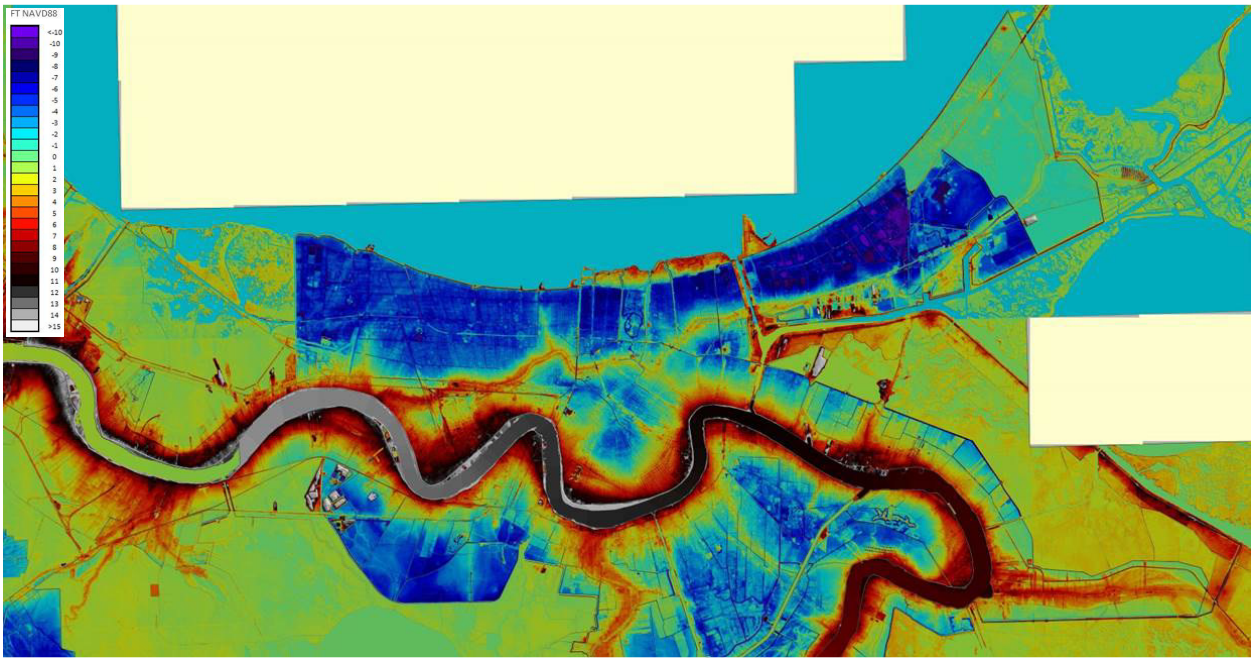
Part II.
East-Bank Compartmentalization Alternatives



LOSCO 2002

Part II examines physical, economic, and demographic conditions in each of the three East-Bank polders affecting the compartmentalization approach to surge inundation risk reduction; reviews previous post-Katrina investigations of East-Bank compartmentalization; and identifies—with the additional assistance of regional stakeholders—36 potential compartmentalization project alternatives.

7. Description of East-Bank Polders

This section provides detailed descriptions for each of the three East-Bank polders in order to facilitate examining potential compartmentalization projects for reducing surge inundation risk. The Google Earth images in Figures 7.1.a-h , with additional overlay information, illustrate the geography of the three East-Bank polders, including sub-basins, pump stations, and major communities and neighborhoods. The sub-basins referred to in this Report correspond to the ones employed by IPET (2009) shown in Figure 3.4. The areas of each sub-basin are given in Part I, Table 5.3.

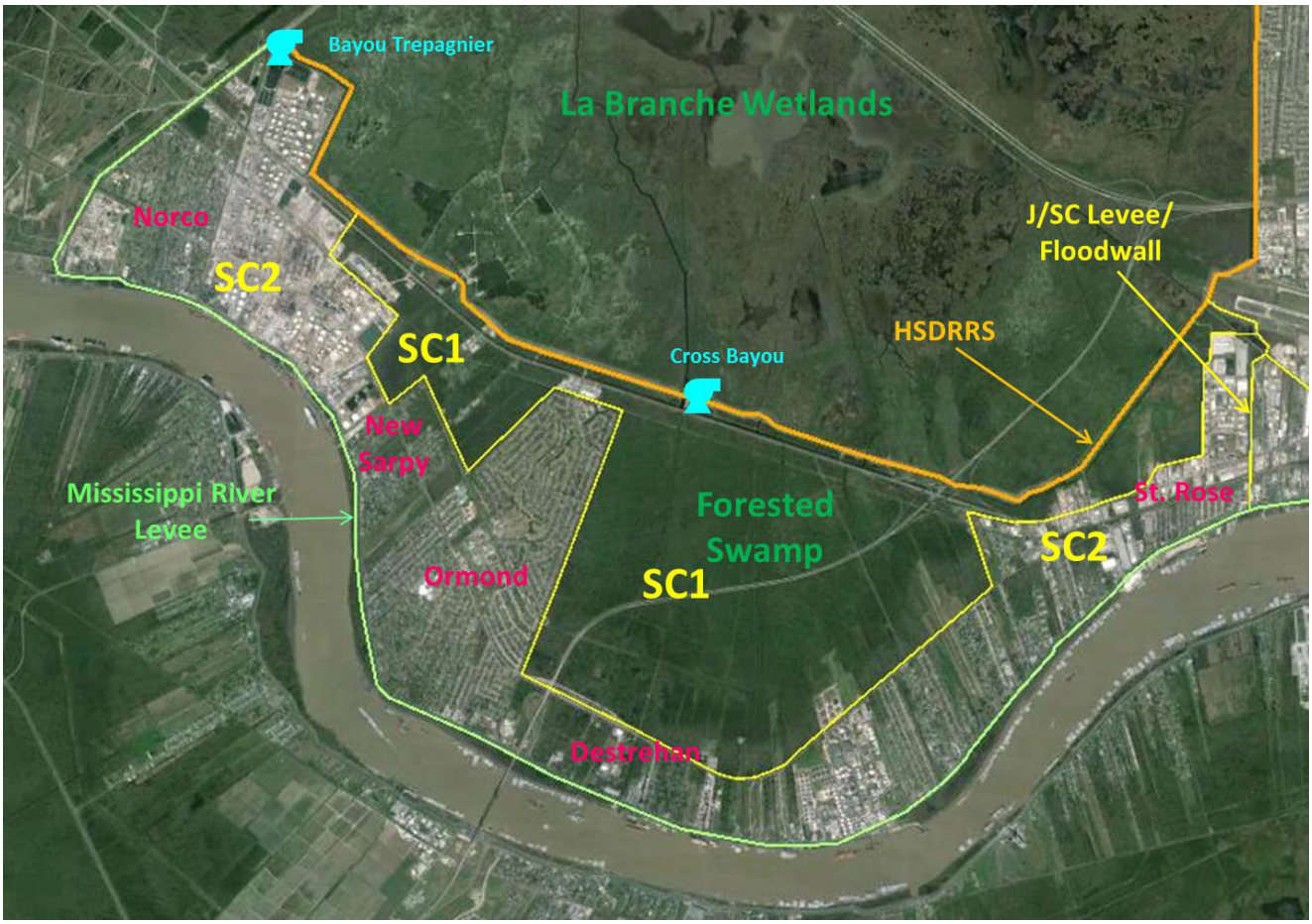
Tables 7.1, 7.2, and 7.3 summarize population, economic, and community assets by sub-basin derived from a 2014 report by DisasterMap.net, LLC (included as Appendix D). The total population of the East-Bank polders is nearly 600,000, with 21 percent ages 18 and younger, and 13 percent ages 65 and older.

Figures 7.2.a-h depict the *generalized* topography of the polders,[1] the interiors of which are dominated by four primary categories of features:

1. The overbank deposits adjacent to the Mississippi River. The natural banks of the Mississippi River provide the highest interior ground—in some locations approaching 10 ft above LMSL. These natural banks contain the oldest development within each polder, and face low flood hazard under Class C and D inundation events.
2. The back swamps. Away from the Mississippi River the original terrain rapidly descended into cypress-tupelo-gum swamp forests. Within the polders, much of these areas were cleared, drained, and developed many decades ago. As illustrated by Figure 7.3, extended forced drainage has caused subsidence of the ground surface in these areas to several feet below LMSL. The resulting depressed "bowls" face higher inundation hazards. The subsidence is also illustrated by comparing natural swamp ground elevations in St. Charles Parish, which are not subject to forced drainage, (Figures 7.2.a.) versus areas with prolonged forced drainage in Jefferson and Orleans Parishes (Figures 7.2.b. and c.).
3. Extended natural ridges within the polder interiors. These features are associated with abandoned Mississippi River distributary channels and former bayous, as well as crevasse deposits, and rise up to a few feet above LMSL. Examples include the Metairie-Gentilly-Sauvage Ridge (which extends from Jefferson Parish to NO East); Sauve Rd (Jefferson Parish); Esplanade Ave (Orleans Parish); and Paris Rd (St. Bernard Parish). These higher locations face lower inundation hazards.
4. Man-made embankments for roads and railroads. These features rise a few feet above the surrounding terrain and also have lower inundation hazards.

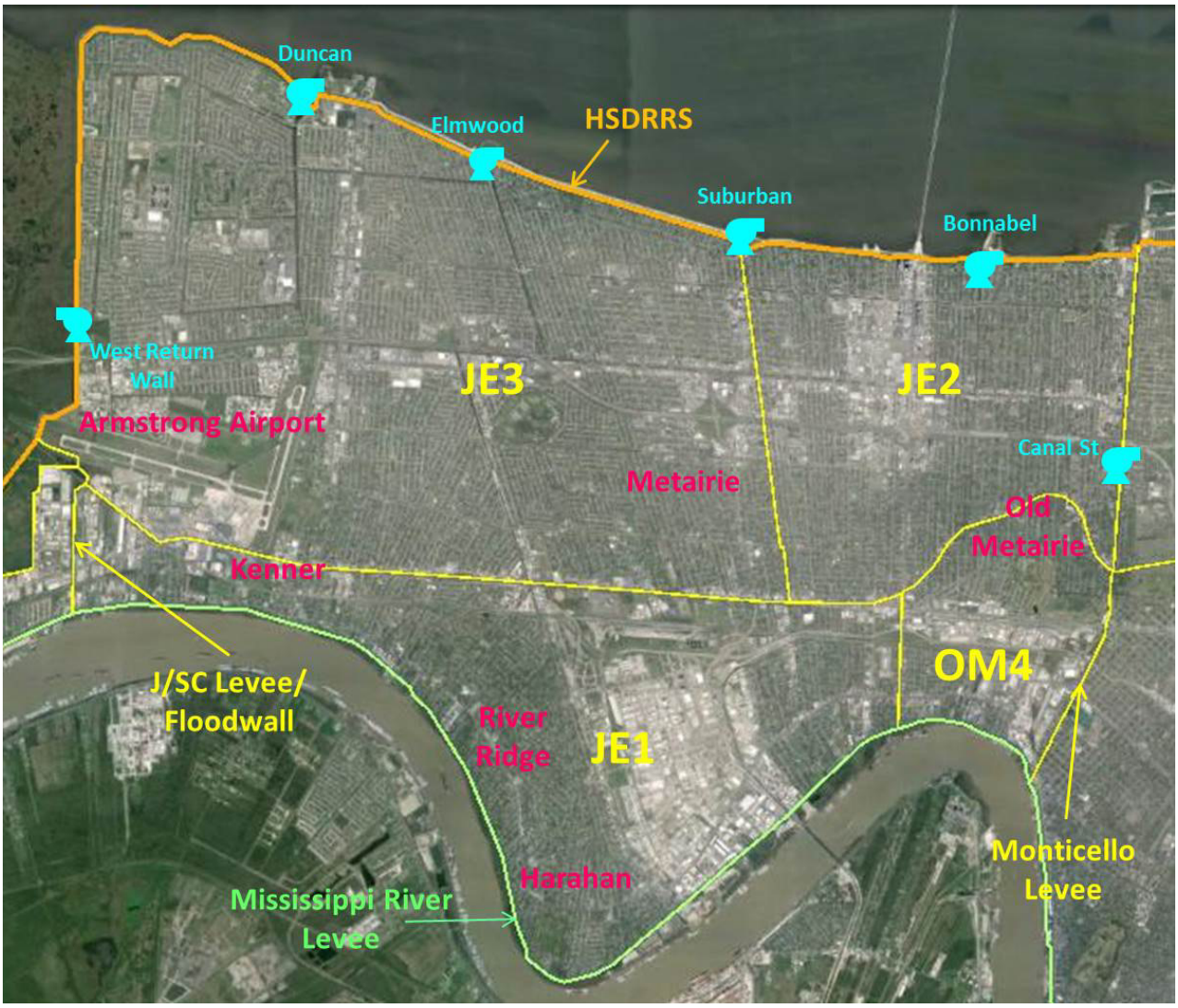
The last two categories of features strongly influence patterns of polder inundation—as in Hurricane Katrina (see Figure 3.3). Importantly, most polder natural and man-made barriers contain some openings to facilitate transportation, drainage, and utility crossings.

[1] Topographic data in this Section are based on a Louisiana coast-wide 5 m Digital Elevation Model (DEM) mosaic prepared by the Louisiana Oil Spill Coordinators Office and Louisiana State University, Coastal Studies Institute. This DEM was derived from pre-2005 quarter quadrangle LIDAR DEMs funded by FEMA. The DEMs lack the resolution for pinpointing the elevation of levee and floodwall crests. In addition, Pre-Katrina south Louisiana topographic data are known to have vertical control issues. The DEMs are sufficiently accurate for the purposes of this Section.



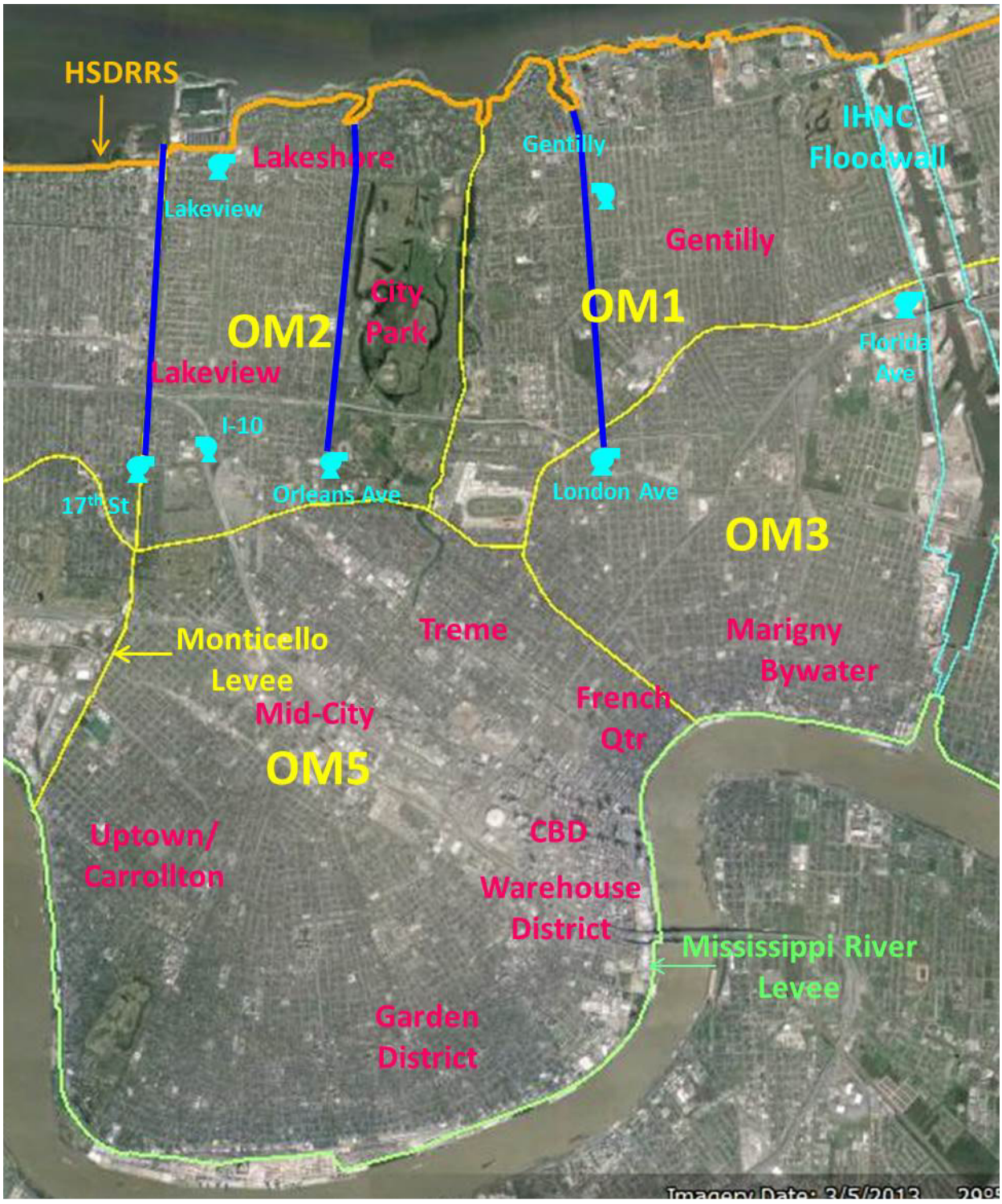
a. Metro Polder, St. Charles Parish

Figure 7.1. Google Earth Images



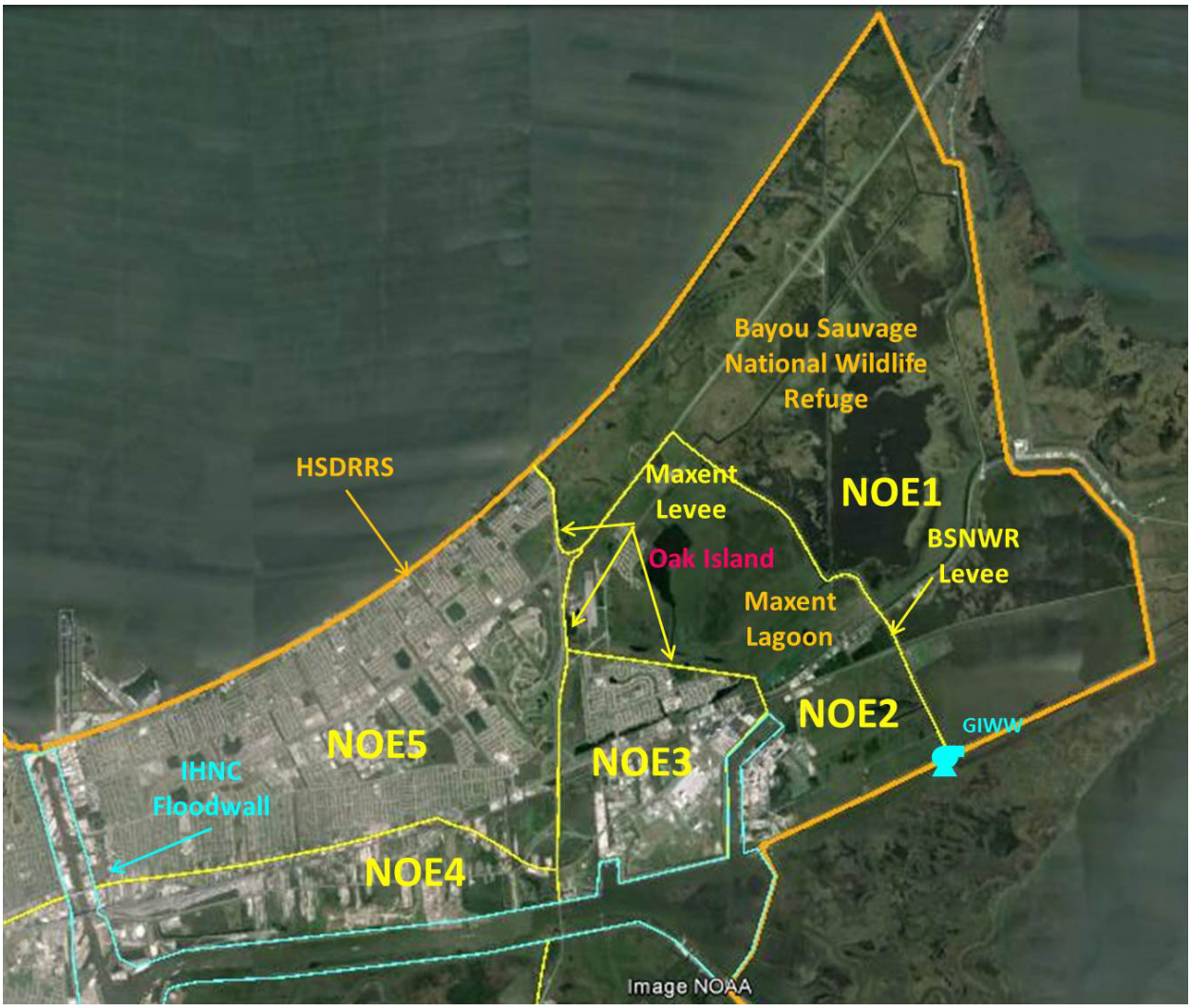
b. Metro Polder, Jefferson Parish

Figure 7.1. Google Earth Images



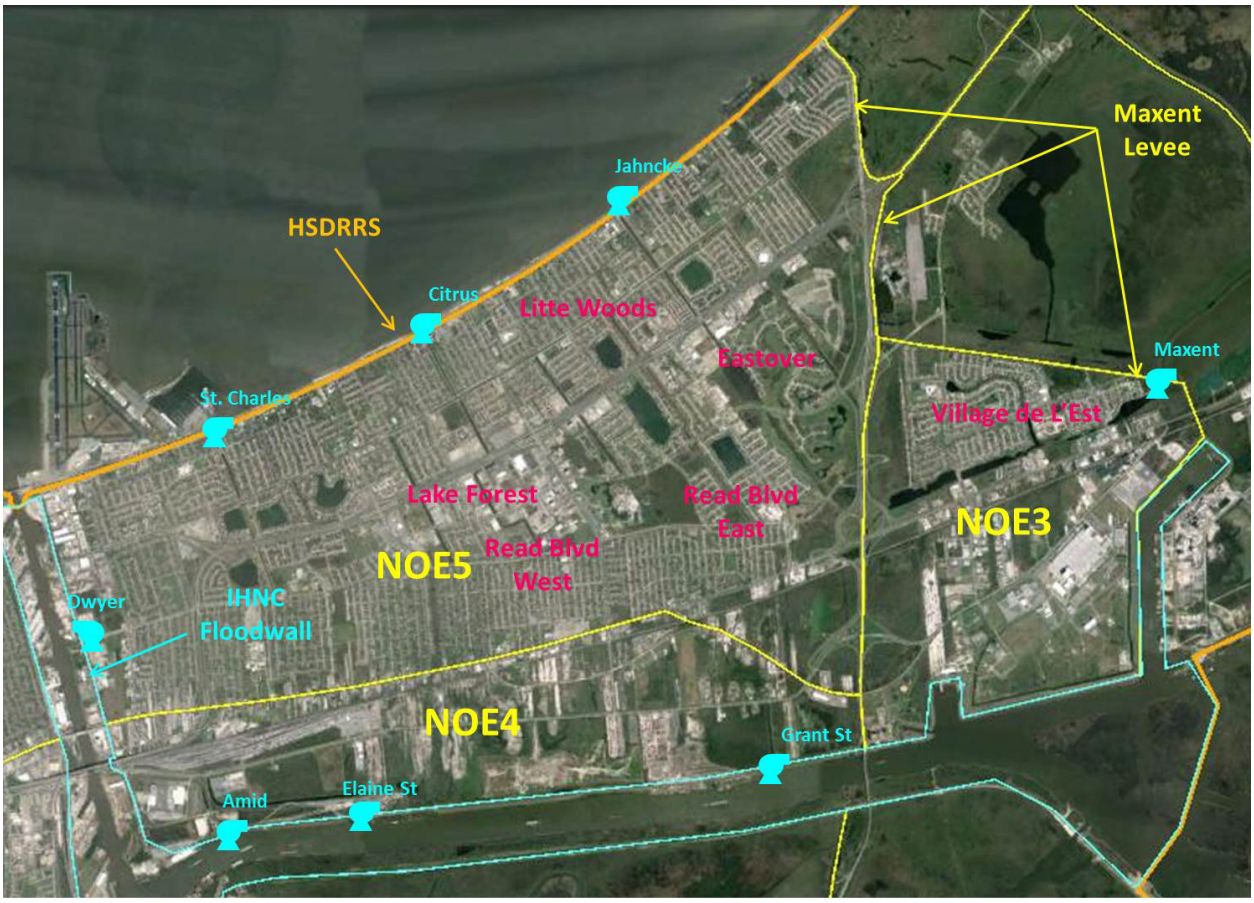
c. Metro Polder, Orleans Parish

Figure 7.1. Google Earth Images



d. NO East Polder

Figure 7.1. Google Earth Images

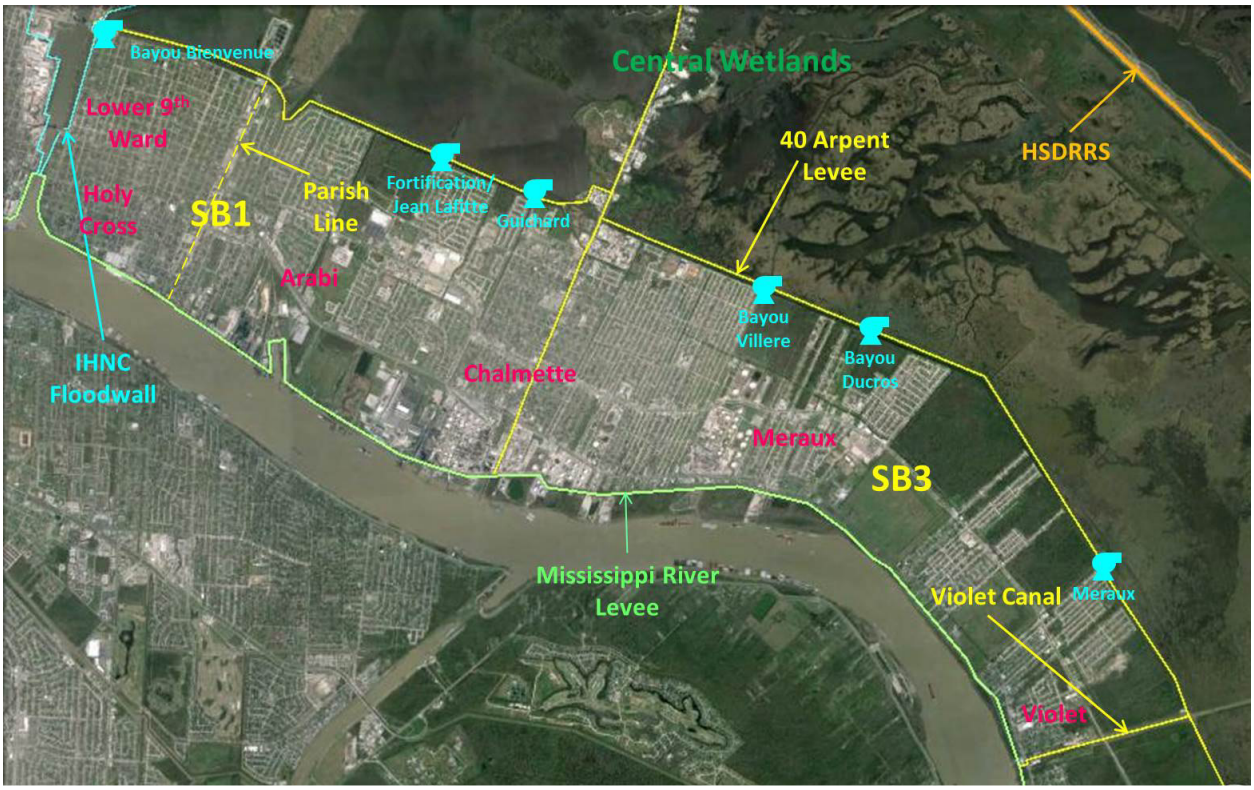


e. NO East Polder, Inside Maxent Levee

Figure 7.1. Google Earth Images

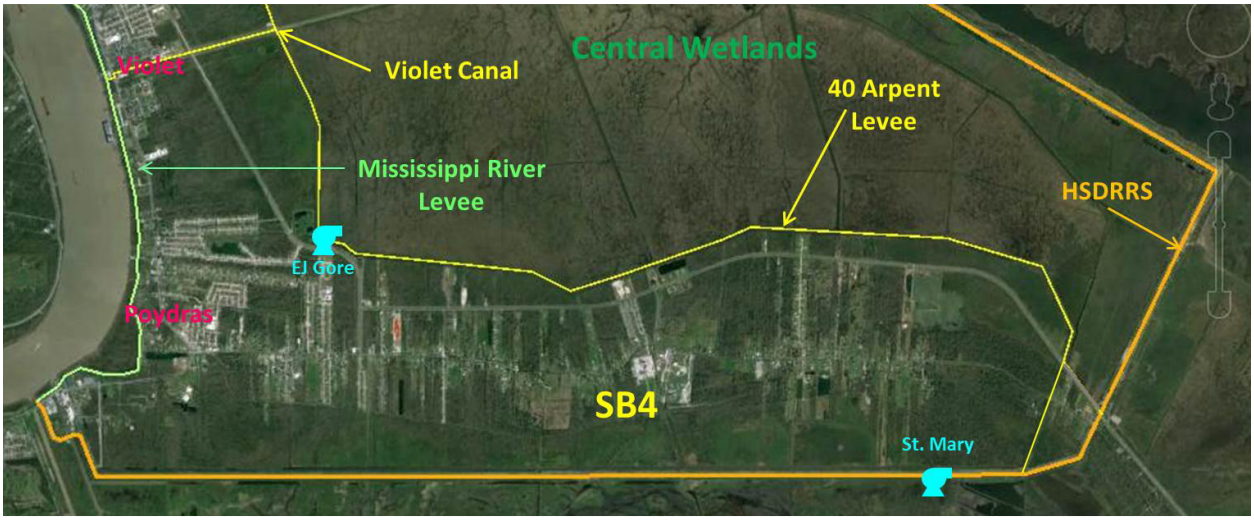
f. St. Bernard Polder

Figure 7.1. Google Earth Images



g. Upper St. Bernard Polder, Upriver from Violet

Figure 7.1. Google Earth Images



h. Lower St. Bernard Polder, Downriver from Violet and Bayou Rd Dog-Leg

Figure 7.1. Google Earth Images

Table 7.1. Population and Housing Characteristics of East-Bank Polders

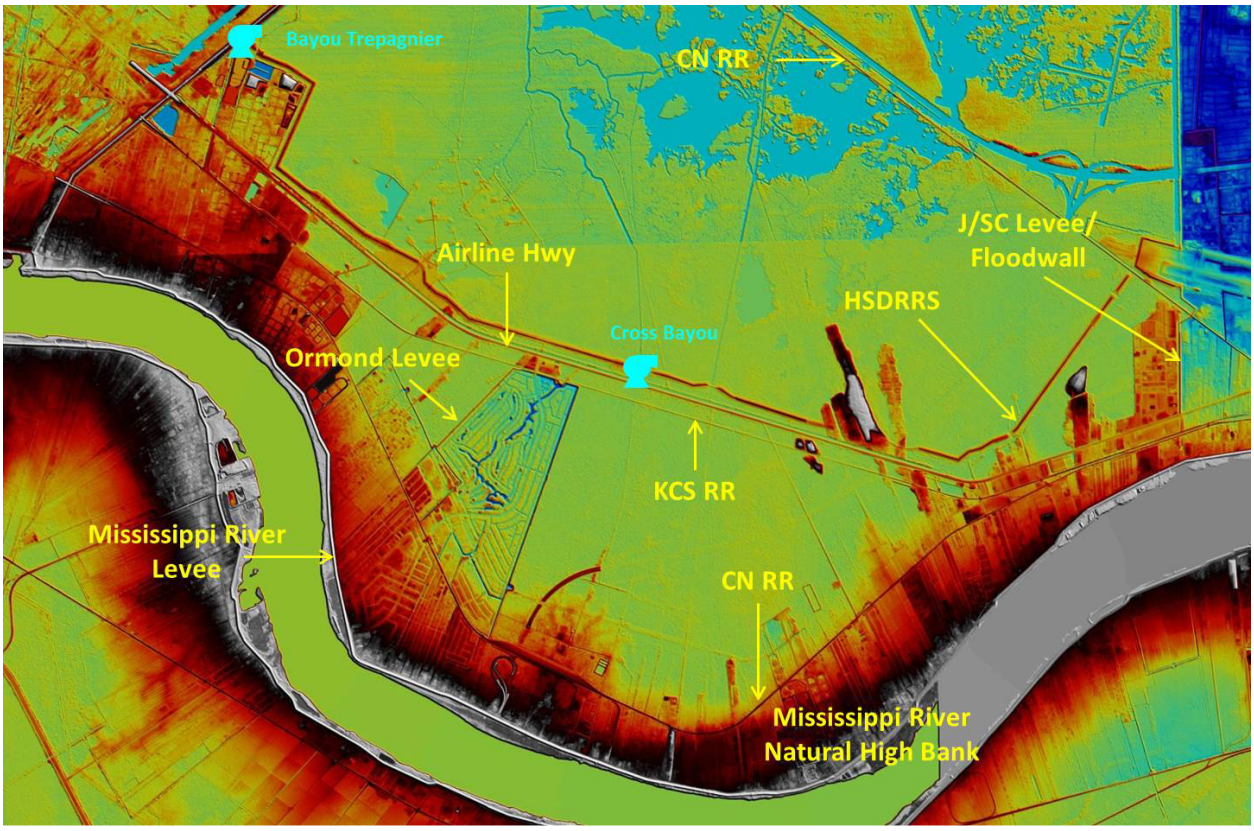
Sub-Basin	Population				Housing Units			
	Total	18 & Under	65 & Over	Disabled	Total	Occupied	Owner Occupied	Renter Occupied
IHNC	2,702	715	279	281	1,384	1,013	560	453
JE1	41,427	7,752	6,856	5,816	20,658	18,626	11,045	7,581
JE2	58,444	10,405	10,231	6,292	30,260	27,113	14,769	12,344
JE3	133,613	28,935	19,725	17,298	57,383	52,225	33,755	18,470
NOE3	7,468	1,966	705	779	2,665	2,262	1,334	928
NOE4	433	75	70	28	239	176	38	138
NOE5	54,814	15,546	4,615	5,051	25,769	19,754	11,374	8,380
OM1	28,978	6,279	3,853	4,330	15,749	11,896	7,187	4,709
OM2	16,810	3,371	1,898	1,240	9,378	7,369	4,963	2,406
OM3	38,916	8,397	4,870	6,226	25,114	16,781	7,447	9,334
OM4	10,385	2,213	1,704	994	5,018	4,473	2,990	1,483
OM5	135,171	21,936	14,509	16,563	80,605	60,117	22,808	37,309
SB1	17,399	4,396	1,722	1,985	9,530	6,582	3,671	2,911
SB3	17,310	4,583	1,415	1,636	7,749	6,277	4,590	1,686
SB4	8,232	1,917	1,067	1,048	3,988	3,012	2,636	376
SC1	8,438	2,360	696	937	3,137	2,953	2,214	739
SC2	17,585	4,717	1,727	1,814	6,634	6,254	4,975	1,279
Total	**598,125**	**125,562**	75,941	**72,318**	**305,260**	**246,883**	**136,356**	**110,527**

Table 7.2. Economic Characteristics of East-Bank Polders

Sub-Basin	Total Personal Income	Personal Income Per Capital	Personal Income per Household	Population Living in Poverty
IHNC	$35,348,638	$13,082.40	$34,895.00	707
JE1	$1,043,494,111	$25,188.74	$56,023.52	4,154
JE2	$1,780,147,807	$30,459.03	$65,656.62	6,999
JE3	$3,380,059,820	$25,297.39	$64,721.11	15,922
NOE3	$98,270,500	$13,158.88	$43,444.08	2,962
NOE4	$983,551	$2,271.48	$5,588.36	40
NOE5	$694,783,409	$12,675.29	$35,171.78	12,244
OM1	$584,157,233	$20,158.65	$49,105.35	6,681
OM2	$613,099,230	$36,472.29	$83,199.79	993
OM3	$610,828,646	$15,696.08	$36,400.01	13,012
OM4	$396,233,041	$38,154.36	$88,583.29	915
OM5	$3,737,326,716	$27,648.88	$62,167.55	34,179
SB1	$269,192,641	$15,471.73	$40,898.30	3,653
SB3	$276,279,060	$15,960.66	$44,014.51	1,567
SB4	$87,874,048	$10,674.69	$29,174.65	1,058
SC1	$206,500,466	$24,472.68	$69,929.04	834
SC2	$311,309,069	$17,703.10	$49,777.59	1,425
Total	**$14,125,887,986**	**$23,616.95**	**$57,216.93**	**107,345**

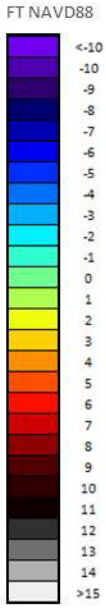
Table 7.3. Community Facilities in East-Bank Polders

Sub-Basin	Hospitals	Schools	Colleges	State	Child Care	Day Care	Adult Care	Fire Stations	Law Enforcement
IHNC									
JE1	5	15	1	7	21	3	16	4	
JE2	1	17		2	29	6	9	2	
JE3	6	38		2	46	4	33	4	2
NOE3		2		2	1		2	2	
NOE4							2		
NOE5	3	20		4	4		12	3	1
OM1		14	3	6	4		3	2	1
OM2		7	1	6	2		1	3	
OM3		28	1	5	11		8	5	1
OM4	1	5		1	4	1	8	2	
OM5	10	99	4	23	52	3	35	12	5
SB1	1	17	1	4	1		5	5	1
SB3		8		1			2	3	
SB4		5		2			2	2	
SC1					1	1			
SC2		11			9	6	3	3	
Total	**27**	**286**	**11**	**65**	**185**	**24**	**141**	**52**	**11**

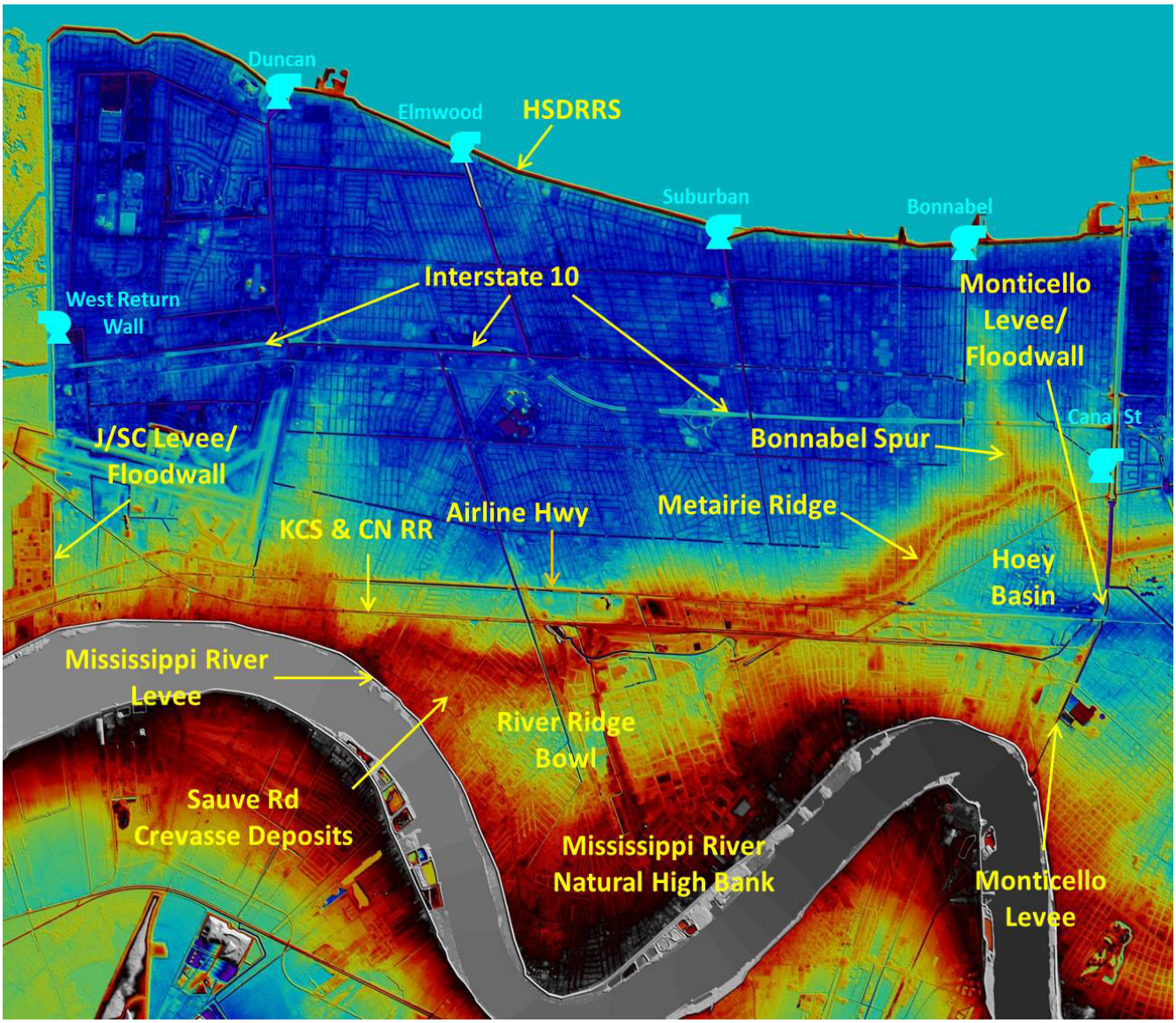


a. Metro Polder, St. Charles Parish

Figure 7.2. LIDAR DEM Topography

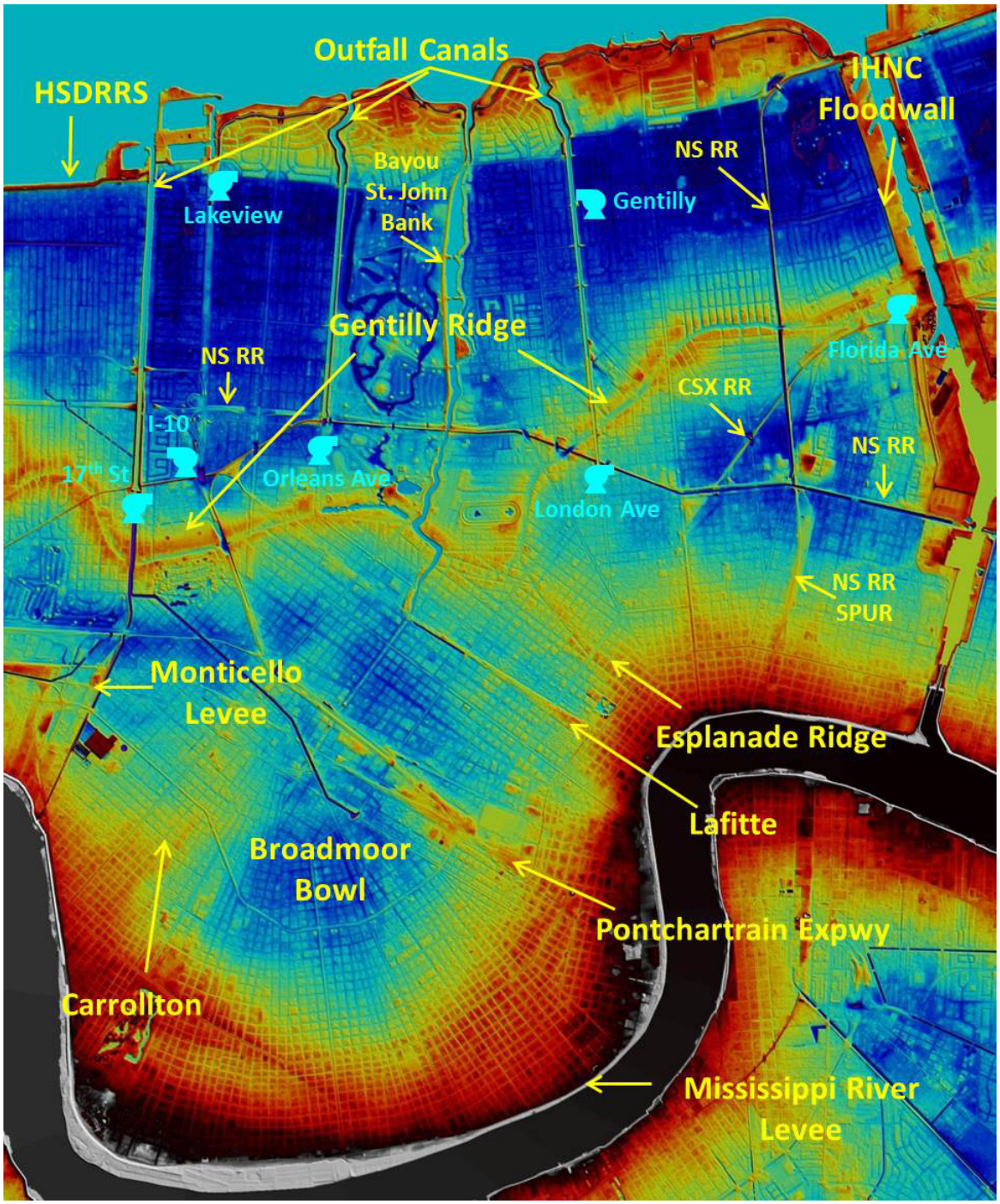


Legend



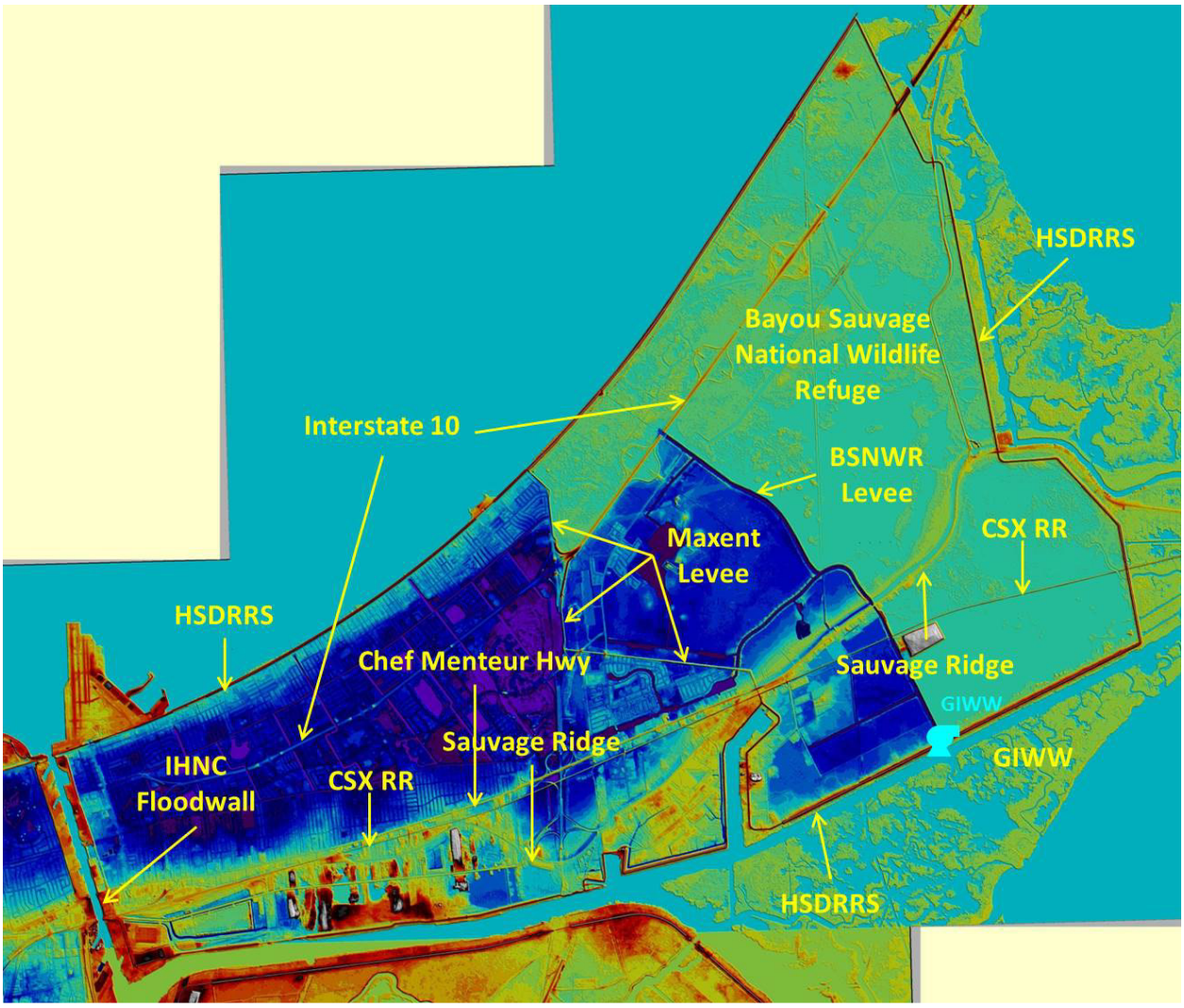
b. Metro Polder, Jefferson Parish

Figure 7.2. LIDAR DEM Topography



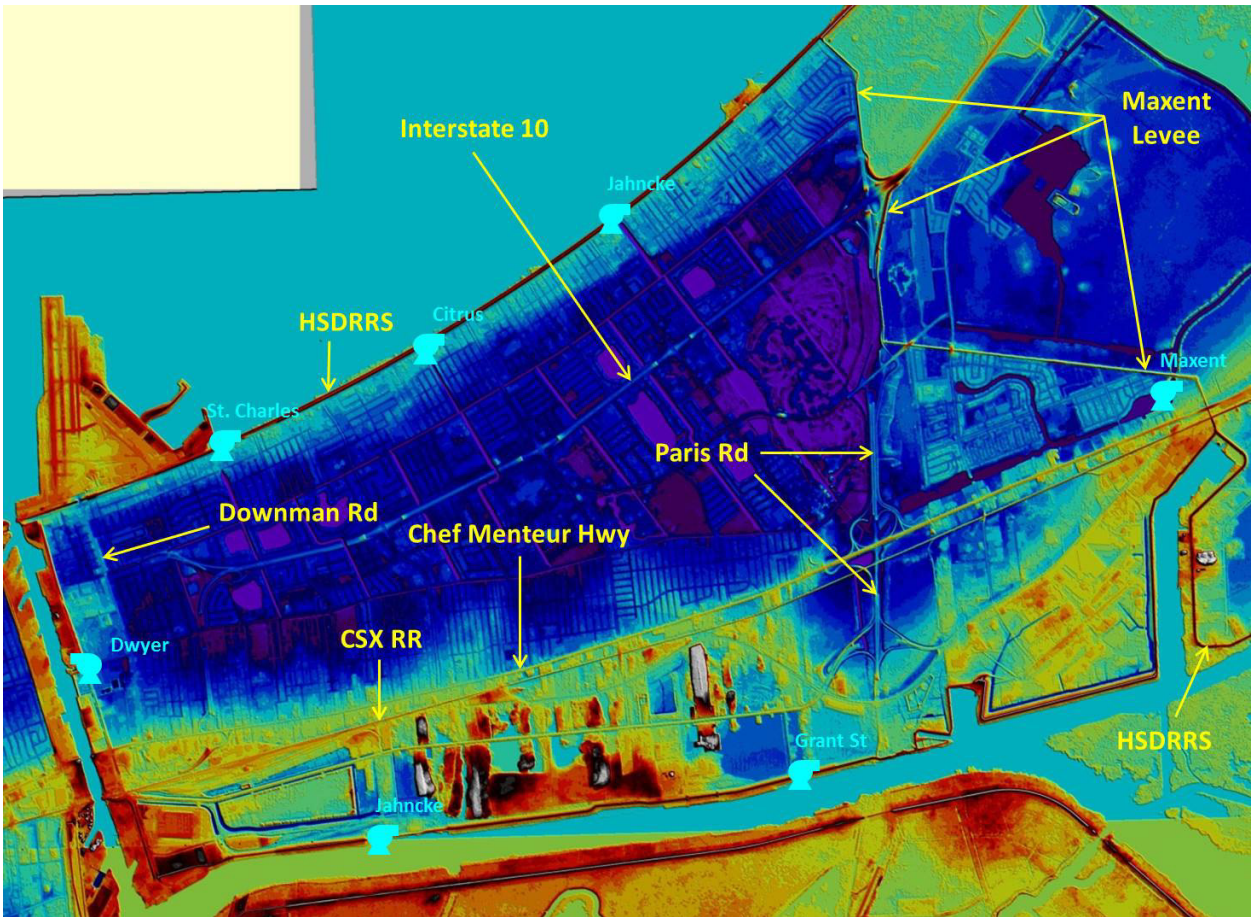
c. Metro Polder, Orleans Parish

Figure 7.2. LIDAR DEM Topography



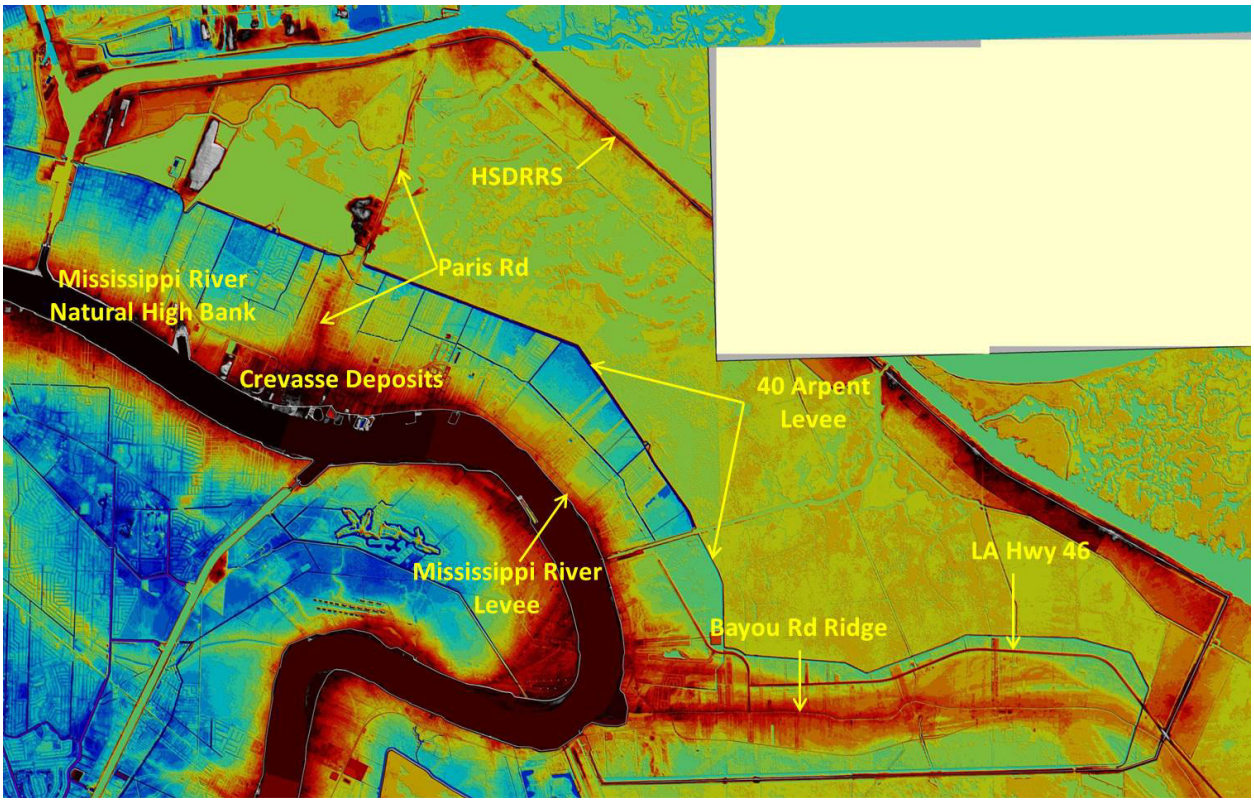
d. NO East Polder

Figure 7.2. LIDAR DEM Topography



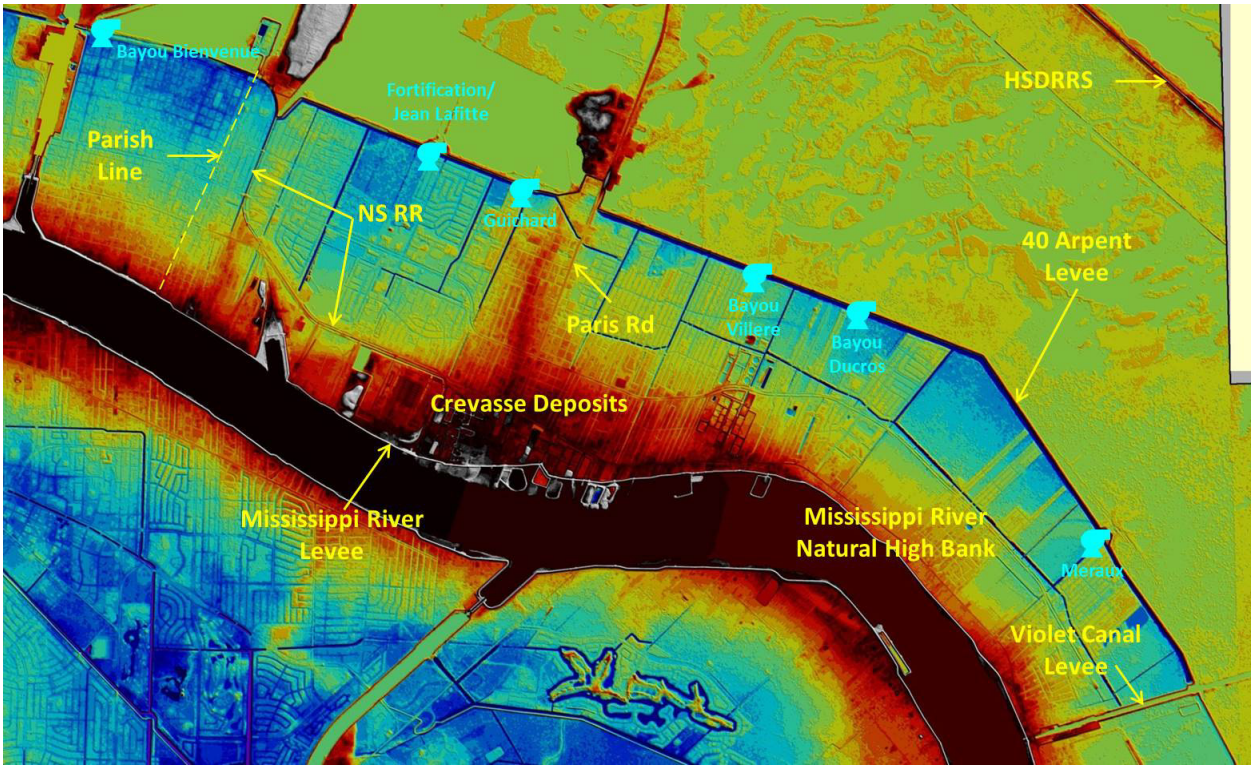
e. NO East Polder, Inside Maxent Levee

Figure 7.2. LIDAR DEM Topography



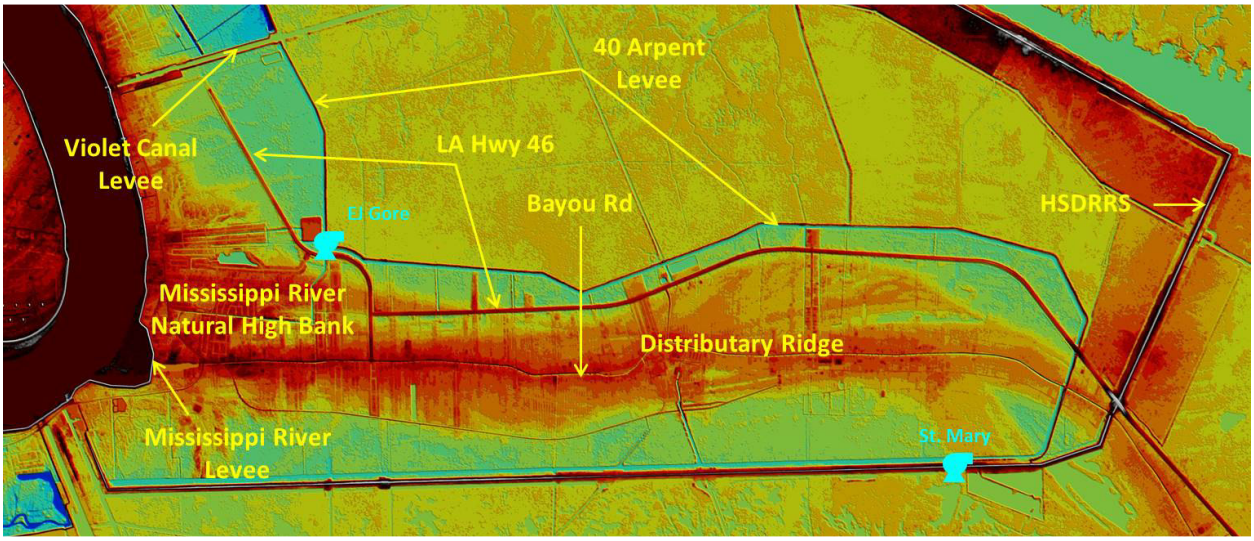
f. St. Bernard Polder

Figure 7.2. LIDAR DEM Topography



g. Upper St. Bernard Polder, Upriver from Violet

Figure 7.2. LIDAR DEM Topography



h. Lower St. Bernard Polder, Downriver from Violet and Bayou Rd Dog-Leg

Figure 7.2. LIDAR DEM Topography

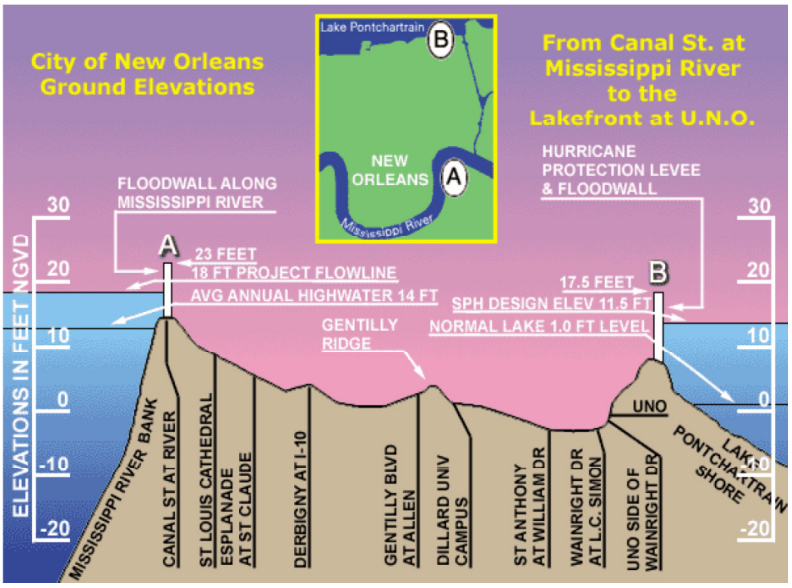


Figure 7.3. Metro Bowl
(Note the Vertical Datum is outdated)
http://www.nola.com/weather/elevationsmap.html

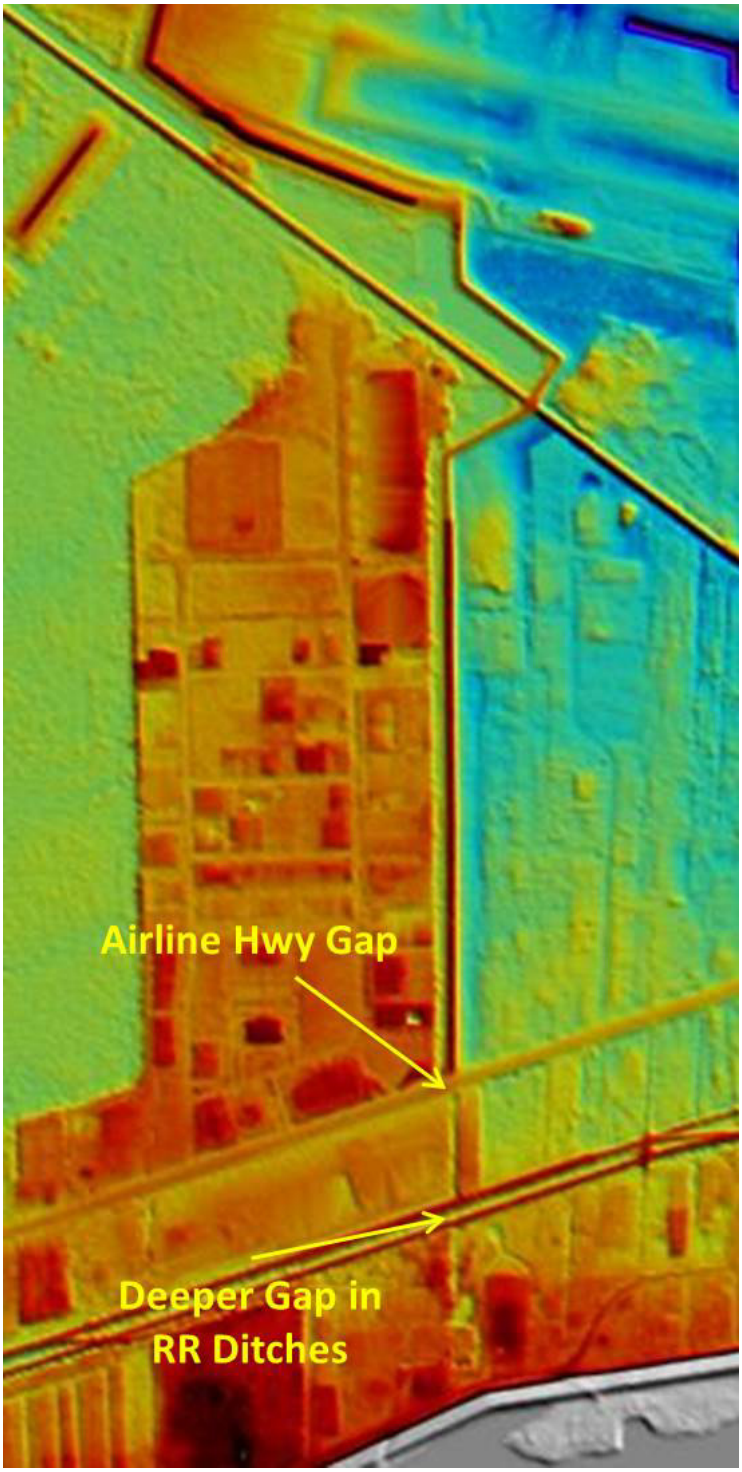
7.1. Metro Polder

Figures 7.1.a - c and 7.2.a - c provide aerial images and topographic maps of the Metro Polder St. Charles, Jefferson, and Orleans Parishes. The total area of the Metro Polder is nearly 70,000 acres, with 19.2, 44.4, and 36.4 percent in each respective parish.

Within the Metro Polder, Jefferson Parish is largely separated from St. Charles Parish to the west and Orleans to the east by legacy levee/floodwalls that run along the parish lines. These parish-line barriers were improved by the USACE during the 1950s but later abandoned with federal construction of the perimeter system enclosing the full polder.[2] LIDAR DEM topographic details and photographs of these legacy levees/floodwalls are shown in Figures 7.4 and 7.5. Both parish-line barriers are generally above 6 ft NAVD88—red is at 6 ft. Both barriers have gaps at US Hwy 61 (Airline Hwy). (Per Footnote 16, the LIDAR DEM topography employed in this Section does not sufficiently resolve barrier crests and gaps. Detailed elevation information on recommended priority compartmentalization features will be addressed in Part IV, Section 14.)

Within the Metro Polder Jefferson and Orleans Parishes have a combined population of almost 464,000, or over 77 percent of the East-Bank total. The two parishes also account for over 80 percent of the owner occupied housing, and the vast majority of the hospitals, schools, colleges, state buildings, care facilities, fire stations, and law enforcement stations.

[2] See USACE, Water Resources Development by the Corps of Engineers in Louisiana, 1955. At that time the USACE was authorized to improve perimeter levees around Jefferson Parish, including the Lake Pontchartrain south shore. Orleans Parish surge protection was not yet part of a federal project. Following Hurricane Betsy (1965) the USACE "Lake Pontchartrain and Vicinity Project" expanded to include the Orleans Parish Lakefront. In the 1980s the Project was again expanded to include eastern St. Charles Parish, establishing the current footprint of the Metro Polder.



a. Detailed Topography

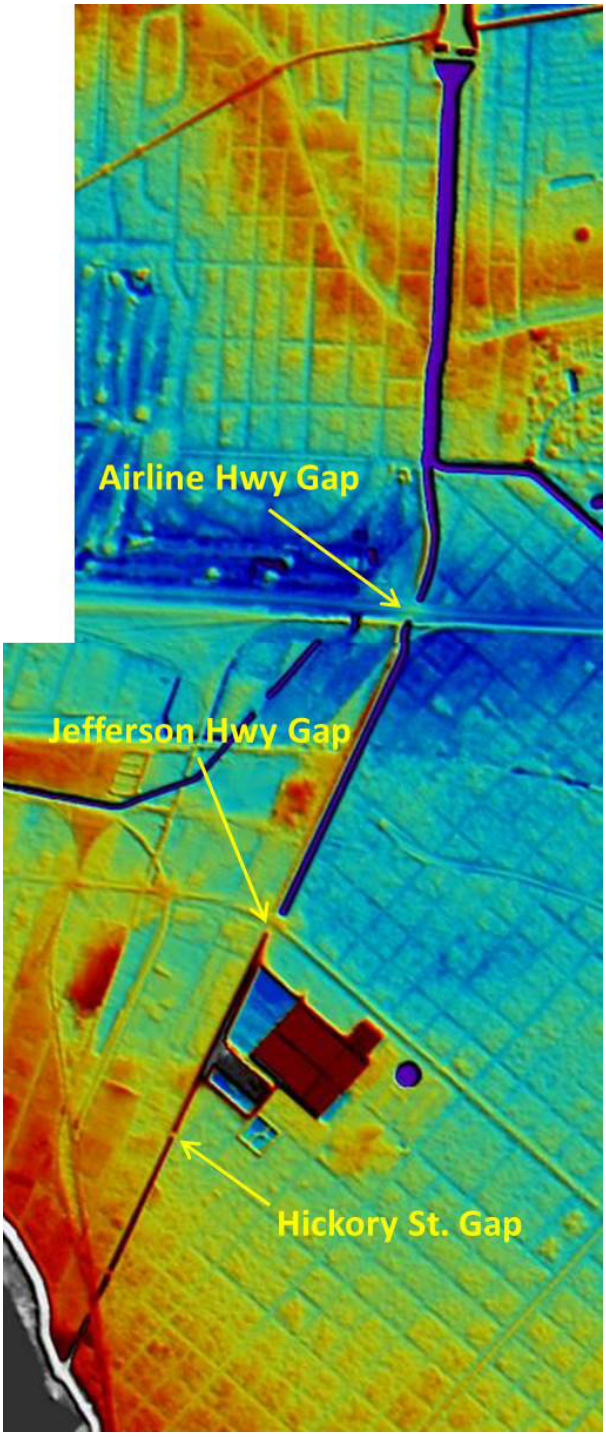
Figure 7.4. EJ/SC Levee/Floodwall

a. Looking North from Near North End of Dixieland Drive, Levee/Sheet Pile

b. Looking North from Airline Hwy, Levee

c. Looking South from Airline Hwy, Sheet Pile

Figure 7.4. EJ/SC Levee/Floodwall

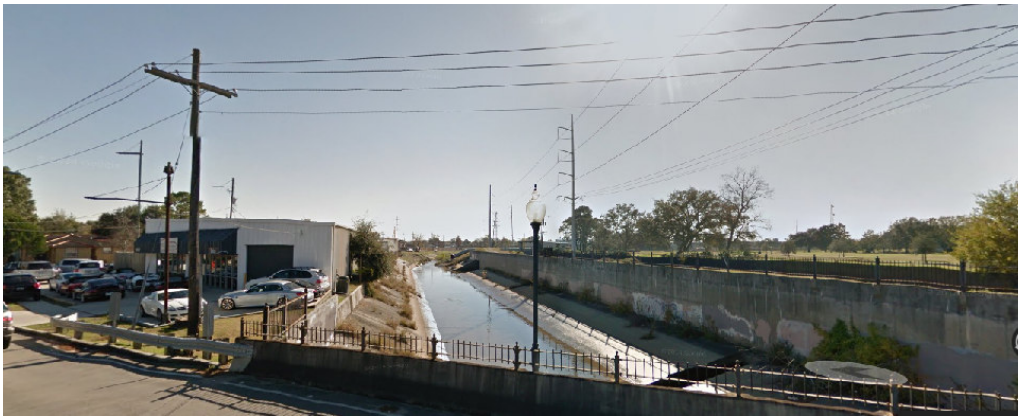


d. Detailed Topography

Figure 7.5. Monticello Levee/Floodwall

e. Looking North; from South of Orleans Parish PS No. 6, Wall

f. Looking North; from South of Metairie Rd Bridge, Wall



g. Looking South, at Palm St. Bridge, Wall

Figure 7.5. Monticello Levee/Floodwall

h. Looking North, from Airline Hwy, Levee

i. Looking South, from Airline Hwy

j. Looking North, from Earhart Expressway, Levee

Figure 7.5. Monticello Levee/Floodwall

k. Looking South, from Earhart Expressway, Levee

l. Looking Southeast, from Jefferson Hwy, Levee

m. Looking South, along Monticello Ave, Levee

Figure 7.5. Monticello Levee/Floodwall

n. Gap at Hickory St

o. Gap at Willow St

p. Gaps at Public Belt Railroad and River Rd

Figure 7.5. Monticello Levee/Floodwall

Along the East Jefferson/St. Charles (EJ/SC) parish line, the EJ/SC Levee/Floodwall begins at the HSDRRS west of Armstrong Airport and terminates about 600 feet south of Airline Hwy, from which point there is no topographic parish-line divide over the remaining 500 feet south to the Mississippi River Levee. According to the DEM, the gap in EJ/SC barrier at Airline Hwy is about 3 to 4 ft NAVD88. A "hump" with a design elevation of about 5 ft NAVD88 was added to Airline Hwy at this location during a recent resurfacing project. South of Airline Hwy the barrier consists of sheet piles, which do not appear on the DEM. Further south, the elevation drops below 2 ft NAVD88 in drainage ditches running parallel with the Kansas City Southern (KCS) and Canadian-Northern (CN) Railroads.

Along the East Jefferson/Orleans (EJ/O) parish line the Monticello Levee/Floodwall extends from the 17th St Canal floodwall to the Mississippi River Levee. Walls in the northern portion are not captured by the DEM. A major gap is present at Airline Hwy (below 0 ft NAVD88)—which allowed flooding across the parish line during Hurricane Katrina. Additional gaps include US Hwy 90 (Jefferson Hwy, below 2 ft NAVD88), and Hickory St. (about 3 ft NAVD88). Gaps at Willow St., the New Orleans Public Belt Railroad, and Louisiana Hwy 611-1 (River Rd), are all above 5 ft NAVD88.

The openings in the two parish line levees/floodwalls provide key routes for very extreme inundations to impact adjacent parishes. Notwithstanding these gaps across the two parish-line levee/floodwalls (and some rainfall drainage flow across the parish lines), these barriers were used by IPET as divisions for polder sub-basins.

St. Charles Parish

Metro St. Charles Parish shown in Figures 7.1.a and 7.2.a is shaped like an elongated semi-circle with pinched corners. The HSDRRS—lying behind the LaBranche Wetlands (and well back from the south shore of Lake Pontchartrain)—forms the northern boundary. The Mississippi River Levee to the south, which becomes the Bonnet Carre Spillway Levee on the west, and the EJ/SC Levee/Floodwall on the east, constitute the remaining perimeter. The natural high ground along the River includes the long-standing unincorporated communities of St. Rose, Destrehan, Ormond, New Sarpy, and Norco. These communities include dense commercial and industrial development.

Away from the river the natural terrain is within a foot or two of LMSL. Absent clearing and filling the low-lying area is occupied by forested swamp. Over one-third of the St. Charles polder area is forested swamp. At the eastern (St. Rose) and western (Norco) corners commercial and industrial development has expanded northward, with many sites in these two areas lying on considerable imported fill, as shown in the topographic map.

Airline Hwy lies just south of the HSDRRS. The highway is itself slightly elevated at generally above 4 ft NAVD88. Along the north side Airline Hwy is the major drainage canal for the parish. Drainage crosses Airline Hwy from the south at numerous culverts. South of and parallel to Airline Hwy is the KCS Railroad embankment, with a general elevation above 3 ft NAVD88 and also with numerous culverts to facilitate south-to-north drainage.

The St. Charles Parish HSDRRS has four gravity drainage channel openings with gates for closure during surge events. At Bayou Trepagnier and Cross Bayou, shown on Figure 7.1.a., the parish operates pump stations with the capacities noted in Table 6.2. The combined pumping capacity is equivalent to about 0.3 ft of water over the entire Metro St. Charles area. (A perimeter pump station is being planned for north of St. Rose.)

At Ormond a large residential development (with some commercial business areas) extends from the Mississippi River northward to Airline Hwy. The development has its own ring levee system, generally above 5 ft NAVD88, and interior drainage. Lift pumps transfer water outside the development, which then flows to Cross Bayou.

Figure 7.1.a illustrates the two main sub-basins within the St. Charles Parish portion of the Metro Polder. Sub-basin SC2 (55 percent of the St. Charles area) includes most of the development along the Mississippi River, at the eastern and western corners, and the Ormond area. Sub-basin SC1 (45 percent of the St. Charles area) includes most of the undeveloped swamp.

The two St. Charles Parish sub-basins have a combined population of less than 26,000, less than five percent of the overall East-Bank polder population. As noted in Table 7.1, the population of SC2 is over twice that of SC1.

Jefferson Parish

Metro Jefferson Parish, shown in Figures 7.1.b and 7.2.b, is bounded by the HSDRRS to the north and west—along the south shoreline of Lake Pontchartrain and from the Lake to Armstrong Airport. The EJ/SC Levee/Floodwall then continues on the western boundary to south of Airline Hwy. Jefferson Parish's eastern boundary with Orleans Parish incudes the 17th St Canal floodwall and Monticello Levee/Floodwall. The Mississippi River Levee forms the Parish's serpentine southern perimeter.

The entirety of the Jefferson Parish portion of the Metro Polder is urbanized, with heavy commercial development along all the major roadways. The four Jefferson sub-basins combine for a population of nearly a quarter million, 41 percent of the East-Bank polder total. The western part of the parish is incorporated as the City of Kenner, which originated on higher ground along the Mississippi River and expanded northwards during the 1900s. In addition to Kenner and Old Metairie two other communities that originated along high ground to the south are River Ridge and Harahan, both unincorporated.

Figure 7.2.b shows that the Metairie Ridge rises several feet above the surrounding grade. This ridge is a remnant natural distributary/bayou bank and topographically isolates the southeast corner of the parish. Development along the ridge is referred to as "Old Metairie." A topographic spur extends northward from the Metairie Ridge, occupied by Bonnabel Blvd. The Sauve Rd crevasse deposit ties into the Metairie Ridge, creating the River Ridge Bowl.

Figure 7.2.b also illustrates that decades of forced drainage (and associated soil oxidation and compaction) have caused ground elevations in the northern part of the Parish (former swamp) to subside to below -5 ft NAVD88 in some locations. Several man-made embankments have elevations a few feet above the surrounding grade, including the east-west Interstate 10, Airline Hwy, and the KCS and CN Railroads, and the north-south Causeway Blvd.

The Metro Jefferson Parish sub-basins are shown on Figures 7.1.b. The percentages of area in sub-basins OM4, JE1, JE2, and JE3 are 7, 25, 18, and 50, respectively.

The OM4 sub-basin south of the Metairie Ridge is hydraulically isolated from the rest of Jefferson Parish and referred to as the Hoey Basin. The Hoey Basin drains to the main Orleans Parish pumping station (Station No. 6) at the head of the 17th St Canal. An alternative "pump to the Mississippi River" plan for the Hoey Basin has been proposed but has not been funded for further evaluation.

Outside of Hoey Basin the Parish implements forced drainage largely via a grid of open canals that convey storm water to the six perimeter pump stations listed in Table 6.2 and shown on Figures 7.1.b. and 7.2.b. Drainage for some neighborhoods is supplemented by lift pumps. For convenience the area outside of Hoey Basin is divided between the portion south (JE1) and north of Airline Hwy, with the northern part further divided into eastern (JE2) and western (JE3) sub-basins by the Suburban Canal. The divisions between JE1, JE2, and JE3 are somewhat artificial as there is essentially one interconnected network of drainage canals. The total current capacity of the six perimeter pump stations is over 40,000 acre-ft/day, equivalent to removing 1.4 ft of water over all of sub-basins JE1, JE2, and JE3 in 24 hours. By comparison, in Section 5.1 a Class D inundation event was described as having a volume in excess of 10,000 acre-ft.

A SELA project is presently underway to expand forced drainage capacity for the River Ridge-Harahan area. The project includes a new 1,200 cfs (2,380 acre-ft/day) "pump-to-the-River" station and enhanced local drainage conveyance.

Orleans Parish

Figures 7.1.c and 7.2.c depict the Orleans Parish portion of the Metro Polder. Metro Orleans Parish is bounded by the Monticello Levee/Floodwall on the west, the HSDRRS to the north (along the Lake Pontchartrain shoreline), the IHNC Basin floodwalls on the east, and the Mississippi River Levee with adjacent natural high ground on the south.

Figure 7.2.c. shows that two major features run east-to-west through Metro Orleans Parish: one natural—the Gentilly Ridge—and one man-made—the Norfolk-Southern (NS) Railroad. The two features cross just west of the London Ave Canal, with the NS Railroad lying to the north/south of Gentilly Ridge west/east of the canal. The Ridge is generally above 3 ft NAVD88 and is traditionally considered a major hydrologic divide in the Parish. As shown on Figure 7.1.c., it forms the boundary between sub-basin OM1/2 to the north and OM3/5 to the south. However, Figure 7.2.c shows the Ridge has been carved by numerous streets at slightly lower elevations.

West of the Gentilly Ridge the NS Railroad is a higher divide, generally above 5 ft NAVD88. However, the railroad has seven major road underpasses: Interstate 10, Canal Blvd, Marconi Drive, Golf Cart Path (Henry Thomas Drive), St. Bernard Ave, Paris Ave, and at Gentilly Blvd itself. Figure 7.6 shows the Marconi Ave underpass.

East of the Gentilly Ridge the NS Railroad has underpasses at North Broad St and, paralleling Florida Ave, at Elysian Fields and Franklin Aves—before crossing the IHNC and heading into St. Bernard Parish. Elevations along Florida Ave are below 1 ft NAVD88 in spots. Between Elysian and Florida Aves the eastbound CSX Railroad forks off to the north, with only slight elevation above the very low terrain bowl north of Florida Ave and west of Peoples Ave. East of Peoples avenues the CSX Railroad rejoins the Gentilly Ridge and then heads east into NO East alongside the Chef Menteur Hwy.

East of Franklin Ave a northerly and a southerly track each split off from the St. Bernard bound NS Railroad. A NS Railroad branch heads north, crosses the CSX Railroad, and proceeds to the Orleans Lakefront, turning east to the NO East Lakefront. This NS track has an elevation largely above 5 ft NAVD88 and has underpasses at Gentilly Blvd and the Press Drive. A south NS spur to the Mississippi River has elevations near Florida Ave below 1 ft NAVD88 but rises toward the River.

Figure 7.6. Marconi Drive Underpass of NS Railroad
Google Earth

In addition to higher Mississippi River banks and Gentilly Ridge, Figure 7.2.c shows the raised ground along the Lakefront associated with the massive fill that accompanied construction of the seawall in the 1930s. The areas north of the Gentilly Ridge and south of the Lakefront are the lowest in the East-Bank due to prolonged forced drainage. Ground elevations in some locations drop to below -8 ft NAVD88.

The banks of Bayou St. John form a natural north-south divide of the area lying between the Gentilly Ridge and the Lakefront, with the eastern and western areas noted as sub-basins OM1 and OM2 on Figure 7.1.c. These banks are typically no higher than 2 ft NAVD88.

OM2 is further divided by the much higher north-south levees/floodwalls along the Orleans Ave Canal. The western half of OM2 includes the Lakeview neighborhood, decimated during Katrina by the 17th St Canal breach. The eastern half of OM2 is largely occupied by City Park.

The OM1 sub-basin—largely referred to as Gentilly—is sub-divided into three parts by two north-south features: the levees/floodwalls along the London Ave Canal and the northerly (NO East bound) NS Railroad track.

The Esplanade Ridge divides the area south of the Gentilly Ridge into sub-basins OM3 and OM5. OM3 includes the neighborhoods east of Esplanade Ave, such as Marigny and Bywater. Within OM3 the NS southerly spur is a minor divide.

OM5 is the largest of the five sub-basins, and encompasses the French Quarter, the Central Business District, the Warehouse District, the Garden District, and the Treme and Mid-City neighborhoods. OM5 includes minor topographic divides along:

- Lafitte St (the former banks of a canal) which extends north from the French Quarter to the head of Bayou St. John;
- The Pontchartrain Expressway Corridor road and railroad embankments; and
- Carrollton Ave.

The Broadmoor topographic bowl in the center of OM5 has elevations falling below -3 ft NAVD88.

The percent of Metro Orleans Parish for sub-basins OM1, OM2, OM3, and OM5 are 20, 16, 19, and 45, respectively.

Figures 7.1.c and 7.2.c show locations for the Orleans Parish seven perimeter pump stations listed in Table 6.2. Interior drainage conveyance in Orleans Parish is accomplished with a combination of pipelines, lift stations, and canals (many covered). As can be seen from Table 6.2, the Orleans pump station drainage areas do not correspond with sub-basin limits. The pump stations at the head of the 17th St and Orleans Ave are north of the Gentilly Ridge and drainage to the pump stations necessarily crosses the Ridge. The head of the London Ave Canal is south of the Ridge. The 17th St., Orleans Ave, and London Ave pump stations discharge nearly all the runoff from south of the Metairie-Gentilly Ridge –including western OM3, OM4 (in Jefferson Parish), and all of OM5—plus some areas north of the Ridge. Backflow through drainage conveyances crossing the Gentilly Ridge and other natural and man-made embankments resulted in the inundation of all areas in Orleans Parish below 2 ft NAVD88 during Hurricane Katrina.

The seven Metro Orleans perimeter pump stations have a combined capacity of over 50,000 acre-ft/day, equivalent to removing 1.8 ft of water over all of sub-basins OM1, OM2, OM3, OM4, and OM5 in 24 hours.

The entire Orleans Parish area is densely urbanized, with heavy commercial development along all major roadways. The parish population is nearly 220,000, or 37 percent of the East-Bank polder total.

7.2. NO East Polder

Figures 7.1.d and 7.2.d show the geography and topography of the nearly 35,000 acre NO East Polder, the only one of the three East-Bank polders not to include the Mississippi River on its perimeter. The HSDRRS, including the IHNC Basin floodwalls, bounds the entire NO East perimeter. The polder is divided by the Maxent Levee, with the eastern 57 percent being largely undeveloped. Figures 7.1.e and 7.2.e show the geography and topography of the western, more developed 43 percent of the NO East Polder in greater detail.

The major topographic high within NO East is the Sauvage Ridge running lengthwise through the polder. This ridge is the eastern extension of the Metairie-Gentilly Ridge in the Metro Polder. Elevations along this topographic feature generally exceed 2 ft NAVD88. Portions of the Sauvage Ridge are occupied by US Hwy 90 (Chef Menteur Hwy) and the slightly higher CSX Railroad embankment. The NO East Polder perimeter has some areas with relatively higher elevation, associated with filling along the Lake Pontchartrain shoreline and the banks of the IHNC and GIWW.[3]

From the HSDRRS at Lake Pontchartrain southward to near Lake Forest Blvd, the Maxent Levee lies along the east side of Louisiana Hwy 47 (Paris Rd). From that point the levee runs eastward for slightly over two miles, and then southward for about 0.4 miles, re-connecting with the HSDRRS at the head of the Michoud Canal. Figure 7.7 shows a Google Earth street level image of the Maxent Levee. The Maxent Levee crown ranges from 2 to over 5 ft NAVD88, well above the surrounding grade.

[3] The branch of the NS Railroad coming from Metro Orleans includes a raised embankment, generally above 6 ft NAVD88, along the south shore of Lake Pontchartrain just *outside* and parallel to the HSDRRS (not visible at the scale of Figures 7.2 and 7.5). This embankment is credited as a wave breakwater in the 2011 *DER*.

Figure 7.7. Maxent Levee, Looking East at Michoud Blvd
Google Earth

Figure 7.2.b shows that developed part of the polder—west of the Maxent Levee—is divided into three sub-basins:

- NOE3 has the Maxent Levee to the north and east and Paris Rd to the west;
- NOE4 is the area west of Paris Rd and south of the Bayou Sauvage Ridge.
- NO5 is the area west of Paris Rd and north of the Bayou Sauvage Ridge.

The overall population of NOE3, 4, and 5 is slightly over 10 percent of the East-Bank total. NOE5 is largely residential/commercial, with the sub-basin accounting for the bulk of the NOE East population and community resources.

Drainage in NOE5 is similar to northern Jefferson Parish, with a network of open canals feeding four perimeter pump stations, shown on Figures 7.1.e and 7.2.e. The four NOE5 pumps together have a capacity of 6,500 acre-ft/day, equivalent to 0.7 ft of runoff in 24 hrs. As with the other areas, forced drainage has lowered ground elevations in NOE5, with some locations below -7 ft NAVD88. Within NOE5 Downman Rd and Interstate 10 are two modest man-made hydrologic barriers. Major neighborhood communities in NOE5 include Little Woods (north of Interstate 10), Lake Forest, Read Blvd-East and –West, and West Lake Forest.

NOE4 development is mostly industrial. Forced drainage for NOE4 is via three pump stations, at about 1,500 acre-ft/day combined capacity, to the IHNC Basin.

NOE3 is divided into a southern industrial versus a northern residential/commercial portion. Village de L'Est—a predominantly Vietnamese American community—constitutes the bulk of the residential area. Drainage in northern NOE3 is to NOE2 via the Maxent Pump Station with a capacity of about 120 acre-ft/day.

The area east of the Maxent Levee is further divided by the Bayou Sauvage National Wildlife Refuge (BSNWR) Levee. The Refuge—a federally protected wetland—lies east of the BSNWR Levee and occupies 41 percent of the total NO East Polder. The Refuge constitutes sub-basin NOE1. The US Fish

and Wildlife Service manages the impounded wetland to enhance a range of fresh to brackish habitats.[4] This is supported by controlling water levels and circulation with the aid of pumps, with water levels generally kept slightly above LMSL.

The remaining drainage area east of Maxant Levee, west of the BSNWR Levee and south of Interstate 10, is sometimes called the Maxent Lagoon and includes the small community of Oak Island. The Maxent Lagoon area—NOE2—receives drainage from NOE3 (via the Maxent Pump Station) and is in turn drained by the 1,500 acre-ft/day capacity GIWW Pump Station.

Water levels west of the Maxent Levee—in NOE3, NOE4, and NOE5—are maintained lower than east of the Maxent Levee—in NOE1 and NOE2. Because the Maxent Levee prevents higher 100-yr rainfall water levels in NOE1 and NOE2 from entering NOE3, NOE4, and NOE5, NFIP accreditation of the Maxent Levee is required.[5]

7.3. St. Bernard Polder

The roughly 50,000-acre St. Bernard Polder, depicted in Figures 7.1.f and 7.2.f, is bounded by the Mississippi River Levee and HSDRRS—with the IHNC Basin on the west and northwest, the MRGO (now blocked) and Lake Borgne on the north, and the Biloxi, Delacroix, and Caernarvon marshes spanning from the northeast to the south (see Figure 6.2). A principal feature of the St. Bernard Polder is the 23-mi man-made 40 Arpent Levee/Floodwall, separating Central Wetlands from the developed areas (see photograph in Figure 7.8). The Orleans-St. Bernard parish line, shown in Figure 7.1, is near the west end of the polder. Inside the 40 Arpent Levee the boundary is perpendicular to the River—with the National Guard Jackson Barracks along the Orleans side. In the Central Wetlands the parish line follows Bayou Bienvenue.

Natural topographic high land within the polder consists of the Mississippi River banks, crevasse deposits at Chalmette surrounding the southern portion of Paris Rd, and a 7-mile ridge extending due east away from the River at Poydras, near the polder's southernmost point. This ridge is occupied by LA Hwy 300 (Bayou Rd).

The Central Wetlands—lying between the 40 Arpent Levee/Floodwall and the HSDRRS—constitutes 60 percent of the polder area. The Central Wetlands is divided by the Paris Rd embankment, with the two sides designated as separate sub-basins SB2 and SB5. Water flows under Parish Rd between the two sub-basins of the Central Wetlands at the Bayou Bienvenue Bridge. A small area of commercial and residential development is present in the Central Wetlands area along Parish Rd. Water exits from the Central Wetlands via gates at Bayou Bienvenue and Dupre. Decades of impoundment, soil mineral and nutrient depletion, and occasional salt-water intrusion have degraded the swamp forests in the Central Wetlands. The area is the subject of several restoration efforts.[6]

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[4] See BSNWR Comprehensive Conservation Plan, August 2009. http://www.fws.gov/southeast/planning/PDFdocuments/BayouSauvageFinal/Bayou%20Sauvage%20Final%20CCP%20FOR%20WEB.pdf

[5] SLFPA-E has retained Tetra Tech to assist with preparing an evaluation report on the Maxent Levee. The BSNWR Levee is not relied upon for flood protection for NOE2 and therefore is not subject to accreditation.

[6] See the USACE MRGO Ecosystem Restoration Feasibility Study (http://www.mrgo.gov/MRGO_restoration_study.aspx); Central Wetlands Assimilation Project under the Coastal Impact Assistance Program

Figure 7.8. 40 Arpent Canal, Levee/Floodwall, and Bayou Villere Pump Station
Google Earth

The 40 Arpent Levee/Floodwall, with an elevation generally above 9 ft NAVD88, was constructed parallel to the Mississippi River decades prior to the HSDRRS to protect a 1.5 to 2-mile wide strip of development. Near its southern end the 40 Arpent Levee/Floodwall makes a "dog-leg" east and runs parallel with the Bayou Rd Ridge, creating (with the HSDRRS to the south) a second 1.5-mile strip of protected area perpendicular to the River. Between Paris Rd and the Bayou Rd "dog leg," the 40 Arpent Levee/Floodwall joins the levees along the northern and southern banks of the 200-ft wide Violet Canal, which effectively divides the polder into an Upper and Lower part. The canal provides access to Bayou Dupre (and Lake Borgne and the adjacent coastal waters) for commercial fishing and other vessels staged in the community of Violet.

Figures 7.1.g and h zoom into the geography of the developed portion of the polder upriver and downriver from Violet. The Orleans Parish portion, at the far upriver end, includes the Lower 9th Ward and Holy Cross neighborhoods. Downriver in St. Bernard are the unincorporated communities of Arabi, Chalmette, Meraux, and Violet. The unincorporated community of Poydras is located on the River at the head of the Bayou Rd Ridge.

As depicted in Figure 7.2.g, the developed area slopes from the River toward the 40 Arpent Levee, with interior elevations dropping to below -3 ft NAVD88 in some locations due to decades of forced drainage. Figure 7.1.h details the Bayou Rd Ridge topography. In addition to Bayou Rd, LA Hwy 46, which runs the length of the dog-leg, is a major embankment with a crest generally above 5 ft NAVD88.

Figures 7.1.f - h show that the developed portion of the St. Bernard Polder is divided into three sub-basins, with Paris Rd and the Violet Canal forming the boundaries. SB1—from the IHNC to Paris Rd—contains no raised drainage divide at the Orleans and St. Bernard parish line. However, just to the east, in Arabi, an embankment for a local spur of the NS railroad effectively divides SB1 into two parts. The initial flooding from the floodwall collapse breach along the IHNC east-bank during Hurricane Katrina

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http://www.slfpae.com/presentations/2014%2002%2020%20-%20Coastal%20Restoration%20&%20Protection%20Projects%20-%20CPRA.pdf

(early on the morning of August 29) was contained by this embankment, causing inundation to rapidly rise in the Lower 9th Ward. The sub-basin between Paris Rd and the Violet Canal is SB3 and the one below Violet Canal, which includes the Bayou Rd dog-leg, is SB4.

The developed portion of the St. Bernard Polder drains to nine pumping stations along the 40 Arpent Levee, which in turn discharge into the Central Wetlands. The pump stations are listed in Table 6.2 and shown in Figures 7.1.g and h and 7.2.g and h. For the St. Bernard Polder, the forced drainage areas generally correspond with the three sub-basins. Within St. Bernard Parish, a continuous canal is present just inside the 40 Arpent Levee (see Figure 7.8), allowing sub-basin pump stations to work together.[7]

Sub-basin SB1 has four pump stations with a total capacity of over 9,600 acre-ft/day. With little wetland storage, the capacity of the SB1 pumps is fairly high, equivalent to 1.9 ft of runoff in 24 hours. Sub-basin SB3, with some wetland storage, has three pump stations with a capacity of nearly 5,500 acre-ft/day, or about 1 ft of runoff per day.

Sub-basin SB4's two pump stations total almost 3,000 acre-ft/day. The relatively large area for runoff storage compared to the developed area along the Bayou Rd Ridge translates into a lower required runoff capacity for the sub-basin—less than 1/3rd ft in 24 hours. Within sub-basin SB4 the storage areas north and south of Bayou Rd Ridge have limited interconnection—with the principle connection being at the far east end of the perimeter 40 Arpent Canal. Similarly, the 40 Arpent Canal at the dog-leg corner, near at the EJ Gore Pump Station, provides limited hydraulic connection between the area south of the Violet Canal and the dog-leg.

The impounded water levels in the Central Wetlands are typically slightly above LMSL. During extreme rainfall events the Central Wetlands water level can rise by a foot or more, with both direct rainfall and the discharge received from the pump stations. Because water levels inside the 40 Arpent Levee are normally kept below LMSL, the 40 Arpent Levee/Floodwall—like the Maxent Levee in the NO East Polder—requires NFIP accreditation.

The three developed sub-basins in the St. Bernard Polder have a population of close to 43,000, or 7 percent of the East-Bank total.

[7] A gate underneath Paris Road allows regulation of 40 Arpent Canal flow between the St. Bernard Parish pump stations in SB1 and SB3. The Violet Canal totally separates pumping in SB3 and SB4.

8. Previous Assessments of Compartmentalization

This section reviews the treatment of compartmentalization in six recent post-Katrina regional studies of East-Bank flood risk management:

1. The 2009 IPET Report, Volume VIII - Engineering and Operational Risk and Reliability;
2. The 2009 USACE Louisiana CPR Report;
3. The 2012 CPRA Louisiana's Comprehensive Master Plan for a Sustainable Coast;
4. The series of reports and presentations documenting proposals and investigations sponsored by the Flood Protection Alliance (FPA);
5. The 2013 Greater New Orleans Urban Water Plan, sponsored by GNO Inc.; and
6. The 2014 Systems Engineering Based Assessment of The Greater New Orleans Hurricane Surge Defense System Using the Multiple Lines-of-Defense Framework, sponsored by the Lake Pontchartrain Basin Foundation (LPBF).

8.1. IPET Report—Volume VIII

As discussed in Section 5.3, the 2009 IPET Volume VIII report examined residual polder surge inundation risk, including an estimate of the *Nominal** 500-yr polder surge inundation. While the estimate entailed several crucial limitations,[8] it did make use of the sub-basin divisions shown in Figure 3.4 and described in Section 7. Figure 5.3, depicting the IPET *Nominal** 500-yr polder inundation depth, gives some indication of the influence of major compartmentalization features:

- In Metro St. Charles Parish the internal features appear to have no role in affecting the *Nominal** 500-yr inundation hazard. This is attributable to St. Charles Parish's high vulnerability to overtopping inflows for this region (see Table 4.2).
- In Metro Jefferson Parish the *Nominal** 500-yr inundation hazard is being affected by the Metairie Ridge, Airline Hwy (and adjacent railroad) embankments, the fill along the west-bank of the Suburban Canal, and the Sauve Rd crevasse high ground.
- In Metro Orleans Parish, the *Nominal** 500-yr hazard inundation is limited to a few low "bowl" areas influenced by the Metairie/Gentilly Ridge, Bayou St. John, and other areas of relatively high ground. Importantly, the IPET *Nominal** 500-yr surge inundation footprint reflects significant underestimation of true 500-yr inflows.
- The gaps in the EJ/SC Levee/Floodwall and the Monticello Levee/Floodwall influence IPET's *Nominal** 500-yr surge inundation.
- In the NO East Polder, the Maxent Levee and the Chef Menteur Hwy both impact the *Nominal** 500-yr inundation hazard.
- In the St. Bernard Polder, the 40 Arpent Levee, the NS Arabi embankment, Paris Rd crevasse high ground, the Violet Canal Levee, and Bayou Rd affect the *Nominal** 500-yr inundation hazard.

[8] The IPET *Nominal** 500-yr inundation hazard is affected by underestimation of exterior 500-yr surge SWLs and overtopping, as well as use of a narrow range of inundation scenarios.

8.2. USACE Louisiana CPR Report

As noted in Section 5.3, the USACE's 2009 LaCPR Report investigated inundation levels for the "makeshift" case of an event with exterior Nominal 1,000-yr SWLs at *all points on the HSDRRS perimeter*.[9] Inundation associated with this "makeshift" case considered HSDRRS overtopping around the perimeter—without breaching—and computed water levels for each IPET sub-basin. The inundation for this "makeshift" case is presented in Figure 8.1.[10] Figure 8.1 shows several interior features influence this inundation case, including the Sauve crevasse deposits and the Metairie/Gentilly Ridge.

The figure shows an erroneous break in the inundation along the EJ/SC parish line—jumping from flood elevations of 15 ft NAVD88 in St. Charles Parish to 3 ft in Jefferson Parish. The LaCPR analysis failed to allow for the proper inter-basin flow at the gaps in the EJ/SC Levee/Floodwall. The figure does illustrate that under a case of extreme inundation in St. Charles Parish, eliminating these gaps could significantly reduce Jefferson Parish flooding.

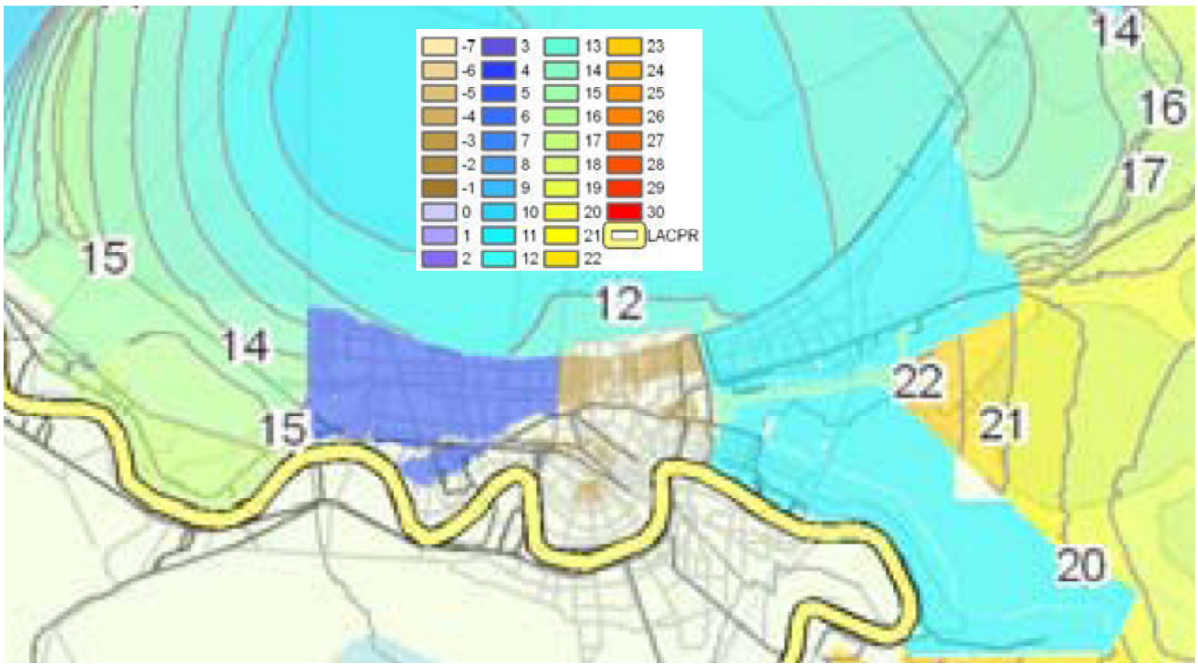

Figure 8.1. Psuedo-1,000-yr Surge Inundation
USACE 2009

[9] A case with the same return period SWL all around the HSDRRS is *very much rarer* than that return period indicates. The LaCPR used a case with complete perimeter 1,000-yr SWLs (as well as ones for 100- and 400-yr because they were convenient for "planning-level" comparisons of protection and restoration alternatives. Actual inundation hazards require a more detailed joint probability analysis using hundreds of storms.

[10] Overtopping of the HSDRRS was computed as a function of a surge hydrograph with the 1,000-yr SWL as the peak. The duration (and volume) of overtopping at each reach was a function of how much the SWL exceeded the reach crest.

8.3. Louisiana CPRA Master Plan

The 2012 CPRA Master Plans for coastal protection and restoration proposed that the New Orleans urban area should be protected from 500-yr surge hazards. The 2012 Plan included upgrading the HSDRRS as well as coastal restoration projects (as discussed above Section 6.3). The Plan also identified the NO East Land-Bridge Barrier for further investigation.

CPRA's development of the 2012 Master Plan included the ARCADIS/Rand tool described in Section 5.3 to facilitate the analysis of surge hazard/risk reduction for proposed coastal projects. This tool incorporates sub-basins within the three East-Bank polders, as delineated by IPET, to assess interior inundation hazard/risk effects for regional projects. However, none of the proposed projects simulated for the 2012 Master Plan involved inundation of the three East-Bank polders.

CPRA did not list any compartmentalization projects for East-Bank surge risk reduction as part of the Master Plan. For the 2017 Master Plan, CPRA is currently expected to continue its focus on coastal restoration and HSDRRS improvements for reducing East-Bank surge risk and not address polder compartmentalization projects.

8.4. Flood Protection Alliance Reports

The FPA was formed as a non-profit organization in 2006 during the Hurricane Katrina recovery by a group of East-Bank individuals. FPA's objective is to promote cost-effective solutions to East-Bank residual polder flood risks from surge, rainfall, and the Mississippi River. The FPA—which succeeded a technical committee of the informal working group Bring New Orleans Back (BNOB)—has provided strong regional leadership in urging a thorough examination of compartmentalization opportunities.

In March 2006 BNOB published a brief paper on compartmentalization options for the three East-Bank polders. The paper noted four major railroad embankments which could have significantly reduced Katrina inundation, had they been improved to remove gaps. These embankments (see figures in Section 7) include:

- The east-west NS line across the southern end of OM2 and the west and central parts of OM1;
- The north-south NS line between the east and central parts of OM1;
- The NS spurs in OM3 and SB1;
- The CSX Railroad line parallel to the Chef Menteur Hwy separating NOE4 and 5, which is typically the highest alignment along the Bayou Sauvage Ridge.

The paper discussed the need for closure mechanisms in stormwater conveyances passing under the embankments, as well as construction of "U-shaped" berms at underpasses as depicted in Figure 8.2. In addition to railroad embankments, the paper discussed enhancing the Monticello Levee/Floodwall as a compartmentalization barrier, with closures at Airline and Jefferson Hwys, and railroad openings.

During 2007, the FPA reiterated these compartmentalization opportunities in a stakeholder submittal to the USACE (associated with the LaCPR Study), adding the Pontchartrain Expressway Corridor as another key feature in the Orleans Parish part of the Metro Polder.

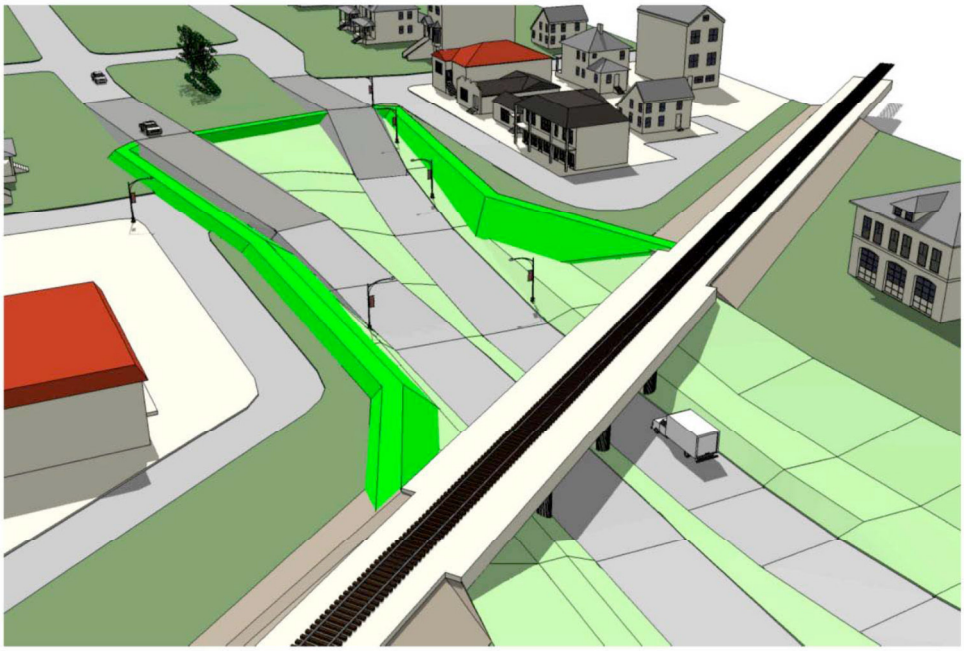

Figure 8.2. U-Shape Berm for Preventing Flow at Railroad Underpass
Flood Protection Alliance 2007[11]

In 2009 FPA retained Royal Haskoning to model the effect of using the above railroad embankments for compartmentalization in Metro Orleans Parish. Royal Haskoning separately modeled inundation resulting from inflows at two locations—West End (on the east bank near the mouth of the 17th St Canal) and along the IHNC (south of the Gentilly Ridge). The inflows were simulated with boundary stage hydrographs and breach lengths and inverts. The inflow volumes for 200 ft breaches at the two locations, without barrier upgrades, were on the order of 30,000 to 37,000 acre-ft, respectively, or a large Class D inundation.

Simulations were then conducted with the above railroad embankments modified to be continuous (without gaps) at elevation 4 ft NAVD88. As shown in Figure 8.3 the compartmentalization features significantly reduced the area of inundation but significantly increased inundation depths within the confinement area. The upgraded barriers reduced the inflow volumes by over 55 percent. The two breaches were also repeated with the barriers at 3 ft NAVD88, which resulted in less containment. A 400 ft breach was also simulated at West End, producing a Class E 57,000 acre-ft inundation without barriers, but only a 40 percent inflow reduction with 4 ft NAVD88 barriers.

In 2009, as a result of reviewing the USACE's LaCPR inundation risk information, the FPA also began urging consideration of enhancing the EJ/SC Levee/Floodwall as a compartmentalization feature.[12] The FPA became a strong proponent of studying measures to eliminate the gap at Airline Hwy and extending the EJ/SC Levee/Floodwall to the Mississippi River Levee.

[11] The "U-shaped" (in plan view) berm connects to the railroad embankment on either side of the underpass, crossing the road at some short distance from the underpass. The berm crest is the same as the railroad embankment. The grade of the road rises to the crest of the berm, crossing it at the base of the "U." The roadway distance from the underpass to the berm is dictated by road grade, right-of-way, cost, and other considerations.

[12] As noted in Section 8.2 the LaCPR's inundation scenarios do not accurately represent true hazard cases. However, these scenarios do point to Jefferson Parish's vulnerability to inundation via St. Charles Parish.

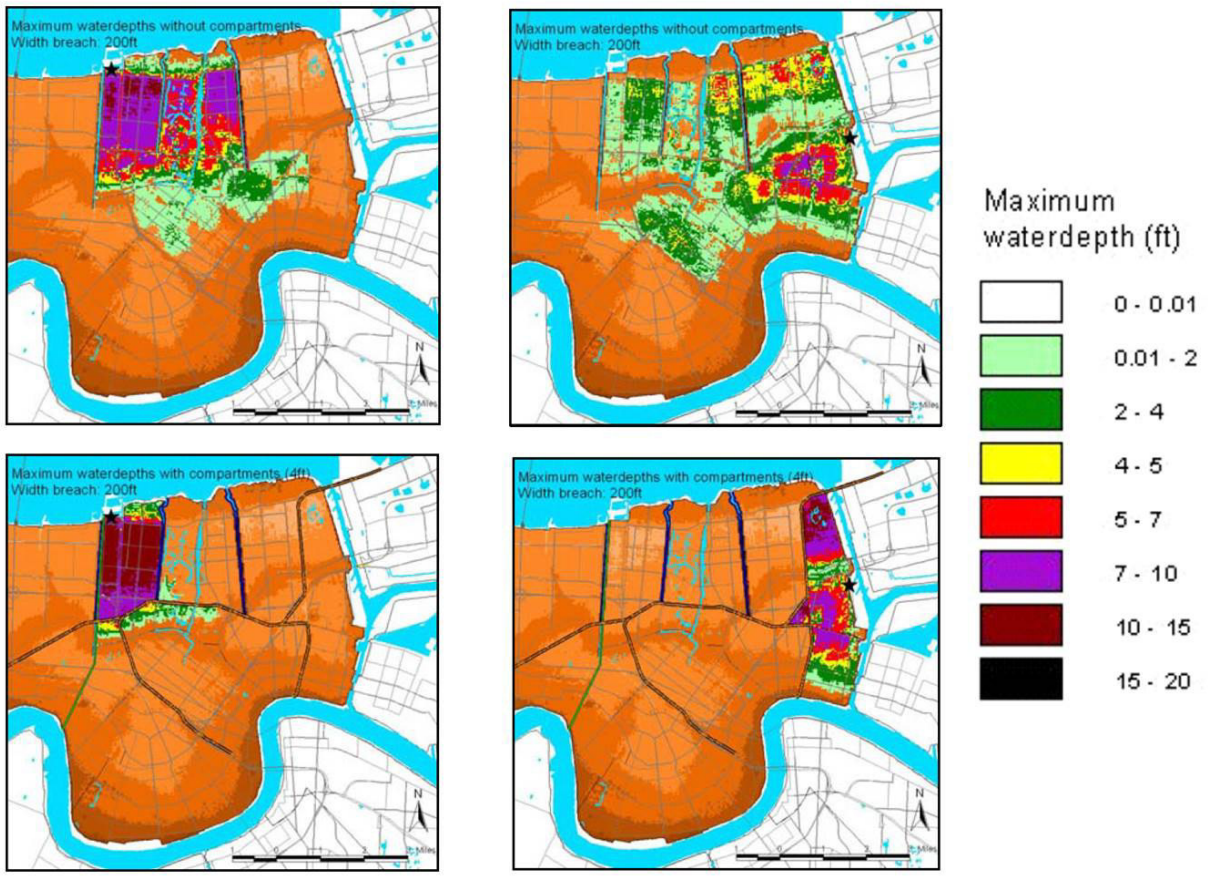

Figure 8.3. Inundation Without versus With Upgraded Railroad Embankments
(Figures on left and right are for West End and IHNC breaches, respectively; top figures are Without Upgrade.)
Flood Protection Alliance 2007[13]

8.5. GNO Urban Water Plan

In 2013 Waggonner and Ball completed an Urban Water Plan for Metropolitan New Orleans, sponsored by GNO, Inc. (the regional chamber of commerce). The primary focus of the plan was reducing rainfall flood risks within the polders, particularly on improving the storage and reuse of runoff as an alternative to additional conveyance and pumping. The Plan recognized basins and sub-basins as critical planning scale units, including key internal dividing features such as the Metairie/Gentilly Ridge and the Violet Canal. The Plan specifically called for making use of sub-basins—as well as subsidiary districts and even block-level features—to increase local retention and environmental/recreational/aesthetic use of runoff. Figure 8.4 taken from Plan illustrates the various scales of runoff management features discussed.

[13] The "U-shaped" (in plan view) berm connects to the railroad embankment on either side of the underpass, crossing the road at some short distance from the underpass. The berm crest is the same as the railroad embankment. The grade of the road rises to the crest of the berm, crossing it at the base of the "U." The roadway distance from the underpass to the berm is dictated by road grade, right-of-way, cost, and other considerations.

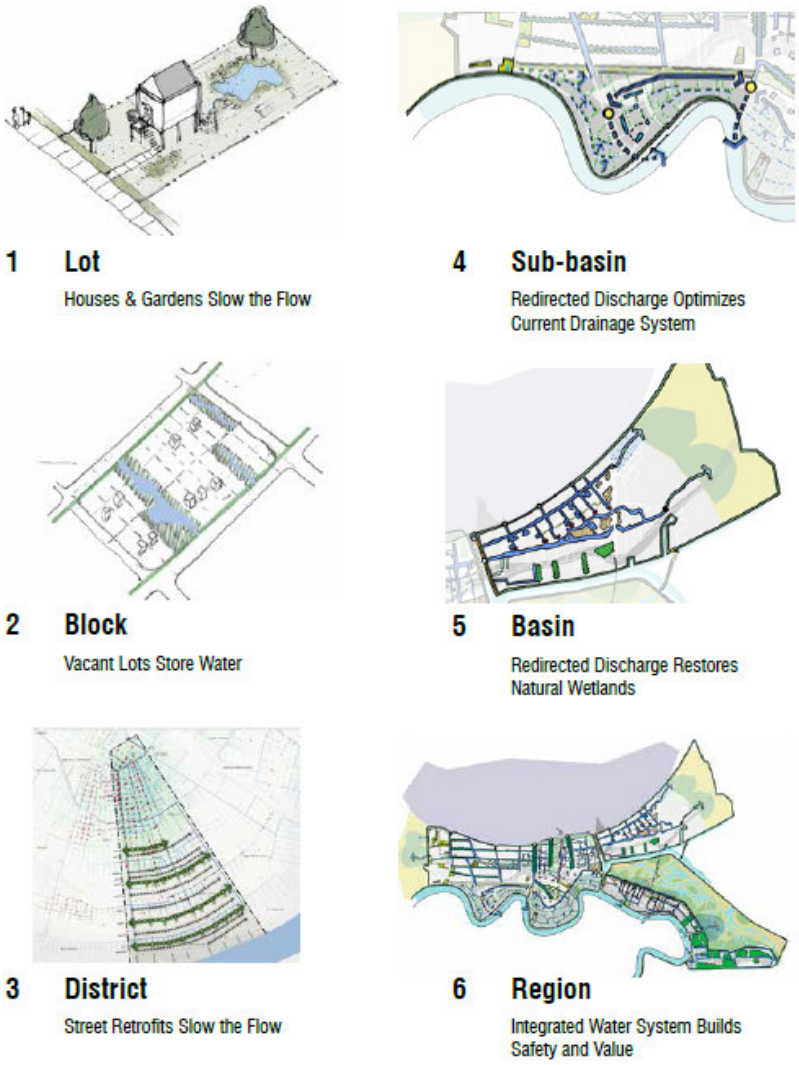

Figure 8.4. Various Scales for Rainfall Runoff Planning
Waggoner and Ball, 2013

The Plan did not examine the role of sub-basin and smaller scale features in residual surge inundation hazards/risks or the implications of such a role in optimizing plans for modifying and enhancing the various features. The Plan is an indication that any consideration of interior features for use in compartmentalization will need to address other important water management goals.

8.6. LPBF MLOD System Assessment

In 2014 the LPBF completed a review of East-Bank surge risk management, employing the MLOD strategy (shown in Figure 6.1) as a framework for defining a *complete risk reduction system*. The LPBF held a series of workshops, featuring a diverse group of professionals, to:

1. Develop a comprehensive inventory of MLOD System physical components, encompassing
   - key exterior elements—both natural (ridges, wetlands, etc.) and man-made (embankments which act as barriers to surge, evacuation routes, etc.);

- the perimeter HSDRRS;
- the interior drainage; and
- interior non-structural measures to reduce consequences (building codes, flood insurance, etc.).

2. Identify the full range of MLOD System organizational responsibilities and operations (i.e., behavioral components) associated with physical component performance.
3. Examine the physical, organizational, and operational component designs (at a general level), their limitations, interactions and interdependencies, and jurisdictional/funding issues, to evaluate critical vulnerabilities and concerns for long-term sustainability.

LPBF used the results of the workshops and a *formal systems analysis* to organize an assessment of the MLOD.[14] A major finding was that the IHNC Basin is currently the system's "Achilles' Heel," for reasons similar to those discussed in Section 5.2.

The LPBF's MLOD System assessment did not address the role of interior features in compartmentalizing residual polder surge inundation hazards/risks. Due to significant political and financial challenges facing regional commitments to sustaining the MLOD physical components as delineated in Figure 6.1, some participants indicated that explicitly purposing additional interior features for surge risk reduction was not appropriate.

[14] LPBF worked with a Systems Engineering expert to apply special tools such as SysML (a systems modeling language which aids in defining and diagramming engineered systems) and QMAS (a technique for information gathering in support of systems analysis).

9. Comprehensive List of Compartmentalization Alternatives

Polder compartmentalization alternatives include a wide range of features to reduce surge breach inundation area and associated risk. Compartmentalization features generally fall into two general categories of internal polder barriers:

- "Parallel" Barriers. In the Metro and NO East Polders these are primarily east-west alignments and run parallel with the Pontchartrain Lakefront HSDRRS. In the St. Bernard Polder they run parallel to the HSDRRS levee along the GIWW/MRGO.
- "Perpendicular" Barriers. In the Metro Polder these are primarily north-south alignments and run between the Lakefront HSDRRS and the Mississippi River Levee. In the NO East Polder they also tend to be north-south, and run from the Lakefront HSDRRS toward the GIWW. In the St. Bernard polder they run from the 40 Arpent Levee to the Mississippi River Levee.

As part of investigating compartmentalization and other surge inundation risk reduction approaches, SLFPA-E held two public meetings (in November 2011 and October 2012) with local flood stakeholders, including drainage officials from all four parishes, authors of previous risk reduction studies, concerned non-governmental organizations, and interested citizens. The attendees are documented in Appendix E.

During the meetings Bob Jacobsen PE reviewed information on regional surge hazard and risk (see Part I), risk reduction alternatives (Part II, Section 6), and polder interior features (Part II, Section 7), including potential compartmentalization options. Input on potential compartmentalization features was solicited from the attendees. This Section provides the resulting list of 36 compartmentalization alternatives for the Metro, NO East, and St. Bernard Polders, as well as the IHNC Basin. The initial screening of these alternatives—encompassing likely upgrade requirements—was also discussed at the meetings and is presented in Part IV, Section 13. Figures 7.2 a-h highlight the location of all proposed compartmentalization alternatives.

9.1. Metro Polder

The Metro Polder as a whole includes a total of 22 potential compartmentalization features: ten parallel barriers and twelve perpendicular barriers.

In St. Charles Parish the HSDRRS lies behind the LaBranche Wetlands and perpendicular barriers run from there to the Mississippi River Levee. Parallel barriers run from the Bonnet Carre Spillway Levee to the HSDRRS or EJ/SC Levee/Floodwall along the parish line. St. Charles Parish has four potential internal compartmentalization features, three parallel barriers:

1. Airline Hwy
2. KCS Railroad
3. CN Railroad (north of River Rd)

and one perpendicular barrier:

4. Ormond Ring Levee

Jefferson Parish has eight potential parallel compartmentalization features, with four parallel barriers running from the St. Charles Parish line (which includes the HSDRRS West Return Wall and the EJ/SC Levee/Floodwall) to the Orleans Parish line (which includes the 17th St Canal Floodwall and the Monticello Levee/Floodwall).

5. Interstate 10
6. Sauve-Metairie Ridge
7. Airline Hwy
8. KCS/CN Railroad.

Four Jefferson Parish has four perpendicular barriers running from the Lakefront towards the Mississippi River:

9. Causeway Blvd
10. Bonnabel Ridge

and the Metro Polder's two legacy parish line levee/floodwalls:

11. EJ/SC Parish Line Levee/Floodwall
12. EJ/O Parish Line Monticello Levee/Floodwall.

Orleans Parish has ten potential internal compartmentalization features, three parallel barriers that run from the 17th St Canal/Monticello Levee/Floodwall to the IHNC Floodwall:

13. Gentilly Ridge
14. NS Railroad to St. Bernard
15. CSX Railroad to NO East

and seven perpendicular barriers—*in addition to the outfall canal floodwalls*:

North of NS Railroad

16. Bayou St. John Banks
17. NS Railroad North to Lakefront and NO East

South of NS Railroad

18. Carrollton Ridge
19. Pontchartrain Expressway Corridor
20. Lafitte St Embankment
21. Esplanade Ridge
22. NS Railroad South to Mississippi River.

9.2. NO East Polder

The NO East Polder includes six potential compartmentalization features. Two, as described in Section 7.2, lie within the HSDRRS but outside the main developed area:

23. Maxent Levee

24. BSNWR Levee.

The legacy Maxent Levee is an important interior non-surge flood barrier—isolating the developed and subsided western portion of the NO East Polder from the Maxent drainage basin and BSNWR to the east. The SLFPA-E—in conjunction with Orleans Parish—has recently undertaken NFIP accreditation of the Maxent Levee, including engineering investigations. A Class D inundation from breaching of the eastern HSDRRS perimeter would be largely contained in the nearly 20,000-acre area east of the Maxent Levee, including the BSNWR. Additional upgrades could be considered for the Maxent Levee to improve its performance as a redundant surge barrier, such as armoring for breach resiliency.

The BSNWR Levee –located outside and parallel to a portion of the Maxent Levee—is not maintained for flood control purposes. Upgrading the BSNWWR Levee could provide some additional protection of the Maxent Levee during Class E inundation of the BSNWR—e.g., potentially acting as a wave breakwater.

The developed area of the NO East Polder includes two parallel barriers running from the IHNC Floodwall to the Maxent Levee

25. Interstate 10;
26. Sauvage Ridge with Chef Menteur Hwy and/or CSX Railroad;

and two perpendicular barriers running from the Lakefront to the GIWW:

27. Downman Rd;
28. Paris Rd.

9.3. St. Bernard Polder

The St. Bernard Polder includes six potential compartmentalization features. One key feature lies within the HSDRRS but outside the main developed area:

29. 40 Arpent Levee/Floodwall.

As described in Section 7.3 the legacy 40 Arpent Levee/Floodwall is a critical non-surge flood barrier for the main developed area of the St. Bernard Polder—isolating the developed and subsided (and forced drained) area from the Central Wetlands. The SLFPA-E—in conjunction with Orleans and St. Bernard Parishes—is undertaking NFIP accreditation of the 40 Arpent Levee/Floodwall, including engineering investigations. A Class D inundation from breaching of the HSDRRS perimeter would likely be contained in the nearly 30,000-acre area outside the 40 Arpent Levee, including the Central Wetlands. Additional upgrades to the 40 Arpent Levee/Floodwall could be considered to improve its performance as a redundant surge barrier, such as armoring for breach resiliency.

The developed Upper St. Bernard Polder includes three perpendicular barriers running from the 40 Arpent Levee/Floodwall toward the Mississippi River

30. NS Railroad Spur in Arabi
31. Paris Rd Ridge

32. Violet Canal Levee (part of the 40 Arpent Levee/Floodwall System; SLFPA-E is upgrading a part of this levee as part of NFIP accreditation).

Lower St. Bernard includes two east-west barriers running parallel with the 40 Arpent Levee/Floodwall to the north and the HSDRRS to the south:

33. Louisiana Hwy 46
34. Bayou Rd Ridge.

9.4. IHNC Basin

A compartmentalization barrier critical to East-Bank surge protection for all three polders is

35. The IHNC Basin Levee/Floodwall.

Section 5.2 described that the IHNC Basin is designed to receive surge overflow at the IHNC and Seabrook Surge Barriers during extreme events. IHNC Basin Levee/Floodwall crests could overtop during a true 500-yr event. Future RSLR and coast change, along with Barrier closure issues increase the IHNC Basin surge hazard. All three polders are exposed to outdated I-Walls which make up portions of the IHNC Basin Levee/Floodwall. These I-Walls are also subject to damage from floating objects during a surge event. Thus the I-Walls pose a significant residual flood risk.

In addition to the IHNC Basin Levee/Floodwall, another available compartmentalization project deemed important by the stakeholders is:

36. IHNC Basin Operational Modifications, including two key elements
    a. Upgrading requirements for mooring barges and large vessels and securing large, potentially buoyant structures to their foundations.
    b. Use of the Bayou Bienvenue Sector Gate to divert IHNC surge inundation to the Central Wetlands. requirements in the IHNC Basin.

SLFPA-E would work with Orleans Parish and the Port of New Orleans to upgrade requirements for a. and b. to reduce the possibility of damage to IHNC I-Walls and breaching during surge inundation. The Bayou Bienvenue Gate provides a connection between the IHNC Basin and the much larger area of the Central Wetlands (by a factor of 8 based on the respective perimeters). Opening the Bayou Bienvenue Sector Gate following closure of the Seabrook and IHNC Surge Barriers could reduce surge build up in the IHNC Basin by several feet—depending on how fast flood water can equalize between the IHNC Basin and the Central Wetlands. A possible disadvantage of this alternative is environmental damage to the Central Wetlands from high salinity surge water.

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