertebrates in the Violet Marshes by ERDC to compare the structure of benthic assemblages in the vicinity of inactive (Pumps 2 and 3) and active (Pumps 4 and 6) pumps (Ray 2006b, 2006c). Sampling within 50 m and 100 m of each of the pump outfalls, it was found that the stations closest to active pumps showed signs of recent disturbance. Specifically, low abundance, diversity, and altered species composition at Pump 6 (actively pumped) was highly indicative of disturbed conditions. The heavy dominance of the station nearest Pump 4 (actively pumped) by the polychaete *Streblospio benedicti* and the presence of large numbers of harpacticoid copepods also suggested disturbance. *Streblospio benedicti* is an early colonizer of recently disturbed sediments and although most harpacticoid species are sensitive to hydrocarbon pollution, a few are relatively insensitive and can achieve high abundances in recently contaminated sediments. These conclusions are at odds however with large numbers of species and relatively high diversity values also present at this site; characteristics generally associated with low stress conditions. The seeming inconsistency between these results may be due to the passage of time. Flushing of Station 4, as suggested by the lower salinities encountered during the second sampling event (Ray 2006c), may have countered stressful conditions present immediately after the storms. Stations further away (100 m) from both active and inactive pumps were similar to one another with the exception of Pump 6. The benthic assemblage at this site was most like the 50 m station at the same pump. Overall, the results of these studies suggest that floodwater pumping affected benthic assemblages, especially those within 50 m of the pump outfalls. These impacts were not entirely consistent among active pumps probably reflecting site-specific conditions

Wildlife

Nearshore and Delta Ecosystems: Information for assessing wildlife in the study area comes primarily from the Coast 2050 report (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998). As previously described, assessments in this report are based on records of the LADWF and report the status of wildlife as general trends in abundance (steady, decreasing, increasing, unknown) of both individual species (e.g. brown pelican) and species groups (e.g. wading birds, dabbling ducks). For a complete list of wildlife species groups, see Appendix Table C10. In the near-shore and delta ecosystem brown pelican (*Pelecanus occidentalis*) populations are increasing and expected to continue to do so (Appendix Table C11). Seabird, wading bird, and shorebird populations are either steady or increasing in most marine habitats. These increases are presumably due to the increase in open-water habitat as the coverage of wetland habitat continues to decline.

Additional information on the birds of the region is available from the Audubon Society. They maintain a listing of the birds of the New Orleans region with comments on their seasonal abundance (Appendix Table C12; available online at http://www.jjaudubon.net/Birds%20of%20GI-NO.htm). Mississippi Audubon Society maintains a similar listing for birds of coastal Mississippi (http://www.mscoastaudubon.org/). The Audubon Society and Cornell University maintain the Bird Source website (http://www.birdsource.org/) from which results of the annual Christmas Bird Count and Great Backyard Bird Count results can be obtained. Unfortunately these results cover very broad spatial scales and the level of detailed information necessary to distinguish between hurricane-related and levee failure-dewatering impacts appears to be lacking. The same is true for the U. S. Fish and Wildlife databases maintained by the Patuxent Wildlife Research Center (http://www.mbr-pwrc.usgs.gov/). Data on trends in breeding bird populations can be accessed for individual species but only on large spatial scales (e.g. Gulf coast).

The only post-storm data presently available for wildlife in the study area are the waterfowl aerial surveys conducted by Louisiana Department of Wildlife and Fisheries (http://www.wlf.state.la.us/apps/netgear/index.asp?cn=lawlf&pid=154). Conducted monthly from November 2005 to January 2006, they report that total numbers of ducks were lower throughout Southeast Louisiana in November 2005 than the previous year. Coastal marshes were described as being nearly "devoid" of ducks. Similar results were reported for the southeast again in December 2005. In January 2006 it was noted that densities of coast-associated waterfowl such as gadwell and green-winged teal were well below last years totals.

Lakes Pontchartrain and Borgne: Brown pelican and bald eagle (*Haliaeetus leucocephalus*) abundances are increasing in the area while raptors are expected to decline in both lakes (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998). Likewise American alligator (*Alligator mississippiensis*) abundances are increasing in the upper basin of Lake Pontchartrain but declining in the lower basin. Furbearing mammals are also declining in the lower basin of the lake. Wading birds, dabbling and diving ducks, rail, coot, gallinule, squirrel, rabbit, and deer are also expected to decline in the Lake Borgne area. Post-Katrina aerial surveys of waterfowl by LADWF found record low numbers of scaup in Lakes Pontchartrain and Borgne in January 2006.

Inner Ecosystem: No site-specific information is available.

Threatened and Endangered Species

Listings of threatened and endangered species in Louisiana are maintained by the Natural Heritage Inventory and can be downloaded from http://www.wlf.state.la.us (Appendix Table D1). Listings of rare species or those considered to be under threat are also maintained for individual parishes (Appendix Tables D2-D9). Mississippi listings of threatened and endangered species are provided by the Mississippi Natural Heritage Program, Mississippi Department of Wildlife and Fisheries (Appendix Table D10; http://www.mdwfp.com/museum/downloads/tandelist.pdf.)

Nearshore and Delta Ecosystems. Endangered marine species in the study include sea turtles, piping plover (*Charadrius melodus*), brown pelican, Alabama beach mouse (*Peromyscus polionotus ammobates*)**,** manatee (*Trichechus manatus*), and several species of whales (Appendix Tables D1 and D10). Thus far, the only post-Katrina assessment available for endangered marine species comes from the U.S. Fish and Wildlife Service (News Release Sept 9, 2005, www.fws.gov/southeast). They report the loss of sea turtle nesting sites along the Alabama coast and beach mouse dune habitat in Noxubee National Wildlife Refuge.

Lakes Pontchartrain and Borgne. Threatened or endangered species most associated with Lakes Pontchartrain and Borgne are the brown pelican and the Gulf sturgeon (*Acipenser oxyrhinchus desoti*). There have been no reports concerning storm impacts on pelicans but there may have been impacts to sturgeon. At the time of the storms, most sturgeon were in their summer resting areas on the Pearl and Bogue Chito Rivers. Of 40 fish carrying telemetry tags, none have been located since the storm (Ruth 2005). Several dead sturgeon were found in the vicinity of Interstate 10 in Pascagoula, MS immediately after the storm.

Inner Ecosystem: No site-specific information is available at this time.

Pest Species

Lists of pest species (also invasive species) for the states of Lousiana and Mississipi were obtained by querying the Global Invasive Species Database (http://invasivespecies.nbii.gov). The Lousiana list is found in Appendix Table E1 and the Mississippi list is in Appendix Table E2. Lists of aquatic pest species were obtained from the Gulf States Marine Fisheries Commission (http://nis.gsmfc.org/), Louisiana's state management plan for aquatic invasive species (Lousiana Aquatic Invasive Species Task Force 2005) and by querying NIS-Base, a national database of nonindigenous species (NIS) listings maintained by the Smithsonian Institution (www.nisbase.org/nisbase/index.jsp). Louisiana aquatic pest species are reported in Appendix Table E3 and Mississippi species Appendix Table E4.

Nearshore and Delta Ecosystems:Only two marine pest species are reported for the study area, the Australian spotted jellyfish (*Phyllorhiza punctata*) and the orange cup coral (*Tubastraea coccinea*). There have been no post-storm reports relevant to these species.

Lakes Ponchartrain and Borgne: The principal pest species associated with Lakes Pontchartrain and Borgne is the nutria or water rat (*Myocaster coypus*). Introduced from South America, it thrives in freshwater and estuarine environments (Gulf States Marine Fisheries Commission 2005). They are widely distributed and can produce large numbers of animals in a short time period. Animals as young as four months have been found to be sexually mature. There have been no post-storm reports concerning this species.

Inner Ecosystem: The pest species of principal interest in the inner ecosystem is the Formosan subterranean termite, *Coptotermes formosanus*. This species is currently found through much of New Orleans, Lake Charles, Southern Louisiana and parts of Southern Mississippi (http://lsuagcenter.com/en/environment/insects/ Termites/formosan_termites/). Concern that the termites might be either spread or encourgaged to increase in abundance during debris disposal led the Louisiana Commissioner of Agriculture to quarantine all wood and cellulose materials on October 3, 2005 (http://www.ldaf.state.la.us/divisions/AES/katrinaquarantine.pdf). Approximately 10 million tons (39 million yd^3) of debris was generated by Hurricane Katrina, 6.25 million tons of which came from the Mississipi Gulf coast (Coblentz 2005). It is estimated that one-third of the debris along the coast was wood or cellulose (vegetative) while approximately 85 percent of the inland debris is vegetative.

Provisions of the quarantine include that no wooden debris be moved unless it is either fumigated, treated or special permission has been authorized by the commissioner. Temporary housing may not be moved from affected parishes except by permission, no architectural elements can be sold or placed in structures unless fumigated and all new construction is advised to use termite–resistant material. A similar quarantine has been imposed for dealing with wooden debris generated by Hurricane Rita (http://www.ldaf.state.la.us/divisions/AES/ritaquarantine.pdf). The Louisiana Department of Environmental Quality has also provided guidance for disposal of potentially contaminated debris as part of the official debris disposal plan (http://www.deq.louisiana.gov/).

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Appendix Report 1
A Pilot Study of Post-Hurricane Katrina Floodwater Pumping on Marsh Infauna

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PURPOSE:

The Interagency Performance Evaluation Taskforce (IPET) is presently evaluating the performance of hurricane protection and damage reduction systems and consequences of structural failures to the New Orleans area following Hurricane Katrina. This evaluation includes determination of environmental impacts to habitat and other biological resources. In this report, preliminary data concerning the effects of pumping of floodwaters on assemblages of benthic invertebrates in the immediate vicinity of the pumping stations are reported for wetlands near Chalmette and Violet, Louisiana.

BACKGROUNDOn August 29, 2005, Hurricane Katrina struck the coasts of Alabama, Mississippi, and Louisiana, resulting in significant physical damage and loss of life. Levees were breached or overtopped, resulting in massive flooding in the City of New Orleans and adjacent areas. Large portions of Saint Bernard Parish were flooded when levees were overtopped by bay waters from the Mississippi River Gulf Outlet channel and Lake Borgne. Floodwaters were subsequently pumped from affected areas into marshes in the vicinity of Chalmettte and Violet, Louisiana. Concerns have been expressed regarding the potential for undesirable environmental impacts on the marsh ecosystem due to elevated salinity and contaminants. To address some of these issues, sampling events were conducted after the storm, including a pilot study to compare benthic invertebrate assemblages of sites in the immediate vicinity of active and inactive pumping stations. Benthic invertebrates are a critical part of estuarine food chains, providing forage for economically and ecologically important finfish and shellfish species and are routinely monitored as part of environmental assessments. The sampling effort reported herein represents a pilot study; that is, an initial effort to discern large-scale patterns in benthic assemblage distributions and determine minimal sample size for potential future studies.

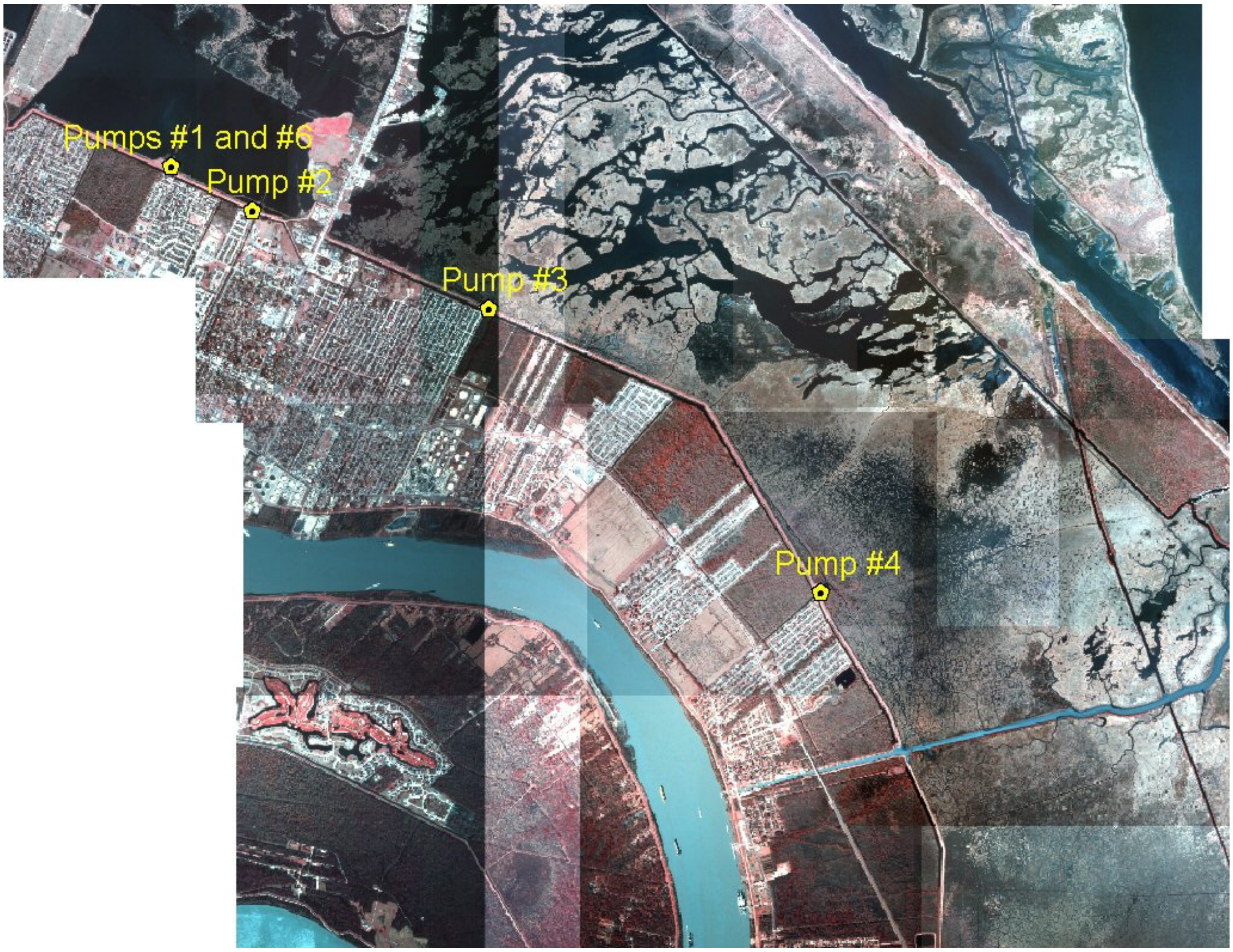

Figure 3. Aerial view of study area

STUDY AREA

Four pumping stations located along the Back Protection Levee were chosen based on their pumping records (Figure 1). Pumps 4 and 6 were in operation through all or most of the emergency whereas Pumps 2 and 3 were selected because they were either not employed or inoperative during this time. Samples were taken in the small basins adjacent to the pumping stations within 50 m of the pumping station outfall (Figures 2 and 3) on December 13-14, 2005, approximately 3-1/2 months after landfall of Hurricane Katrina.

METHODS

Three infaunal samples were taken in waters of approximately 1 m depth at each site (Pumps 2, 3, 4, and 6) using a pole-mounted Eckman dredge (232 cm^2/sample). Samples were rinsed in the field using a sieve bucket with a 0.5-mm mesh screen, placed in labeled cloth bags, and fixed in 4 percent formaldehyde solution. After fixation, the samples were transported to laboratory facilities at the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS where the samples were rinsed with fresh water over a 0.5-mm sieve and material retained on the sieve stored in 70% ethanol. Samples were subsequently stained with Rose Bengal and examined under illuminated 3X magnification to facilitate removal from the sediments. All specimens were identified to the lowest practical identification level and counted.

Although no samples were taken for sediment grain size analysis, visual examination of the materials during sampling indicated that all were very fine, unconsolidated sediments with substantial amounts of decaying vegetative matter. Later examination of the sieved samples confirmed this observation. Water quality measures were taken at the surface of the water column using a handheld YSI Model 85. Salinities at the sampling sites ranged between 11 and 12 ppt and temperatures ranged from 12^{o}C to 15^{o}C. Dissolved oxygen concentrations at the surface were all at or above 100 percent saturation. A distinct petrochemical smell was detected in sediments from Pumps 4 and 6 and an oily sheen was observed at the water surface during sediment sampling at Pump 4.

Figure 2. Pump 4

Figure 3. Pump 4 basin

Both multivariate and univariate statistical techniques were employed to detect potential changes in the benthic assemblages resulting from floodwater pumping. Multivariate techniques test for patterns simultaneously among multiple variables, such as species composition data. Species composition has proven to be a sensitive indicator of assemblage status particularly in response to disturbance (Clarke and Warwick 2001). The specific multivariate techniques employed include Nonmetric Dimensional Scaling (NMDS), Analysis of Similarity (ANOSIM), and similarity percentage analysis (SIMPER). NMDS is an ordination technique that compares species composition among sample pairs and is particularly suited for infaunal data (Clarke and Warwick 2001). It was performed using the Bray-Curtis similarity index and logarithmically transformed (log x+1) abundance values to adjust for the influence of very abundant taxa. ANOSIM is a nonparametric technique that compares similarity values between treatments and can be used as a test of the significance of patterns detected in NMDS. SIMPER estimates the contribution of individual taxa to similarity among treatments and is used to determine the extent to which individual species were responsible for the patterns detected by NMDS and ANOSIM. All three analyses and the calculation of community diversity values (taxa richness, Shannon-Weiner Diversity ($H'Log_e$), and Pielou's Index (J')) were performed using PRIMER statistical software. Univariate statistics, tests of individual variables, were used detect differences in abundance and diversity measures. Analysis of Variance (ANOVA) was used to explore potential differences in total abundance among pumped and unpumped sites, followed by Tukey's test to determine which mean values were different. Because of the low numbers of samples inherent in a pilot study, most of the emphasis in univariate statistical analysis was placed on determining statistical power and estimates of minimum sample size. These estimates are used to describe potential designs for future studies. All univariate statistical tests were conducted with JMP statistical software.

RESULTS

Sample Analysis. The species assemblages were typical of Northern Gulf of Mexico marshes and of low salinity, muddy estuarine sediments in the Gulf of Mexico in general (e.g., Armstrong 1987, Gaston and Nasci 1988, Heard 1979, Horlick and Subrahmanyam 1983, Livingston 1984, La Salle and Rozas 1991).

Differences in species composition were detected both between pumped and unpumped sites and between the two actively pumped stations (4 and 6) by NMDS (Figure 4). A stress value of 0.08 (significant at p value = 0.02) indicates that the data plot provides a good fit to the original distribution of similarity values, i.e. the plot accurately represents the relationships among the samples (Clarke and Warwick 2001). These results were confirmed by ANOSIM (R=0.616 at a significance level of 2%). SIMPER analysis of unpumped and pumped sites indicated an average dissimilarity of 89.37 percent (Table 1).

Benthic assemblages of both pumped and unpumped stations were dominated by the polychaete *Streblospio benedicti*; however, densities of this species were far greater at the pumped sites. Harpacticoid copepods were also dominant at all sites and were also most abundant at pumped sites. Cyclopoid copepods and nemerteans were abundant only at pumped sites, while the polychaete *Hobsonia florida* was collected exclusively at Pump Station 3 (unpumped).

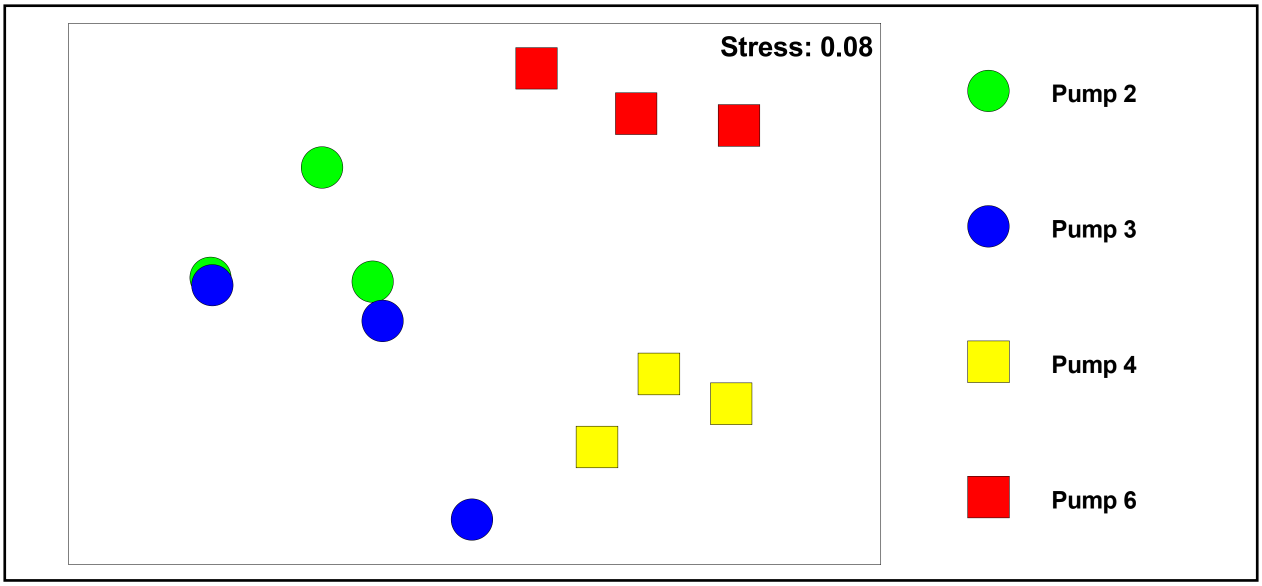

Figure 4. Nonmetric Dimensional Scaling Results for Violet Marsh Infauna. Circles represent unpumped stations and squares represent pumped stations

A subsequent SIMPER analysis based on individual stations detected the least degree of dissimilarity (greatest similarity) among unpumped sites (Table 2). The greatest degree of dissimilarity was found between Pump Stations 4 and 6. Station 4 was dominated (in order of abundance) by *S. benedicti* and cyclopoid copepods whereas Station 6 was dominated by harpacticoids and *S. benedicti.*

Overall community metrics (Abundance, Number of Taxa, Shannon-Weiner Diversity, and Pielou's Evenness) were also calculated (Appendix Table). Abundances (animals per sample) averaged 10 to 11 per sample at the unpumped stations, 21 per sample at Station 4 and 268 per sample at Station 6. The average number of taxa present was 2.5 to 3.5 per sample at the unpumped stations and 5 to 6 per sample at the pumped stations (Appendix Table). Diversity values ranged from 0.820 to 0.886 at all stations except 3, where H' was 0.525. Evenness ranged from 0.706 to 0.786 at all stations except 6, where it was 0.566.

Analysis of Variance (ANOVA) of abundance values yielded a significant difference at a power of 83 percent (effect size = 25 percent of the mean) after logarithmic transformation to correct for non-normality. Tukey's least significant difference test indicated that these differences were statistically significant ($p<0.05$). Statistical testing of the remaining community metrics was precluded by very low statistical power, generally less than 30% for detection of a change equivalent to 25% of the mean. As a result, interpretation of these values is tentative.

Table 1
SIMPER Test results for pumped and unpumped Sites. (Av.= Average, Abund=Abundance, Sim=Similarity, Contrib.=Contribution, Cum= Cumulative)

(Average similarity =50.27)	***Unpumped***			
Species	**Average Abundance**	**Average Similarity**	**Contribution (%)**	**Cumulative (%)**
Streblospio benedicti	11	44.85	89.23	89.23
Harpacticoida	1.33	3.94	7.84	97.07
(Average similarity = 22.40)	***Pumped***			
Species	**Average Abundance**	**Average Similarity**	**Contribution (%)**	**Cumulative (%)**
Harpacticoida	31.5	11.13	49.68	49.68
Streblospio benedicti	155.5	6.99	31.22	80.9
Cyclopodia	111.83	2.3	10.25	91.15
(Average dissimilarity = 89.37)	***Unpumped vs Pumped***			
	Unpumped	**Pumped**		
Species	**Average Abundance**	**Average Similarity**	**Contribution (%)**	**Cumulative (%)**
Streblospio benedicti	11	155.5	37.08	37.08
Harpacticoida	1.33	31.5	28.77	65.85
Cyclopodia	0	111.83	18.66	84.5
Nemertea	0	1.5	2.84	87.35
Tubificidae	0.17	2.17	2.1	89.45
Hobsonia florida	2.33	0	1.94	91.39

Table 2
Pairwise SIMPER results for pump sites

Pairwise Comparison	**Average Dissimilarity**
Pumps 2 & 3	50.74
Pumps 2 & 4	95.08
Pumps 3 & 4	89.19
Pumps 2 & 6	85.31
Pumps 3 & 6	87.90
Pumps 4 & 6	93.02

Sample Size Estimation. The primary purpose of most environmental sampling efforts is to determine if a difference exists between two or more sites or conditions (e.g., pumped vs. unpumped) (Underwood 1997). In order to make this comparison it is necessary to know the variability of the parameters being measured, a basic objective of pilot studies such as described here. It is then necessary to define the effect size, i.e., the degree of difference that is considered to be important, and the statistical power or degree of confidence in the test to be performed (Schmitt and Osenberg 1996, Quinn and Keough 2002).

Table 3 Minimal Sample Sizes.		
	No. Samples	
% Mean	Taxa	Log Abundance
10%	264	105
20%	70	30
30%	32	15
40%	20	10
50%	13	7

There are no strict guidelines in defining either effect size or statistical power; however, both directly affect the minimum number of samples necessary to achieve a valid test. For the purpose of this work it will be assumed that a statistical power of 90 percent is required. This means that there will be a 10 percent probability that a finding of no significant difference was erroneous. Estimates of minimal sample size for different effect sizes (expressed as a percentage of the mean) calculated from the pilot study data are listed in Table 3. The present study design of 12 samples represents an effect size between 30 percent and 40 percent of mean abundance (after log transformation to correct for a non-normal distribution). To detect a 10 percent difference between mean abundances would require 105 samples, while 264 samples are needed to detect the same difference in mean numbers of taxa. A minimum sample size of 80 samples would detect a difference of less than 20% between both mean abundances and mean numbers of taxa and accommodate several potential versions of the design. For instance, number of samples could be increased to 20 per site and sampled during a single effort (20 samples X 4 site = 80). Likewise, potential seasonal variation at the sites could be assessed by sampling on a quarterly basis (5 samples X 4 sites X 4 sampling efforts = 80 samples). Another alternative would be to incorporate additional sampling locations at each pump site, but at greater distances from the outfall to determine the spatial extent of potential impacts. This design could be accomplished within a single sampling effort (5 samples X 4 sampling station X 4 sites = 80). Any of these designs should provide satisfactory statistical results on a cost-effective basis.

DISCUSSION: Benthic assemblages in the study area are typical of low salinity, muddy environments in the Northern Gulf of Mexico (e.g., Armstrong 1987, Gaston and Nasci 1988, Heard 1979, Horlick and Subrahmanyam 1983, Livingston 1984, La Salle and Rozas 1991). In the absence of data from these or nearby sites prior to Hurricane Katrina it is impossible to say if they resemble those present immediately prior to overtopping of the levees; however, the study results do suggest that floodwater pumping affected these assemblages. Stations where no pumping occurred had fewer numbers of animals and a greater similarity in species composition than actively pumped sites. The heavy dominance of the Pump 4 (pumped) assemblage by the polychaete *Streblospio benedicti* and the presence of large numbers of harpacticoid copepods may indicate a history of disturbance. *Streblospio benedicti* is well-known as an early colonizer of recently disturbed sediments (Gaston and Nasci 1988). Carman et al. 1997) report that although most harpacticoid species are sensitive to hydrocarbon pollution, a few such as *Cletocamptus deitersi* are relatively insensitive and may occur in large numbers in recently contaminated sediments.

The study results also provide the data necessary for statistical power testing and minimum sample size calculations. These results have been used to suggest several alternative designs for potential future studies. These include a single sampling event limited to the original four sites with more comprehensive sampling, a single sampling event with greater spatial coverage, and a multiple sampling event design incorporating seasonal variability.

POINTS OF CONTACT: For additional information contact Dr. Gary L. Ray (601-634-2589, Gary.Ray@erdc.usace.army.mil). This technical note should be cited as follows:

> Ray, G. L. 2006. *A Pilot Study of Post-Hurricane Katrina Floodwater Pumping on Marsh Infauna.* Environmental Lab Technical Notes (ERDC/EL TN-06-2). Vicksburg, MS., U.S. Army Engineer Research and Development Center. *http://el.erdc.usace.army.mil/* .

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Appendix Table Summary Species Composition and Community Structure Data				
Taxa	**Pump 2**	**Pump 3**	**Pump 4**	**Pump 6**
Streblospio benedicti	17	49	927	6
Cyclopodia	0	0	671	0
Harpacticoida	4	4	93	96
Chaoborus sp.	0	0	7	0
Tubificidae	0	1	6	7
Polydora sp.	2	2	3	1
Cryptochironomus sp.	0	0	3	0
Nematoda	0	1	2	0
Hobsonia florida	1	13	0	0
Bivalvia	1	0	0	0
Hypereteone heteropoda	1	0	0	0
Syllidae	1	0	0	0
Naididae	0	2	0	0
Chironomus sp.	0	1	0	1
Grandidierella bonneroides	0	2	0	0
Gammarus mucronatus	0	1	0	0
Capitella sp.	0	1	0	1
Nereis succinea	0	0	0	1
Nemertea	0	0	0	9
Heteromastus filiformis	0	0	0	3
Stenoninereis martini	0	0	0	5
Mediomastus sp.	0	0	0	5
Total Taxa	7	11	8	11
Total Abundance	27	77	1712	135
Average Taxa	3.5	2.5	5.0	6.0
Average Abundance (Animals/Sample)	11.0	10.0	21.3	268.3
Shannon Weiner Diversity (H'(loge))	0.864	0.525	0.886	0.820
Pileou’s Evenness Index (J')	0.786	0.757	0.706	0.566

Appendix Report 2
Characterization of Post-Hurricane Katrina Floodwater Pumping on Marsh Infauna

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PURPOSE

The performance of hurricane protection and damage reduction systems and consequences of structural failures following Hurricane Katrina are presently being studied by the Interagency Performance Evaluation Task Force (IPET). The evaluation includes characterization of potential impacts to biological resources. This report describes the effects of pumping of floodwaters on benthic invertebrate assemblages associated with pumping stations in wetlands near Chalmette and Violet, Louisiana.

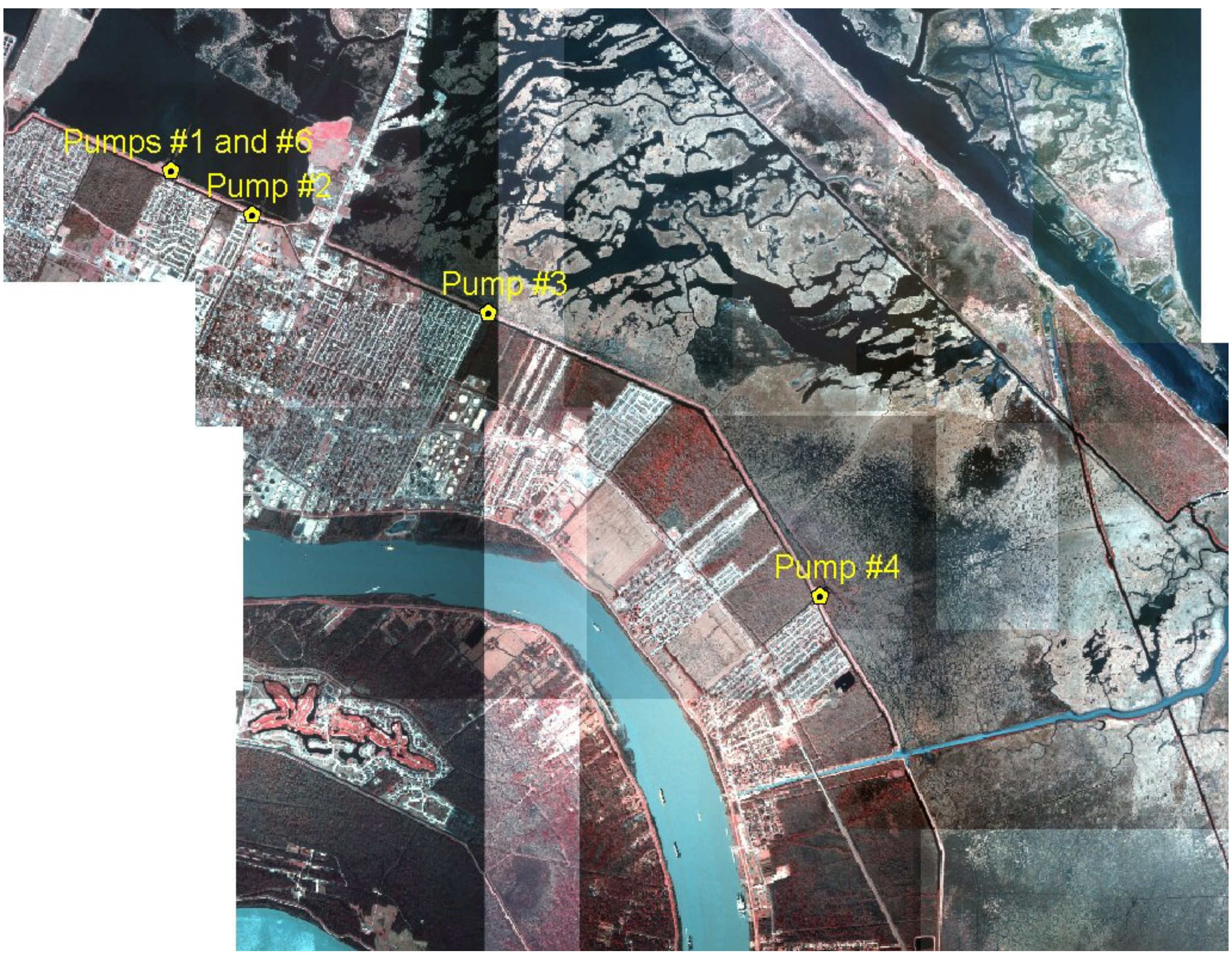

Figure 1. Aerial view of study area

BACKGROUND

Hurricane Katrina struck the coasts of Alabama, Mississippi, and Louisiana, levees were breached or overtopped, resulting in massive flooding in the City of New Orleans and adjacent areas. Saint Bernard Parish, located east of the city, was flooded by water from the Mississippi River Gulf Outlet channel and Lake Borgne. Floodwaters were subsequently pumped into marshes in the vicinity of Chalmettte and Violet, Louisiana. This operation raised concerns that elevated salinities and potential contaminant loads in the floodwaters could have undesirable impacts on the receiving marshes and other biological resources. This includes benthic invertebrates, a critical source of forage for economically and ecologically important finfish and shellfish species. In December 2005 a pilot study was performed to discern large-scale patterns in the distribution of benthic invertebrates and determine minimal sample size for future studies (Ray 2006). Comparison of sites in the immediate vicinity of active and inactive pumping stations detected differences in species composition between sites. There were also indications that assemblages near active pumps had recently been disturbed. Using this information, quantitative sampling of the sites was performed in February 2006.

STUDY AREA

The Violet Marsh covers an area of approximately 81.6 hectares (31.5 sq. miles) between the city of Chalmette and Lake Borgne in St. Bernard Parish, Louisiana (Figure 1). Bordered on the east by the back protection levee and on the west by the federal levee, the marsh is connected directly to both the Mississippi River and the Mississippi River Gulf Outlet Canal (MRGO). Most of the pumps used to remove floodwaters are located along the back protection levee (Figure 1). Four of the pumps were sampled based on their pumping records: Pumps 4 and 6 were active throughout the emergency while Pumps 2 and 3 were inoperative.

METHODS

Samples were taken for water quality conditions, infauna, and sediments at at each of two stations within 50 m and 100 m respectively of the pump outfalls. Water quality measures included salinity, temperature, and dissolved oxygen concentrations, measured at the surface of the water column of each station using a handheld YSI Model 85. A total of 10 infaunal samples were taken at each station using a pole-mounted Eckman dredge (232 cm^2/sample). Samples were rinsed in the field using a sieve bucket with a 0.5 mm mesh screen, placed in labeled cloth bags, and fixed in 4% formaldehyde solution. After fixation the samples were transported to laboratory facilities at the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS where the samples were rinsed with fresh water over a 0.5 mm sieve and material retained on the sieve stored in 70% ethanol. Samples were subsequently stained with Rose Bengal and examined under illuminated 3X magnification to facilitate removal from the sediments. All specimens were identified to the lowest practical identification level and counted.

An additional sample was taken at each station for sediment analyses. Sediment samples were placed in whirl-pac bags and immediately stored on ice. Samples were analyzed for both sediment grain size and total organic content. Sediment grain size was analyzed using a combination of wet-sieving and flotation procedures (Folk 1968, Galehouse 1971). Data analysis was conducted using Gradistat 4.0 (Blott 2000). Sediment organic content was analyzed by loss upon ignition. In this procedure an aliquot of each sample was dried at 100 ^{o}C for 18 hours. After cooling in a drying chamber, samples were weighed then placed in a muffle furnace at 500 ^{o}C for an additional 18 hours. After cooling once again in the drying chamber they were reweighed and total organic content calculated as percentage loss between ash-free and dry-weight.

Multivariate statistical techniques were used to detect changes in species composition, a sensitive indicator of assemblage responses to disturbance (Clarke and Warwick 2001). The techniques included Nonmetric Dimensional Scaling (NMDS), Analysis of Similarity (ANOSIM), and similarity percentage analysis (SIMPER). NMDS is an ordination technique that compares species composition among sample pairs and is particularly suited for infaunal data (Clarke and Warwick 2001). It was performed using the Bray-Curtis similarity index and logarithmically transformed (log x+1) abundance values to adjust for the influence of very abundant taxa. ANOSIM is a nonparametric technique that compares similarity values between treatments and can be used as a test of the significance of patterns observed in NMDS. SIMPER estimates the contribution of individual taxa to similarity among treatments and is used to determine the extent to which individual species were responsible for the patterns detected by NMDS and ANOSIM.

RESULTS

***Water Quality and Sediments*:** Water conditions at the four sites were somewhat different from those encountered during the pilot study (Ray 2006). Salinities were lower, ranging from 5 ppt to 7 ppt at Stations 2A, 3A and 6A and 1.8 at Station 4A. During the previous sampling salinity averaged between 11-12 ppt at all stations. Temperatures were similar to the previous December ranging from 11.6 ^{o}C to 15.6 ^{o}C. Dissolved oxygen concentrations were all well above saturation level ranging from 9.5 mg/l to 13 mg/l. Sediments at all stations are categorized as coarse silts although visual inspection of the samples reveals that the majority of the material is made up of vegetative matter. This fact is emphasized by the high sediment organic contents (9.68%-22.49%). Sediment organic content was highest at Pump 2.

Infaunal Analyses: Species assemblages encountered were nearly identical to those found during the pilot study and were similar to those of other Northern Gulf of Mexico marshes and of low salinity, muddy estuarine sediments (e.g., Armstrong 1987, Gaston and Nasci 1988, Heard 1979, Horlick and Subrahmanyam 1983, Livingston 1984, LaSalle and Rozas 1991). Dominant taxa included the polychaetes Streblospio benedicti and Hobsonia florida, the naidid oligochaetes Paranais littoralis and Dero digitata, immature tubificid oligochaetes (without capillary setae), cyclopoid and harpacticoid copepods, cladocera, larvae of the chironomid flies Chironomus sp. and Cryptochirnomus sp. and phantom midge larvae, Chaoborus sp.(Appendix Table 2). These eleven taxa accounted for more than 95% of all animals collected.

Streblospio bendedicti was found in large numbers at all sites except Pump 6 where Nemertea and the capitellid polychaete *Mediomastus* sp. were the dominant. The naidid *P. littoralis* was most abundant at Pumps 2 and 4, while *Hobsonia florida* was found almost exclusively at Pumps 2 and 3. Cyclopoid copepods were most abundant at Pump 4, as were *D. digitata*, cladocera, and *Chaoborus* sp. larvae. *Chironomus* sp.was most abundant at Pump 4, but was also found at Pumps 2 and 3. *Cryptochironomus* sp. was found primarily at Pumps 3 and 4.

Differences in species composition were detected by NMDS between active and inactive pump areas; however, the differences were not as distinctive as in the pilot study (Figure 2). Pump 6 stations were clearly different from all the remaining sites while Pump 4 stations were far more similar to the inactive pump stations than in December 2005. There is also an indication that those stations furthest from the pumps at Pumps 2, 3, and 4 were more alike than those close to the pumps (A stations). A stress value of 0.12 (significant at p = 0.1%) indicates that the data plot provides a reasonable fit to the original distribution of similarity values, i.e. the plot accurately represents the relationships among the samples (Clarke and Warwick 2001).

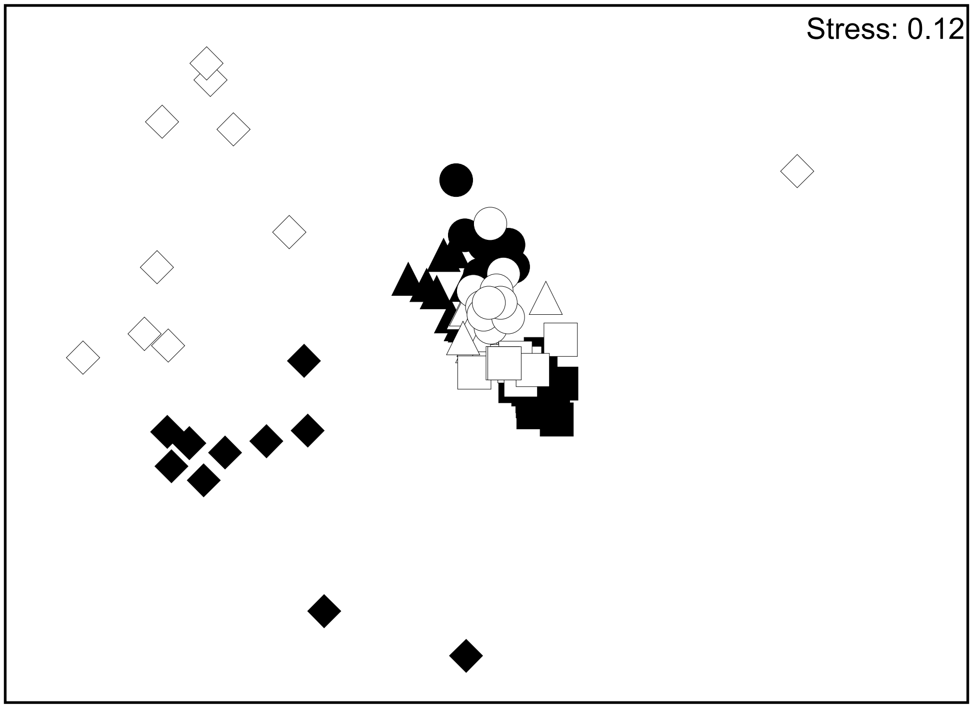

Figure 2. Nonmetric Dimensional Scaling Results for Violet Marsh Infauna. Triangles= Pump 2, Circles = Pump 3, Squares = Pump 4, Diamonds = Pump 6, Filled symbols = A Stations, Open symbols = B Stations

Results from ANOSIM confirmed there were differences between active and inactive pump assemblages (Table 1). However, significant differences (p<0.5%) were also detected between all combinations of sites and stations and the R values for these tests were generally higher than those between active and inactive pumps suggesting the former were of a greater magnitude. Within the tests for differences among sites and stations the lowest R values were associated with comparisons of inactive sites (2 vs 3) suggesting assemblages at these sites were most alike. Pairwise comparisons of individual stations had uniformly higher R values for those tests where one of the pair was the station closest to an active pump (Appendix Table 3).

SIMPER results support these findings. The lowest degree of similarity was found among replicate samples at active pump sites, especially at Pump 6 (Table 2). Pairwise comparisons of the sites detected the greatest dissimilarity among combinations including Site 6, a clear indication that species composition at this site was different from the remaining sites. This pattern is repeated in pairwise comparisons of the individual stations (Appendix Table 3). The greatest dissimilarity values were found in comparisons of active versus inactive pump stations and Stations 6A and 6B in particular.

Table 1. ANOSIM Results		
Global Tests	**R**	**p (%)**
Active vs Inactive Pumps	0.339	0.1%
Sites	0.592	0.1%
Stations	0.646	0.1%
	Pairwise Tests	
2, 3	0.572	0.1%
2, 4	0.811	0.1%
2, 6	0.578	0.1%
3, 4	0.799	0.2%
3, 6	0.614	0.1%
4, 6	0.625	0.1%

Table 2. SIMPER Results for Pumps and Sites	
Global Tests	**Similarity**
Active	16.48
Inactive	40.90
Site 2	46.98
Site 3	48.84
Site 4	45.06
Site 6	18.15
Pairwise Comparisons	**Dissimilarity**
Active vs Inactive	83.38
Site 2 & 3	65.77
Site 2 & 4	69.02
Site 3 & 4	71.51
Site 2 & 6	95.85
Site 3 & 6	97.12
Site 4 & 6	97.89

The principal difference in species composition among stations with inactive pumps (2 and 3) was the relatively high abundance of *Hobsonia florida*. Differences among the active pump stations are related to the very low overall abundances at Pump 6 and the low densities of *S. benedicti* and *P. littoralis.* Inactive pump stations also differed from Pump 6 in that they had higher abundances particularly of *S.* benedicti (both stations), *P. littoralis* and *H. florida*. Differences between the inactive pump sites and Pump 4 can be traced to the presence of large numbers of cyclopoid copepods and low numbers of *H. florida* at the actively pumped station.

DISCUSSION: As was found during the pilot study, benthic assemblages in the study area are typical of low salinity, muddy environments in the Northern Gulf of Mexico (e.g., Armstrong

1987, Gaston and Nasci 1988, Heard 1979, Horlick and Subrahmanyam 1983, Livingston 1984, La Salle and Rozas 1991). While the absence of data from these sites prior to Hurricane Katrina makes it is impossible to determine if they resemble pre-storm conditions, the study results do suggest that floodwater pumping affected the assemblages. The low abundance, diversity, altered species composition, and high degree of variability in this area is highly indicative of disturbed conditions. The heavy dominance of Pump 4 by the polychaete *Streblospio benedicti* and the presence of large numbers of harpacticoid copepods may be indicate recent disturbance. *Streblospio benedicti* is well known as an early colonizer of recently disturbed sediments (Gaston and Nasci 1988) and Carman et al. (1997) report that although most harpacticoid species are sensitive to hydrocarbon pollution, a few such as *Cletocamptus deitersi* are relatively insensitive and may occur in large numbers in recently contaminated sediments. The presence of relatively large numbers of oligochaetes and tubificid oligochaetes in particular suggests that this site may have been subjected to organic enrichment (Pearson and Rosenberg 1978). These conclusions are at odds however with the presence of large numbers of species and relatively high diversity values at this station, characteristics generally associated with low stress conditions. The seeming inconsistency between these results and the clearer difference between active and inactive pump stations detected in the pilot study may be due to the passage of time or to the sampling of additional sites further from the orginal stations. For instance, flushing of Pump 4, as suggested by the lower salinities encountered, may have countered stressful conditions present during the earlier sampling event. Likewise, the greater similarity between stations further from the pump sites (B Stations) may have diluted the distinction between actively pumped and unpumped sites. In either case, there is still evidence that the actively pumped areas experienced some perturbation not shared by the unpumped sites.

POINTS OF CONTACT: For additional information contact Dr. Gary L. Ray (601-634-2589, Gary.Ray@erdc.usace.army.mil). This technical note should be cited as follows:

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Appendix Table 1. Summary Water Quality and Sediment Data

Water Quality Data	**2A**	**2B**	**3A**	**3B**	**4A**	**4B**	**6A**	**6B**
Temperature (^{o}C)	11.6	ND	15.6	ND	13.6	ND	12.0	ND
Salinity (ppt)	7.0	ND	5.1	ND	1.8	ND	5.1	ND
Dissolved Oxygen (mg/l)	13	ND	14.5	ND	11.3	ND	9.52	ND
Depth (cm)	100	100	100	100	120	100	100	100
Sediment Data	Coarse Silt	Coarse Silt	Coarse Silt	Coarse Silt	Coarse Silt	Coarse Silt	Coarse Silt	Coarse Silt
Organic Content (%)	22.49	21.02	9.68	15.83	14.45	13.24	21.61	15.65
Mean Grain Size (um)	31.22	29.52	38.06	31.74	39.6	47.48	31.23	34.39
Sorting Coefficient	57.6	25.58	104.5	53.48	110.7	178.1	53.19	69.89
Sediment Fractions								
% Gravel	0.0%	0.0%	0.3%	0.0%	0.2%	0.6%	0.1%	0.1%
% Very Coarse Sand	0.0%	0.0%	0.1%	0.0%	0.1%	0.3%	0.0%	0.1%
% Coarse Sand	0.0%	0.0%	0.2%	0.0%	0.3%	0.4%	0.0%	0.1%
% Medium Sand	0.0%	0.0%	0.1%	0.0%	0.3%	0.2%	0.0%	0.2%
% Fine Sand	0.2%	0.1%	0.3%	0.1%	0.7%	0.5%	0.1%	0.1%
% Very Fine Sand	13.4%	12.9%	15.5%	14.1%	15.1%	14.8%	13.5%	14.9%
% Silt	85.9%	86.6%	83.1%	85.4%	82.8%	82.8%	85.7%	84.2%
% Clay	0.4%	0.4%	0.3%	0.4%	0.4%	0.4%	0.4%	0.4%

ND= No Data

Appendix Table 2. Summary Species Composition and Community Structure Data										
Taxa	**2A**	**2B**	**3A**	**3B**	**4A**	**4B**	**6A**	**6B**	**Total**	**%**
Streblospio benedicti	188	382	835	397	1743	496	2	2	4045	30.16
Paranais littoralis	398	800	13	56	1135	367	0	1	2770	20.66
Harpacticoida	98	651	80	58	424	122	9	0	1442	10.75
Cyclopodia	2	96	5	23	821	272	8	1	1228	9.16
Hobsonia florida	83	171	714	156	0	3	1	2	1130	8.43
Chironomus sp.	28	56	35	53	693	94	4	0	963	7.18
Cryptochironomus sp.	2	3	36	221	82	84	1	0	429	3.20
Dero digitata	0	0	0	0	221	48	3	0	272	2.03
Immature Tubificid /w cap. setae	5	8	7	24	56	85	5	3	193	1.44
Cladocera	0	2	0	0	175	8	0	0	185	1.38
Chaoborus sp.	0	1	0	4	79	18	9	1	112	0.84
Ceratopogonidae	0	0	4	14	55	33	0	0	106	0.79
Mediomastus sp.	16	23	2	15	0	1	0	21	78	0.58
Nemertea	5	3	4	1	0	0	52	12	77	0.57
Immature Tubificid w/ cap. setae	1	0	0	0	51	1	0	0	53	0.40
Platyhelminthes	13	20	0	5	0	0	7	1	46	0.34
Gammarus mucronatus	2	12	0	4	23	1	0	0	42	0.31
Physella sp.	1	6	0	1	29	1	0	0	38	0.28
Nematoda	1	0	1	1	19	12	0	0	34	0.25
Limnodrilus hoffmeisteri	0	3	1	0	8	10	0	0	22	0.16
Hypereteone heteropoda	4	17	0	0	0	0	0	0	21	0.16
Mulinia sp.	0	15	0	0	0	0	0	0	15	0.11
Dipolydora ligni	3	3	4	1	2	0	1	0	14	0.10
Ostracoda	0	0	3	1	8	1	0	0	13	0.10
Grandidierella bonneroides	0	0	4	7	0	0	0	0	11	0.08
Capitella sp.	2	7	0	0	0	0	0	1	10	0.07
Rangia cuneata	5	2	0	0	0	0	1	0	8	0.06
Stenoinereis martini	0	0	0	6	0	0	2	0	8	0.06
Tubificoides sp.	0	0	0	0	0	0	0	6	6	0.04
Chironomid pupa	0	0	0	0	5	0	0	0	5	0.04
Corophium lacustre	3	2	0	0	0	0	0	0	5	0.04
Mysidopsis bahia	0	0	1	4	0	0	0	0	5	0.04
Palaemonetes pugio	0	0	0	4	0	0	0	0	4	0.03
Aeshnidae	0	0	0	0	2	1	0	0	3	0.02
Namalycastis abiuma	0	0	0	0	0	3	0	0	3	0.02
Parandalia sp.	1	0	0	0	0	0	0	1	2	0.01
Glycinde solitaria	0	2	0	0	0	0	0	0	2	0.01
Macoma mitchelli	0	0	0	0	0	0	1	1	2	0.01
Stylaria lacustris	0	0	0	0	1	0	0	0	1	0.01
Hirudinea	0	0	0	0	1	0	0	0	1	0.01
Anax sp.	0	0	0	0	1	0	0	0	1	0.01
Ephemeroptera	0	0	0	0	1	0	0	0	1	0.01
Nereis succinea	0	0	0	1	0	0	0	0	1	0.01
Mytilidae	1	0	0	0	0	0	0	0	1	0.01
Polymesoda sp.	0	1	0	0	0	0	0	0	1	0.01
Anemone	1	0	0	0	0	0	0	0	1	0.01
Mulinia sp 2	0	1	0	0	0	0	0	0	0	0.01

Appendix Table 3. ANOSIM Results - Pairwise Comparisons of Stations		
Stns	**R**	**p**
2A, 4A	0.985	0.2
4A, 3B	0.975	0.1
2A, 4B	0.970	0.1
3A, 4A	0.966	0.1
4A, 2B	0.956	0.1
3A, 4B	0.915	0.1
2B, 4B	0.857	0.1
3A, 6A	0.813	0.1
4A, 6A	0.810	0.1
2B, 3B	0.804	0.1
6A, 2B	0.796	0.2
2A, 6A	0.791	0.1
3B, 4B	0.790	0.1
6A, 3B	0.788	0.1
3A, 2B	0.787	0.1
2A, 3B	0.781	0.1
6A, 4B	0.775	0.1
4A, 6B	0.760	0.1
3A, 6B	0.745	0.1
4B, 6B	0.732	0.1
3B, 6B	0.674	0.1
2B, 6B	0.672	0.1
2A, 3A	0.652	0.1
2A, 6B	0.639	0.1
4A, 4B	0.519	0.1
6A, 6B	0.418	0.1
2A, 2B	0.410	0.1
3A, 3B	0.405	0.1

Appendix Table 4. SIMPER Results – Station Comparisons	
Station	**Average Similarity**
2A	50.77
2B	50.64
3B	62.90
3A	47.43
4A	56.41
4B	52.16
6A	31.27
6B	19.81
PairwiseComparion	**Average Dissimilarity**
4A & 6B	99.72
3A & 6B	98.76
4B & 6B	98.57
4A & 6A	98.48
2B & 6B	97.89
3A & 6A	97.38
3B & 6B	97.15
6A & 2B	96.63
6A & 3B	95.18
6A & 4B	94.79
2A & 6B	94.58
2A & 6A	94.32
6A & 6B	88.50
2A & 4A	80.00
4A & 3B	77.39
3A & 4A	76.54
3A & 4B	72.18
2A & 3A	71.33
3A & 2B	69.95
4A & 2B	67.84
2A & 4B	67.55
4A & 4B	63.24
2B & 3B	61.38
2B & 4B	60.69
2A & 3B	60.41
3B & 4B	59.95
3A & 3B	56.85
2A & 2B	56.37

Appendix Table C1. Representative data from SEAMAP program. Abundance (animals collected per hour) of select species trawled from a depth of 0-30 m in Statistical Zone 13 (Lower Louisiana Shelf)			
		Year	
Species	**1998**	**1999**	**2000**
Peneaus aztecus	175	126.7	517.3
Chloroscombrus chrysurus	150	0	606.3
Micropogonia undulatus	545	940	0
Trichiurus lepturus	0	36.7	12.2
Leistomus xanthurus	400	0	0
Peprilus burti	50	0	0
Cynoscion arenarius	55	56.7	3.3
Anchoa nasuta	0	0	128.3
Anchoa hepsetus	0	0	122.4
Callinectes similis	5	0	6.7

Appendix Table C2. Representative data from EPA – EMAP Louisiana Province Data collections (1991-1994). Values = total numbers of animals collected

Species	**1991**	**1992**	**1993**	**1994**	**Total**
Penaeus aztecus	647	707	2121	1494	4969
Micropogonia undulatus	674	720	1743	1746	4883
Penaeus setiferus	296	609	2300	586	3791
Brevoorita patronus	76	914	658	807	2455
Anchoa mitchelli	107	1206	455	592	2360
Lagadon rhomboides	299	466	877	563	2205
Choloroscombrus chrysurus	1053	509	225	406	2193
Leiostomus xanthurus	324	259	441	712	1736
Bagre marinus	515	244	400	499	1658
Cynoscion arenarius	167	91	938	383	1579

Appendix Table C3. Coast 2050 Fish and Invertebrate Population Status Assessments for Fish and Invertebrates Guilds in Region 1 (Pontchartrain Drainage Area)

Table 7-1. Region 1 fish and invertebrate population status and 2050 change (Cont.).

	Fish and Invertebrate Guilds (Species)												
	Red drum	Black drum	Spotted seatrout	Gulf menhaden	Southern flounder	American oyster	White shrimp	Brown shrimp	Blue crab	Spanish mackerel	Largemouth bass	Channel catfish	
Mapping Unit	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Comments
North Shore Marshes	Sy/D	Sy/D	Sy/D	Sy/Sy	Sy/D	NA/NA	Sy/D	Sy/D	Sy/Sy	U/U	Sy/Sy	Sy/Sy	
Pearl River Mouth	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	D/D	Sy/Sy	Sy/Sy	Sy/Sy	U/U	Sy/Sy	Sy/Sy	
East Orleans Land Bridge	Sy/D	Sy/D	Sy/D	Sy/Sy	Sy/D	Sy/Sy	Sy/D	Sy/D	Sy/D	U/I	Sy/Sy	U/U	
Bayou Sauvage	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA	U/U	NA/NA	D/I	D/I	Freshwater impoundment
Chandeleur Sound	I/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	NA/NA	NA/NA	
Chandeleur Islands	I/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	NA/NA	NA/NA	
Lake Borgne	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	NA/NA	NA/NA	
South Lake Borgne	Sy/D	Sy/D	Sy/D	Sy/Sy	Sy/D	Sy/D	Sy/D	Sy/D	Sy/D	Sy/Sy	NA/NA	NA/NA	
Central Wetlands	Sy/Sy	Sy/Sy	Sy/Sy	Sy/I	Sy/Sy	D/D	Sy/Sy	Sy/Sy	Sy/Sy	NA/NA	NA/NA	NA/NA	
Biloxi Marshes	I/D	Sy/D	Sy/D	Sy/Sy	Sy/D	Sy/Sy	Sy/D	Sy/D	Sy/D	Sy/Sy	NA/NA	NA/NA	
Eloi Bay	I/Sy	Sy/D	Sy/D	Sy/Sy	Sy/D	D/D	Sy/D	Sy/D	Sy/Sy	Sy/Sy	NA/NA	NA/NA	

NOTES: Steady=Sy, Decrease=D, Increase=I, Unknown=U, Not Applicable=NA

Table 7-1. Region 1 fish and invertebrate population status and 2050 change.

	Fish and Invertebrate Guilds (Species)												
	Red drum	Black drum	Spotted seatrout	Gulf menhaden	Southern flounder	American oyster	White shrimp	Brown shrimp	Blue crab	Spanish mackerel	Largemouth bass	Channel catfish	
Mapping Unit	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Trend/ Projection	Comments
Amite/Blind	NA/NA	NA/NA	NA/NA	U/U	NA/NA	NA/NA	NA/NA	NA/NA	Sy/Sy	NA/NA	Sy/Sy	Sy/Sy	
Lake Maurepas	NA/NA	NA/NA	NA/NA	U/U	NA/NA	NA/NA	NA/NA	NA/NA	Sy/Sy	NA/NA	Sy/Sy	Sy/Sy	
Tickfaw River Mouth	NA/NA	NA/NA	NA/NA	U/U	NA/NA	NA/NA	NA/NA	NA/NA	Sy/Sy	NA/NA	Sy/Sy	Sy/Sy	
West Manchac Land Bridge	U/U	U/U	NA/NA	U/U	U/U	NA/NA	NA/NA	NA/NA	Sy/Sy	NA/NA	Sy/Sy	Sy/Sy	
Tangipahoa River Mouth	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	NA/NA	Sy/Sy	D/D	Sy/Sy	NA/NA	Sy/Sy	Sy/Sy	
East Manchac Land Bridge	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	NA/NA	Sy/Sy	Sy/Sy	Sy/Sy	NA/NA	Sy/Sy	Sy/Sy	
Lake Pontchartrain	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	Sy/Sy	NA/NA	Sy/Sy	Sy/Sy	Sy/Sy	U/U	Sy/Sy	Sy/Sy	
Bonnet Carre'	U/U	U/U	U/U	U/U	U/U	NA/NA	Sy/Sy	Sy/Sy	Sy/Sy	NA/	Sy/Sy	Sy/Sy	
La Branche Wetlands	U/U	U/U	U/U	U/U	U/U	NA/NA	Sy/D	Sy/D	Sy/Sy	NA/NA	Sy/Sy	Sy/Sy	
Tchefuncte River Mouth	Sy/D	Sy/D	Sy/D	Sy/Sy	Sy/D	NA/NA	Sy/D	Sy/D	Sy/D	NA/NA	Sy/Sy	Sy/Sy	

NOTES: Steady=Sy, Decrease=D, Increase=I, Unknown=U, Not Applicable=NA

Appendix Table C4. Representative Tissue Contaminant Levels from EPA – EMAP Louisiana Province Data collections (1991-1994)

		Micropognias undulatus			*Peneaus aztecus*		
Analyte	**Unit**	**L. Borgne**	**L. Pontchartrain**	**MS Sound**	**L. Borgne**	**L. Pontchartrain**	**MS Sound**
AG	ug/g	0.0021	0.1818	0.0873	0.0427	---	---
AL	ug/g	1.8957	1.5847	2.3963	2.8102	---	---
ALDRIN	ng/g	---	0.4047	0.3834	0.4144	---	---
AS	ug/g	0.0639	0.2130	0.3941	0.7511	---	---
CD	ug/g	0.0213	0.0266	0.0213	0.0259	---	---
CR	ug/g	---	0.1012	0.0426	0.1036	---	---
CU	ug/g	0.3195	0.4207	0.4260	0.1166	---	---
DIELDRIN	ng/g	1.6188	1.3153	0.3621	0.2461	---	---
FE	ug/g	7.5402	5.1674	6.6350	10.5284	---	---
HG	ug/g	0.0324	0.0099	0.0084	0.0442	---	---
MIREX	ng/g	47.2541	4.8529	0.7988	1.3727	---	1.6188
NI	ug/g	0.0639	0.1491	0.1917	0.1166	---	---
OPDDD	ng/g	1.6188	1.5052	0.6497	0.2979	---	---
OPDDE	ng/g	0.7455	0.7721	---	---	---	---
OPDDT	ng/g	0.6497	0.7065	0.5325	---	---	---
PCB101	ng/g	0.7029	0.4984	---	---	---	---
PCB105	ng/g	0.7242	1.3206	---	0.6216	---	---
PCB118	ng/g	0.5432	0.4952	---	0.2849	---	---
PCB126	ng/g	0.3302	0.4100	---	2.3051	---	---
PCB128	ng/g	---	0.2237	---	0.6216	---	---
PCB153	ng/g	2.3643	0.8982	0.2769	0.5698	---	---
PCB170	ng/g	2.2898	0.3355	0.3408	0.2590	---	---
PCB180	ng/g	0.2982	0.4345	0.3834	0.6087	---	---
PCB187	ng/g	---	0.2237	0.1491	0.6216	---	---
PCB195	ng/g	0.5112	0.6461	0.1917	0.6216	---	0.1554
PCB206	ng/g	1.6188	0.3834	0.1704	0.6734	---	0.3626
PCB209	ng/g	0.8840	0.4899	0.6177	0.8288	---	0.3885
PCB28	ng/g	0.6816	0.4899	---	---	---	---
PCB44	ng/g	0.7349	0.6603	---	---	---	---
PCB52	ng/g	---	0.8307	---	1.0101	---	0.8029
PCB66	ng/g	---	0.2556	---	1.3209	---	---
PCB99	ng/g	0.8094	0.7100	0.2343	0.2331	---	---
PPDDD	ng/g	---	0.4047	---	0.2849	---	---
PPDDE	ng/g	0.8307	0.7136	---	0.4144	---	---
PPDDT	ng/g	0.9159	1.4449	1.9809	6.5398	---	---
SE	ug/g	0.0426	0.2087	0.2663	0.1554	---	---
SN	ng/g	0.1235	0.1926	0.4931	0.0984	---	---
ZN	ug/g	7.5402	5.7297	8.5413	7.1873	---	---

Appendix Table C5. Representative benthic invertebrate abundances for Mississippi Sound from EPA – EMAP Louisiana Province Data collections (1991-1994)						
Species	**1991**	**1992**	**1993**	**1994**	**Total**	**%**
CAECUM JOHNSONI	6295	81	36	129	6541	16
STREBLOSPIO BENEDICTI	149	8	866	1213	2237	5
NOTOMASTUS LATERICEUS	20	1116	0	605	1741	4
MEDIOMASTUS CALIFORNIENSIS	8	0	1104	596	1709	4
ASYCHIS ELONGATUS	806	137	97	60	1100	3
MYRIOCHELE OCULATA	56	69	113	857	1096	3
POLYGORDIUS SP.	32	0	0	870	903	2
SEMELE NUCULOIDES	782	46	0	0	828	2
ACANTHOHAUSTORIUS SP.A	8	0	754	0	762	2
HEMICHORDATA	24	717	0	0	742	2
MEDIOMASTUS AMBISETA	0	0	0	725	725	2
PARACAPRELLA TENUIS	0	0	677	40	717	2
MEDIOMASTUS SP.	150	172	8	322	652	2
PSEUDEURYTHOE PAUCIBRANCHIATA	0	73	113	437	622	2
NOTOMASTUS LOBATUS	0	0	556	16	572	1
BHAWANIA HETEROSETA	32	133	379	8	552	1
PARAONIS FULGENS	0	0	16	508	524	1
MELLITA QUINQUIESPERFORATA	226	62	117	97	501	1
HEMIPHOLIS ELONGATA	250	124	64	36	474	1
PARAPRIONOSPIO PINNATA	47	62	95	261	466	1
NEMERTEA SP.C	16	41	232	139	428	1
PHORONIS MUELLERI	66	47	171	75	359	1
MYSELLA SP.A	330	0	0	0	330	1
OWENIA FUSIFORMIS	0	0	314	0	314	1
COSSURA SOYERI	0	32	137	125	294	1
MALMGRENIELLA SP.B	81	91	121	0	292	1
SPIOPHANES BOMBYX	8	141	129	0	278	1
MULINIA LATERALIS	8	16	244	8	277	1
PARANINOE BREVIPES	0	0	0	258	258	1
PINNIXA SP.	12	47	97	99	255	1
OPHIUROIDEA	44	71	108	30	253	1
MAGELONA SP.I	0	181	48	19	248	1
PHASCOLION SP.B	32	52	0	161	246	1
CARAZZIELLA HOBSONAE	8	218	0	8	234	1
LEPIDACTYLUS SP.A	202	0	16	8	226	1
PERIPLOMA MARGARITACEUM	48	60	24	89	222	1
PRIONOSPIO PYGMAEA	81	0	121	16	218	1
NEMERTEA SP.A	24	96	35	62	217	1
SIGAMBRA TENTACULATA	30	72	53	58	213	1
MICROPHIOPHOLIS ATRA	40	59	39	70	208	1
Total Animals/m2	13252	6712	10180	11027	41171	
Total Species	126	149	185	159	343	

Appendix Table C6. USEPA EMAP Fish data for Lake Pontchartrian (1991-1994)					
Species	**LAKE PONTCHARTRAIN**				
	1991	**1992**	**1993**	**1994**	**Total**
MICROPOGONIAS UNDULATUS	107	0	255	107	469
ICTALURUS FURCATUS	302	9	2	6	319
ANCHOA MITCHILLI	0	174	88	28	290
BREVOORTIA PATRONUS	0	0	40	50	90
CYNOSCION ARENARIUS	3	0	37	14	54
ARIUS FELIS	4	0	31	11	46
DASYATIS SABINA	0	0	0	41	41
LEPOMIS MACROCHIRUS	0	21	0	0	21
CALLINECTES SAPIDUS	10	0	0	2	12
LEIOSTOMUS XANTHURUS	1	0	1	9	11
PENAEUS AZTECUS	0	0	5	3	8
DOROSOMA PETENENSE	1	0	3	0	4
MORONE SAXATILIS	0	2	0	1	3
TRINECTES MACULATUS	0	0	2	1	3
DOROSOMA CEPEDIANUM	0	1	1	0	2
LAGODON RHOMBOIDES	1	0	1	0	2
PARALICHTHYS LETHOSTIGMA	0	0	1	1	2
BREVOORTIA GUNTERI	0	0	0	1	1
ELOPS SAURUS	0	0	0	1	1
GYMNACHIRUS TEXAE	0	0	0	1	1
ICTALURUS PUNCTATUS	0	0	0	1	1
POMOXIS ANNULARIS	1	0	0	0	1
Grand Total	430	207	467	278	1382

Appendix Table C7. USEPA EMAP Fish data for Lake Borgne (1991-1994)					
Species	**LAKE BORGNE**				
	1991	**1992**	**1993**	**1994**	**Total**
CHLOROSCOMBRUS CHRYSURUS	0	220	0	0	220
MICROPOGONIAS UNDULATUS	24	36	3	86	149
PENAEUS AZTECUS	13	67	0	64	144
ARIUS FELIS	28	19	2	21	70
PENAEUS SETIFERUS	2	1	0	62	65
BAGRE MARINUS	4	5	0	38	47
ANCHOA MITCHILLI	17	14	13	0	44
CYNOSCION ARENARIUS	2	7	1	20	30
LEIOSTOMUS XANTHURUS	1	1	1	25	28
BREVOORTIA PATRONUS	1	0	2	15	18
CALLINECTES SAPIDUS	9	5	0	4	18
SCOMBEROMORUS MACULATUS	2	0	9	3	14
LAGODON RHOMBOIDES	3	1	0	3	7
PEPRILUS BURTI	0	7	0	0	7
CARANX HIPPOS	0	6	0	0	6
ANCHOA HEPSETUS	0	1	0	4	5
BAIRDIELLA CHRYSURA	0	0	0	4	4
ICTALURUS FURCATUS	0	0	4	0	4
SCOMBEROMORUS CAVALLA	0	4	0	0	4
PARALICHTHYS LETHOSTIGMA	0	0	0	2	2
PEPRILUS ALEPIDOTUS	0	0	0	2	2
ALOSA PSEUDOHARENGUS	0	0	1	0	1
CITHARICHTHYS SPILOPTERUS	1	0	0	0	1
CYNOSCION NEBULOSUS	0	0	0	1	1
DESMODEMA POLYSTICTUM	0	1	0	0	1
DOROSOMA PETENENSE	1	0	0	0	1
SYMPHURUS PLAGIUSA	0	0	0	1	1
SYNODUS FOETENS	0	1	0	0	1
TRACHINOTUS CAROLINUS	0	0	1	0	1
Grand Total	108	396	37	355	896

Appendix Table C8. Representative benthic invertebrate abundances for Lake Ponchartrain from EPA – EMAP Louisiana Province Data collections (1991-1994)						
Species	**1991**	**1992**	**1993**	**1994**	**Total**	**%**
CHAOBORUS SP.	6295	0	0	0	6295	16
PROBYTHINELLA LOUISIANAE	1829	398	282	85	2593	12
CERAPUS BENTHOPHILUS	8	0	0	2354	2362	11
TEXADINA SPHINCTOSTOMA	532	254	353	401	1540	7
RANGIA CUNEATA	570	192	349	329	1439	7
MYTILOPSIS LEUCOPHAEATA	128	139	43	756	1065	5
HOBSONIA FLORIDA	372	67	371	210	1019	5
TUBIFICIDAE	883	8	0	24	915	4
TUBIFICOIDES HETEROCHAETUS	26	317	118	69	529	2
MACTRIDAE	0	282	0	105	387	2
CYATHURA POLITA	48	121	20	137	326	2
MULINIA LATERALIS	232	0	0	56	289	1
MEDIOMASTUS SP.	117	24	52	24	218	1
MULINIA PONTCHARTRAINENSIS	43	8	0	161	212	1
COELOTANYPUS SP.	90	53	58	0	200	1
COROPHIUM LACUSTRE	85	0	24	64	173	1
AULODRILUS PIGUETI	169	0	0	0	169	1
PARANDALIA SP.A	0	16	8	116	140	1
MEDIOMASTUS CALIFORNIENSIS	0	0	50	81	131	1
UNIONIDAE SP.A	129	0	0	0	129	1
Grand Total	11925	2257	2258	5247	21686	
Total Species	37	35	35	31	114	

Appendix Table C9. Comparison of species composition of Lake Borgne samples from Ray (in prep) and EMAP						
Taxa	**2005**	**EMAP 1991**	**EMAP 1992**	**EMAP 1993**	**EMAP 1994**	**EMAP Total**
Dipolydora (=Polydora) socialis	76.29	0.02*	0.09*	0.00*	0.00*	0.02*
Nereis (=Neanthes) succinea	11.42	0.05	0.00	0.08	0.00	0.05
Streblospio benedicti	0.77	40.49	21.38	0.00	3.86	22.91
Mediomastus sp.	4.78	6.43	32.98	3.72	42.03	23.01
Texadina sphinctostoma	-	5.16	13.77	0.20	0.48	9.26
Probythinella louisianae	**	5.43	6.95	0.00	0.00	5.38
Hobsonia florida	-	14.67	0.99	0.59	15.46	5.19
Parandalia sp.	1.78	0.00	4.32	11.74	6.76	4.21
Tellina versicolor	-	2.94	0.09	5.10	0.00	0.00
Mulinia lateralis	-	1.36	4.15	1.37	0.00	2.89
Mulinia pontchartrainensis	-	0.36	1.77	0.59	3.38	1.34
Mulinia sp.	0.34	1.01	2.90	0.41	0.00	0.48
Rangia cuneata	**	6.43	0.04	3.52	6.28	2.42
Ameroculodes(=Monoculodes) sp.	0.05	0.75	1.09	0.45	0.98	1.93
Nemertea	0.69	0.09	1.56	0.00	1.93	1.01

* The species *Dipolydora socialis* was not encountered in the EMAP study. Values are for the related species *Polydora cornuta*.

**** SUBSTANTIAL NUMBERS OF *RANGIA CUNEATA AND PROBYTHINELLA LOUISIANAE* SHELLS WERE PRESENT THROUGHOUT THE SAMPLING AREA BUT NO LIVE SPECIMENS WERE ENCOUNTERED.**

Appendix Table C10. LADWF Wildlife Species Groups for Coast 2050 Report
Species Groups
Brown Pelican
Bald Eagle
Seabirds
Wading Birds
Shoerbirds
Dablling Ducks
Diving Ducks
Geese
Raptors
Rails, Coots and Galllinules
Other marsh residents
Other woodland residents
Other marsh migrants
Other woodland migrants
Nturia
Muskrat
Mink, Otter and Racoon
Rabbits
Squirells
Deer
Aligator

Appendix Table C11. Coast 2050 Wildlife Population Status Assessments for Region 1 (Pontchartrain Drainage Area)

Table 7-2. Region 1 wildlife functions, status, trends, and projections.

Habitat Types: OW = Open Water; AB = Aquatic Bed; FM = Fresh Marsh; IM = Intermediate Marsh; BM = Brackish Marsh; SM = Saline Marsh; FS = Fresh Swamp; HF = Hardwood Forest BB = Barrier Beach; AU = Agriculture/Upland. Habitat types comprising less than 5% of unit are shown only if habitat type is particularly rare or important to wildlife.
Status: NH = Not Historically Present; NL = No Longer Present; Lo = Low Numbers; Mo = Moderate Numbers; Hi = High Numbers
Functions of Particular Interest: Ne = Nesting; St = Stopover Habitat; W = Wintering Area; Mu = Multiple Functions
Trends (since 1985) / **Projections** (through 2050): Sy = Steady; D = Decrease; I = Increase; U = Unknown

Mapping Unit	1988 Habitat Type	% of Unit	Avifauna: Brown Pelican				Bald Eagle				Seabirds				Wading Birds				Shorebirds				Dabbling Ducks				Diving Ducks				Geese				Raptors				Rails, Coots, and Gallinules			
			Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.
Upper Pontchartrain Basin																																										
Amite / Blind	FS	73		NH			Ne	Hi	I	I		NH			Ne	Hi	I	Sy		NH			Mu	Lo	Sy	Sy		NH				NH				NH				NH		
	HF	21		NH				NH				NH				NH				NH			Mu	Lo	Sy	Sy		NH				NH				NH				NH		
Lake Maurepas	OW	100		NH				NH			Mu	Mo	Sy	Sy		NH				NH			W	Lo	Sy	Sy	W	Lo	Sy	Sy		NH				NH			W	Lo	Sy	Sy
Tickfaw River Mouth	FS	53		NH			Ne	Lo	Sy	Sy		NH			Ne	Hi	I	Sy		NH			Mu	Lo	Sy	Sy		NH				NH			Mu	Mo	Sy	Sy		NH		
	HF	37		NH				NH				NH				NH				NH			Mu	Lo	Sy	Sy		NH				NH			Mu	Hi	I	D		NH		
West Manchac Land Bridge	OW	6		NH				NH			Mu	Mo	Sy	Sy		NH				NH			W	Lo	Sy	Sy	W	Lo	Sy	Sy		NH				NH			W	Lo	Sy	Sy
	FM	22		NH				NH			Mu	Lo	Sy	Sy	Mu	Hi	I	Sy	Mu	Hi	Sy	Sy	W	Lo	D	D	W	Lo	D	D		NH			Mu	Lo	Sy	Sy	Mu	Lo	D	D
	FS	61		NH			Ne	Lo	I	I		NH			Ne	Hi	I	Sy		NH			W	Lo	Sy	Sy		NH				NH			Mu	Mo	I	Sy		NH		
	HF	11		NH				NH				NH				NH				NH			W	Lo	Sy	Sy		NH				NH			Mu	Hi	I	D		NH		
Middle Pontchartrain Basin																																										
East Manchac Land Bridge	OW	7		NH				NH			Mu	Mo	Sy	Sy		NH				NH			W	Lo	Sy	Sy	W	Lo	Sy	Sy		NH				NH			W	Lo	Sy	Sy
	IM	41		NH				NH			Mu	Mo	Sy	Sy	Mu	Hi	I	Sy	Mu	Hi	Sy	Sy	W	Lo	D	D	W	Lo	D	D		NH			Mu	Lo	Sy	Sy	Mu	Lo	D	D
	FS	15		NH				NH				NH			Ne	Hi	I	Sy		NH			W	Lo	Sy	Sy		NH				NH			Mu	Mo	I	Sy		NH		
	HF	34		NH				NH				NH				NH				NH			W	Lo	Sy	Sy		NH				NH			Mu	Hi	I	D		NH		
Tangipahoa River Mouth	FM	10		NH				NH			Mu	Lo	Sy	Sy	Mu	Hi	I	Sy	Mu	Hi	Sy	Sy	W	Lo	Sy	Sy	W	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	FS	53		NH			Ne	Lo	Sy	Sy		NH			Ne	Hi	I	Sy		NH			W	Lo	Sy	Sy		NH				NH			Mu	Mo	I	Sy		NH		
	HF	34		NH				NH				NH				NH				NH			W	Lo	Sy	Sy		NH				NH			Mu	Hi	I	D		NH		
Tchefuncte River Mouth	OW	18		NH				NH			Mu	Mo	Sy	Sy		NH				NH			W	Lo	Sy	Sy	W	Lo	Sy	Sy		NH				NH			W	Lo	Sy	Sy
	FM	28		NH				NH			Mu	Lo	Sy	Sy	Mu	Hi	I	Sy	Mu	Hi	Sy	Sy	W	Lo	Sy	Sy	W	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	FS	26		NH				NH				NH			Ne	Hi	I	Sy		NH			W	Lo	Sy	Sy		NH				NH			Mu	Mo	I	Sy		NH		
	HF	22		NH			Ne	Lo	Sy	Sy		NH				NH				NH			W	Lo	Sy	Sy		NH				NH			Mu	Hi	I	D		NH		

Table 7-2. Region 1 wildlife functions, status, trends, and projections.

Habitat Types: OW = Open Water; AB = Aquatic Bed; FM = Fresh Marsh; IM = Intermediate Marsh; BM = Brackish Marsh; SM = Saline Marsh; FS = Fresh Swamp; HF = Hardwood Forest BB = Barrier Beach; AU = Agriculture/Upland. Habitat types comprising less than 5% of unit are shown only if habitat type is particularly rare or important to wildlife.
Status: NH = Not Historically Present; NL = No Longer Present; Lo = Low Numbers; Mo = Moderate Numbers; Hi = High Numbers
Functions of Particular Interest: Ne = Nesting; St = Stopover Habitat; W = Wintering Area; Mu = Multiple Functions
Trends (since 1985) / **Projections** (through 2050): Sy = Steady; D = Decrease; I = Increase; U = Unknown

Mapping Unit	1988 Habitat Type	% of Unit	Avifauna (cont.): Other Marsh/ OW Residents				Other Wood-land Resid.				Other Marsh/ OW Migrants				Other Wood-land Migrants				Furbearers: Nutria				Muskrat				Mink, Otter, and Raccoon				Game Mammals: Rabbits				Squirrels				Deer				Reptiles: American Alligator			
			Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.
Upper Pontchartrain Basin																																														
Amite / Blind	FS	73	Ne	Lo	Sy	Sy	Ne	Mo	I	Sy	Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	D	D	Mu	Lo	Sy	D	Mu	Mo	I	D	Mu	Mo	I	I
	HF	21		NH			Ne	Hi	I	D		NH			Mu	Mu	Sy	D	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	D	D	Mu	Mo	Sy	D	Mu	Mo	I	S	Mu	Lo	Sy	Sy
Lake Maurepas	OW	100	Mu	Mo	Sy	Sy		NH			Mu	Mo	Sy	Sy		NH				NH				NH				NH				NH				NH				NH				NH		
Tickfaw River Mouth	FS	53	Ne	Lo	Sy	Sy	Ne	Mo	I	Sy	Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	D	Mu	Lo	Sy	Sy	Mu	Mo	I	D	Mu	Mo	I	I
	HF	37		NH			Ne	Hi	I	D		NH			Mu	Hi	Sy	D	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	D	Mu	Mo	Sy	Sy	Mu	Mo	I	S	Mu	Lo	Sy	Sy
West Manchac Land Bridge	OW	6	Mu	Mo	Sy	Sy		NH			Mu	Mo	Sy	Sy		NH			Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy		NH				NH				NH			Mu	Mo	I	I
	FM	22	Ne	Hi	Sy	Sy		NH			Mu	Hi	Sy	Sy		NH			Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	D	D		NH			Mu	Lo	Sy	D	Mu	Mo	I	I
	FS	61	Ne	Lo	Sy	Sy	Ne	Mo	I	Sy	Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Mo	Sy	D	Mu	Mo	I	I
	HF	11		NH			Ne	Hi	I	D		NH			Mu	Hi	Sy	D	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	D	D	Mu	Mo	D	D	Mu	Mo	Sy	D	Mu	Lo	Sy	Sy
Middle Pontchartrain Basin																																														
East Manchac Land Bridge	OW	7	Mu	Mo	Sy	Sy		NH			Mu	Mo	Sy	Sy		NH			Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy		NH				NH				NH			Mu	Mo	I	I
	IM	41	Ne	Hi	Sy	Sy		NH			Mu	Hi	Sy	Sy		NH			Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	D	D		NH			Mu	Lo	Sy	D	Mu	Mo	I	I
	FS	15	Ne	Lo	Sy	Sy	Ne	Mo	I	Sy	Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	Sy	D	Mu	Mo	I	I
	HF	34		NH			Ne	Hi	I	D		NH			Mu	Hi	Sy	D	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	D	D	Mu	Mo	D	D	Mu	Lo	Sy	D	Mu	Lo	Sy	Sy
Tangipahoa River Mouth	FM	10	Ne	Hi	Sy	Sy		NH			Mu	Hi	Sy	Sy		NH			Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	D	D		NH			Mu	Lo	Sy	D	Mu	Mo	I	I
	FS	53	Ne	Lo	Sy	Sy	Ne	Mo	I	Sy	Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Mo	Sy	D	Mu	Mo	I	I
	HF	34		NH			Ne	Hi	I	D		NH			Mu	Hi	Sy	D	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	D	D	Mu	Mo	D	D	Mu	Mo	Sy	D	Mu	Lo	Sy	Sy
Tchefuncte River Mouth	OW	18	Mu	Mo	Sy	Sy		NH			Mu	Mu	Sy	Sy		NH			Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy		NH				NH				NH			Mu	Mo	I	I
	FM	28	Ne	Hi	Sy	Sy		NH			Mu	Hi	Sy	Sy		NH			Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	D	D		NH			Mu	Lo	Sy	D	Mu	Mo	I	I
	FS	26	Ne	Lo	Sy	Sy	Ne	Mo	I	Sy	Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Mo	Sy	D	Mu	Mo	I	I
	HF	22		NH			Ne	Hi	I	D		NH			Mu	Hi	Sy	D	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	D	D	Mu	Mo	D	D	Mu	Mo	Sy	D	Mu	Lo	Sy	Sy

Table 7-2. Region 1 wildlife functions, status, trends, and projections.

Habitat Types: OW = Open Water; AB = Aquatic Bed; FM = Fresh Marsh; IM = Intermediate Marsh; BM = Brackish Marsh; SM = Saline Marsh; FS = Fresh Swamp; HF = Hardwood Forest BB = Barrier Beach; AU = Agriculture/Upland. Habitat types comprising less than 5% of unit are shown only if habitat type is particularly rare or important to wildlife.

Status: NH = Not Historically Present; NL = No Longer Present; Lo = Low Numbers; Mo = Moderate Numbers; Hi = High Numbers

Functions of Particular Interest: Ne = Nesting; St = Stopover Habitat; W = Wintering Area; Mu = Multiple Functions

Trends (since 1985) / **Projections** (through 2050): Sy = Steady; D = Decrease; I = Increase; U = Unknown

Mapping Unit	1988 Habitat Type	1988 Habitat % of Unit	Avifauna: Brown Pelican Func.	Status	Trend	Proj.	Bald Eagle Func.	Status	Trend	Proj.	Seabirds Func.	Status	Trend	Proj.	Wading Birds Func.	Status	Trend	Proj.	Shorebirds Func.	Status	Trend	Proj.
Bonnet Carre'	OW	5		NH				NH			Mu	Mo	Sy	Sy		NH				NH		
	FM	17		NH				NH			Mu	Lo	Sy	D	Ne	Hi	I	Sy	Mu	Hi	Sy	Sy
	FS	30		NH				NH				NH			Ne	Hi	I	Sy		NH		
	HF	41		NH				NH				NH				NH				NH		
	AU	6		NH				NH				NH			St	Lo	I	Sy	Mu	Lo	I	Sy
LaBranche Wetlands	OW	16	W	Lo	I	I		NH			Mu	Mo	Sy	Sy		NH				NH		
	IM	10		NH				NH			Mu	Mo	Sy	D	Mu	Hi	I	Sy	Mu	Hi	Sy	D
	BM	17		NH				NH			Mu	Mo	Sy	D	Mu	Hi	I	Sy	Mu	Hi	Sy	D
	FS	41		NH			Ne	Mo	I	Sy		NH			Ne	Hi	I	Sy		NH		
	HF	9		NH				NH				NH				NH				NH		
Lake Pontchartrain	OW	100	W	Mo	I	I		NH			Mu	Mo	Sy	Sy		NH				NH		
North Shore Marshes	OW	27	W	Mo	I	I		NH			Mu	Mo	Sy	Sy		NH				NH		
	IM	25		NH				NH			Mu	Mo	Sy	Sy	Mu	Hi	I	Sy	Mu	Hi	Sy	Sy
	BM	40		NH				NH			Mu	Mo	Sy	Sy	Mu	Hi	I	Sy	Mu	Hi	Sy	Sy
	HF	6		NH			Ne	Lo	Sy	Sy		NH				NH				NH		
Bayou Sauvage	OW	23	W	Lo	I	I		NH			Mu	Mo	Sy	Sy		NH				NH		
	FM	36		NH				NH			Mu	Lo	Sy	Sy	Mu	Hi	I	Sy	Mu	Hi	Sy	Sy
	IM	8		NH				NH			Mu	Mo	Sy	Sy	Mu	Hi	I	Sy	Mu	Hi	Sy	Sy
	HF	26		NH				NH				NH				NH				NH		
East Orleans Land Bridge	OW	39	W	Mo	I	I		NH			Mu	Mo	Sy	Sy		NH				NH		
	BM	56		NH				NH			Mu	Mo	Sy	D	Mu	Hi	Sy	D	Mu	Hi	Sy	D

Mapping Unit	1988 Habitat Type	1988 Habitat % of Unit	Avifauna: Dabbling Ducks Func.	Status	Trend	Proj.	Diving Ducks Func.	Status	Trend	Proj.	Geese Func.	Status	Trend	Proj.	Raptors Func.	Status	Trend	Proj.	Rails, Coots, and Gallinules Func.	Status	Trend	Proj.
Bonnet Carre'	OW	5	W	Lo	Sy	Sy	W	Lo	Sy	Sy		NH				NH			W	Lo	Sy	Sy
	FM	17	W	Lo	Sy	Sy	W	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	FS	30	Mu	Lo	Sy	Sy		NH				NH			Mu	Mo	I	Sy		NH		
	HF	41	Mu	Lo	Sy	Sy		NH				NH			Mu	Hi	I	D		NH		
	AU	6		NH				NH				NH			Mu	Lo	I	Sy		NH		
LaBranche Wetlands	OW	16	W	Mo	Sy	Sy	W	Mo	Sy	Sy		NH				NH			W	Mo	Sy	Sy
	IM	10	W	Mo	Sy	Sy	W	Mo	Sy	Sy		NH			Mu	Lo	Sy	D	Mu	Mo	Sy	Sy
	BM	17	W	Lo	Sy	Sy	W	Lo	Sy	Sy		NH			Mu	Lo	Sy	D	Mu	Lo	Sy	Sy
	FS	41	Mu	Lo	Sy	Sy		NH				NH			Mu	Mo	I	Sy		NH		
	HF	9	Mu	Lo	Sy	Sy		NH				NH			Mu	Hi	I	D		NH		
Lake Pontchartrain	OW	100	W	Lo	Sy	Sy	W	Hi	Sy	Sy		NH				NH			W	Lo	Sy	Sy
North Shore Marshes	OW	27	W	Lo	Sy	Sy	W	Lo	Sy	Sy		NH				NH			W	Lo	Sy	Sy
	IM	25	W	Lo	Sy	Sy	W	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	BM	40	W	Lo	Sy	Sy	W	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	HF	6	Mu	Lo	Sy	Sy		NH				NH			Mu	Hi	I	D		NH		
Bayou Sauvage	OW	23	W	Mo	Sy	Sy	W	Mo	Sy	Sy		NH				NH			W	Mo	Sy	Sy
	FM	36	W	Mo	Sy	Sy	W	Mo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy
	IM	8	W	Mo	Sy	Sy	W	Mo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy
	HF	26	Mu	Lo	Sy	Sy		NH				NH			Mu	Hi	Sy	D		NH		
East Orleans Land Bridge	OW	39	W	Mo	Sy	D	W	Mo	Sy	D		NH				NH			W	Mo	Sy	Sy
	BM	56	W	Mo	Sy	D	W	Mo	Sy	D		NH			Mu	Lo	Sy	D	Mu	Mo	Sy	Sy

Table 7-2. Region 1 wildlife functions, status, trends, and projections.

Habitat Types: OW = Open Water; AB = Aquatic Bed; FM = Fresh Marsh; IM = Intermediate Marsh; BM = Brackish Marsh; SM = Saline Marsh; FS = Fresh Swamp; HF = Hardwood Forest BB = Barrier Beach; AU = Agriculture/Upland. Habitat types comprising less than 5% of unit are shown only if habitat type is particularly rare or important to wildlife.

Status: NH = Not Historically Present; NL = No Longer Present; Lo = Low Numbers; Mo = Moderate Numbers; Hi = High Numbers

Functions of Particular Interest: Ne = Nesting; St = Stopover Habitat; W = Wintering Area; Mu = Multiple Functions

Trends (since 1985) / **Projections** (through 2050): Sy = Steady; D = Decrease; I = Increase; U = Unknown

Mapping Unit	1988 Habitat Type	1988 Habitat % of Unit	Avifauna (cont.): Other Marsh/ OW Residents Func.	Status	Trend	Proj.	Other Woodland Resid. Func.	Status	Trend	Proj.	Other Marsh/ OW Migrants Func.	Status	Trend	Proj.	Other Woodland Migrants Func.	Status	Trend	Proj.
Bonnet Carre'	OW	5	Mu	Mo	Sy	Sy		NH			Mu	Mu	Sy	Sy		NH		
	FM	17	Ne	Hi	Sy	Sy		NH			Ne	Mu	Sy	Sy		NH		
	FS	30	Ne	Lo	Sy	Sy	Mo	Ne	I	Sy	Ne	Mu	Sy	Sy	Mo	Mu	I	Sy
	HF	41		NH			Ne	Hi	I	D		NH			Mu	Hi	Sy	D
	AU	6		NH			Ne	Lo	I	Sy		NH			Mu	Lo	Sy	Sy
LaBranche Wetlands	OW	16	Mu	Mo	Sy	Sy		NH			Mu	Mo	Sy	Sy		NH		
	IM	10	Ne	Hi	Sy	D		NH			Mu	Hi	Sy	D		NH		
	BM	17	Ne	Hi	Sy	D		NH			Mu	Hi	Sy	D		NH		
	FS	41	Ne	Lo	Sy	Sy	Ne	Mo	I	Sy	Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy
	HF	9		NH			Ne	Hi	I	D		NH			Mu	Hi	Sy	D
Lake Pontchartrain	OW	100	Mu	Mo	Sy	Sy		NH			Mu	Mo	Sy	Sy		NH		
North Shore Marshes	OW	27	Mu	Mo	Sy	Sy		NH			Mu	Mo	Sy	Sy		NH		
	IM	25	Ne	Hi	Sy	Sy		NH			Ne	Hi	Sy	Sy		NH		
	BM	40	Ne	Hi	Sy	Sy		NH			Ne	Hi	Sy	Sy		NH		
	HF	6		NH			Ne	Hi	I	D		NH			Mu	Hi	Sy	D
Bayou Sauvage	OW	23	Mu	Mo	Sy	Sy		NH			Mu	Mo	Sy	Sy		NH		
	FM	36	Ne	Hi	Sy	Sy		NH			Ne	Hi	Sy	Sy		NH		
	IM	8	Ne	Hi	Sy	Sy		NH			Mu	Mo	Sy	SY		NH		
	HF	26		NH			Ne	Hi	I	D		NH			Mu	Hi	Sy	D
East Orleans Land Bridge	OW	39	Mu	Mo	Sy	Sy		NH			Mu	Mo	Sy	Sy		NH		
	BM	56	Ne	Hi	Sy	Sy		NH			Mu	Hi	Sy	D		NH		

Mapping Unit	1988 Habitat Type	1988 Habitat % of Unit	Furbearers: Nutria Func.	Status	Trend	Proj.	Muskrat Func.	Status	Trend	Proj.	Mink, Otter, and Raccoon Func.	Status	Trend	Proj.
Bonnet Carre'	OW	5	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	FM	17	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	FS	30	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	HF	41	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	AU	6	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
LaBranche Wetlands	OW	16	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	IM	10	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	BM	17	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	FS	41	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	HF	9	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
Lake Pontchartrain	OW	100		NH				NH				NH		
North Shore Marshes	OW	27	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy
	IM	25	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy
	BM	40	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy
	HF	6	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
Bayou Sauvage	OW	23	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	FM	36	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	IM	8	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	HF	26	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
East Orleans Land Bridge	OW	39	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
	BM	56	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy

Mapping Unit	1988 Habitat Type	1988 Habitat % of Unit	Game Mammals: Rabbits Func.	Status	Trend	Proj.	Squirrels Func.	Status	Trend	Proj.	Deer Func.	Status	Trend	Proj.	Reptiles: American Alligator Func.	Status	Trend	Proj.
Bonnet Carre'	OW	5		NH				NH				NH			Mu	Mo	Sy	Sy
	FM	17	Mu	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy
	FS	30	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy
	HF	41	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy
	AU	6	Mu	Mo	Sy	Sy		NH			Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy
LaBranche Wetlands	OW	16		NH				NH				NH			Mu	Mo	I	Sy
	IM	10	Mu	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	I	Sy
	BM	17	Mu	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	I	Sy
	FS	41	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Mo	I	Sy
	HF	9	Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
Lake Pontchartrain	OW	100		NH				NH				NH				NH		
North Shore Marshes	OW	27		NH				NH				NH			Mu	Mo	I	Sy
	IM	25	Mu	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	I	Sy
	BM	40	Mu	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	I	Sy
	HF	6	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
Bayou Sauvage	OW	23		NH				NH				NH			Mu	Mo	I	I
	FM	36	Mu	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	I	I
	IM	8	Mu	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	I	I
	HF	26	Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
East Orleans Land Bridge	OW	39		NH				NH				NH			Mu	Lo	Sy	Sy
	BM	56	Mu	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy

Table 7-2. Region 1 wildlife functions, status, trends, and projections.

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Mapping Unit	1988 Habitat Type	1988 Habitat % of Unit	Avifauna: Brown Pelican				Bald Eagle				Seabirds				Wading Birds				Shorebirds				Dabbling Ducks				Diving Ducks				Geese				Raptors				Rails, Coots, and Gallinules			
			Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.
Pearl River Mouth	OW	28	W	Lo	I	I		NH			Mu	Mo	Sy	Sy		NH				NH			W	Mo	Sy	Sy	W	Mo	Sy	Sy		NH				NH			W	Mo	Sy	Sy
	FM	15		NH			Ne	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Hi	I	Sy	Mu	Hi	Sy	Sy	W	Mo	Sy	Sy	W	Mo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy
	IM	17		NH				NH			Mu	Mo	Sy	Sy	Mu	Hi	I	Sy	Mu	Hi	Sy	Sy	W	Mo	Sy	Sy	W	Mo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy
	BM	15		NH				NH			Mu	Mo	Sy	Sy	Mu	Hi	I	Sy	Mu	Hi	Sy	Sy	W	Mo	Sy	Sy	W	Mo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy
	HF	21		NH			Ne	Lo	Sy	Sy		NH				NH				NH			Mu	Lo	Sy	Sy		NH				NH			Mu	Hi	I	D		NH		
Lower Pontchartrain Basin																																										
Central Wetlands	OW	19	W	Lo	I	I		NH			Mu	Hi	Sy	Sy		NH				NH			W	Lo	D	D	W	Lo	D	D		NH				NH			W	Lo	D	D
	FM	5		NH				NH			Mu	Lo	Sy	D	Mu	Hi	I	Sy	Mu	Hi	Sy	Sy	W	Lo	D	D	W	Lo	D	D		NH			Mu	Lo	Sy	Sy	Mu	Lo	D	D
	BM	45		NH				NH			Mu	Hi	Sy	D	Mu	Hi	I	Sy	Mu	Hi	Sy	Sy	W	Lo	D	D	W	Lo	D	D		NH			Mu	Lo	Sy	Sy	Mu	Lo	D	D
	AU	26		NH				NH				NH			St	Lo	I	Sy	Mu	Lo	I	Sy		NH				NH				NH				NH				NH		
South Lake Borgne	OW	42	W	Mo	I	I		NH			Mu	Hi	Sy	Sy		NH				NH			W	Lo	D	D	W	Lo	D	D		NH				NH			W	Lo	D	D
	BM	24		NH				NH			Mu	Hi	Sy	D	Mu	Hi	Sy	D	Mu	Hi	Sy	D	W	Lo	D	D	W	Lo	D	D		NH			Mu	Lo	Sy	D	Mu	Lo	D	D
	SM	32		NH				NH			Mu	Hi	Sy	D	Mu	Hi	Sy	D	Mu	Hi	Sy	D	W	Lo	D	D	W	Lo	D	D		NH				NH			Mu	Lo	D	D
Lake Borgne	OW	100	W	Mo	I	I		NH			Mu	Hi	Sy	Sy		NH				NH				NH			W	Hi	Sy	Sy		NH				NH				NH		
Biloxi Marshes	OW	76	W	Mo	I	I		NH			Mu	Hi	Sy	Sy		NH				NH			W	Mo	Sy	Sy	W	Hi	Sy	Sy	W	Lo	Sy	Sy		NH				NH		
	BM	10		NH				NH			Mu	Hi	Sy	D	Mu	Hi	Sy	D	Mu	Hi	Sy	D	W	Mo	Sy	Sy	W	Mo	Sy	Sy	W	Lo	Sy	Sy	Mu	Lo	Sy	D	Mu	Mo	Sy	Sy
	SM	14		NH				NH			Mu	Hi	Sy	D	Mu	Hi	Sy	D	Mu	Hi	Sy	D	W	Lo	Sy	Sy	W	Lo	Sy	Sy	W	Lo	Sy	Sy		NH			Mu	Mo	Sy	Sy
Eloi Bay	OW	69	W	Mo	I	I		NH			Mu	Hi	Sy	Sy		NH				NH			W	Mo	Sy	Sy	W	Mo	Sy	Sy	W	Lo	Sy	Sy		NH				NH		
	BM	5		NH				NH			Mu	Hi	Sy	D	Mu	Hi	Sy	D	Mu	Hi	Sy	D	W	Mo	Sy	Sy	W	Mo	Sy	Sy	W	Lo	Sy	Sy	Mu	Lo	Sy	D	Mu	Mo	Sy	Sy
	SM	20		NH				NH			Mu	Hi	Sy	D	Mu	Hi	Sy	D	Mu	Hi	Sy	D	W	Lo	Sy	Sy	W	Lo	Sy	Sy	W	Lo	Sy	Sy		NH			Mu	Mo	Sy	Sy
	AU	5		NH				NH				NH			St	Lo	I	Sy	Mu	Lo	I	Sy		NH				NH				NH				NH				NH		
Chandeleur Sound	OW	100	W	Hi	I	I		NH			Mu	Hi	Sy	Sy		NH				NH				NH			W	Mo	Sy	Sy		NH				NH				NH		

Table 7-2. Region 1 wildlife functions, status, trends, and projections.

Habitat Types: OW = Open Water; AB = Aquatic Bed; FM = Fresh Marsh; IM = Intermediate Marsh; BM = Brackish Marsh; SM = Saline Marsh; FS = Fresh Swamp; HF = Hardwood Forest BB = Barrier Beach; AU = Agriculture/Upland. Habitat types comprising less than 5% of unit are shown only if habitat type is particularly rare or important to wildlife.
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Mapping Unit	1988 Habitat Type	1988 Habitat % of Unit	Avifauna (cont.): Other Marsh/ OW Residents				Other Wood-land Resid.				Other Marsh/ OW Migrants				Other Wood-land Migrants				Furbearers: Nutria				Muskrat				Mink, Otter, and Raccoon				Game Mammals: Rabbits				Squirrels				Deer				Reptiles: American Alligator			
			Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.
Pearl River Mouth	OW	28	Mu	Mo	Sy	Sy		NH			Mu	Mo	Sy	Sy		NH			Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy		NH				NH				NH			Mu	Mo	Sy	Sy
	FM	15	Ne	Hi	Sy	Sy		NH			Mu	Hi	Sy	Sy		NH			Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy
	IM	17	Ne	Hi	Sy	Sy		NH			Mu	Hi	Sy	Sy		NH			Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy
	BM	15	Ne	Hi	Sy	Sy		NH			Mu	Hi	Sy	Sy		NH			Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Mo	Sy	Sy	Mu	Lo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Mo	Sy	Sy
	HF	21		NH			Ne	Hi	I	D		NH			Mu	Hi	Sy	D	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy	Mu	Lo	Sy	Sy
Lower Pontchartrain Basin																																														
Central Wetlands	OW	19	Mu	Mo	Sy	Sy					Mu	Lo	Sy	Sy		NH			Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D		NH				NH				NH			Mu	Lo	D	D
	FM	5	Ne	Hi	Sy	Sy					Mu	Hi	Sy	Sy		NH			Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D		NH			Mu	Lo	D	D	Mu	Lo	D	D
	BM	45	Ne	Hi	Sy	Sy					Mu	Hi	Sy	Sy		NH			Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D		NH			Mu	Lo	D	D	Mu	Lo	D	D
	AU	26		NH			Ne	Lo	I	Sy					Mu	Lo	Sy	Sy	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Mo	Sy	Sy		NH			Mu	Mo	Sy	Sy	Mu	Lo	D	D
South Lake Borgne	OW	42	Mu	Mo	Sy	Sy					Mu	Mo	Sy	Sy		NH			Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D		NH				NH				NH			Mu	Lo	D	D
	BM	24	Ne	Hi	Sy	D					Mu	Hi	Sy	D		NH			Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D		NH			Mu	Lo	D	D	Mu	Lo	D	D
	SM	32	Ne	Hi	Sy	D					Mu	Hi	Sy	D		NH			Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D		NH			Mu	Lo	D	D	Mu	Lo	D	D
Lake Borgne	OW	100	Mu	Mo	Sy	Sy					Mu	Mo	Sy	Sy		NH				NH				NH				NH				NH				NH				NH				NH		
Biloxi Marshes	OW	76	Mu	Mo	Sy	Sy					Mu	Mo	Sy	Sy		NH			Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D		NH				NH				NH			Mu	Lo	D	D
	BM	10	Ne	Hi	Sy	D					Mu	Hi	Sy	D		NH			Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	Sy	Sy		NH				NL			Mu	Lo	D	D
	SM	14	Ne	Hi	Sy	D					Mu	Hi	Sy	D		NH			Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	Sy	Sy		NH				NL			Mu	Lo	D	D
Eloi Bay	OW	69	Mu	Mo	Sy	Sy					Mu	Mo	Sy	Sy		NH			Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D		NH				NH				NH			Mu	Lo	D	D
	BM	5	Ne	Hi	Sy	D					Mu	Hi	Sy	D		NH			Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	Sy	Sy		NH				NL			Mu	Lo	D	D
	SM	20	Ne	Hi	Sy	D					Mu	Hi	Sy	D		NH			Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	Sy	Sy		NH				NL			Mu	Lo	D	D
	AU	5		NH			Ne	Lo	I	Sy	Mu	NH			Mu	Lo	Sy	Sy	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Lo	D	D	Mu	Mo	Sy	Sy		NH			Mu	Lo	Sy	Sy	Mu	Lo	D	D
Chandeleur Sound	OW	100	Mu	Mo	Sy	Sy					Mu	Mo	Sy	Sy		NH				NH				NH				NH				NH				NH				NH				NH		

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			Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.
Chandeleur Islands	OW	87	W	Hi	I	I		NH			Mu	Hi	Sy	Sy		NH				NH				NH			W	Mo	Sy	Sy		NH				NH				NH		
	AB	8	W	Hi	I	I		NH			Mu	Hi	Sy	D		NH				NH			W	Lo	Sy	Sy	W	Mo	Sy	Sy		NH				NH				NH		
	SM	2	Ne	Hi	I	I		NH				NH				NH				NH			W	Lo	Sy	Sy	W	Mo	Sy	Sy		NH				NH			Mu	Lo	Sy	Sy
	BB	3	Ne	Hi	I	I		NH			Mu	Hi	Sy	D		NH				NH				NH				NH				NH				NH				NH		

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			Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.	Func.	Status	Trend	Proj.
Chandeleur Islands	OW	87	Mu	Mo	Sy	Sy					Mu	Mo	Sy	Sy		NH				NH				NH				NH				NH				NH				NH				NH		
	AB	8		NH								NH				NH				NH				NH				NH				NH				NH				NH				NH		
	SM	2		NH								NH				NH				NH				NH				NH				NH				NH				NH				NH		
	BB	3	Mu	Mo	Sy	D					Mu	Mo	Sy	D		NH				NH				NH				NH				NH				NH				NH				NH		

Appendix Table C12 **Audubon Society list of birds of Grand Isle and New Orleans Area**								
	Grand Isle				**New Orleans Area**			
BIRDS	**S**	**SU**	**F**	**W**	**S**	**SU**	**F**	**W**
Red-throated Loon								
Common Loon	U			U	O	R	U	U
Least Grebe								
Pied-billed Grebe	U	U	U	U	C	U	C	C
Horned Grebe				O	U			U
Red-necked Grebe								X
Eared Grebe				R				R
Western Grebe								
Yellow-nosed Albatross								
Greater Shearwater						X		
Audubon's Shearwater						R		
Wilson's Storm-Petrel		U				U		
Leach's Storm-Petrel						R		
Masked Booby						U		
Brown Booby						X		
Red-footed Booby			X			X		
Northern Gannet	U			U				
American White Pelican	C	C	C	C	U		U	U
Brown Pelican	C	C	C	C	O		O	O
Double-crested Cormorant	C		C	C	C		C	A
Neotropic Cormorant								
Anhinga			R		U	U	U	R
Magnificent Frigatebird	R	R	R					
American Bittern	O			O	R		R	R
Least Bittern	U	U	U		U	U	U	
Great Blue Heron	C	C	C	C	C	C	C	C
Great Egret	C	C	C	C	C	C	C	C
Snowy Egret	C	C	C	C	C	C	C	C
Little Blue Heron	U	U	U	U	U	U	U	C
Tricolored Heron	C	C	C	C	U	U	U	U
Reddish Egret	U	U	U	U			R	
Cattle Egret	C	C	C	U	C	C	C	C
Green Heron	C	C	C	O	C	C	C	R
Black-crowned Night-Heron	U		U	U	U	U	U	U
Yellow-crowned Night-Heron	U	O	U	R	C	C	U	O
White Ibis	U	U	U	U	U	U	U	U
Glossy Ibis	U	U	U	U	U	U	U	U
White-faced Ibis	U	U	U	U	C	C	C	C
Roseate Spoonbill							R	
Wood Stork								
Fulvous Whistling-Duck								R
Black-bellied Whistling-Duck								
Tundra Swan								

Appendix Table C12
Audubon Society list of birds of Grand Isle and New Orleans Area

	Grand Isle				New Orleans Area			
BIRDS	**S**	**SU**	**F**	**W**	**S**	**SU**	**F**	**W**
Trumpeter Swan								
Greater White-fronted Goose								O
Snow Goose			O		O		U	U
Ross' Goose								
Brant							X	X
Canada Goose					O		O	O
Wood Duck					C	C	C	C
Green-winged Teal	C		C	U	C		C	C
American Black Duck								R
Mottled Duck	C	C	C	C	C	C	C	C
Mallard	U		U	U	U		U	U
Northern Pintail	U		U	U	U		U	U
Blue-winged Teal	C	O	C	C	A		A	C
Cinnamon Teal								R
Northern Shoveler	C	O	C	C	C		C	C
Gadwall	C			C	C		C	C
Eurasian Wigeon				X				O
American Wigeon	C			C	C		C	C
Canvasback	C	O	C	C				O
Redhead	U			U	O		O	U
Ring-necked Duck	O		O	O	U		U	C
Greater Scaup				O				O
Lesser Scaup	C			C	C		U	C
King Eider				X				
Oldsquaw				O				O
Black Scoter				R				O
Surf Scoter								O
White-winged Scoter				R				R
Common Goldeneye				O	O		O	U
Bufflehead				O	C		O	C
Hooded Merganser			O	U	O	O	O	O
Common Merganser								R
Red-breasted Merganser	C			C	U		U	U
Ruddy Duck				U	U		O	U
Masked Duck				X				X
Black Vulture	O		O	O	U	U	U	U
Turkey Vulture	U	U	U	U	C	C	C	C
Osprey	U		U	R	U		U	U
American Swallow-tailed Kite					U	U	R	
White-tailed Kite							O	O
Mississippi Kite					C	C	C	
Bald Eagle					O		O	O
Northern Harrier	C		C	C				
Sharp-shinned Hawk	U		U	U	U		U	U
Cooper's Hawk	U		U	U	O	R	U	O

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Audubon Society list of birds of Grand Isle and New Orleans Area

	Grand Isle				New Orleans Area			
BIRDS	**S**	**SU**	**F**	**W**	**S**	**SU**	**F**	**W**
Northern Goshawk								X
Red-shouldered Hawk	U		U	U	C	C	C	C
Broad-winged Hawk	U		U	R	U	O	U	R
Swainson's Hawk							O	X
White-tailed Hawk								
Zone-tailed Hawk								X
Red-tailed Hawk	U		U	U	C	O	U	C
Ferruginous Hawk								
Rough-legged Hawk							O	O
Golden Eagle								
Crested Caracara								
American Kestrel	C	X	C	C	C	O	C	C
Merlin	U		U	U	O		U	O
Peregrine Falcon	U		U	U	O		U	O
Greater Prairie Chicken								
Wild Turkey					U	U	U	U
Northern Bobwhite					U	U	U	U
Yellow Rail								
Black Rail				H				
Clapper Rail	C	C	C	C	U	U	U	U
King Rail	C	C	C	C	U	U	U	U
Virginia Rail	U		U	U	O		U	O
Sora	U		U	U	U		C	C
Purple Gallinule					U	U	O	X
Common Moorhen	U	U	U	U	U	U	U	U
American Coot	C	O	C	C	C	O	C	A
Sandhill Crane								
Whooping Crane								
Black-bellied Plover	C		C	C	U		U	U
American Golden Plover								
Mongolian Plover	X							
Snowy Plover								
Wilson's Plover	C	C	C	O				
Semipalmated Plover	C		C	U	U		U	O
Piping Plover	U		U	U				
Killdeer	C	U	C	C	C	C	C	C
American Oystercatcher						R		
Black-necked Stilt	U	O	U	U	C	C	C	O
American Avocet	U	O	U	U				O
Greater Yellowlegs	C	U	C	C	U		U	U
Lesser Yellowlegs	C	U	C	C	U	U	U	U
Solitary Sandpiper					C		U	X
Willet	C	C	C	C	U		U	U
Spotted Sandpiper	U	O	U	U	C		C	U
Upland Sandpiper	O	X	O		U		U	

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Audubon Society list of birds of Grand Isle and New Orleans Area

	Grand Isle				New Orleans Area			
BIRDS	**S**	**SU**	**F**	**W**	**S**	**SU**	**F**	**W**
Eskimo Curlew								
Whimbrel	U		O		O			
Long-billed Curlew	R		R					
Black-tailed Godwit								
Hudsonian Godwit								
Marbled Godwit	C		C	O				
Ruddy Turnstone	C	U	C	C	U		U	
Red Knot	U	R	U	U				
Sanderling	C	U	C		O		O	
Semipalmated Sandpiper	C	X	C	X	U		U	
Western Sandpiper	C	U	C	C	U		U	U
Least Sandpiper	C	U	C	C	C	U	C	U
White-rumped Sandpiper	C				R		R	
Baird's Sandpiper					O		O	
Pectoral Sandpiper	C		C		C		C	X
Purple Sandpiper	O			O				
Dunlin	C		C	C	U		U	U
Curlew Sandpiper								
Stilt Sandpiper	C	X	C		C		C	R
Buff-breasted Sandpiper	O		O		U		U	
Ruff								
Short-billed Dowitcher	C	O	C	U	U		U	O
Long-billed Dowitcher	C	O	C	C	U		U	U
Common Snipe	U		U	C	U		U	C
American Woodcock								U
Wilson's Phalarope	O		O		O		O	
Red-necked Phalarope								
Red Phalarope			X					
Pomarine Jaeger								
Parasitic Jaeger								
Long-tailed Jaeger					X			
Laughing Gull	A	A	A	A	A	C	A	C
Franklin's Gull					O		O	
Little Gull								
Bonaparte's Gull	U		U	U	U		O	U
Ring-billed Gull	A	U	A	A	U		U	A
California Gull								X
Herring Gull	C	U	C	C	U		U	C
Thayer's Gull				R				O
Lesser Black-backed Gull	O		O	O				
Glaucous Gull	R		R	R				R
Great Black-backed Gull								
Black-legged Kittiwake								
Sabine's Gull			X				X	
Gull-billed Tern	U	R	U	U	O	U	O	O

Appendix Table C12
Audubon Society list of birds of Grand Isle and New Orleans Area

	Grand Isle				New Orleans Area			
BIRDS	**S**	**SU**	**F**	**W**	**S**	**SU**	**F**	**W**
Caspian Tern	C	C	C	C	U	U	U	U
Royal Tern	A	C	A	A	C	U	C	C
Sandwich Tern	C	C	U	O				
Common Tern	C	C	U	U				R
Arctic Tern								
Forster's Tern	C	C	C	C	C	C	C	C
Least Tern	C	C	U		C	C		
Bridled Tern		U	X					
Sooty Tern		U	X			X		
Black Tern	C	C	U		U		U	
Brown Noddy								
Black Skimmer	C	C	C	C	U	U	O	O
Ancient Murrelet					X			
Rock Dove	C	C	C	C	C	C	C	C
Band-tailed Pigeon								X
Eurasian Collared-Dove	U	U	U	U	U	U	U	U
White-winged Dove					O		O	O
Mourning Dove	C	C	C	C	C	C	C	C
Passenger Pigeon								
Inca Dove								
Common Ground-Dove	O		O	O	O		O	O
Carolina Parakeet								
Black-billed Cuckoo	R		R		U		U	
Yellow-billed Cuckoo	C	C	C		C	C	C	
Greater Roadrunner								
Groove-billed Anni			R	R	O		O	O
Barn Owl	O	O	O	O	U	U	U	U
Flammulated Owl								
Eastern Screech-Owl	R	R	R	R	C	C	C	C
Great Horned Owl	U	U	U	U	U	U	U	U
Snowy Owl							X	
Burrowing Owl				R			O	O
Barred Owl	R	R	R	R	C	C	C	C
Long-eared Owl								
Short-eared Owl								
Northern Saw-whet Owl								
Lesser Nighthawk							R	R
Common Nighthawk	C	C	C	X	C	C	C	
Antillean Nighthawk							X	
Chucks-will's-widow	O		O	O	U	U	U	O
Whip-poor-will	R		R	R	U		U	R
Chimney Swift	C	C	C		C	C	C	
Vaux's Swift				X				X
Broad-billed Hummingbird							X	X
Buff-bellied Hummingbird					O		O	O

Appendix Table C12
Audubon Society list of birds of Grand Isle and New Orleans Area

	Grand Isle				New Orleans Area			
BIRDS	**S**	**SU**	**F**	**W**	**S**	**SU**	**F**	**W**
Blue-throated Hummingbird					X			X
Ruby-throated Hummingbird	C	C	C	R	C	C	C	R
Black-chinned Hummingbird					U		U	U
Anna's Hummingbird								O
Calliope Hummingbird								
Broad-tailed Hummingbird					R		R	R
Rufous Hummingbird					U	U	U	
Allen's Hummingbird							X	X
Belted Kingfisher	C	U	C	C	C	U	C	C
Red-headed Woodpecker					U	U	U	U
Red-bellied Woodpecker	R	R	R	R	C	C	C	C
Yellow-bellied Sapsucker	U		U	U	U		U	U
Red-naped Sapsucker				X				X
Williamson's Sapsucker								
Downy Woodpecker	U	U	U	U	C	C	C	C
Hairy Woodpecker	R	R	R	R	U	U	U	U
Red-cockaded Woodpecker					O	O	O	O
Northern Flicker	C		C	C	C	U	C	C
Pileated Woodpecker	R	R	R	R	U	U	U	U
Ivory-billed Woodpecker								
Olive-sided Flycatcher	R		U		O		U	
Western Wood-Pewee							X	
Eastern Wood-Pewee	C		C		C	U	C	
Yellow-bellied Flycatcher	O		O		O		O	
Acadian Flycatcher	U		U		C	C	C	
Alder Flycatcher	R		R		O		O	
Willow Flycatcher	R		R		U		U	
Least Flycatcher	U		U		U		U	
Hammond's Flycatcher								
Pacific Slope								
Cordilleran								X
Eastern Phoebe			C	C	U		C	C
Say's Phoebe								
Vermillion Flycatcher							O	O
Ash-throated Flycatcher					R		O	O
Great-crested Flycatcher	C	C	C		C	C	U	
Brown-crested Flycatcher							O	O
Great Kiskadee							X	X
Sulphur-bellied Flycatcher								
Tropical Kingbird	X							
Couch's Kingbird	X		X					
Cassin's Kingbird								
Western Kingbird	O		O		O		U	O
Eastern Kingbird	C	C	C		C	C	C	
Gray Kingbird	O		O					

Appendix Table C12
Audubon Society list of birds of Grand Isle and New Orleans Area

	Grand Isle				New Orleans Area			
BIRDS	**S**	**SU**	**F**	**W**	**S**	**SU**	**F**	**W**
Scissor-tailed Flycatcher	O		O	U	O		U	O
Horned Lark								R
Purple Martin	C	C	C	X	C	C	U	
Tree Swallow	C	C	C	C	C		C	C
N. Rough-winged Swallow	C	X	C		U	U	U	O
Bank Swallow	C		C		U		U	
Cliff Swallow	O		O		O	U	O	
Cave Swallow						X		
Barn Swallow	C	C	C		C	C	C	R
Blue Jay	C	C	C	C	C	C	C	C
American Crow	U	U	U	U	C	C	C	C
Fish Crow	C	U	C	C	C	C	C	U
Carolina Chickadee	R	R	R	R	C	C	C	C
Tufted Titmouse					C	C	C	C
Red-breasted Nuthatch					I		I	I
White-breasted Nuthatch								
Brown-headed Nuthatch					C	C	C	C
Brown Creeper					U		U	U
Rock Wren							X	
Carolina Wren	U	U	U	U	C	C	C	C
Bewick's Wren							R	R
House Wren	C		C	C	C		C	C
Winter Wren				U	U		U	U
Sedge Wren	C		C	C	C		C	C
Marsh Wren	C	C	C	C	C	U	C	C
Golden-crowned Kinglet				U	U		U	U
Ruby-crowned Kinglet	C		C	C	C		C	C
Blue-gray Gnatcatcher	C	X	X	U	C	U	C	C
Northern Wheatear							X	
Eastern Bluebird					C	C	C	C
Mountain Bluebird								
Veery	C		C		C		C	
Gray-cheeked Thrush	C		C		C		C	
Swainson's Thrush	C		C		C		C	
Hermit Thrush					U		U	U
Wood Thrush	C	X	C		C	C	C	X
American Robin	C		C	C	C	U	C	C
Varied Thrush	X		X					
Gray Catbird	C	U	C	U	C		C	U
Northern Mockingbird	C	C	C	C	C	C	C	C
Sage Thrasher							R	
Brown Thrasher	U	U	U	U	C	U	C	C
Curve-billed Thrasher								
American Pipit					U		U	U
Sprague's Pipit								O

Appendix Table C12
Audubon Society list of birds of Grand Isle and New Orleans Area

	Grand Isle				New Orleans Area			
BIRDS	**S**	**SU**	**F**	**W**	**S**	**SU**	**F**	**W**
Cedar Waxwing	C			C	C			U
Loggerhead Shrike	C	C	C	C	C	C	C	C
European Starling	C	C	C	C	A	A	A	A
White-eyed Vireo	C	C	C	R	C	C	C	U
Bell's Vireo							R	R
Blue-headed Vireo	U		U	U	U		U	U
Cassin's Vireo								
Plumbeous Vireo								
Yellow-throated Vireo	C		C		C	C	C	
Warbling Vireo			R		O		U	
Philadelphia Vireo	U		U		U		U	
Red-eyed Vireo	C	R	C		C	C	C	
Yellow-green Vireo								
Black-whiskered Vireo	R		R		R		O	
Bachman's Warbler								
Blue-winged Warbler	C		C		U		U	
Golden-winged Warbler	U		U		U		U	
Tennessee Warbler	C		C		C		C	
Orange-crowned Warbler	C		C	C	C		C	C
Nashville Warbler	R		O				O	
Virginia's Warbler								
Lucy's Warbler							X	
Northern Parula	C		C	R	C	C	C	R
Tropical Parula								
Yellow Warbler	C	C	C	O	C		C	R
Chestnut-sided Warbler	C		U		U		U	
Magnolia Warbler	C		C		C		C	R
Cape May Warbler	U		U		O		R	
Black-throated Blue Warbler	R		U		O		O	
Yellow-rumped Warbler	C		C	C	C		C	A
Black-throated Gray Warbler					R		O	O
Townsend's Warbler								
Hermit Warbler								X
Black-throated Green Warbler	C		O	O	C		C	R
Blackburnian Warbler	U		U		U		U	
Yellow-throated Warbler	U		U	O	C	C	C	
Pine Warbler	U		U	U	U	C	C	C
Prairie Warbler	O		U		U	U	C	R
Palm Warbler	U		U	U	U		U	U
Bay-breasted Warbler	C		U		C		C	
Blackpoll Warbler	U				C		O	
Cerulean Warbler	U		U		U		U	
Black-and-white Warbler	C		C	O	C		C	O
American Redstart	C		C		C	U	C	O
Prothonotary Warbler	C		C		C	C	C	

Appendix Table C12
Audubon Society list of birds of Grand Isle and New Orleans Area

	Grand Isle				New Orleans Area			
BIRDS	**S**	**SU**	**F**	**W**	**S**	**SU**	**F**	**W**
Worm-eating Warbler	U		U		U		U	R
Swainson's Warbler	R		R		O	U	O	
Ovenbird	U		U		C		C	O
Northern Waterthrush	C		C	O	C		C	O
Louisiana Waterthrush	U		U		U	O	U	R
Kentucky Warbler	U		U		C	C	C	
Mourning Warbler	R		O				O	
MacGillivray's Warbler							X	X
Common Yellowthroat	C	U	C	C	C	C	C	C
Hooded Warbler	C		C		C	C	C	
Wilson's Warbler	U		U	U	U		U	U
Canada Warbler	R		U		O		U	
Red-faced Warbler								
Painted Redstart	X						X	X
Yellow-breasted Chat	U		U		U	C	U	R
Hepatic Tanager								
Summer Tanager	C		C		C	C	C	O
Scarlet Tanager	C		C		C		C	
Western Tanager							R	R
Northern Cardinal	C	C	C	C	C	C	C	C
Rose-breasted Grosbeak	C		C		C		C	
Black-headed Grosbeak	O		O				O	O
Blue Bunting								
Blue Grosbeak	C		C		C	C	C	O
Lazuli Bunting								
Indigo Bunting	C		C		A	O	A	O
Painted Bunting	U		U		U	C	U	O
Dickcissel	R		O				O	R
Green-tailed Towhee								
Eastern Towhee					C	C	C	C
Spotted Towhee								
Bachman's Sparrow					U	U	U	U
American Tree Sparrow								
Chipping Sparrow					U	O	C	C
Clay-colored Sparrow			R				O	X
Brewer's Sparrow								
Field Sparrow					U		U	U
Vesper Sparrow					U		U	U
Lark Sparrow	O		O		R		U	O
Lark Bunting			X					X
Savannah Sparrow	C		C	C	C		C	C
Grasshopper Sparrow					U		U	U
Henslow's Sparrow					O		U	U
LeConte's Sparrow					U		U	U
Nelson's Sharp-tailed Sparrow	U		U	U	U		U	U

Appendix Table C12
Audubon Society list of birds of Grand Isle and New Orleans Area

	Grand Isle				New Orleans Area			
BIRDS	**S**	**SU**	**F**	**W**	**S**	**SU**	**F**	**W**
Seaside Sparrow	C	C	C	C	C	C	C	C
Fox Sparrow					O		O	O
Song Sparrow				R	C		C	C
Lincoln's Sparrow	O				U		O	O
Swamp Sparrow	C		C	C	C		C	A
White-throated Sparrow	C		C	C	C		C	C
Golden-crowned Sparrow	X							
White-crowned Sparrow					U		U	U
Harris' Sparrow							R	R
Dark-eyed Junco				O	U		U	U
McCown's Longspur							X	
Lapland Longspur								I
Smith's Longspur								X
Chestnut-collared Longspur								
Bobolink	U		O		U		O	
Red-winged Blackbird	A	A	A	A	A	A	A	A
Eastern Meadowlark	C	C	C	C	C	C	C	C
Western Meadowlark								R
Yellow-headed Blackbird	O		O		O		O	
Rusty Blackbird					U		U	U
Brewer's Blackbird					U		U	U
Great-tailed Grackle								
Boat-tailed Grackle	A	A	A	A	C	C	C	C
Common Grackle	U	U	U	U	C	C	C	C
Shiny Cowbird	R	R			R		R	
Bronzed Cowbird					U	U	U	O
Brown-headed Cowbird	C	C	C	C	C	C	C	C
Orchard Oriole	C	U	C		C	C	C	X
Hooded Oriole								
Baltimore Oriole	U		U	O	U		U	O
Bullock's Oriole					R		O	O
Scott's Oriole							X	X
Purple Finch				R				O
House Finch					O	O	O	O
Red Crossbill								
Pine Siskin								O
Lesser Goldfinch								X
American Goldfinch				U	C		U	C
Evening Grosbeak								I
House Sparrow	A	A	A	A	A	A	A	A
A = Abundant								
C = Common								
O = Occassional								
U = Uncommon								

Appendix Table C12
Audubon Society list of birds of Grand Isle and New Orleans Area

	Grand Isle				New Orleans Area			
BIRDS	**S**	**SU**	**F**	**W**	**S**	**SU**	**F**	**W**
R = Rare								
I = Irregular								
X = Accidental								
H = Questionable record								
S = Spring								
SU = Summer								
F = Fall								
W = Winter								

Appendix Table D1
Threatened and Endangered Species of Louisiana (Natural Heritage Inventory, Louisiana Department of Wildlife and Fisheries

	Common Name	Scientific Name	Federal Status	State Status
Plants	American chaffseed	*Schwalbea americana*	E	*
	earthfruit	*Geocarpon minimum*	T	*
	Louisiana quillwort	*Isoetes louisianensis*	E	*
Invertebrates	American burying beetle	*Nicrophorus americanus*	E	E
	fat pocketbook	*Potamilus capax*	E	*
	inflated heelsplitter	*Potamilus inflatus*	T	T
	Louisiana pearlshell	*Margaritifera hembeli*	T	E
	pink mucket	*Lampsilis abrupta*	E	*
Amphibians	Mississippi gopher frog	*Rana sevosa*	E	*
Fish	pallid sturgeon	*Scaphirhynchus albus*	E	E
	Gulf sturgeon	*Acipenser oxyrhinchus desotoi*	T	T
	pearl darter	*Percina aurora*	C	*
	Alabama shad	*Alosa alabamae*	C	*
Reptiles	green sea turtle	*Chelonia mydas*	T/E	T
	hawksbill sea turtle	*Eretmochelys imbricata*	E	E
	Kemp's Ridley sea turtle	*Lepidochelys kempii*	E	E
	leatherback sea turtle	*Dermochelys coriacea*	E	E
	loggerhead sea turtle	*Caretta caretta*	T	T
	gopher tortoise	*Gopherus polyphemus*	T	T
	ringed map turtle	*Graptemys oculifera*	T	T
	black pine snake	*Pituophis melanoleucus lodingi*	C	*
	Louisiana pine snake	*Pituophis ruthveni*	C	*
Birds	brown pelican	*Pelecanus occidentalis*	E	E
	bald eagle	*Haliaeetus leucocephalus*	T	E
	peregrine falcon	*Falco peregrinus*		T/E
	Attwater's greater prairie chicken**	*Tympanuchus cupido attwateri*	E	E
	whooping crane**	*Grus americana*	E	E
	Eskimo curlew**	*Numenius borealis*	E	E
	piping plover	*Charadrius melodus*	T/E	T/E
	interior least tern	*Sterna antillarum athalassos*	E	E
	ivory-billed woodpecker**	*Campephilus principalis*	E	E
	red-cockaded woodpecker	*Picoides borealis*	E	E
	Bachman's warbler**	*Vermivora bachmanii*	E	E
Mammals	manatee	*Trichechus manatus*	E	E
	blue whale	*Balaenoptera musculus*	E	E
	finback whale	*Balaenoptera physalus*	E	E
	Sei whale	*Balaenoptera borealis*	E	E
	sperm whale	*Physeter macrocephalus*	E	E
	red wolf**	*Canis rufus*	E	*
	Louisiana black bear	*Ursus americanus luteolus*	T	T
	Florida panther**	*Felis concolor coryi*	E	E

E = Endangered, T = Threatened, C = Candidate, PS = Partial Status. *Unlisted, **Extinct or nearly extinct in Louisiana

Appendix Table D3. Species of Concern in Saint Bernard Parish (Natural Heritage Inventory, Louisiana Department of Wildlife and Fisheries	
Scientific Name	**Common Name**
Acipenser oxyrinchus desotoi	Gulf Sturgeon
Ajaia ajaja	Roseate Spoonbill
Caretta caretta	Loggerhead Sea Turtle
Cenchrus tribuloides	Dune Sandbur
Chamaesyce bombensis	Sand Dune Spurge
Charadriusalexandrinus	Snowy Plover
Charadrius melodus	Piping Plover
Egretta rufescens	Reddish Egret
Eleocharis fallax	Creeping Spike-rush
Haematopus palliatus	American Oystercatcher
Haliaeetus leucocephalus	Bald Eagle
Malaclemys terrapin	Diamondback Terrapin
Pelecanus occidentalis	Brown Pelican
Physalis angustifolia	
Sabatia arenicola	Sand Rose-gentian
Scaphirhynchus albus	Pallid Sturgeon
Smilax auriculata	Eared Greenbrier
Sterna caspia	Caspian Tern
Sterna nilotica	Gull-billed Tern
Thalassia testudina	Turtle-grass
Trichechus manatus	Manatee
Uniola paniculata	Sea Oats

Appendix Table D4. Species of Concern in Orleans Parish (Natural Heritage Inventory, Louisiana Department of Wildlife and Fisheries	
Scientific Name	**Common Name**
Accipiter cooperii	Cooper's Hawk
Acipenser oxyrinchus desotoi	Gulf Sturgeon
Echinochloa polystachya	River Grass
Eptesicus fuscus	Big Brown Bat
Fuirena scirpoidea	Southern Umbrella-sedge
Haliaeetus leucocephalus	Bald Eagle
Malaclemys terrapin	Diamondback Terrapin
Plegadis falcinellus	Glossy Ibis
Potamogeton perfoliatus	Clasping-leaf Pondweed
Pseudacris ornata	Ornate Choms Frog
Sabatia arenicola	Sand Rose-gentian
Scaphirhynchus albus	Pallid Sturgeon
Serenoa repens	Saw Palmetto
Trichechus manatus	Manatee

Appendix Table D5. Species of Concern in St. John the Baptist Parish (Natural Heritage Inventory, Louisiana Department of Wildlife and Fisheries	
Scientific Name	**Common Name**
Ceratopteris pteridoides	Floating Antler-fern
Eleocharis radicans	Rooted Sprike-rush
Haliaeetus leucocephalus	Bald Eagle
Macroclemys temminckii	Aligator Snapping Turtle
Pandion haliaetus	Osprey
Trichechus manatus	Manatee

Appendix Table D6. Species of Concern in Livingston Parish (Natural Heritage Inventory, Louisiana Department of Wildlife and Fisheries	
Scientific Name	**Common Name**
Acipenser oxyrinchus desotoi	Gulf Sturgeon
Aimophila aestivalis	Bachman's Sparrow
Alosa alabamae	Alabama shad
Haliaeetus leucocephalus	Bald Eagle
Lampsilis ornata	Southern Pocketbook
Mustela frenata	Long-tailed weasel
Ophisaurus ventralis	Eastern Glass Lizard
Picoides borealis	Red-cockcaded woodpecker
Potamilus inflatus	Inflated Heel-splitter
Rhadinaea flavilata	Pine Woods Snake
Rhynchospora milliacea	Millet Beakbrush
Sorex longirostris	Southeastern Shrew
Spilogale putoris	Eastern Spotted Skunk
Stewartia malacodendron	Silky Camelia
Trichomanes petersii	Dwarf Filmy-fern

Appendix Table D7. Species of Concern in Plaquemines Parish (Natural Heritage Inventory, Louisiana Department of Wildlife and Fisheries	
Scientific Name	**Common Name**
Accipiter cooperii	Cooper's Hawk
Ajaia ajaja	Roseate Spoonbill
Asio flammeus	Short-eared Owl
Canna flaccida	Golden Canna
Chamaesyce bombensis	Sand Dune Spurge
Charadrius alexandrinus	Snowy Plover
Charadrius melodus	Piping Plover
Charadrius wi/sonia	Wilson's Plover
Egretta rufescens	Reddish Egret
Eleocharis fal/ax	Creeping Spike-rush
Eleocharis geniculata	Canada Spikesedge
Falco peregrinus	Peregrine Falcon
Haematopus palliatus	American Oystercatcher
Haliaeetus leucocephalus	Bald Eagle
Pandion haliaetus	Osprey
Pelecanus occidentalis	Brown Pelican
Sabatia arenicola	Sand Rose-gentian
Scaevola plumieri	Scaevola
Scirpus deltarum	
Sterna caspia	Caspian Tern
Sterna fuscata	Sooty Tern
Sterna nilotica	Gull-billed Tern
Trichechus manatus	Manatee
Triglochin striata	Arrow-grass
Uniola paniculata	Sea Oats

Appendix Table D8. Species of Concern in St. Tammany Parish (Natural Heritage Inventory, Louisiana Department of Wildlife and Fisheries	
Scientific Name	**Common Name**
Accipiter cooperii	Cooper's Hawk
Acipenser oxyrinchus desotoi	Gulf Sturgeon
Agalinis aphyl/a	Coastal Plain False-foxglove
Agalinis filicaulis	Purple False-foxglove
Agalinis linifolia	Flax-leaf False-foxglove
Aimophila aestivalis	Bachman's Sparrow
Alosa alabamae	Alabama Shad
Ambystoma tigrinum	Eastern Tiger Salamander
Asclepias michauxii	Michaux Milkweed
Burmannia biflora	Northern Burmannia
Calopogon barbatus	Bearded Grass-pink
Calopogon multiflorus	Many-flowered Grass-pink
Calopogon pal/idus	Pale Grass-pink
Carex decomposita	Cypress-knee Sedge
Carex turgescens	
Carex venusta	Caric Sedge
Chamaelirium luteum	Fairy Wand
Chasmanthium ornithorhynchum	Bird-bill Spikegrass
Chrysopsis gossypina ssp. Hyssopifolia	A Golden Aster
Cirsium lecontei	Lecont's Thistle
Cleistes divaricata	Spreading Pogonia
Cliftonia monophylla	Buckwheat-tree
Collinsonia canadensis	
Collinsonia serotina	
Coreopsis nudata	Georgia Tickseed
Crystallaria asprella	Crystal Darter
Cyc/eptus meridionalis	Southeastern Blue Sucker
Deparia acrostichoides	Silvery Glade Fern
Drosera intermedia	Spoon-leaved Sundew
Dulichium arundinaceum	Three-way Sedge
Elanoides forficatus	American Swallow-tailed Kite
Eleocharis elongata	Slim Spike-rush
Eleocharis fallax	Creeping Spike-rush
Eleocharis wolfii	Wolf Spikerush
Elliptio crassidens	Elephant-ear
Fallicambarus oryktes	Flatwoods Digger
Farancia erytrogramma	Rainbow Snake
Fuirena scirpoidea	Southern Umbrella-sedge
Fuirena simplex	Western Umbrella-grass
Fusconaia ebena	Ebonyshell
Gopherus polyphemus	Gopher Tortoise
Graptemys gibbonsi	Pascagoula Map Turtle

Appendix Table D8. Species of Concern in St. Tammany Parish (Natural Heritage Inventory, Louisiana Department of Wildlife and Fisheries

Scientific Name	**Common Name**
Graptemys oculifera	Ringed Map Turtle
Gratiola ramosa	Hedgehyssop
Haliaeetus leucocephalus	Bald Eagle
Helenium brevifolium	Short1eaf Sneezeweed
Hemidactylium scutatum	Four-toed Salamander
Ilex amelanchier	Sarvis Holly
Ilex myrtifolia	Myrtle Holly
Isoetes louisianensis	Louisiana Quillwort
Isotria verticil/ata	Large Whorled Pogonia
Justicia americana	Common Water-willow
Lachnanthes caroliniana	Carolina Redroot
Lampropeltis calligaster rhombomaculata	Mole Kingsnake
Lampsilis ornata	Southern Pocketbook
Liatris tenuis	Slender Gay-feather
Lilium catesbaei	Southern Red Lily
Lilium superbum	Turk's Cap Lily
Linum macrocarpum	
Lophiola aurea	Golden Crest
Ludwigia alata	
Lupinus villosus	Lady Lupine
Lycopodiel/a cernua var. cernua	Staghorn C1ubmoss
Macranthera flammea	Flame Flower
Macroclemys temminckii	Alligator Snapping Turtle
Malaclemys terrapin	Diamondback Terrapin
Mayaca fluviatilis	Bog Moss
Micrurus fulvius fulvius	Eastern Coral Snake
Moxostoma carinatum	River Redhorse
Myrica inodora	Odorless Bayberry
National champion tree	National Champion Tree
Noturus munitus	Frecklebelly Madtom
Obovaria unicolor	Alabama Hickorynut
Ophisaurus ventralis	Eastern Glass Lizard
Pandion haliaetus	Osprey
Panicum tenerum	Southeastern Panic Grass
Paronychia erecta var. corymbosa	Paronychia Corymbosa
Percina aurora	Pearl Darter
Percina lenticula	Freckled Darter
Physalis carpenteri	Carpenter's Ground-cherry
Physostegia correllii	Correll's False Dragon-head
Picoides borealis	Red-cockaded Woodpecker
Pine flatwoods	Pine Flatwoods
Pinguicula lutea	Yellow Butterwort
Platanthera blephariglottis var. conspicua	White-fringe Orchis
Platanthera integra	Yellow Fringeless Orchid

Appendix Table D8. Species of Concern in St. Tammany Parish (Natural Heritage Inventory, Louisiana Department of Wildlife and Fisheries	
Scientific Name	**Common Name**
Podostemum ceratophyllum	Riverweed
Polygala chapmanii	
Polygala crenata	
Polygala hookeri	Hooker Milkwort
Polyodon spathula	Paddlefish
Potami/us in flatus	Inflated Heelsplitter
Potamogeton perfoliatus	Clasping-leaf Pondweed
Procambarus bivittatus	Ribbon Crawfish
Procambarus shermani	Plain Brown Crawfish
Pseudacris ornata	Ornate Chorus Frog
Pseudo triton montanus	Oulf Coast Mud Salamander
Pteroglossaspis ecristata	A Wild Coco
Pteronotropis welaka	Bluenose Shiner
Quercus arkansana	Arkansas Oak
Quercus rubra	Red Oak
Rana sevosa	Dusky Oopher Frog
Reithrodontomys humulis	Eastern Harvest Mouse
Rhadinaea flavilata	Pine Woods Snake
Rhynchospora chapmanii	Chapman Beakrush
Rhynchospora ciliaris	Ciliate Beakrush
Rhynchospora compressa	Flat-fruit Beakrush
Rhynchospora debilis	Savannah Beakrush
Rhynchospora decurrens	Swamp-forest Beakrush
Rhynchospora diver gens	Spreading Beakrush
Rhynchospora miliacea	Millet Beakrush
Rhynchospora perplexa	
Ruellia noctijlora	Night-flowering Wild-petunia
Sabatia arenicola	Sand Rose-gentian
Saccharum brevibarbe	Short-beard Plumegrass
Salix caroliniana	Coastal Plain Willow
Sanicula marilandica	Maryland's Black Snake-root
Sarracenia psittacina	Parrot Pitcherplant
Scirpus etuberculatus	Bulrush
Sclerolepis unijlora	Pink Bob Button
Selaginella ludoviciana	Louisiana Spikemoss
Serenoa repens	Saw Palmetto
Sericocarpus linifolius	Narrowleaf Aster
Sida elliottii	Elliott Sida
Sium suave	Hemlock Water-parsnip
Smilax auriculata	Eared Greenbrier
Stewartia malacodendron	Silky Camellia
Stipulicida setacea	Pineland Scaly-pink
Tephrosia hispidula	
Tojieldia racemosa	Coastal False-asphodel

Appendix Table D8. Species of Concern in St. Tammany Parish (Natural Heritage Inventory, Louisiana Department of Wildlife and Fisheries	
Scientific Name	**Common Name**
Trichechus manatus	Manatee
Trichomanes petersii	Dwarf Filmy-fern
Tridens carolinianus	Carolina Fluff Grass
Uniola paniculata	Sea Oats
Ursus american us luteolus	Louisiana Black Bear
Utricularia juncea	Southern Bladderwort
Utricularia purpurea	Purple Bladderwort
Xyris jimbriata	Fringed Yellow-eyed Grass
Zigadenus leimanthoides	Death Camus

Appendix Table D9. Species of Concern in Tangipahoa Parish (Natural Heritage Inventory, Louisiana Department of Wildlife and Fisheries

Scientific Name	Common Name
Acipenser oxyrinchus desotoi	Gulf Sturgeon
Aimophila aestivalis	Bachman's Sparrow
Alosa alabamae	Alabama Shad
Anodontoides radiatus	Rayed Creekshell
Asclepias michauxii	Michaux Milkweed
Calopogon pal/idus	Pale Grass-pink
Carya pallida	Sand Hickory
Chamaelirium luteum	Fairy Wand
Chasmanthium ornithorhynchum	Bird-bill Spikegrass
Chasmanthium x 1	Grass Hybrid
Cirsium muticum	Swamp Thistle
Crotalus adamanteus	Eastern Diamondback Rattlesnake
Cypress swamp	Cypress Swamp
Dryopteris ludoviciana	Southern Shield Wood-fern
Echinodorus tenel/us	Dwarf Burhead
Elanoides forficatus	American Swallow-tailed Kite
E/liptio crassidens	Elephant-ear
Eptesicus fuscus	Big Brown Bat
Farancia erytrogramma	Rainbow Snake
Fundulus euryzonus	Broadstripe Topminnow
Gopherus polyphemus	Gopher Tortoise
Graptemys gibbonsi	Pascagoula Map Turtle
Haliaeetus leucocephalus	Bald Eagle
Hardwood slope forest	Hardwood Slope Forest
Helenium brevifolium	Shortleaf Sneezeweed
/lex amelanchier	Sarvis Holly
Ilex myrtifolia	Myrtle Holly
Lampropeltis calligaster rhombomaculata	Mole Kingsnake
Lampsilis ornata	Southern Pocketbook
Lilium catesbaei	Southern Red Lily
Macroclemys temminckii	Alligator Snapping Turtle
Micrurus fulvius fulvius	Eastern Coral Snake
Nymphoides cordata	Floating-heart
Obovaria unicolor	Alabama Hickorynut
Oenothera rhombipetala	Four-point Evening Primrose
Ophaurus ventral	Eastern Glass Lizard
Physalis carpenteri	Carpenter's Ground-cherry
Picoides boreal	Red-cockaded Woodpecker
Pleurobema beadleianum	Mississippi Pigtoe
Podostemum ceratophyllum	Riverweed
Polygala crenata	
Polyodon spathula	Paddlefish
Potamogeton epihydrus	Nuttall Pondweed
Pteroglossaspis ecristata	A Wild Coco

Appendix Table D9. Species of Concern in Tangipahoa Parish (Natural Heritage Inventory, Louisiana Department of Wildlife and Fisheries	
Scientific Name	**Common Name**
Quercus coccinea	
Rhynchospora compressa	Flat-fruit Beakrush
Salix humilis var. tristis	Dwarf Gray Willow
Sarracenia psittacina	Parrot Pitcherplant
Sericocarpus linifolius	Narrowleaf Aster
Sium suave	Hemlock Water-parsnip
Small stream forest	Small Stream Forest
Sorex longirostris	Southeastern Shrew
Spilogale putorius	Eastern Spotted Skunk
State champion tree	State Champion Tree
Stewartia malacodendron	Silky Camellia
Trichechus manatus	Manatee
Trichomanes petersii	Dwarf Filmy-fern
Tridens carolinianus	Carolina Fluff Grass
Villosa vibex	Southern Rainbow
Waterbird nesting colony	Waterbird Nesting Colony
Zornia bracteata	Viperina

Appendix Table D10. Threatened and Endangered Species of Mississippi. Mississippi Natural Heritage Program. E = Endangered, T = Threatened, C = Candidate, PS = Partial Status		
SPECIES NAME	**COMMON NAME**	**Federal Rank**
BIVALVIA		
ACTINONAIAS LIGAMENTINA	MUCKET	
CYCLONAIAS TUBERCULATA	PURPLE WARTYBACK	
ELLIPTIO ARCTATA	DELICATE SPIKE	
ELLIPTIO DILATATA	SPIKE	
EPIOBLASMA BREVIDENS	CUMBERLANDIAN COMBSHELL	E
EPIOBLASMA PENIT A	SOUTHERN COMBSHELL	E
EPIOBLASMA TRIQUETRA	SNUFFBOX	
LAMPSILIS PEROVALIS	ORANGE-NACRE MUCKET	T
LEXINGTONIA DOLABELLOIDES	SLABSIDE PEARLYMUSSEL	C
MEDIONIDUS ACUTISSIMUS	ALABAMA MOCCASINSHELL	T
PLETHOBASUS CYPHYUS	SHEEPNOSE	
PLEUROBEMA CURTUM	BLACK CLUBSHELL	E
PLEUROBEMA DECISUM	SOUTHERN CLUBSHELL	E
PLEUROBEMA MARSHALLI	FLAT PIGTOE	E
PLEUROBEMA PEROVATUM	OVATE CLUBSHELL	E
PLEUROBEMA RUBRUM	PYRAMID PIGTOE	
PLEUROBEMA TAITIANUM	HEAVY PIGTOE	E
POT AMILUS CAPAX	FAT POCKETBOOK	E
POTAMILUS INFLATUS	INFLATED HEELSPLITTER	T
PTYCHOBRANCHUS FASCIOLARIS	KIDNEYSHELL	
QUADRULA CYLINDRICA CYLINDRICA	RABBITS FOOT	
QUADRULA METANEVRA	MONKEYFACE	
QUADRULA STAPES	STIRRUPSHELL	E
MALACOSTRACA		
FALLICAMBARUS GORDONI	CAMP SHELBY BURROWING CRAWFISH	C
INSECTA		
NICROPHORUS AMERICANUS	AMERICAN BURYING BEETLE	E
OSTEICHTHYES		
ACIPENSER OXYRINCHUS DESOTOI	GULF STURGEON	T
CRYST ALLARIA ASPRELLA	CRYSTAL DARTER	
ETHEOSTOMA BLENNIOIDES	GREENSIDE DARTER	
ETHEOSTOMA RUBRUM	BAYOU DARTER	T
NOTROPIS BOOPS	BIGEYE SHINER	
NOTROPIS CHALYBAEUS	IRONCOLOR SHINER	
NOTURUS EXILIS	SLENDER MADTOM	
NOTURUS MUNITUS	FRECKLEBELLY MADTOM	
NOTURUS STIGMOSUS	NORTHERN MADTOM	
PERCINA AURORA	PEARL DARTER	C
PERCINA PHOXOCEPHALA	SLENDERHEAD DARTER	
PHENACOBIUS MIRABILIS	SUCKERMOUTH MINNOW	
PHOXINUS ERYTHROGASTER	SOUTHERN REDBELL Y DACE	
SCAPHIRHYNCHUS ALBUS	PALLID STURGEON	E

Appendix Table D10. Threatened and Endangered Species of Mississippi. Mississippi Natural Heritage Program. E = Endangered, T = Threatened, C = Candidate, PS = Partial Status		
SPECIES NAME	**COMMON NAME**	**Federal Rank**
SCAPHIRHYNCHUS SUTTKUSI	ALABAMA STURGEON	E
AMPHIBIA		
AMPHIUMA PHOLETER	ONE-TOED AMPHIUMA	
ANEIDES AENEUS	GREEN SALAMANDER	
EURYCEA LUCIFUGA	CAVE SALAMANDER	
GYRINOPHILUS PORPHYRITICUS	SPRING SALAMANDER	
RANA SEVOSA	DARK GOPHER FROG	PE
REPTILIA		
CARETTA CARETTA	LOGGERHEAD; CABEZON	T
CHELONIA MYDAS	GREEN TURTLE	ET
DERMOCHELYS CORIACEA	LEATHERBACK; TINGLAR	E
DRYMARCHON CORAIS COUPERI	EASTERN INDIGO SNAKE	T
ERETMOCHELYS IMBRICATA	HAWKSBILL; CAREY	E
FARANCIA ERYTROGRAMMA	RAINBOW SNAKE	
GOPHERUS POLYPHEMUS	GOPHER TORTOISE	PS
GRAPTEMYS FLAVIMACULATA	YELLOW-BLOTCHED MAP TURTLE	T
GRAPTEMYS NIGRINODA	BLACK-KNOBBED MAP TURTLE	
GRAPTEMYS OCULIFERA	RINGED MAP TURTLE	T
HETERODON SIMUS	SOUTHERN HOGNOSE SNAKE	
LEPIDOCHELYS KEMPII	KEMP'S OR ATLANTIC RIDLEY	E
PITUOPHIS MELANOLEUCUS LODINGI	BLACK PINE SNAKE	C
PSEUDEMYS POP 1	MISSISSIPPI REDBELLY TURTLE	
AVES		
CAMPEPHILUS PRINCIPALIS	IVORY-BILLED WOODPECKER	E
CHARADRIUS ALEXANDRINUS TENUIROSTRIS	SOUTHEASTERN SNOWY PLOVER	
CHARADRIUS MELODUS	PIPING PLOVER	ET
FALCO PEREGRINUS	PEREGRINE FALCON	E
GRUS CANADENSIS PULLA	MISSISSIPPI SANDHILL CRANE	E
HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	T
MYAERIA AMERICANA	WOOD STORK	E
PELECANUS OCCIDENTALIS	BROWN PELICAN	E
PICOIDES BOREALIS	RED-COCKADED WOODPECKER	E
STERNA ANTILLARUM ATHALASSOS	INTERIOR LEAST TERN	E
THRYOMANES BEWICKII	BEWICK'S WREN	
VERMIVORA BACHMANII	BACHMAN'S WARBLER	E
MAMMALIA		
MYOTIS GRISESCENS	GRAY MYOTIS	E
MYOTIS SODALIS	INDIANA OR SOCIAL MYOTIS	E
PUMA CONCOLOR CORYI	FLORIDA PANTHER	E
TRICHECHUS MANATUS	MANATEE	E
URSUS AMERICANUS	BLACK BEAR	PS
URSUS AMERICAN US LUTEOLUS	LOUISIANA BLACK BEAR	T

Appendix Table D10. Threatened and Endangered Species of Mississippi. Mississippi Natural Heritage Program. E = Endangered, T = Threatened, C = Candidate, PS = Partial Status		
SPECIES NAME	**COMMON NAME**	**Federal Rank**
ISOETOPSIDA		
* *ISOETES LOUISIANENSIS*	LOUISIANA QUILLWORT	E
DICOTYLEDONEAE		
* *APIOS PRICEANA*	PRICE'S POTATO BEAN	T
* *LINDERA MELISSIFOLIA*	PONDBERRY	E
* *SCHWALBEA AMERICANA*	CHAFFSEED	E

Appendix Table E1. Invasive Species listed for Louisiana. Global Invasive Species Database (Queried 3/06)

Alien Species

1. ***Ailanthus altissima*** (shrub, tree)
Common Names: Chinese sumac, stinking shumac, tree of heaven
2. ***Akebia quinata*** (vine, climber)
Common Names: chocolate vine
3. ***Albizia julibrissin*** (tree)
Common Names: mimosa
4. ***Alternanthera philoxeroides*** (aquatic plant, herb)
Common Names: alligator weed
5. ***Anredera cordifolia*** (vine, climber)
Common Names: Gulf madeiravine
6. ***Anthonomus grandis*** (insect)
Common Names: boll weevil
7. ***Aristichthys nobilis*** (fish)
Common Names: bighead carp
8. ***Aulacaspis yasumatsui*** (insect)
Common Names: Asian cycad scale
9. ***Bromus tectorum*** (grass)
Common Names: broncograss, cheatgrass
10. ***Bufo marinus*** (amphibian)
Common Names: bullfrog, cane toad
11. ***Carduus nutans*** (herb)
Common Names: nodding plumeless thistle
12. ***Celastrus orbiculatus*** (vine, climber)
Common Names: Asian bittersweet, Asiatic bittersweet
13. ***Centaurea biebersteinii*** (herb)
Common Names: spotted knapweed
14. ***Cinnamomum camphora*** (tree)
Common Names: camphor laurel
15. ***Coptotermes formosanus*** (insect)
Common Names: Formosan subterranean termite
16. ***Corbicula fluminea*** (mollusc)
Common Names: Asian clam
17. ***Cortaderia selloana*** (grass)
Common Names: pampas grass
18. ***Cyprinus carpio*** (fish)
Common Names: carp,
19. ***Dioscorea oppositifolia*** (herb, vine, climber)
Common Names: Chinese yam
20. ***Egeria densa*** (aquatic plant)
Common Names: Brazilian elodea, Brazilian waterweed
21. ***Eichhornia crassipes*** (aquatic plant)
Common Names: water hyacinth
22. ***Elaeagnus umbellata*** (shrub, tree)
Common Names: autumn-olive, silverberry
23. ***Erodium cicutarium*** (herb)
Common Names: California filaree, cutleaf filaree
24. ***Fallopia japonica*** (herb, shrub)
Common Names: crimson beauty

25. ***Harmonia axyridis*** (insect)
    Common Names: Asian lady beetle
26. ***Hedera helix*** (vine, climber)
    Common Names: English Ivy
27. ***Houttuynia cordata*** (aquatic plant, shrub)
    Common Names: chameleon-plant
28. ***Hydrilla verticillata*** (aquatic plant)
    Common Names: hydrilla
29. ***Hypophthalmichthys molitrix*** (fish)
    Common Names: Chinese schemer
30. ***Imperata cylindrica*** (grass)
    Common Names: cogon grass
31. ***Iris pseudacorus*** (herb)
    Common Names: pale-yellow iris
32. ***Lespedeza cuneata*** (herb, shrub)
    Common Names: Chinese bush-clover
33. ***Ligustrum lucidum*** (tree)
    Common Names: broadleaf privet
34. ***Ligustrum sinense*** (shrub, tree)
    Common Names: Chinese privet
35. ***Linepithema humile*** (insect)
    Common Names: Argentine ant,
36. ***Lonicera japonica*** (vine, climber)
    Common Names: Chinese honeysuckle
37. ***Lythrum salicaria*** (aquatic plant, herb).
    Common Names: purple loosestrife.
38. ***Melia azedarach*** (shrub, tree)
    Common Names: Indian lilac
39. ***Microstegium vimineum*** (grass)
    Common Names: annual jewgrass
40. ***Molothrus bonariensis*** (bird)
    Common Names: shiny cowbird
41. ***Myriophyllum aquaticum*** (aquatic plant)
    Common Names: brazilian watermilfoil
42. ***Myriophyllum spicatum*** (aquatic plant)
    Common Names: Eurasian water-milfoil
43. ***Norops sagrei*** (reptile)
    Common Names: Bahamian brown anole
44. ***Oncorhynchus mykiss*** (fish)
    Common Names: California rainbow trout
45. ***Ophiostoma ulmi sensu lato*** (fungus)
    Common Names: dutch elm disease
46. ***Paederia foetida*** (vine, climber)
    Common Names: Chinese fever vine
47. ***Panicum repens*** (grass)
    Common Names: canota, couch panicum , creeping panic
48. ***Passer domesticus*** (bird)
    Common Names: English sparrow
49. ***Paulownia tomentosa*** (tree)
    Common Names: foxglove-tree
50. ***Pennisetum ciliare*** (grass)
    Common Names: African foxtail grass
51. ***Pennisetum setaceum*** (grass)
    Common Names: fountaingrass

52. ***Phragmites australis*** (grass)
    Common Names: cane
53. ***Populus alba*** (tree)
    Common Names: silver-leaf poplar
54. ***Potamogeton crispus*** (aquatic plant)
    Common Names: curly pondweed
55. ***Pueraria montana var. lobata*** (vine, climber)
    Common Names: kudzu
56. ***Robinia pseudoacacia*** (tree)
    Common Names: black locust
57. ***Rosa multiflora*** (shrub)
    Common Names: baby rose
58. ***Rottboellia cochinchinensis*** (grass)
    Common Names: itch grass
59. ***Salix cinerea*** (shrub, tree)
    Common Names: gray sallow
60. ***Salsola tragus*** (shrub)
    Common Names: Russian tumbleweed
61. ***Salvinia molesta*** (aquatic plant, herb)
    Common Names: African payal
62. ***Sirococcus clavigignenti-juglandacearum*** (fungus)
    Common Names: butternut canker
63. ***Solenopsis invicta*** (insect)
    Common Names: red imported fire ant (RIFA)
64. ***Solenopsis richteri*** (insect)
    Common Names: black imported fire ant
65. ***Tamarix ramosissima*** (shrub, tree)
    Common Names: salt cedar
66. ***Tradescantia fluminensis*** (herb)
    Common Names: wandering creeper
67. ***Tradescantia spathacea*** (herb)
    Common Names: boat lily.
68. ***Triadica sebifera*** (tree)
    Common Names: candleberry-tree
69. ***Urochloa maxima*** (grass)
    Common Names: buffalograss
70. ***Verbascum thapsus*** (herb)
    Common Names: Aaron's-rod
71. ***Vinca major*** (herb)
    Common Names: bigleaf periwinkle
72. ***Vulpes vulpes*** (mammal)
    Common Names: silver, black or cross fox
73. ***Wisteria sinensis*** (vine, climber)
    Common Names: Chinese wisteria

Biostatus Uncertain Species

1. ***Canna indica*** (herb)
    Common Names: African arrowroot
2. ***Molothrus ater*** (bird)
    Common Names: brown-headed cowbird
3. ***Pistia stratiotes*** (aquatic plant)
    Common Names: tropical duckweed,

Appendix Table E2. Invasive Species listed for Mississippi. Global Invasive Species Database (Queried 3/06)

Alien Species

1. ***Ailanthus altissima*** (shrub, tree)
  Common Names: Chinese sumac, stinking shumac, tree of heaven
2. ***Albizia julibrissin*** (tree)
  Common Names: mimosa, powderpuff tree, silk tree, silky acacia
3. ***Alternanthera philoxeroides*** (aquatic plant, herb)
  Common Names: alligator weed, alligatorweed
4. ***Aristichthys nobilis*** (fish)
  Common Names: bighead carp
5. ***Bromus tectorum*** (grass)
  Common Names: broncograss, cheatgrass
6. ***Carduus nutans*** (herb)
  Common Names: nodding plumeless thistle
7. ***Cinnamomum camphora*** (tree)
  Common Names: camphor tree
8. ***Coptotermes formosanus*** (insect)
  Common Names: Formosan subterranean termite
9. ***Corbicula fluminea*** (mollusc)
  Common Names: Asian clam
10. ***Coronilla varia*** (herb)
  Common Names: trailing crown-vetch
11. ***Cryphonectria parasitica*** (fungus)
  Common Names: chestnut blight
12. ***Cyprinus carpio*** (fish)
  Common Names: carp
13. ***Dioscorea oppositifolia*** (herb, vine, climber)
  Common Names: Chinese yam, cinnamon vine
14. ***Egeria densa*** (aquatic plant)
  Common Names: Brazilian waterweed
15. ***Eichhornia crassipes*** (aquatic plant)
  Common Names: water hyacinth
16. ***Elaeagnus umbellata*** (shrub, tree)
  Common Names: autumn-olive, silverberry
17. ***Euonymus fortunei*** (vine, climber)
  Common Names: wintercreeper
18. ***Fallopia japonica*** (herb, shrub) .
  Common Names: crimson beauty
19. ***Harmonia axyridis*** (insect)
  Common Names: Asian lady beetle
20. ***Hedera helix*** (vine, climber)
  Common Names: English Ivy
21. ***Hydrilla verticillata*** (aquatic plant)
  Common Names: hydrilla
22. ***Hypophthalmichthys molitrix*** (fish)
  Common Names: Chinese schemer
23. ***Imperata cylindrica*** (grass)
  Common Names: cogon grass
24. ***Iris pseudacorus*** (herb)
  Common Names: pale-yellow iris

25. ***Lespedeza cuneata*** (herb, shrub)

Common Names: Chinese bush-clover

26. ***Ligustrum lucidum*** (tree)
Common Names: broadleaf privet

27. ***Ligustrum sinense*** (shrub, tree)
Common Names: Chinese privet

28. ***Linepithema humile*** (insect)
Common Names: Argentine ant

29. ***Lonicera japonica*** (vine, climber)
Common Names: Chinese honeysuckle

30. ***Lythrum salicaria*** (aquatic plant, herb)
Common Names: purple loosestrife

31. ***Melia azedarach*** (shrub, tree)
Common Names: Persian lilac

32. ***Microstegium vimineum*** (grass)
Common Names: annual jewgrass

33. ***Myriophyllum aquaticum*** (aquatic plant)
Common Names: brazilian watermilfoil

34. ***Myriophyllum spicatum*** (aquatic plant)
Common Names: Eurasian water-milfoil

35. ***Nymphoides peltata*** (aquatic plant)
Common Names: entire marshwort

36. ***Oncorhynchus mykiss*** (fish) .
Common Names: Baja California rainbow trout,

37. ***Orconectes virilis*** (crustacean)
Common Names: northern crayfish, virile crayfish

38. ***Paederia foetida*** (vine, climber)
Common Names: Chinese fever vine, skunk vine

39. ***Panicum repens*** (grass)
Common Names: canota, couch panicum , creeping panic

40. ***Passer domesticus*** (bird)
Common Names: English sparrow

41. ***Paulownia tomentosa*** (tree)
Common Names: empress tree, foxglove-tree

42. ***Pennisetum ciliare*** (grass)
Common Names: African foxtail grass

43. ***Phragmites australis*** (grass)
Common Names: cane, giant reedgrass, phragmites

44. ***Populus alba*** (tree)
Common Names: silver-leaf poplar

45. ***Potamogeton crispus*** (aquatic plant)
Common Names: curly pondweed, curly-leaved pondweed

46. ***Pueraria montana var. lobata*** (vine, climber)
Common Names: kudz.

47. ***Robinia pseudoacacia*** (tree)
Common Names: black locust

48. ***Rosa multiflora*** (shrub)
Common Names: baby rose, Japanese rose, multiflora rose

49. ***Salsola tragus*** (shrub)
Common Names: Russian tumbleweed

50. ***Salvinia molesta*** (aquatic plant, herb)
Common Names: African payal

51. ***Sirococcus clavigignenti-juglandacearum*** (fungus)
Common Names: butternut canker

52. ***Solanum viarum*** (shrub)

Common Names: tropical soda apple

53. ***Solenopsis invicta*** (insect)
    Common Names: red imported fire ant (RIFA)
54. ***Solenopsis richteri*** (insect)
    Common Names: black imported fire ant
55. ***Tamarix ramosissima*** (shrub, tree)
    Common Names: salt cedar, tamarisk,
56. ***Triadica sebifera*** (tree)
    Common Names: candleberry-tree
57. ***Verbascum thapsus*** (herb)
    Common Names: Aaron's-rod
58. ***Vinca major*** (herb)
    Common Names: bigleaf periwinkle
59. ***Vulpes vulpes*** (mammal)
    Common Names: silver, black or cross fox
60. ***Wisteria sinensis*** (vine, climber)
    Common Names: Chinese wisteria

Biostatus Uncertain Species

1. ***Molothrus ater*** (bird)
    Common Names: brown-headed cowbird
2. ***Pistia stratiotes*** (aquatic plant)
    Common Names: tropical duckweed

Appendix Table E3
Aquatic Invasive Species of Louisiana. NISBase (Queried 3/06)

Group	Species	Common Name
Amphibians-Frogs	*Bufo marinus*	Cane Toad
	Eleutherodactylus coqui	
	Eleutherodactylus planirostris	Greenhouse Frog
	Eleutherodactylus planirostris planirostris	Greenhouse Frog
Coelenterates-Anthozoan	*Tubastraea coccinea*	orange cup coral
Coelenterates-Hydrozoans	*Craspedacusta sowerbyii*	freshwater jellyfish
Coelenterates-Scyphozoan	*Phyllorhiza punctata*	Australian spotted jellyfish
Crustaceans-Cladocerans	*Daphnia lumholtzi*	water flea
Crustaceans-Copepods	*Argulus japonicus*	parasitic copepod
	Eurytemora affinis	calanoid copepod
Crustaceans-Crabs	*Eriocheir sinensis*	Chinese mitten crab
Fishes	*Alosa sapidissima*	American shad
	Ameiurus nebulosus	brown bullhead
	Astronotus ocellatus	oscar
	Astyanax mexicanus	Mexican tetra
	Carassius auratus	goldfish
	Cichlasoma cyanoguttatum	Rio Grande cichlid
	Cichlasoma managuense	jaguar guapote
	Cichlasoma nigrofasciatum	convict cichlid
	Cichlidae	
	Colossoma or Piaract sp.	
	Colossoma or Piaractus sp.	unidentified pacu
	Ctenopharyngodon idella	grass carp
	Cyprinus carpio	common carp
	Gymnocorymbus ternetzi	black tetra
	Hypophthalmichthys molitrix	silver carp
	Hypophthalmichthys nobilis	bighead carp
	Hypostomus sp.	suckermouth catfish
	Lepomis auritus	redbreast sunfish
	Leuciscus idus	ide
	Macropodus opercularis	paradisefish
	Misgurnus anguillicaudatus	Oriental weatherfish
	Morone chrysops	white bass
	Morone chrysops x saxatilis	wiper
	Morone mississippiensis x s	
	Morone mississippiensis x saxatilis	yellow bass x striped bass
	Morone saxatilis	striped bass
	Mylopharyngodon piceus	black carp
	Notropis potteri	chub shiner
	Notropis shumardi	silverband shiner
	Oncorhynchus mykiss	rainbow trout
	Oncorhynchus tshawytscha	Chinook salmon
	Oreochromis, Sarotherodon, Tilapia sp.	tilapia
	Osmerus mordax	rainbow smelt

Appendix Table E3 Aquatic Invasive Species of Louisiana. NISBase (Queried 3/06)		
Group	**Species**	**Common Name**
	Piaractus brachypomus	pirapatinga, red-bellied pacu
	Pimephales promelas	fathead minnow
	Sander canadense	sauger
	Sander vitreus	walleye
	Stizostedion canadense	
	Stizostedion vitreum	
	Tetraodon nigroviridis	spotted green pufferfish
	Tinca tinca	tench
	Xiphophorus helleri	green swordtail
	Xiphophorus maculatus	southern platyfish
Mammals	*Myocastor coypus*	nutria
Mollusks-Bivalves	*Corbicula fluminea*	Asian clam
	Dreissena polymorpha	zebra mussel
Mollusks-Gastropods	*Melanoides tuberculatus*	red-rim melania

Appendix Table E4
Aquatic Invasive Species of Mississippi. NISBase (Queried 3/06)

Group	Species	Common Name
Amphibians-Frogs	*Eleutherodactylus planirostris*	Greenhouse Frog
Coelenterates-Hydrozoans	*Craspedacusta sowerbyii*	freshwater jellyfish
Coelenterates-Scyphozoan	*Drymonema dalmatinum*	pink meanie
	Phyllorhiza punctata	Australian spotted jellyfish
Crustaceans-Cladocerans	*Daphnia lumholtzi*	water flea
Crustaceans-Copepods	*Eurytemora affinis*	calanoid copepod
Crustaceans-Crabs	*Callinectes bocourti*	Bocourt swimming Crab, red blue crab
Crustaceans-Crayfish	*Orconectes virilis*	virile crayfish
Fishes	*Alosa sapidissima*	American shad
	Ameiurus catus	
	Astronotus ocellatus	oscar
	Carassius auratus	goldfish
	Cichlidae	
	Ctenopharyngodon idella	grass carp
	Cyprinus carpio	common carp
	Enneacanthus gloriosus	bluespotted sunfish
	Gambusia affinis	mosquitofish
	Hypophthalmichthys molitrix	silver carp
	Hypophthalmichthys nobilis	bighead carp
	Lepomis cyanellus	
	Lepomis cyanellus x macrochi	
	Lepomis cyanellus x macrochirus	green sunfish x bluegill
	Micropterus dolomieu	smallmouth bass
	Micropterus salmoides	
	Morone chrysops	white bass
	Morone chrysops x saxatilis	wiper
	Morone saxatilis	striped bass
	Oncorhynchus mykiss	rainbow trout
	Oreochromis, Sarotherodon, Tilapia	tilapia
	Oreochromis niloticus	Nile tilapia
	Perca flavescens	yellow perch
	Piaractus brachypomus	pirapatinga, red-bellied pacu
	Pimephales promelas	fathead minnow
	Pterygoplichthys disjunctivus	vermiculated sailfin catfish
	Salmo salar	
	Salmo salar sebago	landlocked Atlantic salmon
	Sander canadense	sauger
	Sander vitreus	walleye
	Stizostedion canadense	
	Stizostedion vitreum	
	Tinca tinca	tench

Appendix Table E4
Aquatic Invasive Species of Mississippi. NISBase (Queried 3/06)

Group	Species	Common Name
Mammals	*Myocastor coypus*	nutria
Mollusks-Bivalves	*Corbicula fluminea*	Asian clam
	Dreissena polymorpha	zebra mussel
Reptiles-Crocodilians	*Crocodylus niloticus*	Nile Crocodile
Reptiles-Turtles	*Graptemys pseudogeographica kohnii*	Mississippi Map Turtle