Appendix 13
Risk Analysis Results

Introduction

The results of the risk analysis of the New Orleans Hurricane Protection System (HPS) are presented in this appendix. The purpose of the analysis was to evaluate the risk of inundation and the corresponding risks to life and property posed by the HPS prior to the arrival of hurricane Katrina and as it existed on 1 June 2007. These points in time studied are referred to as the "Pre-Katrina" and "June 2007" conditions, respectively. Specifically, the risk analysis intends to answer specific questions concerning the performance of the HPS:

- What was the reliability of the pre-Katrina HPS for preventing flooding of protected areas given the range of hurricanes expected to impact New Orleans?
- What is the reliability of the current post-Katrina HPS for preventing flooding of protected areas given the range of hurricanes expected to impact New Orleans? Specifically, what is the annual rate of occurrence of system failure due to the range of expected hurricane events?
- What are the annual rates of occurrence of economic consequences and loss of life resulting from failures of the HPS given the range of hurricanes expected to impact New Orleans?
- What is the uncertainty in these estimates of annual rates of occurrence?

The spreadsheet computer program FoRTE (presented in Appendix 15) developed by the risk team was used as the basis for establishing elevation-exceedance curves for the scenarios studied for three states of pumping system effectiveness. Analyses were run for no pumping, pumping at 50% of capacity and at 100% of capacity. The program determined inflow water volumes for each storm due to overtopping, breaching and open gates. These water volumes were converted to elevations using the stage-storage relationships for each sub basin.

The computer runs included pumping by modifying the sub-basin rainfall by the amount of pumping volume expected for each storm. Pumping volumes were estimated deterministically and subtracted from the rainfall volume calculated for each storm. Elevations used to produce inundation mapping were selected using several factors to modify the computer generated elevation-exceedance curves. The computer runs did not include overtopping water volumes due to wave run-up so this item was added to the runs using deterministic models. The risk program conducted interflow analyses between sub-basins at the basin level by individual storms but did not do interflow analyses for the basins when the storms were aggregated. Therefore, the program results at the 50-, 100-, and 500-year exceedance rates were examined and in a few cases balanced by looking at the water volumes produced at each exceedance level using the stage-storage relationships for the sub-basins. If the interflow elevations between sub-basins were exceeded, water volumes were redistributed and new water surface elevations determined. Note that the exceedance rates are conditional on the storm set provided to the risk team with frequencies as shown in Appendix 8, which does not consider tropical storms and lower intensity, more frequent hurricanes.

Summary of Risk Analysis Results

The following is a summary of the major findings of the risk analysis. These findings are representative of the more detailed findings presented later in this Appendix and represent a big picture perspective. The maps flood depth maps in Figure 13-1 provide a big picture perspective of the flooding vulnerability of the entire area of greater New Orleans for which the risk assessment was performed, for three different flood frequencies (.02, .01 and .002), and for the two HPS and the three pumping scenarios modeled. Economic and Life Loss risk maps are shown in Figure 13-2. Detailed maps for each of the individual major basins are also provided at the end of this Appendix.

50-Year Flood Event

Flood Risk

- New Orleans is widely vulnerable to light to moderate flooding at the 50-year or 2% frequency of occurrence level if significant pumping capacity is not available.

- There is no significant difference in the flood elevations between the Pre-Katrina and 2007 HPS at the 50 Year (2%) frequency of occurrence. This is likely due to the dominance of rainfall as the source of water at this level of event. At this return period, the dominant threat to New Orleans is tropical rainfall and not hurricanes.

- The impact of pumping is directly related to the total volume of water that must be managed, therefore, pumping is most effective when flooding is not extensive or deep.

- Pumping operating at a capacity that is equivalent to or greater than the 50% of the nameplate capacity of the sub basins modeled, can have a dramatic impact in reducing the flood elevations at the 50 Year or 2% frequency of occurrence in a number of the basins modeled. There is a small benefit in NOE and a significant benefit in OM, portions of JE and JW as well as PL.

Life Loss Risk

- Pre-Katrina potential for loss of life risk was extreme in OM2 sub-basin and very high in portions of JE, JW, PL and OW.

- The 2007 HPS (without pumping) reduced loss of life risk in the majority of OM and JE and portions of QW, JW, NOE and PL north. Loss of life risk remains high in OM2 due primarily to the IHNC vulnerability.

- Pumping at an operational capacity equal to or greater than the 50% ideal capacity modeled reduces loss of life risk to the lowest category at the 50-year (2%) flood frequency.

Economic Risk

- Economic risk is relatively low for the 50-year (2%) flood frequency, being below 10% of total value in most areas and from 10 to 20% in areas of Orleans Main near the canals and Orleans West.

- Economic risk maps for Pre-Katrina and 2007 HPS are essentially the same at this return period.

- Pumping at operational capacities equal to or greater than the 50% ideal value modeled would reduce the entire region to the lowest category with the exception of OW which remains the same.

100-Year Flood Event

Flood Risk

- Without pumping, the majority of the New Orleans area remains vulnerable to moderate to deep flooding (greater than 4 feet) at the 100-year or 1% frequency of occurrence. The area with least vulnerability is Jefferson Parish East and Saint Charles Parish where flood threats are moderate.

- The improvements in the HPS from Pre-Katrina to the 2007 HPS have provided significantly reduced flood levels in a few areas, notably portions of Orleans Main (OM2 and OM4) and moderate reductions in the 1% flood level in St. Bernard (SB) and Plaquemines (PL11).

- Improvements in Orleans Main are largely due to the presence of the new gates and temporary pumps at the ends of the outfall canals. Continued vulnerability of the areas adjacent to the Inner Harbor Navigation Canal can be attributed to the significant fragility of the I-walls along the IHNC and the top of wall elevations which are unchanged from pre-Katrina elevations. Strengthening of the I-walls with stability berms and relief wells has improved the performance of the structures in the IHNC, but they remain unable to cope with surge conditions created by large storms.

- Pumping capacity equal to or greater than the 50% ideal capacity modeled can have a significant impact on the 100-year or 1% flood elevations. Primary areas that benefit the most are OM and JE. The sub-basins adjacent to the IHNC remain vulnerable to flooding even when pumping is considered.

- The west bank area remains highly vulnerable to flooding in 2007 and pumping will likely have little impact until all of the fundamental protective structures are completed.

Life Loss Risk

- At the 100-year flood frequency, Pre-Katrina potential for loss of life risk was extreme for OM2 very high for SB and portions of OW and JW.

- The 2007 HPS, without pumping, reduces loss of life risk for OM2 but has little impact elsewhere.

- Pumping at an operational capacity equal or greater than the 50% ideal capacity modeled would reduce loss of life risk in portions of OW, JE and PL north.

Economic Risk

- Prior to Katrina, with the exception of a portion of Jefferson East, Jefferson West and northern Plaquemines, economic risk was very high across New Orleans at the 100-year or 1% flood frequency. In most cases property would experience damages greater than half of its total value in this type of flood event.

- The 2007 HPS provides a risk reduction in 3 of the 5 sub-basins of Orleans Main, those nearest the IHNC remaining at higher risk levels. There is also some reduction in St Bernard but none on the west bank or in New Orleans East.

- Without pumping, in 2007, moderate to high risk exists in most of New Orleans East, St Bernard and the west bank.

- Pumping at an operational capacity equal to or greater than the ideal 50% capacity modeled would provide significant economic risk reduction in all of Jefferson East and Orleans Main, and in portions of New Orleans East. Economic risk remains high elsewhere with the exception of northern part of Plaquemines.

500-Year Flood Event

Flood Risk

- Virtually all of New Orleans region remains highly vulnerable to deep and catastrophic flooding at the 500-year or 0.2% flood frequency. The vast majority of the region would experience catastrophic flooding depths.

- There is essentially no difference in the flooding vulnerability at this frequency of occurrence between the Pre-Katrina and 2007 HPS.

- Pumping has no impact at this level of flooding for either the Pre-Katrina or the 2007 HPS because of the large volume of water entering the system from overtopping and breaching of fragility of portions of the HPS.

Life Loss Risk

- The 500-year (0.2) flood frequency presents an extremely high potential for high loss of life risk for all of OM, most of JE and a good portion of NOE, SB, OW, and JW for both Pre-Katrina HPS and the 2007 HPS.

- Areas with lower loss of life risk are primarily areas with lower populations exposed to flooding such as portion of NOE, SB and SC.

- Pumping makes no difference in loss of life risk at the 500-year flood frequency for either HPS.

Economic Risk

- The economic risk for the 500-year (0.2%) flood frequency is extremely high in all areas.

- There is essentially no change in economic risk at this level between the Pre-Katrina HPS and 2007 HPS.

- Pumping capacity has little impact on the economic risk at this level of flooding.

Based on the above summary of the results, following are brief answers to the specific questions concerning the performance of the HPS:

- **What was the reliability of the pre-Katrina HPS for preventing flooding of protected areas given the range of hurricanes expected to impact New Orleans?**

While the Katrina experience provides the real answer to this question, the results of the analysis confirm that the reliability of structures in portions of the HPS was very low. The drainage canal walls are the most vivid example of low reliability while the levees proved to be of high reliability. The reliability of entire HPS in preventing flooding was also low as demonstrated by the high rate of overtopping of the perimeter walls and levees by the storms studied. The range of expected storms that were studied produced almost 3,200 incidents of overtopping at the reaches that form the hurricane barriers. This represents 16% of the 20,520 possible incidents. Some of this is attributed to unfinished portions of the HPS on the west bank and is also due the tops of levees and walls at lower than their authorized level due to subsidence or use of incorrect datum.

- **What is the reliability of the current post-Katrina HPS for preventing flooding of protected areas given the range of hurricanes expected to impact New Orleans?**

Specifically, what is the annual rate of occurrence of system failure due to the range of expected hurricane events?

The reliability of the post-Katrina (June 2007) HPS has been significantly increased in many portions of the system that did not perform well during Katrina and ongoing improvements are steadily making the system more reliable. Reasons for this are: the gates at the ends of the drainage canals reduce the chance of I-wall failure along the canals; adding overtopping protection at many transitions throughout the system makes them less likely to erode and fail; replacing relatively lower reliable I-walls with more reliable T-walls or L-walls reduces probability of failure in those areas; adding erosion protection to levees reduces their susceptibility to damage from waves overtopping them; and the raising of some levees reduces the chance of overtopping erosion. There are, however, areas of the HPS where the project is unfinished, such as on the west bank, and areas where the structures still have low reliability, such as along the IHNC and GIWW in New Orleans East and St. Bernard. These areas act as weak points in the HPS perimeter chain that lowers the overall reliability of the system. Because these weak points provide possible HPS failure points, the reliability of the June 2007 HPS was found to remain low.

Annual rates of system failure are best judged by examining the elevation-exceedance results. Failure of the HPS is defined as the amount of interior flooding of the basins due to combinations of overtopping, breaching or open gates. For annual rates up to .02 per year (1/50), the system flooding appears to be primarily due to rainfall and therefore failure of HPS components would not be expected. At lower rates of occurrence such as .01 per year (1/100), HPS components would experience failures and/or overtopping that would lead to significant flooding and for extremely low rates such the .002 per year (1/500) complete failure of the HPS would be expected leading to deep inundation at all locations in the system .

- **What are the annual rates of occurrence of economic consequences and loss of life resulting from failures of the HPS given the range of hurricanes expected to impact New Orleans?**

Annual rates of occurrence of economic consequences and loss of life system failure are directly related to the elevation-exceedance results discussed above. For annual rates of .02 per year (1/50), $1.2 Billion of economic damages could be expected and about 400 potential fatalities could occur. The loss of life estimates are based on a mean value for evacuation effectiveness. This results in fatalities which are considered to be much higher than would actually occur based the high evacuation effectiveness experienced during Katrina. At a lower annual rate of occurrence of .01 per year (1/100), $31 Billion of economic damages could be expected and as many as 3,700 potential fatalities could occur and for extremely low rates such the .002 per year (1/500) complete failure of the HPS could lead to $72 Billion of economic damages and as many as 42,000 potential fatalities with a less than a very effective evacuation.

- **What is the uncertainty in these estimates of annual rates of occurrence?**

Measuring System Performance

The primary measure used to evaluate the risks associated with the New Orleans HPS is water elevations within the system based on the amount of inflow water volume from overtopping, breaching, rainfall and closure structures left open. These elevations were used to determine the rate of overtopping of the reaches, construct inundation maps, and to determine life and economic risks. In addition to the issues raised by the questions above, the primary measures of the risk in the New Orleans area are as follows:

- Rate of overtopping of the HPS by hurricane surges and waves.
- Volume of water entering the HPS from breaching, open gates and overtopping.
- Depth of water due to flooding during hurricanes and the rate at which it occurs
- Economic damages caused by flooding and the rate at which they occurs
- Lives lost due to flooding and the rate at which they occurs

Overtopping Rates

One measure of the effectiveness of the HPS is how often the system can be expected to be overtopped by the storms predicted to strike the New Orleans area. This measure, while not risk based, provides decision makers with additional information about system performance and vulnerability. The rates of overtopping were determined for the Pre-K and June 2007 HPS for the total 152 storm set provided by the storm team. Note that while the entire 152 storm set was used to determine overtopping rates, only the 77 storms with frequencies provided by the storm team were used in the actual risk analysis. Peak surge and wave elevations at each of the 135 reaches in the pre-Katrina HPS (138 in the June 2007HPS) for each of the 152 storms developed by the LaCPR unified USACE/FEMA team were compared to the top of levee or wall elevations at each reach. The number of times that each reach within the basins was overtopped was calculated by counting the storm events whose peak surge exceeded the reach elevation. The overtopping rate was then determined by dividing the total number of times that a reach was overtopped by the number of storms (152). Basin and HPS overtopping rates were also determined and are presented in Table 13-1. The rates are also graphically shown in Figure 13-3 for the Pre-K and June 2007 HPS with color coding to rank areas by the overtopping rate.

As shown in Table 13-1, the number of overtopping events in the June 2007 HPS is reduced somewhat from those of Pre-K levels in most basins and at many reaches. This is due to restoring damaged levees to the Pre-Katrina authorized elevation, which in many cases is higher than the actual Pre-K elevation because of subsidence and datum changes. Areas that show high rates of overtopping, greater than 25% of the storms, in the Pre-Katrina HPS are in New Orleans East along the IHNC and MRGO, all of the southern portions of Jefferson West Bank and most of Plaquemines.

Table 13-1 Overtopping Rates for Reaches and Sub-basins

Station No.	Reach Name	Sub-basin	Pre-K			Current			Color Legend
			No of OT	% of storms OT	Color	No of OT	% of storms OT	Color	
1	NOE 1	NOE5	5.0	0.033		6.0	0.039		**0=Dark Green**
2	NOE 2	NOE5	5.0	0.033		6.0	0.039		**0-.1 = Lt Green**
3	NOE 3	NOE5	5.0	0.033		6.0	0.039		**.1-.2 = Lt Blue**
4	NOE 4	NOE5	5.0	0.033		6.0	0.039		**.2-.3 = Yellow**
5	NOE 5	NOE5	5.0	0.033		6.0	0.039		**.3-.4 = Orange**
6	NOE 6	NOE5	1.0	0.007		2.0	0.013		**.4-.5 = Red**
7	NOE 7	NOE5	1.0	0.007		2.0	0.013		
8	NOE 8	NOE5	2.0	0.013		3.0	0.020		
9	NOE 9	NOE1	0.0	0.000		0.0	0.000		
10	NOE 10	NOE1	2.0	0.013		3.0	0.020		
11	NOE 11	NOE1	3.0	0.020		4.0	0.026		
12	NOE 12	NOE1	3.0	0.020		4.0	0.026		
13	NOE 13	NOE1	3.0	0.020		4.0	0.026		
14	NOE 14	NOE1	13.0	0.086		14.0	0.092		
15	NOE 15	NOE1	18.0	0.118		10.0	0.066		
16	NOE 16	NOE1	27.0	0.178		14.0	0.092		
17	NOE 17	NOE2	34.0	0.224		18.0	0.118		
18	NOE 18	NOE2	27.0	0.178		27.0	0.178		
19	NOE 19	NOE3	28.0	0.184		28.0	0.184		
20	NOE 20	NOE3	39.0	0.257		38.0	0.250		
21	NOE 21	NOE3	39.0	0.257		38.0	0.250		
22	NOE 22	NOE3	34.0	0.224		33.0	0.217		
23	NOE 23	NOE4	56.0	0.368		55.0	0.362		
24	NOE 24	NOE4	56.0	0.368		55.0	0.362		
25	NOE 25	NOE4	54.0	0.355		53.0	0.349		
26	NOE 26	NOE4	52.0	0.342		51.0	0.336		
27	NOE 27	NOE4	51.0	0.336		50.0	0.329		
28	NOE 28	NOE4	69.0	0.454		54.0	0.355		
29	NOE 29	NOE5	3.0	0.020		4.0	0.026		
Total NOE			**640.0**	**0.145**		**594.0**	**0.135**		
30	JE1	JE3	12.0	0.079		13.0	0.086		
31	JE2	JE3	6.0	0.039		7.0	0.046		
32	JE3	JE3	1.0	0.007		2.0	0.013		
33	JE4	JE3	0.0	0.000		0.0	0.000		
34	JE5	JE2	0.0	0.000		0.0	0.000		
35	JE6	JE2	0.0	0.000		0.0	0.000		
37	JE8	JE1	0.0	0.000		0.0	0.000		
38	JE9	JE3	38.0	0.250		38.0	0.250		
Total JE			**57.0**	**0.013**		**60.0**	**0.014**		
39	SC1	SC1	32.0	0.211		31.0	0.204		
40	SC2	SC1	44.0	0.289		17.0	0.112		
41	SC3	SC1	37.0	0.243		36.0	0.237		
42	SC4	SC2	0.0	0.000		0.0	0.000		

Table 13-1 Overtopping Rates for Reaches and Sub-basins

Station No.	Reach Name	Sub-basin	Pre-K No of OT	Pre-K % of storms OT	Pre-K Color	Current No of OT	Current % of storms OT	Current Color	Color Legend
43	SC5	SC2	0.0	0.000		0.0	0.000		
44	SC6	SC2	0.0	0.000		0.0	0.000		
Total SC			**113.0**	**0.124**		**84.0**	**0.092**		
45	OM1	OM2	0.0	0.000		0.0	0.000		
46	OM2	OM2	0.0	0.000		0.0	0.000		
47	OM3	OM2	0.0	0.000		0.0	0.000		
48	OM4	OM2	0.0	0.000		0.0	0.000		
49	OM5	OM2	0.0	0.000		0.0	0.000		
50	OM6	OM1	0.0	0.000		0.0	0.000		
51	OM7	OM1	0.0	0.000		0.0	0.000		
52	OM8	OM1	0.0	0.000		0.0	0.000		
53	OM9	OM1	0.0	0.000		0.0	0.000		
54	OM10	OM2	3.0	0.020		4.0	0.026		
55	OM11	OM2	0.0	0.000		0.0	0.000		
56	OM12	OM1	0.0	0.000		0.0	0.000		
57	OM13	OM1	0.0	0.000		0.0	0.000		
58	OM14	OM1	0.0	0.000		0.0	0.000		
59	OM15	OM1	0.0	0.000		0.0	0.000		
60	OM16	OM1	0.0	0.000		0.0	0.000		
61	OM17	OM1	2.0	0.013		3.0	0.020		
62	OM18	OM3	33.0	0.217		32.0	0.211		
63	OM19	OM3	49.0	0.322		20.0	0.132		
64	OM20	OM3	51.0	0.336		50.0	0.329		
65	OM21	OM3	0.0	0.000		0.0	0.000		
66	OM22	OM3	0.0	0.000		0.0	0.000		
67	OM23	OM3	0.0	0.000		0.0	0.000		
68	OM24	OM5	0.0	0.000		0.0	0.000		
69	OM25	OM5	0.0	0.000		0.0	0.000		
70	OM26	OM5	0.0	0.000		0.0	0.000		
71	OM27	OM4	0.0	0.000		0.0	0.000		
36	JE7	OM4	0.0	0.000		0.0	0.000		
	Total OM		**138.0**	**0.032**		**109.0**	**0.026**		
72	SB1	SB1	50.0	0.329		20.0	0.132		
73	SB2	SB2	12.0	0.079		13.0	0.086		
74	SB3	SB2	20.0	0.132		21.0	0.138		
75	SB4	SB5	2.0	0.013		0.0	0.000		
76	SB5	SB4	0.0	0.000		0.0	0.000		
77	SB6	SB4	0.0	0.000		0.0	0.000		
78	SB7	SB3	0.0	0.000		0.0	0.000		
79	SB8	SB1	0.0	0.000		0.0	0.000		
80	SB9	SB1	0.0	0.000		0.0	0.000		
Total SB			**84.0**	**0.061**		**54.0**	**0.039**		
81	PL1	PL1	140.0	0.921		133.0	0.875		
82	PL2	PL1	48.0	0.316		48.0	0.316		

Table 13-1 Overtopping Rates for Reaches and Sub-basins

Station No.	Reach Name	Sub-basin	Pre-K No of OT	Pre-K % of storms OT	Pre-K Color	Current No of OT	Current % of storms OT	Current Color	Color Legend
83	PL3	PL1	0.0	0.000		0.0	0.000		
84	PL4	PL2	39.0	0.257		39.0	0.257		
85	PL5	PL2	2.0	0.013		3.0	0.020		
86	PL6	PL3	136.0	0.895		130.0	0.855		
87	PL7	PL3	0.0	0.000		0.0	0.000		
88	PL8	PL7	31.0	0.204		30.0	0.197		
89	PL9	PL7	3.0	0.020		4.0	0.026		
90	PL10	PL7	20.0	0.132		21.0	0.138		
91	PL11	PL8	21.0	0.138		22.0	0.145		
92	PL12	PL8	1.0	0.007		2.0	0.013		
94	PL13	PL8	44.0	0.289		45.0	0.296		
95	PL14	PL8	2.0	0.013		3.0	0.020		
96	PL15	PL8	0.0	0.000		0.0	0.000		
96	PL16	PL9	13.0	0.086		14.0	0.092		
97	PL17	PL10	22.0	0.145		23.0	0.151		
98	PL18	PL10	26.0	0.171		27.0	0.178		
99	PL19	PL9	44.0	0.289		45.0	0.296		
100	PL20	PL4	0.0	0.000		0.0	0.000		
101	PL21	PL5	0.0	0.000		0.0	0.000		
102	PL22	PL4	0.0	0.000		0.0	0.000		
103	PL23	PL5	0.0	0.000		0.0	0.000		
104	PL24	PL1	3.0	0.020		4.0	0.026		
105	PL25	PL6	1.0	0.007		2.0	0.013		
106	PL26	PL1	0.0	0.000		0.0	0.000		
107	PL27	PL6	0.0	0.000		0.0	0.000		
Total PL			**596.0**	**0.145**		**595.0**	**0.145**		
108	CW1	JW1	133.0	0.875		128.0	0.842		
109	CW2	JW2	122.0	0.803		118.0	0.776		
110	CW3	JW2	127.0	0.836		115.0	0.757		
111	CW4	JW2	127.0	0.836		122.0	0.803		
112	CW5	JW2	136.0	0.895		130.0	0.855		
113	CW6	JW2	115.0	0.757		111.0	0.730		
114	CW7	JW3	26.0	0.171		26.0	0.171		
115	CW8	JW1	0.0	0.000		0.0	0.000		
116	WH1	JW3	19.0	0.125		19.0	0.125		
117	WH2	JW3	97.0	0.638		68.0	0.447		
118	WH3	JW3	48.0	0.316		47.0	0.309		
119	WH4	JW3	1.0	0.007		2.0	0.013		
120	WH5	JW3	4.0	0.026		2.0	0.013		
121	WH6	JW3	26.0	0.171		26.0	0.171		
122	WH7	JW3	96.0	0.632		71.0	0.467		
123	WH8	JW3	48.0	0.316		6.0	0.039		
124	WH9	JW3	0.0	0.000		0.0	0.000		
125	WH10	JW3	0.0	0.000		0.0	0.000		
127	HA2	JW4	0.0	0.000		0.0	0.000		

Table 13-1 Overtopping Rates for Reaches and Sub-basins										
Station No.	Reach Name	Sub-basin	Pre-K			Current			Color Legend	
			No of OT	% of storms OT	Color	No of OT	% of storms OT	Color		
128	HA3	JW4	122.0	0.803		47.0	0.309			
129	HA4	JW4	60.0	0.395		59.0	0.388			
135	HA10	JW4	0.0	0.000		0.0	0.000			
Total JW			**1307.0**	**0.391**		**1097.0**	**0.328**			
126	HA1	OW2	0.0	0.000		0.0	0.000			
130	HA5	OW2	17.0	0.112		18.0	0.118			
131	HA6	OW1	0.0	0.000		0.0	0.000			
132	HA7	OW1	3.0	0.020		4.0	0.026			
133	HA8	OW1	145.0	0.954		138.0	0.908			
134	HA9	OW2	94.0	0.618		91.0	0.599			
Total OW			**259.0**	**0.284**		**251.0**	**0.275**			
Total All Basins			**3194.00**	**0.157**		**2844.00**	**0.140**			

Expected Water Volumes and Surface Elevations

The stage-storage curves for each sub basin are the basis of generating maps showing vulnerability to flooding. For example, given the volume of water for a sub-basin that equates to a frequency chance of occurrence of 1% in any given year, the stage-storage curve can be used to determine the corresponding water elevation for that basin. While this is commonly referred to as the “100 Year” flood, it really is the chance (1% or 1/100) that the flood elevation will occur in any year and should not be compared to the 100 Year flood used in the FEMA NFIP.

The water elevations for other events, such as the 2% (1/50) or .2% (1/500) year floods can be determined similarly. Note that the 2%, 1% and .2% elevations are represented in these charts as the 50, 100 and 500 year elevations respectively. The elevations from these curves can be plotted on a map to show the extent of flooding at that frequency.

The chance of flooding numbers (2%, 1%, and .2 %) and their comparable designation as return periods in “years” can be quite confusing. The Table 13-2 is provided to assist in interpreting what these mean in a practical sense.

Table 13-2. Relationship between terms used to describe probabilities and chance of events.					
Recurrence Interval	**Probability of Occurring in any year**		**% Chance of Occurring In:**		
"X Year"	**"1in X"**	**"%"**	**30 years (mortgage)**	**78 years (Average US lifespan)**	**100 years**
500	1 in 500	0.2 %	5.8 %	14.5 %	18 %
100	1 in 100	1 %	26 %	54 %	63 %
50	1 in 50	2 %	45 %	79 %	86 %
25	1 in 25	4 %	64 %	96 %	98 %
10	1 in 10	10 %	96 %	99.9 %	100 %

The risk analysis produced elevation-exceedance curves for all elevations, and the elevations used in the maps were selected from those curves. The maps depict the "best estimate" elevation. Since the risk model determines inundation potential at the sub-basin level, some local areas within a sub basin may have additional drainage conditions that cannot be modeled with the risk model. These areas may show lower levels of inundation, especially near sub-basin boundaries, if a more accurate HEC-RAS type analysis was conducted.

The same modeling approach can include the impact of pumping stations operating at different levels of capacity. For this analysis, a simplified pumping model, as described in Appendix 15, was used. For each drainage area, the pumping capacity of all of the individual pumps supporting that area was combined to generate a single "representative" pump station. The impact of having that pump operating at 50 and 100 percent of full capacity was computed and the water volumes that would be removed by the representative pump station were subtracted from the total rainfall volumes for each storm previously computed. The new net volume was input to the risk model. The risk model was then rerun to estimate a new water elevation for each flood frequency.

The results of the risk analysis were estimates of the water volumes that would enter the system for each storm that were converted to water surface elevations using the stage-storage characteristics of each sub basin. These results are presented in terms of the water surface elevations expected in each sub-basin for the "no pumping," "50% pumping," and "100% pumping" scenarios in Tables 13-4 to 13-6 and the three exceedance (50, 100 and 500-Year) rates used to construct the inundation maps. Inundation maps for all basins for the 50, 100 and 500-Year exceedance rates and pumping for the no pumping, 50% and 100% pumping scenarios are provided in the Figures 13-15 through 13-52 at the end of this Appendix.

Results without pumping – Table 13-3 shows the water elevations within each sub-basin for the Pre-K and June 2007 HPS if the pumping system is considered to not be operating. The 50-year water volumes and resulting elevations (Figure 13-4 through 13-6) are primarily hurricane rainfall in the basins, while the 100-year elevations (Figures 13-7 through 13-9) show the impact of the large amount of overtopping, levee or wall breaching and open closure structures.

Reductions in water surface elevations expected for the June 2007 HPS were noted in the OM and SB basins, but were largely unchanged in all other basins. SB showed the most reduction in water elevation due to the improvements made in the June 2007 HPS with reductions of 2 to 2.5 feet. All basins fill during 500-year events in both the Pre-Katrina and June 2007 HPS (Figures 13-10, 13-11 and 13-12).

Table 13-3 Risk Analysis Results Without Pumping
Elevations NAVD88 2004.65

Sub-basin	50-year elevations		100-year elevations		500-year elevations	
	Pre-k	Current	Pre-k	Current	Pre-k	Current
OW1	-1	-1	1	1	6	6
OW2	-3	-3	4	4	8	8
NOE1	0	0	2	1	12	13
NOE2	-4	-4	2	2	12	13
NOE3	-4	-4	2	2	12	13
NOE4	-1	-1	4	4	12	13
NOE5	-8	-8	-1	-1	12	13
OM1	-5	-5	3	3	14	14
OM2	-5	-5	3	-2	14	14
OM3	-1	-1	3	3	14	14
OM4	-1	-1	3	-1	14	14
OM5	-1	-1	3	-1	14	14
SB1	-1	-1	12	10	14	14
SB2	1	1	12	10	14	14
SB3	0	0	12	10	14	14
SB4	2	2	12	10	14	14
SB5	3	3	12	10	14	14
JE1	3	3	4	4	14	14
JE2	-4	-4	-3	-3	14	14
JE3	-5	-5	-3	-3	14	14
JW1	0	0	4	4	8	8
JW2	-4	-4	4	4	8	8
JW3	-2	-2	4	4	8	8
JW4	-5	-5	4	4	8	8
PL11	-2	-2	0	-1	6	9
SC1	2	2	4	4	10	10
SC2	4	4	5	5	10	10

Results with 50% pumping – Table 13-4 shows the water elevations within each sub-basin for the Pre-K and June 2007 HPS if the pumping system is considered to be operating at 50% capacity. The 50-year water inflow volumes and resulting elevations are primarily hurricane rainfall in the basins. This pumping scenario most closely approximates the possible performance of the system during a 50-year event for both Pre-K and June 2007 HPS when the pumps would only have to evacuate hurricane rains, which would be expected to be less than the design rainfall for the pumps (about a 10-year tropical storm). Therefore, the differences in water elevations between the no pumping and 50% pumping scenarios, for both the Pre-K and June 2007 HPS, are small for the 50-year event.

Table 13-4 Risk Analysis Results With 50% Pumping Elevations NAVD88 2004.65

Sub-basin	50-Year elevations		100-Year elevations		500-Year elevations	
	Pre-k	Current	Pre-k	Current	Pre-k	Current
OW1	-1	-1	0	0	6	6
OW2	-3	-3	3	3	8	8
NOE1	0	0	2	1	12	13
NOE2	-5	-5	1	1	11	12
NOE3	-5	-5	1	1	11	12
NOE4	-2	-2	2	2	11	12
NOE5	-9	-9	-2	-2	11	12
OM1	-7	-7	2	1	12	12
OM2	-12	-12	1	-7	11	11
OM3	-6	-6	2	1	12	12
OM4	-5	-5	3	-2	13	13
OM5	-4	-4	2	0	12	12
SB1	-5	-5	11	8	12	12
SB2	1	1	12	9	13	13
SB3	-1	-1	11	8	12	12
SB4	1	1	11	9	12	12
SB5	3	3	12	10	13	13
JE1	2	2	3	3	12	12
JE2	-12	-12	-5	-5	12	12
JE3	-6	-6	-5	-5	12	12
JW1	0	0	4	4	8	8
JW2	-5	-5	3	3	7	7
JW3	-5	-5	3	3	7	7
JW4	-12	-12	3	3	7	7
PL11	-12	-12	-4	-8	1	2
SC1	2	2	4	4	10	10
SC2	4	4	5	5	10	10

Results with 100% pumping – Table 13-5 shows the water elevations within each sub-basin for the Pre-K and June 2007 HPS if the pumping system is considered to be operating at 100% of capacity. This scenario is presented for comparison purposes with the other scenarios only since the New Orleans pumping system, or any other pumping system, cannot realistically be expected to perform at this level. The significant impact is the reduction of interior flooding. Water elevations could be reduced by as much as 4 feet in show areas for the 50 year event, while the at the 100-Year even, even with at pumping 100 % capacity, the large amount of overtopping, levee or wall breaching and open closure structures significant flooding would occur. During hurricanes with intensities and frequencies similar to Katrina, the Pre-K pumping system would be expected to perform as it did during Katrina and not be able to handle flooding from overtopping or breaching inflows. Reductions in water surface elevations expected for the June 2007 HPS were noted in the OM and SB basins, but were largely unchanged in all other basins. All basins fill during 500-year events in both the Pre-Katrina and June 2007 HPS. These maps show inundation for selected return periods, specifically the 50-, 100-, and 500-year inundations.

Table 13-5 Risk Analysis Results With 100% Pumping Elevations NAVD88 2004.65

Sub-basin	50-Year elevations		100-Year elevations		500-Year elevations	
	Pre-k	Current	Pre-k	Current	Pre-k	Current
OW1	-1	-1	0	0	6	6
OW2	-3	-3	3	3	8	8
NOE1	0	0	2	1	12	13
NOE2	-5	-5	1	1	11	12
NOE3	-5	-5	1	1	11	12
NOE4	-3	-3	2	2	11	12
NOE5	-11	-11	-2	-2	11	12
OM1	-12	-12	2	1	12	12
OM2	-12	-12	0	-12	10	10
OM3	-12	-12	1	-1	11	11
OM4	-5	-5	3	-2	13	13
OM5	-12	-12	1	-2	12	12
SB1	-12	-12	11	8	12	12
SB2	1	1	12	9	13	13
SB3	-3	-3	11	8	12	12
SB4	1	1	11	9	12	12
SB5	3	3	12	10	13	13
JE1	2	2	3	3	12	12
JE2	-12	-12	-12	-12	11	11
JE3	-10	-10	-5	-5	12	12
JW1	0	0	4	4	8	8
JW2	-5	-5	3	3	7	7
JW3	-12	-12	3	3	7	7
JW4	-12	-12	3	3	7	7
PL11	-12	-12	-5	-12	1	2
SC1	2	2	4	4	10	10
SC2	3	3	4	4	10	10

Floodplain Maps

The elevations shown in Table 13-3 through 13-5 were plotted on the topographic maps of each basin. The boundaries on these maps represent the inundation frequency and indicate the relative vulnerability of an area to being flooded. If a location is within the dark blue or 50 year floodplain, it has a 2% chance each year of being flooded. Locations within the 100 year or medium blue area have a 1% chance each year of flooding. Similarly, areas within the light blue have a 0.2 % chance of flooding each year. These boundaries are, in terms of the flood insurance program, the 50, 100 and 500 year floodplains, computed in a different manner than that typically used for Flood insurance maps. Obviously, areas in light blue are less likely to flood than areas in dark blue. Note that this type of map does not display the depth of flooding, just the boundaries of flooding at different frequencies of occurrence.

Flood Depth Frequency Maps

A second type of map was generated to display the potential depth of flooding at different return periods. These maps are called Hurricane Flood Depth Frequency Maps. This type map is based on flood depths as illustrated in Figure 13-13. Individual maps display for a single floodplain frequency, the estimated depth of flooding that could occur by location. These maps are created by simply overlaying the water elevation representing that frequency of flood event on the local topography as previously illustrated in Figure 13-13. By subtracting the land elevation from the water elevation at each point, an estimate of the potential water depth is obtained. **This does not represent flood depth with respect to the first floor elevation of individual structures, but depth of water above the ground surface. It should also be considered a general estimate because of the resolution of the ground elevation data and the uncertainty in the estimated flood elevations.** Depth maps are displayed in 2 – foot increments because of the wide variability of the topographic data inside the basins. If the depth category is 0-2 feet, there is little chance of significant flooding, especially for structures with some height above ground level. Darker blue areas represent deeper flooding and higher potential for serious losses. The map legend and graphics display a greater than 8 ft. depth category to simplify the display and the assumption was made that flooding beyond that level represented severe consequences.

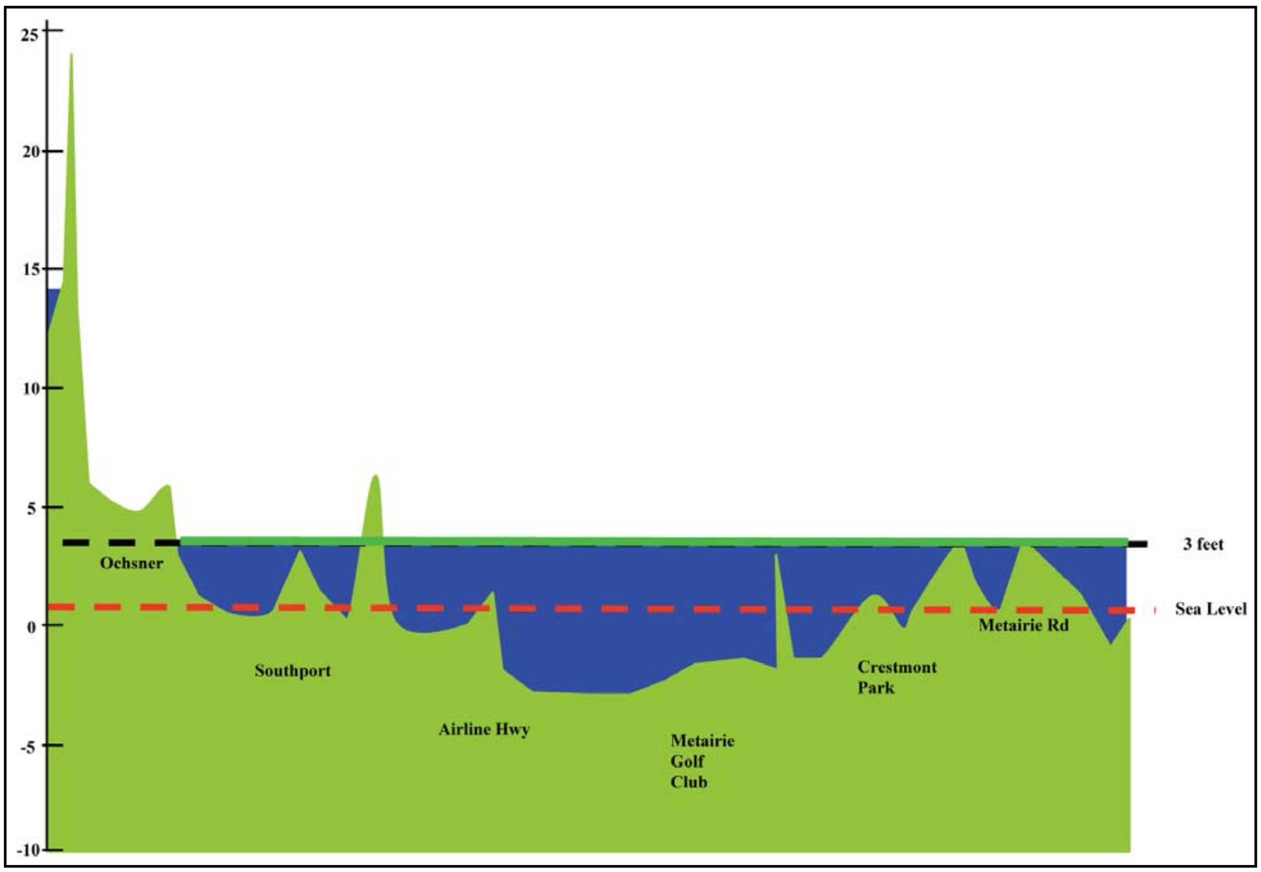


Figure 13-13. Flood Depth information desired by local officials to better understand and communicate vulnerability.

Human and Economic Risks

The water elevations and exceedance rates presented in the foregoing sections were combined with the stage-damage and stage-fatality relationships developed by the IPET Consequence Team to determine the risks to life and property under the scenarios studied. Reference is made to the IPET Volume 7 for a complete explanation of the analyses conducted in support of loss relationships used herein. Appendix 12 of this volume provides a discussion of the consequences used in the risk analysis.

The losses considered for this analysis are all based on the pre-Katrina distribution of population and property and pre-Katrina property values. This results in all reductions in risk being attributed to the changes in the hurricane protection system, not to changes in exposure of property or people. This was a deliberate decision made to avoid speculation on and the uncertainty of rates and distribution of redevelopment and recovery.

Using the processes in IPET Volume VII, the expected losses for different water elevations were determined for each sub-basin. Economic losses are based on the known structure elevations, geographic distribution and property value at the census block level. Loss of life was estimated using the pre-Katrina population demographics and distribution (again by census block) through the use of two computer models described in detail in IPET Volume VII.

Economic Risks - The economic consequences considered by the Consequence Team included: 1) direct property damages, and 2) indirect economic impacts on local and regional economies. Direct property damages were monetary damages to property at risk such as residential, commercial, industrial, public buildings, vehicles and infrastructure. For the risk scenarios, both pre- and post-Katrina stage-damage functions for properties, are based on base property conditions that existed prior to Katrina. Only the direct economic damages were used in the risk assessment.

The estimates of potential economic loss due to direct property damages are provided in Tables 13-9 to 13-10. The losses are presented by sub-basin for each HPS (Pre-Katrina and 2007) and the three pumping capacities (0, 50 and 100 % of ideal capacity) modeled.

Table13-6. Summary statistics for the economic risk for the Pre-Katrina and 2007 HPS and for the 0, 50 and 100-% pumping options, ($B).

Level	Pre-K 50 Yr	2007 50 yr	Pre-K 100 yr	2007 100 yr	500 yr (both)
No Pump	4.7	4.7	43	40	74
50% Pump	1.2	1.2	31	26	72
100% Pump	1.0	1.0	29	24	72

Table 13-6 shows that the 2007 HPS does provide a small reduction overall in the economic risk in comparison to the Pre-Katrina HPS. It also shows that there is no difference in economic risk between the two HPS at the 50- and 500-year frequencies. The 50-year level is dominantly rainfall flooding and the 500 year level has such extensive flooding regardless of which HPS is in place.

The economic damage values are an indicator of the magnitude of the impact that flooding expected from the hurricanes studied would have on the New Orleans area. Another indicator of the economic impact on the individual basins is the percent of the total property value that these damages represent. This indicator provides a normalized measure that considers the demographics of a sub basin and allows for comparison of the economic impact on lower income areas to the economic impact on higher income areas. This was computed by dividing the damages for each sub basin by the total estimated value of the property in the basin. The total property values selected for these calculations are the maximum value from the loss damage curves presented in Appendix 12. The total property values selected for each sub basin are shown in Table 13-7.

Figure 13- 2 shows maps providing a graphical portrayal of the data in Tables 13-11 through 13-19. The maps show color coded groupings of estimated economic risk in terms expected losses as a percent of total value, for the 50, 100 and 500-year flood frequencies and the Pre-Katrina and 2007 HPS. Thus, economic risk is presented in two contrasting ways, the actual dollar (in 2005 dollars) losses in the tables and the percent of total value on the maps. The map representations were chosen to normalize the influence of high cost structures in the risk estimates.

Table 13-7 - Estimated total value, Millions of 2005 Dollars			
Pre-K Property Value		**Pre-K Property Value**	
Sub basin	**Value**	**Sub basin**	**Value**
JE1	$6,443.60	OW1	$212.83
JE2	$6,300.70	OW2	$3,625.50
JE3	$12,090.60	PL11	$665.60
JW1	$959.60	SB1	$2,733.60
JW2	$447.50	SB2	$29.10
JW3	$6,389.90	SB3	$2,580.60
JW4	$6,968.90	SB4	$554.50
NOE1	$12.41	SB5	$46.90
NOE2	$132.47	SC1	$146.00
NOE3	$680.32	SC2	$1,924.80
NOE4	$65.97	Total	$78,493.90

The potential economic damages for the Pre-K and June 2007 HPS without pumping (Table 13-7) are equal at about $4.7 Billion for the 50-Year event. The 100-Year potential damages are $43 Billion for the Pre-K HPS and are reduced by about $3 Billion to about $40.2 Billion for the June 2007 HPS. For the 500-Year event, the sub-basins in both scenarios are expected to fill so the potential damages are equal at about $73.5 Billion.

The potential economic damages for the Pre-K and June 2007 HPS with 50% pumping (Table 13-8) are equal at about $1.2 Billion for the 50-Year event. This represents a significant $3.5 Billion reduction from the no pumping scenario and demonstrates the importance of maintaining pumping operations during the more frequent events. The 100-Year potential damages are $30.7 Billion for the Pre-K HPS and are reduced by about $4 Billion to about $26 Billion for the June 2007 HPS which is about $14 Billion less than the no pumping scenario, again demonstrating the effectiveness of the pumping system at reducing potential damages. For the 500-Year event, the sub-basins in both scenarios are expected to fill so the potential damages are equal at about $71.3 Billion which is down slightly from the no pumping scenario.

The potential economic damages for the Pre-K and June 2007 HPS with 100% pumping (Table 13-9) are equal at about $1.0 Billion for the 50-Year event. The 100-Year potential damages are $29.4 Billion for the Pre-K HPS and are reduced to about $24.4 Billion for the June 2007 HPS or about a $5 Billion reduction from 50% pumping scenario and about a $16 Billion reduction from the no pumping case. For the 500-Year event, the sub-basins in both scenarios are expected to fill so the potential damages are equal at about $71.6 Billion. As may be expected, these values are all less than for the 50% pumping scenarios, however, the 100 % pumping scenario is presented for comparison purpose only to show how increased efficiency of the pumping system can reduce damages. Note that the most significant reductions were attained by the 50% pumping scenario.

Economic Risk Findings

50-Year:

- Economic risk is relatively low for the 50-year (2%) flood frequency, being below 10% of total value in most areas and from 10 to 20% in areas of Orleans Main near the canals and Orleans West.

- Economic risk maps for Pre-Katrina and 2007 HPS are essentially the same at this return period.

- Pumping at operational capacities equal to or greater than the 50% of the nameplate capacity modeled would reduce the entire region to the lowest category (<10%) with the exception of OW which remains the same.

100-Year:

- Prior to Katrina, with the exception of a portion of Jefferson East, Jefferson West and northern Plaquemines, economic risk was very high across New Orleans at the 100-year or 1% flood frequency. In most cases property would experience damages greater than half of its total value in this type of flood event.

- The 2007 HPS provides a risk reduction in 3 of the 5 sub-basins of Orleans Main, those nearest the IHNC remaining at higher risk levels. There is also some reduction in St Bernard but none on the west bank or in New Orleans East.

- Without pumping, in 2007, moderate to high risk exists in most of New Orleans East, St Bernard and the west bank.

- Pumping at an operational capacity equal to or greater than the 50% of the nameplate capacity modeled would provide significant economic risk reduction in all of Jefferson East and Orleans Main, and in portions of New Orleans East. Economic risk remains high elsewhere with the exception of northern part of Plaquemines.

500-Year:

- The economic risk for the 500-year (0.2%) flood frequency is extremely high in all areas.

- There is essentially no change in economic risk at this level between the Pre-Katrina HPS and 2007 HPS.

- Pumping capacity has little impact on the economic risk at this level of flooding.

Table 13-8 – Potential Damages – No Pumping						
Sub-basin	**Potential Damages Without Pumping In Millions of 2005 Dollars**					
	50-Year elevations		**100-Year elevations**		**500-Year elevations**	
	Pre-k	**Current**	**Pre-k**	**Current**	**Pre-k**	**Current**
OW1	23	23	39	39	170	170
OW2	412	412	2405	2405	3,105	3,105
NOE1	0	0	8	6	12	12
NOE2	19	19	123	123	143	143
NOE3	8	8	510	510	668	671
NOE4	0	0	49	49	61	62
NOE5	43	43	4,561	4,561	6,022	6,026
OM1	402	402	2,209	2209	2718	2718
OM2	348	348	1,573	1040	1945	1945
OM3	376	376	1,709	1709	3010	3010
OM4	68	68	420	68	1111	1111
OM5	785	785	3,721	2167	9680	9680
SB1	196	196	2,617	2542	2677	2677
SB2	-	-	25	24	26	26
SB3	71	71	2,456	2289	2510	2510
SB4	0	0	497	465	516	516
SB5	2	2	43	41	44	44
JE1	420	420	1,093	1,093	5728	5728
JE2	471	471	2,190	2,190	6278	6278
JE3	515	515	6174	6174	12081	12081
JW1	0	0	230	230	542	542
JW2	5	5	393	393	426	426
JW3	122	122	3,660	3,660	5,625	5,625
JW4	23	23	5,551	5,551	6,437	6,437
PL11	33	33	152	90	481	591
SC1	19	19	113	113	132	132
SC2	390	390	485	485	1,355	1,355
Totals	**4751**	**4751**	**43006**	**40226**	**73503**	**73621**

Table 13-9 – Potential Damages – 50% Pumping

Sub-basin	Potential Damages With 50% Pumping In Millions of 2005 Dollars					
	50-Year elevations		100-Year elevations		500-Year elevations	
	Pre-k	Current	Pre-k	Current	Pre-k	Current
OW1	23	23	28	28	170	170
OW2	412	412	2,205	2,205	3,105	3,105
NOE1	0	0	8	6	12	12
NOE2	1	1	121	121	143	143
NOE3	0	0	416	416	667	668
NOE4	0	0	33	33	60	61
NOE5	5	5	4,121	4,121	6,007	6,022
OM1	8	8	2,012	1,864	2,689	2,689
OM2	-	-	1,377	2	1,922	1,922
OM3	1	1	1,365	1,031	2,953	2,953
OM4	3	3	420	308	1,096	1,096
OM5	7	7	2,860	1,483	9,306	9,306
SB1	-	-	2,582	2,403	2,617	2,617
SB2	-	-	25	24	25	25
SB3	4	4	2,393	2,077	2,456	2,456
SB4	-	-	491	439	497	497
SB5	2	2	43	41	44	44
JE1	218	218	420	420	5,122	5,122
JE2	-	-	52	52	6,243	6,243
JE3	116	116	515	515	12,062	12,062
JW1	0	0	230	230	542	542
JW2	1	1	383	383	416	416
JW3	0	0	2,750	2,750	5,466	5,466
JW4	-	-	5,236	5,236	6,272	6,272
PL11	-	-	0	-	217	245
SC1	19	19	113	113	132	132
SC2	390	390	485	485	1355	1355
Totals	**1210**	**1210**	**30684**	**26786**	**71596**	**71641**

Table 13-10 – Potential Damages – 100% Pumping						
	Potential Damages With 100% Pumping					
	In Millions of 2005 Dollars					
	50-Year elevations		100-Year elevations		500-Year elevations	
Sub-basin	Pre-k	Current	Pre-k	Current	Pre-k	Current
OW1	23	23	28	28	170	170
OW2	412	412	2,205	2,205	3,105	3,105
NOE1	0	0	8	6	12	12
NOE2	1	1	121	121	143	143
NOE3	0	0	416	416	667	668
NOE4	0	0	33	33	60	61
NOE5	0	0	4,121	4,121	6,007	6,022
OM1	-	-	2,012	1,864	2,689	2,689
OM2	-	-	1,261	-	1,910	1,910
OM3	-	-	1,031	376	2,910	2,910
OM4	3	3	420	308	1,096	1,096
OM5	-	-	2,167	200	9,306	9,306
SB1	-	-	2,582	2,403	2,617	2,617
SB2	-	-	25	24	25	25
SB3	0	0	2,393	2,077	2,456	2,456
SB4	-	-	491	439	497	497
SB5	2	2	43	41	44	44
JE1	218	218	420	420	5,122	5,122
JE2	-	-	-	-	6,216	6,216
JE3	0	0	515	515	12,062	12,062
JW1	0	0	230	230	542	542
JW2	1	1	383	383	416	416
JW3	-	-	2,750	2,750	5,466	5,466
JW4	-	-	5,236	5,236	6,272	6,272
PL11	-	-	-	-	217	245
SC1	19	19	113	113	132	132
SC2	290	290	390	390	1355	1355
Totals	**969**	**969**	**29394**	**24669**	**71514**	**71559**

Table 13-11 - Economic Damages - % of Total Value, No Pumping								
	50 year elevations							
Sub basin	Pre-k			Current				
	Damages	% of Total	Color	Damages	% of Total	Color	Color Legend	
OW1	23	0.11		23	0.11		Less than 10%	
OW2	412	0.11		412	0.11		10%-30%	
NOE1	0	0.00		0	0.00		30&-50%	
NOE2	19	0.15		19	0.15		50%-70%	
NOE3	8	0.01		8	0.01		70%-90%	
NOE4	0	0.00		0	0.00		Greater than 90%	
NOE5	43	0.01		43	0.01			
OM1	402	0.15		402	0.15			
OM2	348	0.18		348	0.18			
OM3	376	0.12		376	0.12			
OM4	68	0.06		68	0.06			
OM5	785	0.07		785	0.07			
SB1	196	0.07		196	0.07			
SB2	-	0.00		-	0.00			
SB3	71	0.03		71	0.03			
SB4	0	0.00		0	0.00			
SB5	2	0.04		2	0.04			
JE1	420	0.07		420	0.07			
JE2	471	0.07		471	0.07			
JE3	515	0.04		515	0.04			
JW1	0	0.00		0	0.00			
JW2	5	0.01		5	0.01			
JW3	122	0.02		122	0.02			
JW4	23	0.00		23	0.00			
PL11	33	0.05		33	0.05			
SC1	19	0.13		19	0.13			
SC2	390	0.20		390	0.20			
Totals	4,751	0.06		4,751	0.06			

Table 13-12 - Economic Damages - % of Total Value, No Pumping								
100 year elevations								
Sub basin	Pre-k			Current				
	Damages	% of Total	Color	Damages	% of Total	Color	Color Legend	
OW1	39	0.18		39	0.18		Less than 10%	
OW2	2,405	0.66		2,405	0.66		10%-30%	
NOE1	8	0.64		6	0.49		30&-50%	
NOE2	123	0.93		123	0.93		50%-70%	
NOE3	510	0.75		510	0.75		70%-90%	
NOE4	49	0.74		49	0.74		Greater than 90%	
NOE5	4,561	0.76		4,561	0.76			
OM1	2,209	0.81		2,209	0.81			
OM2	1,573	0.81		1,040	0.53			
OM3	1,709	0.56		1,709	0.56			
OM4	420	0.36		68	0.06			
OM5	3,721	0.35		2,167	0.21			
SB1	2,617	0.96		2,542	0.93			
SB2	25	0.87		24	0.84			
SB3	2,456	0.95		2,298	0.89			
SB4	497	0.90		465	0.84			
SB5	43	0.91		41	0.87			
JE1	1,093	0.17		1,093	0.17			
JE2	2,190	0.35		2,190	0.35			
JE3	6,174	0.51		6,174	0.51			
JW1	230	0.24		230	0.24			
JW2	393	0.88		393	0.88			
JW3	3,660	0.57		3,660	0.57			
JW4	5,551	0.80		5,551	0.80			
PL11	152	0.23		90	0.13			
SC1	113	0.78		113	0.78			
SC2	485	0.25		485	0.25			
Totals	43,008	0.55		40,237	0.51			

Table 13-13 - Economic Damages - % of Total Value, No Pumping

500 year elevations							Color Legend
Sub basin	Pre-k			Current			
	Damages	% of Total	Color	Damages	% of Total	Color	
OW1	170	0.80		170	0.80		Less than 10%
OW2	3,105	0.86		3,105	0.86		10%-30%
NOE1	12	0.98		12	0.99		30&-50%
NOE2	143	1.08		143	1.08		50%-70%
NOE3	668	0.98		671	0.99		70%-90%
NOE4	61	0.92		62	0.94		Greater than 90%
NOE5	6,022	1.00		6,026	1.00		
OM1	2,718	0.99		2,718	0.99		
OM2	1,945	1.00		1,945	1.00		
OM3	3,010	0.98		3,010	0.98		
OM4	1,111	0.96		1,111	0.96		
OM5	9,680	0.92		9,680	0.92		
SB1	2,677	0.98		2,677	0.98		
SB2	26	0.90		26	0.90		
SB3	2,510	0.97		2,510	0.97		
SB4	516	0.93		516	0.93		
SB5	44	0.95		44	0.95		
JE1	5,728	0.89		5,728	0.89		
JE2	6,278	1.00		6,278	1.00		
JE3	12,081	1.00		12,081	1.00		
JW1	542	0.56		542	0.56		
JW2	426	0.95		426	0.95		
JW3	5,625	0.88		5,625	0.88		
JW4	6,437	0.92		6,437	0.92		
PL11	481	0.72		591	0.89		
SC1	132	0.91		132	0.91		
SC2	1,355	0.70		1,355	0.70		
Totals	73,501	0.94		73,619	0.94		

Table 13-14 - Economic Damages - % of Total Value, 50% Pumping

	50 year elevations							
Sub basin	Pre-k			Current				
	Damages	% of Total	Color	Damages	% of Total	Color	Color Legend	
OW1	23	0.11		23	0.11		Less than 10%	
OW2	412	0.11		412	0.11		10%-30%	
NOE1	0	0.00		0	0.00		30&-50%	
NOE2	1	0.00		1	0.00		50%-70%	
NOE3	0	0.00		0	0.00		70%-90%	
NOE4	0	0.00		0	0.00		Greater than 90%	
NOE5	5	0.00		5	0.00			
OM1	8	0.00		8	0.00			
OM2	-	0.00		-	0.00			
OM3	1	0.00		1	0.00			
OM4	3	0.00		3	0.00			
OM5	7	0.00		7	0.00			
SB1	-	0.00		-	0.00			
SB2	-	0.00		-	0.00			
SB3	4	0.00		4	0.00			
SB4	-	0.00		-	0.00			
SB5	2	0.04		2	0.04			
JE1	218	0.03		218	0.03			
JE2	-	0.00		-	0.00			
JE3	116	0.01		116	0.01			
JW1	0	0.00		0	0.00			
JW2	1	0.00		1	0.00			
JW3	0	0.00		0	0.00			
JW4	-	0.00		-	0.00			
PL11	-	0.00		-	0.00			
SC1	19	0.13		19	0.13			
SC2	390	0.20		390	0.20			
Total	1,209	0.02		1,209	0.02			

Table 13-15 - Economic Damages - % of Total Value, 50% Pumping

	100 year elevations						
Sub basin	Pre-k			Current			Color Legend
	Damages	% of Total	Color	Damages	% of Total	Color	Less than 10%
OW1	28	0.13		28	0.13		10%-30%
OW2	2,205	0.61		2,205	0.61		30&-50%
NOE1	8	0.64		6	0.49		50%-70%
NOE2	121	0.91		121	0.91		70%-90%
NOE3	416	0.61		416	0.61		Greater than 90%
NOE4	33	0.49		33	0.49		
NOE5	4,121	0.68		4,121	0.68		
OM1	2,012	0.73		1,864	0.68		
OM2	1,377	0.71		2	0.00		
OM3	1,365	0.44		1,031	0.33		
OM4	420	0.36		28	0.02		
OM5	2,860	0.27		1,483	0.14		
SB1	2,582	0.94		2,403	0.88		
SB2	25	0.87		24	0.83		
SB3	2,393	0.93		2,077	0.80		
SB4	491	0.89		439	0.79		
SB5	43	0.91		41	0.87		
JE1	420	0.07		420	0.07		
JE2	52	0.01		52	0.01		
JE3	515	0.04		515	0.04		
JW1	230	0.24		230	0.24		
JW2	383	0.85		383	0.85		
JW3	2,750	0.43		2,750	0.43		
JW4	5,236	0.75		5,236	0.75		
PL11	0	0.00		-	0.00		
SC1	113	0.78		113	0.78		
SC2	485	0.25		485	0.25		
	30,684	0.39		26,506	0.34		

Table 13-16 - Economic Damages - % of Total Value, 50% Pumping

	500 year elevations							
Sub basin	Pre-k			Current			Color Legend	
	Damages	% of Total	Color	Damages	% of Total	Color		
OW1	170	0.80		170	0.80		Less than 10%	
OW2	3,105	0.86		3,105	0.86		10%-30%	
NOE1	12	0.98		12	0.99		30&-50%	
NOE2	143	1.08		143	1.08		50%-70%	
NOE3	667	0.98		668	0.98		70%-90%	
NOE4	60	0.91		61	0.92		Greater than 90%	
NOE5	6,007	1.00		6,022	1.00			
OM1	2,689	0.98		2,689	0.98			
OM2	1,922	0.99		1,922	0.99			
OM3	2,953	0.96		2,953	0.96			
OM4	1,096	0.95		1,096	0.95			
OM5	9,306	0.88		9,306	0.88			
SB1	2,617	0.96		2,617	0.96			
SB2	25	0.87		25	0.87			
SB3	2,456	0.95		2,456	0.95			
SB4	497	0.90		497	0.90			
SB5	44	0.93		44	0.93			
JE1	5,122	0.79		5,122	0.79			
JE2	6,243	0.99		6,243	0.99			
JE3	12,062	1.00		12,062	1.00			
JW1	542	0.56		542	0.56			
JW2	416	0.93		416	0.93			
JW3	5,466	0.86		5,466	0.86			
JW4	6,272	0.90		6,272	0.90			
PL11	217	0.33		245	0.37			
SC1	132	0.91		132	0.91			
SC2	1,355	0.70		1,355	0.70			
Total	71,596	0.91		71,641	0.91			

Table 13-17 - Economic Damages - % of Total Value, 100% Pumping

	50 year elevations							
Sub basin	Pre-k			Current			Color Legend	
	Damages	% of Total	Color	Damages	% of Total	Color		
OW1	23	0.11		23	0.11		Less than 10%	
OW2	412	0.11		412	0.11		10%-30%	
NOE1	0	0.00		0	0.00		30&-50%	
NOE2	1	0.00		1	0.00		50%-70%	
NOE3	0	0.00		0	0.00		70%-90%	
NOE4	0	0.00		0	0.00		Greater than 90%	
NOE5	0	0.00		0	0.00			
OM1	-	0.00		-	0.00			
OM2	-	0.00		-	0.00			
OM3	-	0.00		-	0.00			
OM4	3	0.00		3	0.00			
OM5	-	0.00		-	0.00			
SB1	-	0.00		-	0.00			
SB2	-	0.00		-	0.00			
SB3	0	0.00		0	0.00			
SB4	-	0.00		-	0.00			
SB5	2	0.04		2	0.04			
JE1	218	0.03		218	0.03			
JE2	-	0.00		-	0.00			
JE3	0	0.00		0	0.00			
JW1	0	0.00		0	0.00			
JW2	1	0.00		1	0.00			
JW3	-	0.00		-	0.00			
JW4	-	0.00		-	0.00			
PL11	-	0.00		-	0.00			
SC1	19	0.13		19	0.13			
SC2	290	0.15		290	0.15			
Total	969	0.01		969	0.01			

Table 13-18 - Economic Damages - % of Total Value, 100% Pumping

100 year elevations							Color Legend
Sub basin	**Pre-k**			**Current**			
	Damages	**% of Total**	**Color**	**Damages**	**% of Total**	**Color**	Less than 10%
OW1	28	0.13		28	0.13		10%-30%
OW2	2,205	0.61		2,205	0.61		30&-50%
NOE1	8	0.64		6	0.49		50%-70%
NOE2	121	0.91		121	0.91		70%-90%
NOE3	416	0.61		416	0.61		Greater than 90%
NOE4	33	0.49		33	0.49		
NOE5	4,121	0.68		4,121	0.68		
OM1	2,012	0.73		1,864	0.68		
OM2	1,261	0.65		-	0.00		
OM3	1,031	0.33		376	0.12		
OM4	420	0.36		28	0.02		
OM5	2,167	0.21		200	0.02		
SB1	2,582	0.94		2,403	0.88		
SB2	25	0.87		24	0.83		
SB3	2,393	0.93		2,077	0.80		
SB4	491	0.89		439	0.79		
SB5	43	0.91		41	0.87		
JE1	420	0.07		420	0.07		
JE2	-	0.00		-	0.00		
JE3	515	0.04		515	0.04		
JW1	230	0.24		230	0.24		
JW2	383	0.85		383	0.85		
JW3	2,750	0.43		2,750	0.43		
JW4	5,236	0.75		5,236	0.75		
PL11	-	0.00		-	0.00		
SC1	113	0.78		113	0.78		
SC2	390	0.20		390	0.20		
	29,394	0.37		24,419	0.31		

Table 13-19 - Economic Damages - % of Total Value, 100% Pumping							
500 year elevations							
Sub basin	**Pre-k**			**Current**			**Color Legend**
	Damages	**% of Total**	**Color**	**Damages**	**% of Total**	**Color**	
OW1	170	0.80		170	0.80		Less than 10%
OW2	3,105	0.86		3,105	0.86		10%-30%
NOE1	12	0.98		12	0.99		30&-50%
NOE2	143	1.08		143	1.08		50%-70%
NOE3	667	0.98		668	0.98		70%-90%
NOE4	60	0.91		61	0.92		Greater than 90%
NOE5	6,007	1.00		6,022	1.00		
OM1	2,689	0.98		2,689	0.98		
OM2	1,910	0.98		1,910	0.98		
OM3	2,910	0.95		2,910	0.95		
OM4	1,096	0.95		1,096	0.95		
OM5	9,306	0.88		9,306	0.88		
SB1	2,617	0.96		2,617	0.96		
SB2	25	0.87		25	0.87		
SB3	2,456	0.95		2,456	0.95		
SB4	497	0.90		497	0.90		
SB5	44	0.93		44	0.93		
JE1	5,122	0.79		5,122	0.79		
JE2	6,216	0.99		6,216	0.99		
JE3	12,062	1.00		12,062	1.00		
JW1	542	0.56		542	0.56		
JW2	416	0.93		416	0.93		
JW3	5,466	0.86		5,466	0.86		
JW4	6,272	0.90		6,272	0.90		
PL11	217	0.33		245	0.37		
SC1	132	0.91		132	0.91		
SC2	1,355	0.70		1,355	0.70		
Total	71,514	0.91		71,559	0.91		

Human Risks - The Consequence Team also examined the human health and safety consequences for a variety of event scenarios. For the actual Katrina scenario, the effects considered include recorded mortality as well as actual and potential morbidity, including both physical and mental health impacts. For the risk scenarios, both pre- and post-Katrina stage-fatality functions were developed and provided to the Risk Team for modeling residual risks in greater New Orleans. The post-Katrina stage-fatality curves are based on population and structure conditions that existed prior to Katrina. The mortality risk estimates consider a distribution of evacuation rates on the rate of fatalities within the population at risk. The fatalities shown in Tables 13-11, 13-12 and 13-13 are potential fatalities only based on mean estimates of evacuation and are not intended to be predictions of actual loss of life. Since the actual Katrina evacuation was highly successful, the fatality estimates based on a mean value for evacuation are high.

The data in Tables 13-20 through 13-22 represent estimates of annualized loss of life risk at the specific frequency of occurrences cited in the table. These data have been mapped using a color code to provide a visual graphical presentation of the relative risk for the New Orleans area. The loss of life risk maps derived from these data are presented in Figure 13-2. Figure 13-2 provides comparisons between the Pre-Katrina HPS and 2007 HPS at the 50, 100, and 500-year flood frequencies for 0% and 50% of ideal pumping capacities.

Table 13-19 presents a summary of the loss of life estimates for the entire region as a function of the HPS and level of pumping. This shows that the loss of life, given the assumptions in the analysis, is somewhat improved for the 2007 HPS at the 100-year frequency of occurrence, but little different at the 50 and 500-year frequencies. There is no difference between the HPS at the 50-year level because flooding is dominantly from rainfall. For the 500-year level, there is such extensive flooding that the improvements made for the 2007 HPS have little impact. These numbers also show that pumping can have a significant impact on loss of life if an operational capability comparable to the 50% ideal capacity modeled can be achieved.

Table 13-19. Potential Loss of Life summary statistics for entire region modeled, (x1000).

Level	Pre-K 50 Yr	2007 50 yr	Pre-K 100 yr	2007 100 yr	500 yr
No Pump	.4	.4	3.7	2.6	42
50% Pump	.3	.3	2.6	1.1	29
100% Pump	.2	.2	2.5	.9	27

The potential fatalities for the Pre-K and June 2007 HPS without pumping (Table 13-20) are equal at about 391 for the 50-Year event. The 100-Year potential fatalities are 3,662 for the Pre-K HPS and are reduced to about 2,584 for the June 2007 HPS. For the 500-Year event, the potential fatalities are 44,412 for the Pre-K HPS and increase to 46,185 for the June 2007 HPS. The increase in potential fatalities for the June 2007 HPS is due to higher levee elevations in some sub-basins, which allow more water to collect in the basins.

The potential fatalities for the Pre-K and June 2007 HPS with 50% pumping (Table 13-21) are equal at about 35 for the 50-Year event. This represents a reduction of more than 350 potential fatalities from the no pumping scenario and demonstrates the importance of maintaining pumping operations during the more frequent events. The 100-Year potential fatalities are 2,706 for the Pre-K HPS and are reduced to about 1053 for the June 2007 HPS, again demonstrating the effectiveness of the pumping system at reducing potential damages by showing a reduction of 1,500 in potential fatalities. For the 500-Year event, the potential fatalities are 28,972 for the Pre-K HPS and increase to 30,498 for the June 2007 HPS. The increase in potential fatalities for the June 2007 HPS is due to higher levee elevations in some sub-basins, which allow more water to collect in the basins.

The potential fatalities for the Pre-K and June 2007 HPS with 100% pumping (Table 13-22) are equal at about 20 for the 50-Year event. The 100-Year potential fatalities are 2,458 for the Pre-K HPS and are reduced to about 920 for the June 2007 HPS. For the 500-Year event, the potential fatalities are 27,550 for the Pre-K HPS and increase to 29,076 for the June 2007 HPS. The increase in potential fatalities for the June 2007 HPS is due to higher levee elevations in some sub-basins, which allow more water to collect in the basins. The potential fatalities in the 100% pumping scenario are all less than for the 50% pumping scenarios, but the most significant risk reductions were attained by the 50% pumping scenario.

Loss of Life Risk Findings

50-Year:

- Pre-Katrina potential for loss of life risk was extreme in OM2 sub-basin and very high in portions of JE, JW, PL and OW.

- The 2007 HPS (without pumping) reduced loss of life risk in the majority of OM and JE and portions of QW, JW, NOE and PL north. Loss of life risk remains high in OM2 due primarily to the IHNC vulnerability.

- Pumping at an operational capacity equal to or greater than the 50% ideal capacity modeled reduces loss of life risk to the lowest category at the 50-year (2%) flood frequency.

100-Year:

- At the 100-year flood frequency, Pre-Katrina potential for loss of life risk was extreme for OM2 and very high for SB and portions of OW and JW.

- The 2007 HPS, without pumping, reduces loss of life risk for OM2 but has little impact elsewhere.

- Pumping at an operational capacity equal or greater than the 50% ideal capacity modeled, would reduce loss of life risk in portions of OW, JE and PL north.

500-Year:

- The 500-year (0.2) flood frequency presents an extremely high potential for high loss of life risk for all of OM, most of JE and a good portion of NOE, SB, OW, and JW for both Pre-Katrina HPS and the 2007 HPS.

- Areas with lower loss of life risk are primarily areas with lower populations exposed to flooding.

- Pumping makes no difference in loss of life risk at the 500-year flood frequency for either HPS.

Table 13-20 – Potential Fatalities – No Pumping

Sub-basin	Risk Analysis Results Without Pumping					
	50-Year elevations		100-Year elevations		500-Year elevations	
	Pre-k	Current	Pre-k	Current	Pre-k	Current
OW1	0	0	0	0	1	1
OW2	6	6	101	101	420	420
NOE1	0	0	0	0	0	0
NOE2	0	0	1	1	91	154
NOE3	0	0	13	13	298	524
NOE4	0	0	0	0	2	2
NOE5	4	4	63	63	6,528	7,945
OM1	2	2	80	80	2217	2217
OM2	237	237	1,289	329	3179	3179
OM3	10	10	61	61	2079	2079
OM4	8	8	35	8	530	530
OM5	21	21	70	41	3262	3262
SB1	-	-	915	888	915	915
SB2	-	-	-	-	-	-
SB3	-	-	561	561	646	646
SB4	0	0	82	49	107	107
SB5	0	0	3	3	3	3
JE1	0	0	0	0	3	3
JE2	37	37	50	50	5886	5886
JE3	31	31	93	93	17136	17136
JW1	4	4	31	31	63	63
JW2	0	0	6	6	40	40
JW3	1	1	42	42	195	195
JW4	1	1	132	132	607	607
PL11	28	28	33	31	180	247
SC1	-	-	-	-	1	1
SC2	1	1	1	1	23	23
Totals	**391**	**391**	**3662**	**2584**	**44412**	**46185**

Table 13-21 – Potential Fatalities – 50% Pumping

Sub-basin	Risk Analysis Results with 50% pumping					
	50-Year elevations		100-Year elevations		500-Year elevations	
	Pre-k	Current	Pre-k	Current	Pre-k	Current
OW1	0	0	0	0	1	1
OW2	6	6	52	52	420	420
NOE1	0	0	0	0	0	0
NOE2	0	0	1	1	56	91
NOE3	-	-	9	9	228	298
NOE4	0	0	0	0	2	2
NOE5	2	2	45	45	5,111	6,528
OM1	1	1	54	29	1,241	1,241
OM2	6	6	586	113	2,683	2,683
OM3	-	-	32	24	1,055	1,055
OM4	3	3	35	6	438	438
OM5	2	2	56	31	2,075	2,075
SB1	-	-	901	393	915	915
SB2	-	-	-	-	-	-
SB3	-	-	561	136	561	561
SB4	0	0	66	34	82	82
SB5	0	0	3	3	3	3
JE1	-	-	0	0	3	3
JE2	-	-	23	23	3,716	3,716
JE3	9	9	31	0	9,678	9,678
JW1	4	4	31	31	63	63
JW2	0	0	5	5	24	24
JW3	0	0	33	33	138	138
JW4	-	-	83	83	418	418
PL11	1	1	16	1	37	41
SC1	-	-	-	-	1	1
SC2	1	1	1	1	23	23
Totals	**35**	**35**	**2624**	**1053**	**28972**	**30498**

Table 13-22 – Potential Fatalities – 100% Pumping						
Sub-basin	Risk Analysis Results with 100% pumping					
	50-Year elevations		100-Year elevations		500-Year elevations	
	Pre-k	Current	Pre-k	Current	Pre-k	Current
OW1	0	0	0	0	1	1
OW2	6	6	52	52	420	420
NOE1	0	0	0	0	0	0
NOE2	0	0	1	1	56	91
NOE3	-	-	9	9	228	298
NOE4	0	0	0	0	2	2
NOE5	-	-	45	45	5,111	6,528
OM1	-	-	54	29	1,241	1,241
OM2	6	6	472	6	2,560	2,560
OM3	-	-	24	10	888	888
OM4	3	3	35	6	438	438
OM5	-	-	41	12	2,075	2,075
SB1	-	-	901	393	915	915
SB2	-	-	-	-	-	-
SB3	-	-	561	136	561	561
SB4	0	0	66	34	82	82
SB5	0	0	3	3	3	3
JE1	-	-	0	0	3	3
JE2	-	-	-	-	2,584	2,584
JE3	-	-	31	31	9,678	9,678
JW1	4	4	31	31	63	63
JW2	0	0	5	5	24	24
JW3	-	-	33	33	138	138
JW4	-	-	83	83	418	418
PL11	1	1	10	0	37	41
SC1	-	-	-	-	1	1
SC2	0	0	1	1	23	23
Totals	**20**	**20**	**2458**	**920**	**27550**	**29076**

Conclusions

The experience of Katrina proved that the risk to life and property in the New Orleans area before Katrina was high and the results of the risk analysis quantifies the extent of that risk to the Pre-Katrina economy and population. The actual direct damages incurred due to the hurricane exceeded $28 Billion and the loss of life was more than 1200. These values correspond to potential damages and life loss values obtained by the risk analysis for less than a 100 year event if no pumping is available. While this conflicts somewhat with the estimated 300-400 year frequency of Katrina, it points to the severity of the risk in New Orleans and attests to the effectiveness of the evacuation prior to the hurricane in reducing the loss of life.

Examination of the three pumping scenarios shows the importance of the pumping system in reducing damages during the more frequent events, but also shows that the system was not capable of handling large inflow water volumes from overtopping or breaching during extreme events. The installation of surge gates at the Lake Pontchartrain end of the drainage canals has reduced the potential for failure of the I-walls along the canals that failed during Katrina. This fact has reduced the risks in Orleans Metro and Jefferson East for more frequent events and increases the importance of having reliable pumping system operation during these events.

While the HPS has been repaired and improved dramatically over the Pre- Katrina HPS, the risk associated with the June 2007 HPS to the area is still considered to be high for extreme events if the pre-Katrina potential consequences are used in the analysis. There are still areas of vulnerability along the IHNC and GIWW that amount to weak points in the system and limit the risk reduction in parts of Orleans Metro, New Orleans East and St. Bernard. In addition, the unfinished west bank HPS makes that area as vulnerable in the June 2007 analysis as it was before Katrina.

The risks to life and property as determined in the risk analysis would be expected to be reduced if existing demographics and redevelopment values were used, however the reductions would be due entirely to the reduced consequences of system failure and not due to the improvements to the system. In any case, the human and economic risks to New Orleans are still considered to be high during extreme events similar to Katrina and the most effective risk reduction measure remains to be implementation and execution of an effective evacuation plan.

The analysis presented herein in Volume VIII was a prototype risk analysis that indicates the value of, and need to, consider risk in the planning of hurricane protection projects. The study also shows that the reliability of all of the components of a hurricane protection project play a role in the performance of the overall project and, therefore, the project must be looked at as a system if the risks are to be fully evaluated. The large uncertainty in this study, and in any analysis of a project of the magnitude of the New Orleans HPS, shows that the system must be continually monitored, maintained and periodically reevaluated in order to identify potential weaknesses and gain understanding of the factors that affect uncertainty in the performance of the HPS. Part of the uncertainty associated with this study is due to the prototypical nature of the computational processes used and to the lack of a more sophisticated analysis tool. This uncertainty and the accuracy of future analyses can be improved by research and the development of better tools.

Figure 13-1 Depth Maps

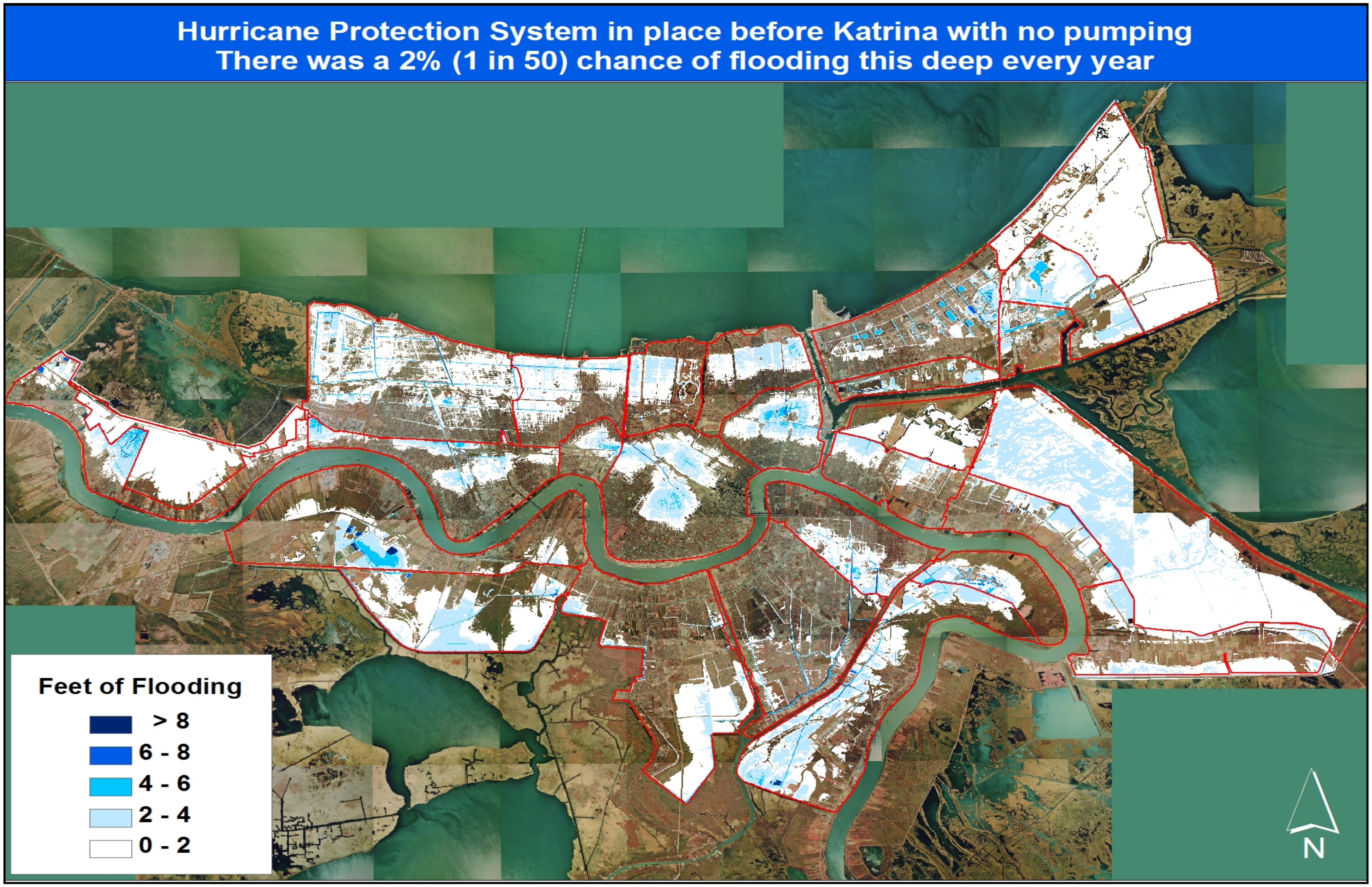
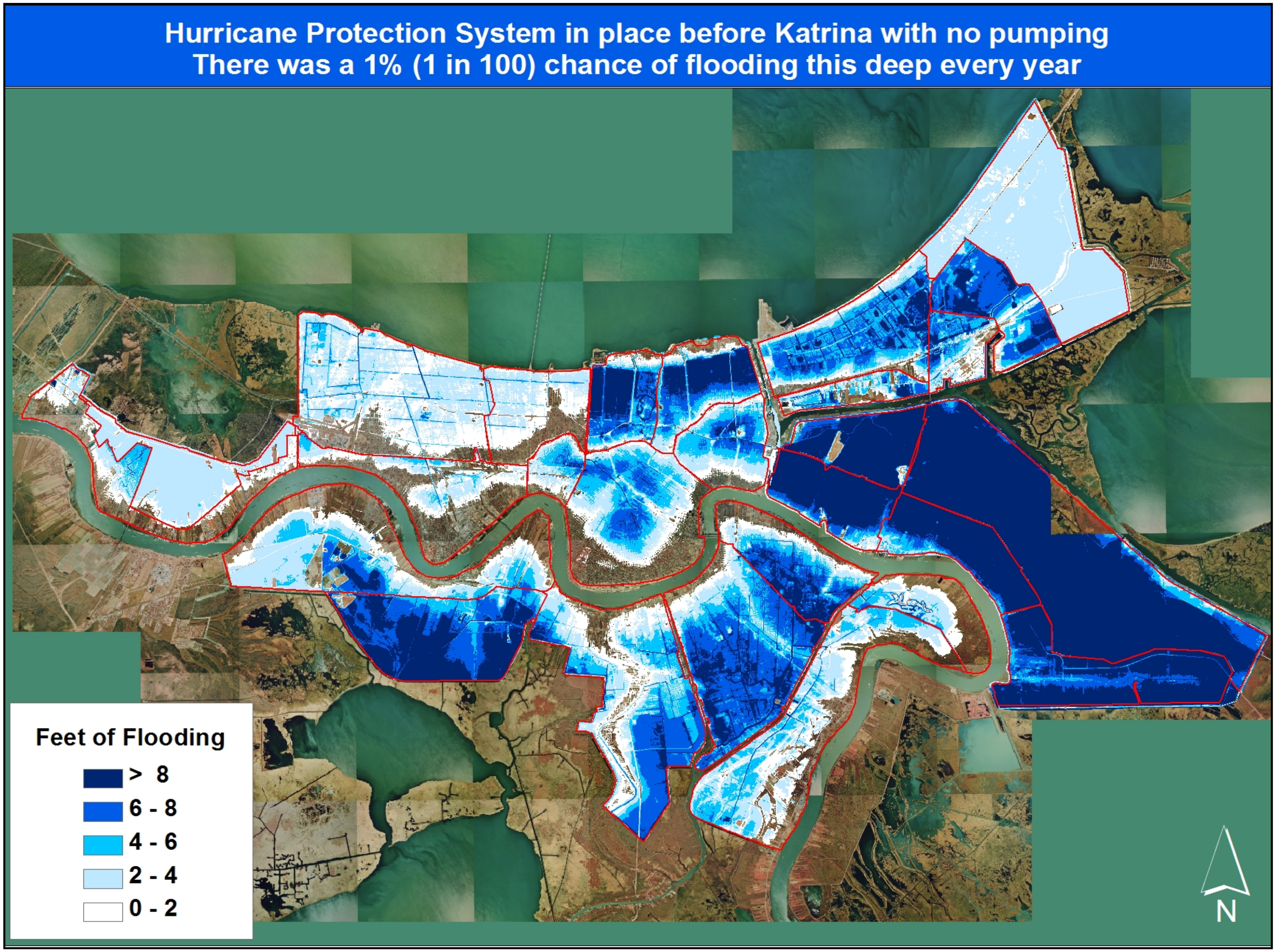
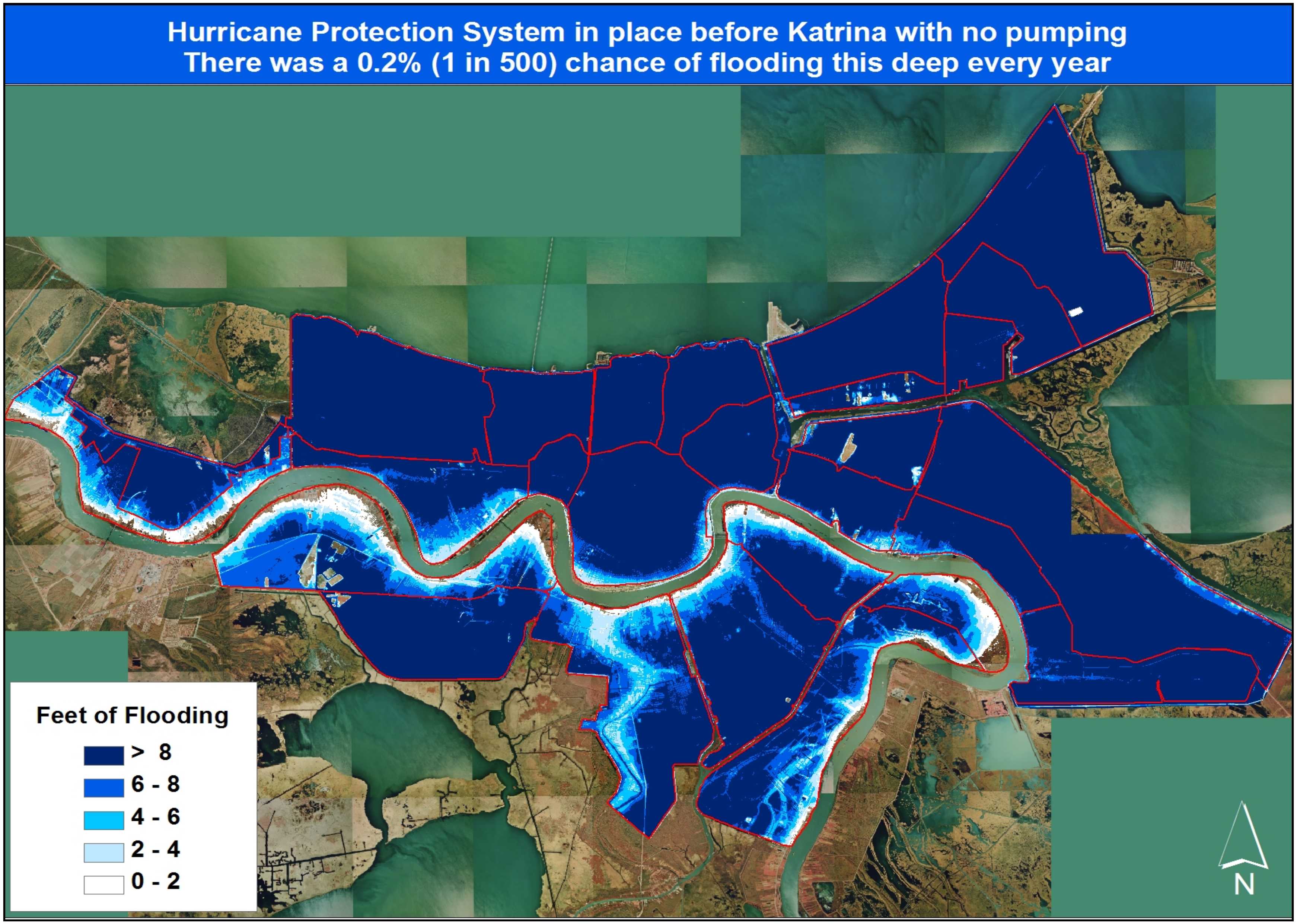
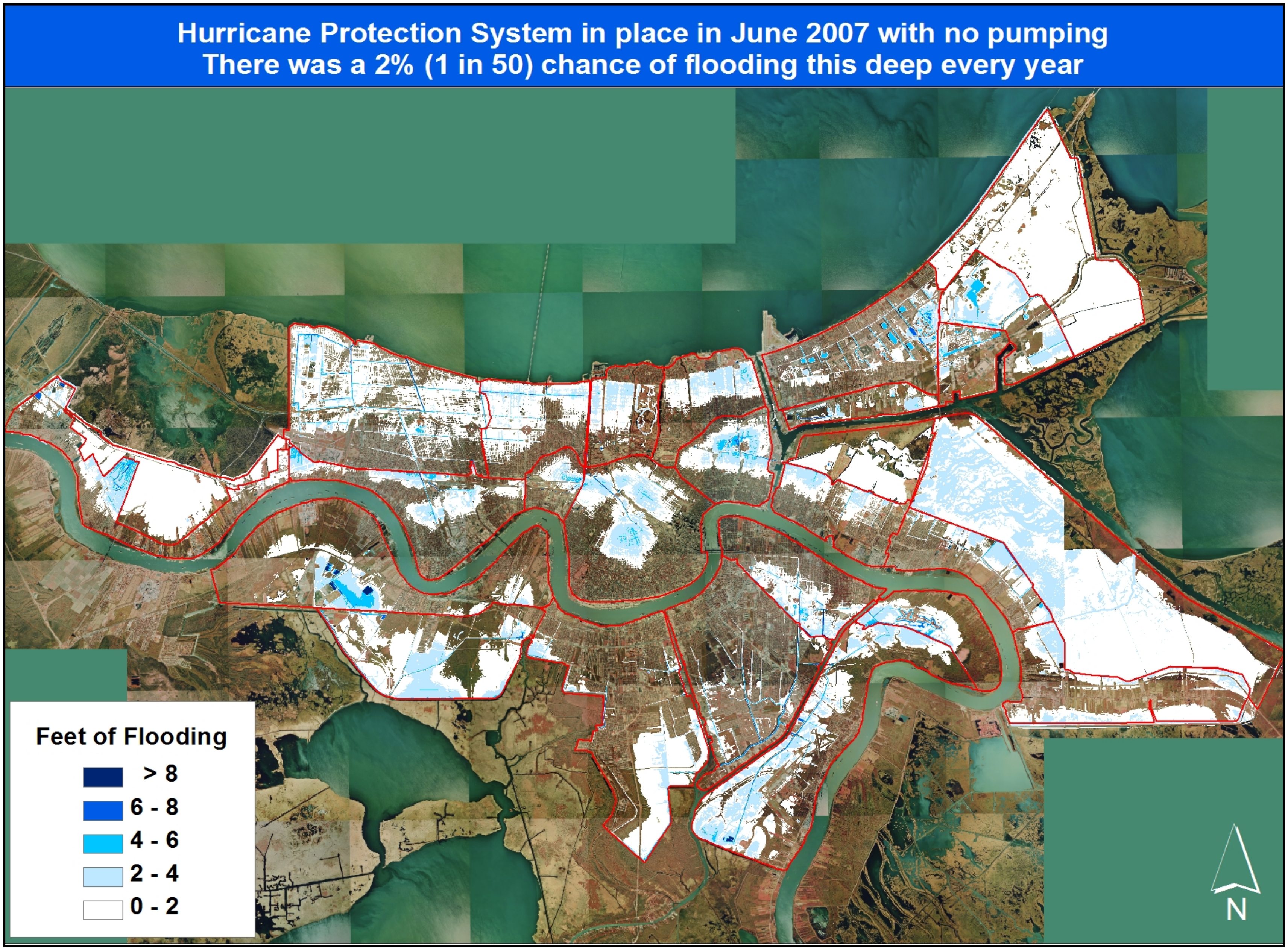


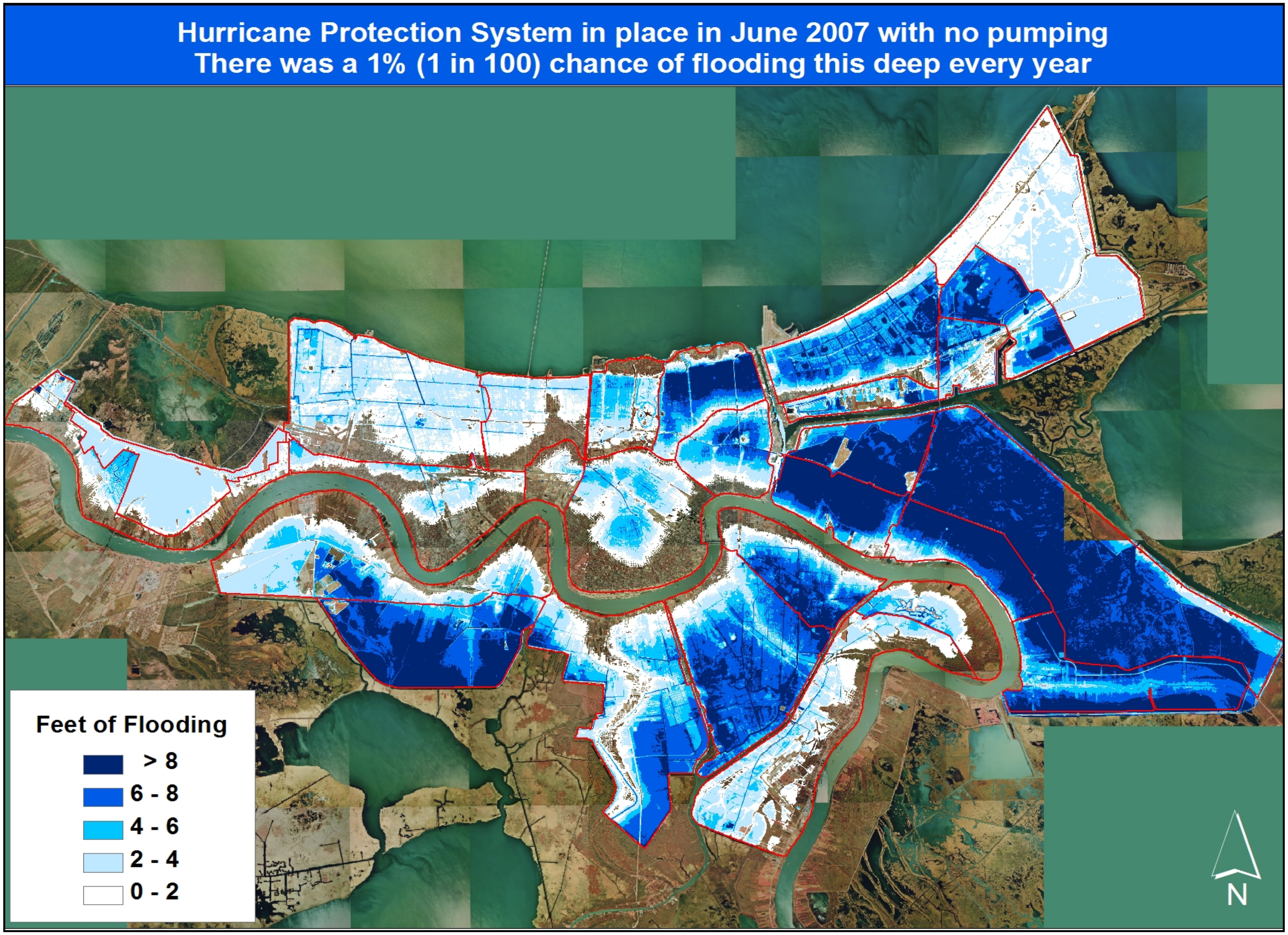
Figure 13-1. Pre-Katrina Depth Map (2% Chance, No Pumping)

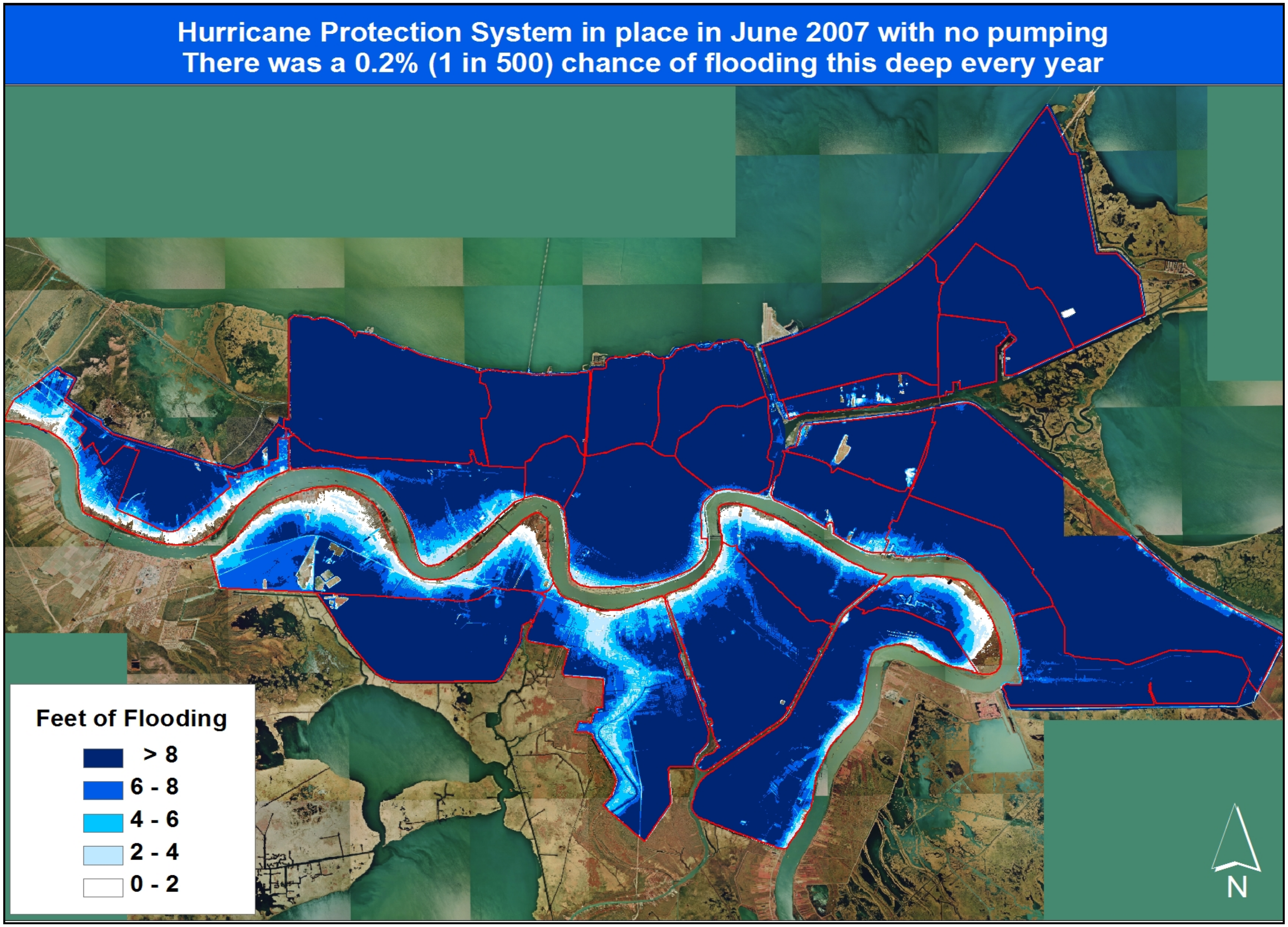

Hurricane Protection System in place before Katrina with no pumping
There was a 1% (1 in 100) chance of flooding this deep every year
Feet of Flooding
> 8
6 - 8
4 - 6
2 - 4
0 - 2
N



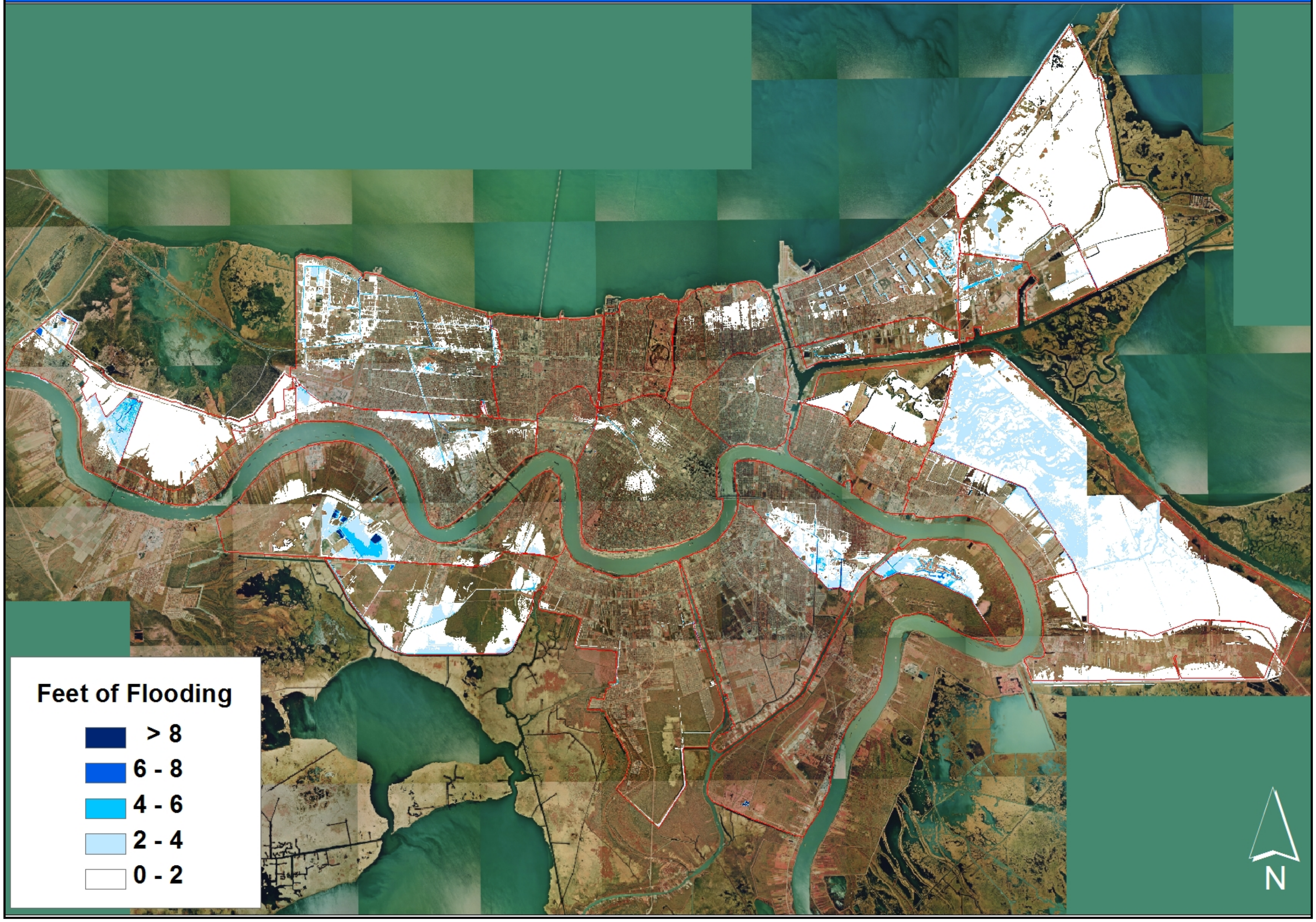
Hurricane Protection System in place before Katrina with no pumping
There was a 0.2% (1 in 500) chance of flooding this deep every year
Feet of Flooding
> 8
6 - 8
4 - 6
2 - 4
0 - 2
N

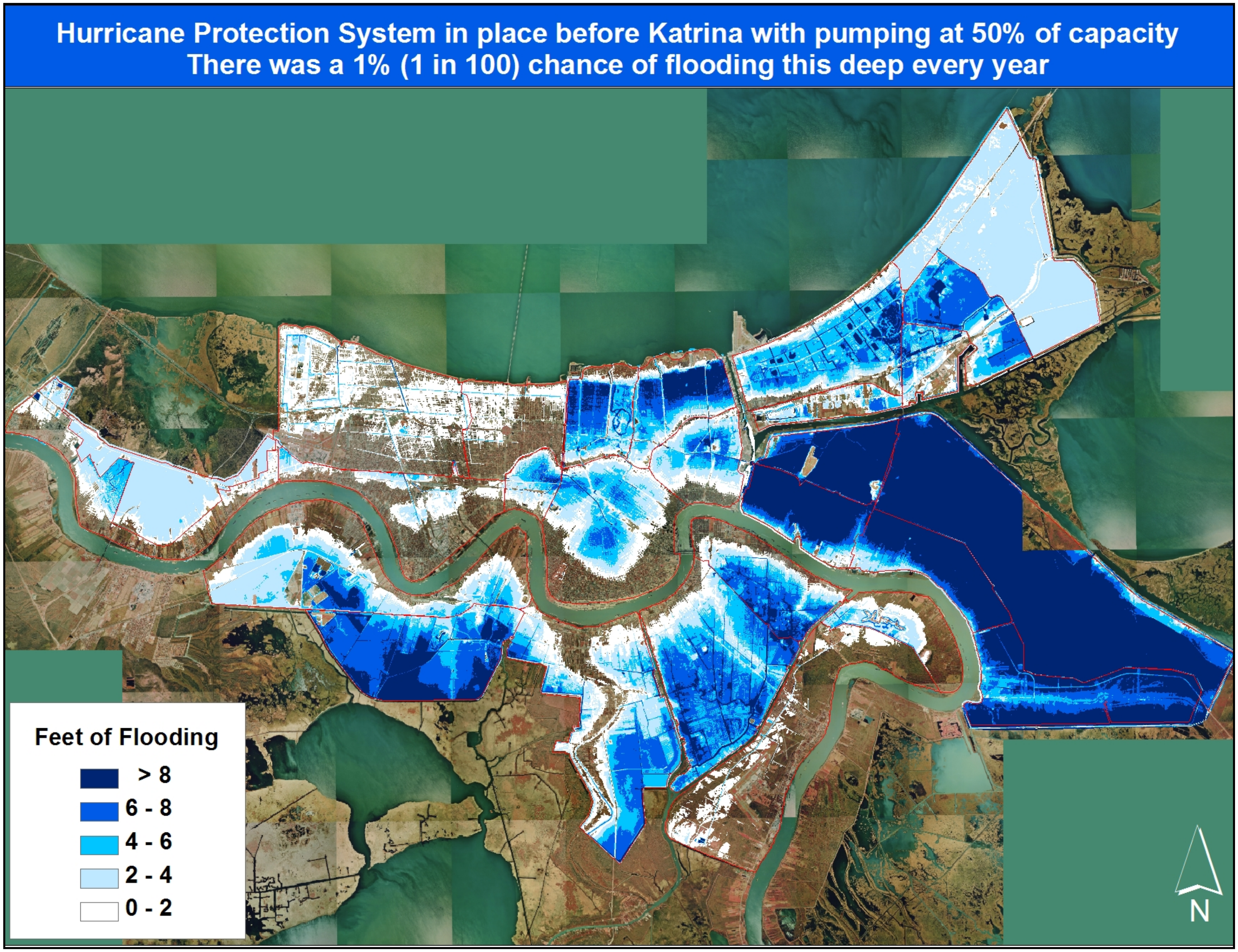

Hurricane Protection System in place in June 2007 with no pumping
There was a 2% (1 in 50) chance of flooding this deep every year
Feet of Flooding
> 8
6 - 8
4 - 6
2 - 4
0 - 2
N

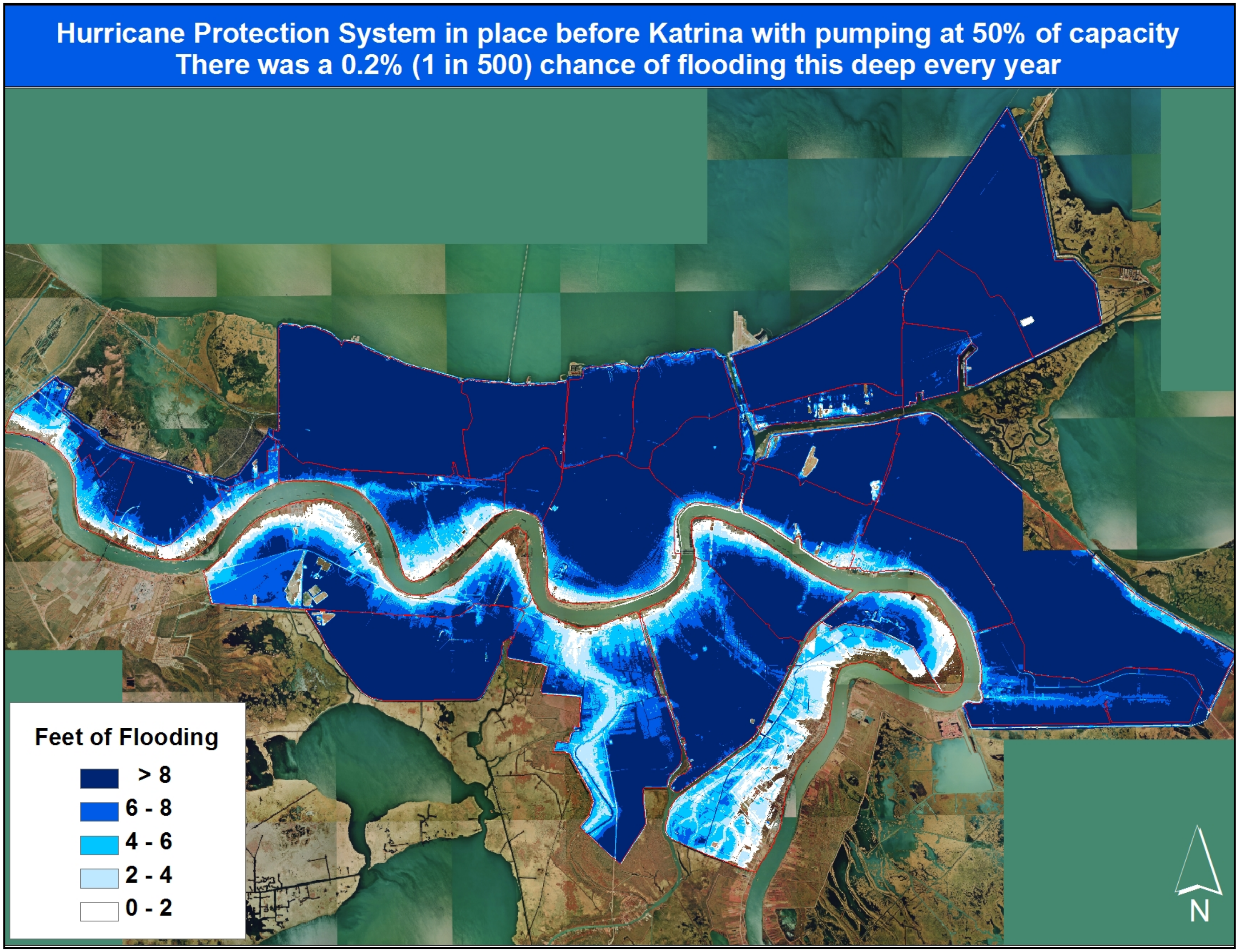

Hurricane Protection System in place in June 2007 with no pumping
There was a 1% (1 in 100) chance of flooding this deep every year
Feet of Flooding
> 8
6 - 8
4 - 6
2 - 4
0 - 2
N

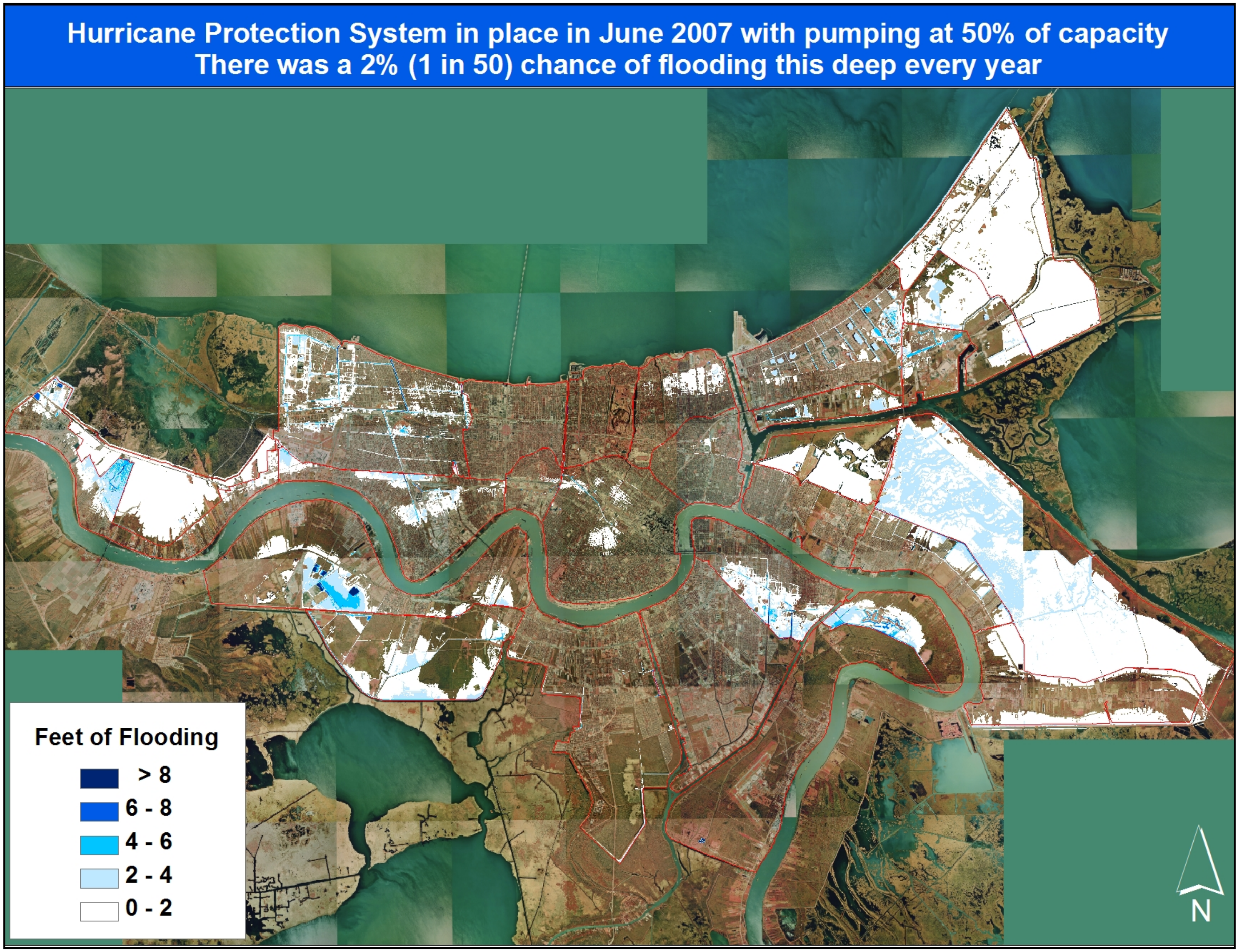

Hurricane Protection System in place in June 2007 with no pumping
There was a 0.2% (1 in 500) chance of flooding this deep every year
Feet of Flooding
> 8
6 - 8
4 - 6
2 - 4
0 - 2
N

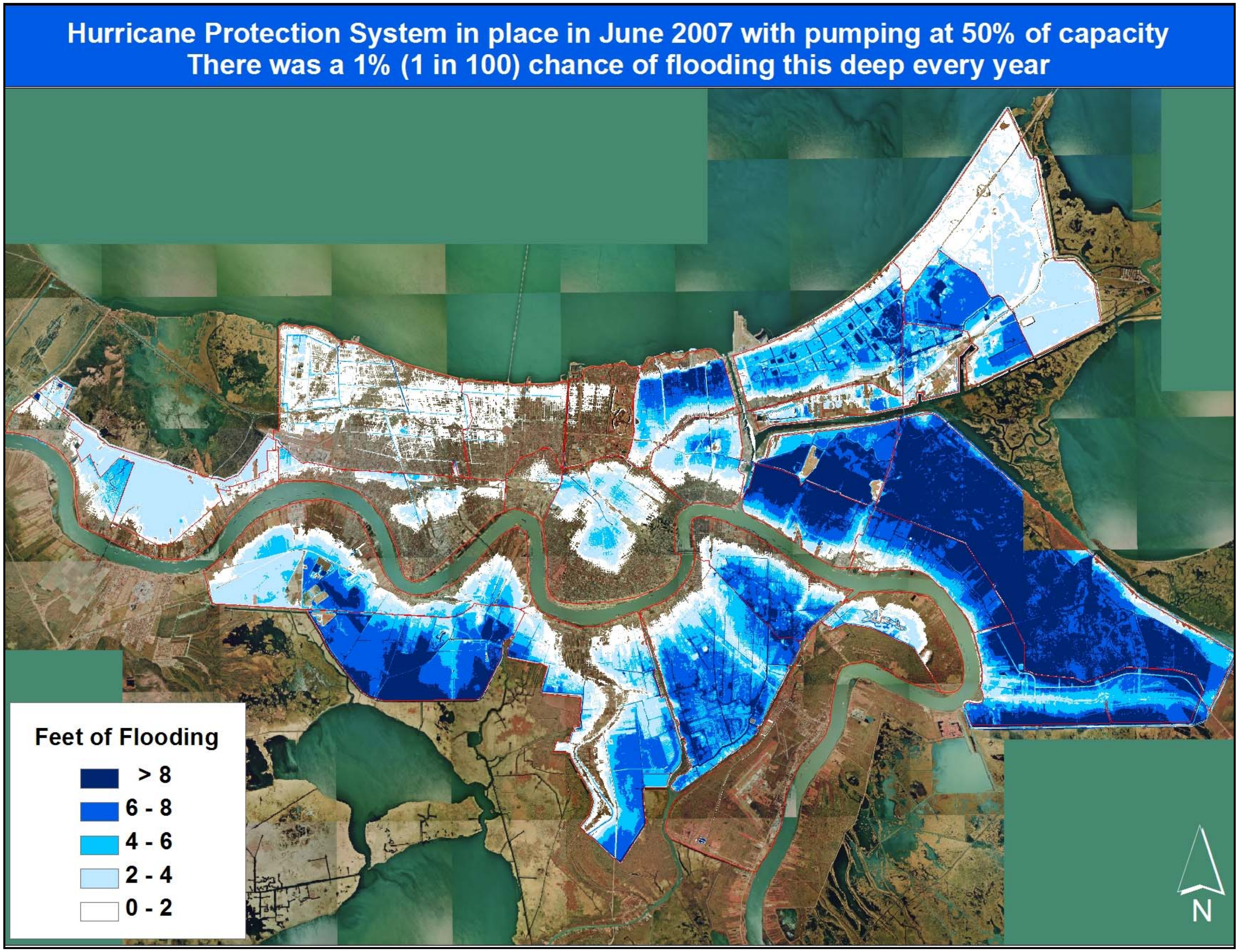
Hurricane Protection System in place before Katrina with pumping at 50% of capacity
There was a 2% (1 in 50) chance of flooding this deep every year

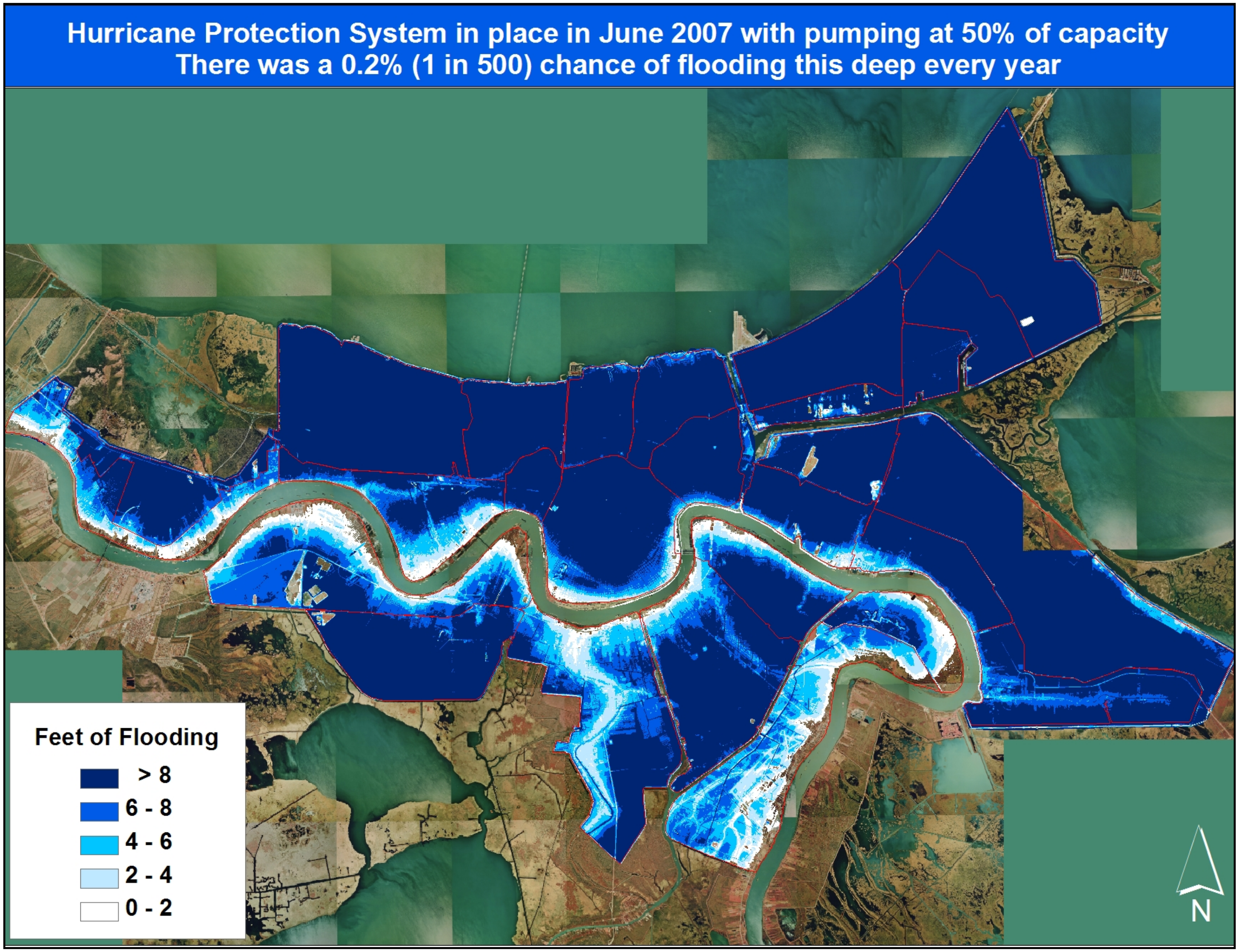


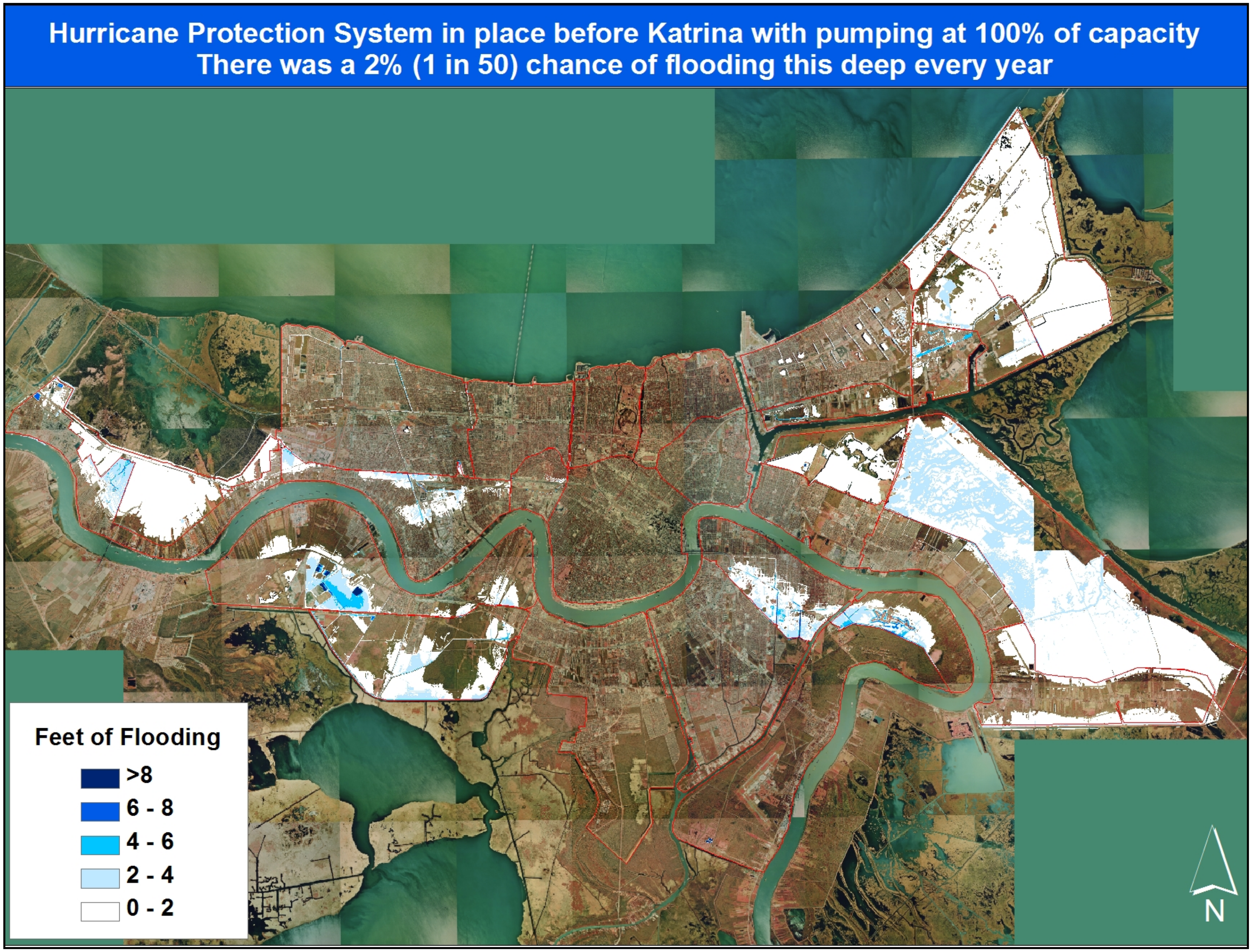

Hurricane Protection System in place before Katrina with pumping at 50% of capacity
There was a 1% (1 in 100) chance of flooding this deep every year
Feet of Flooding
> 8
6 - 8
4 - 6
2 - 4
0 - 2
N


Hurricane Protection System in place before Katrina with pumping at 50% of capacity
There was a 0.2% (1 in 500) chance of flooding this deep every year
Feet of Flooding
> 8
6 - 8
4 - 6
2 - 4
0 - 2
N

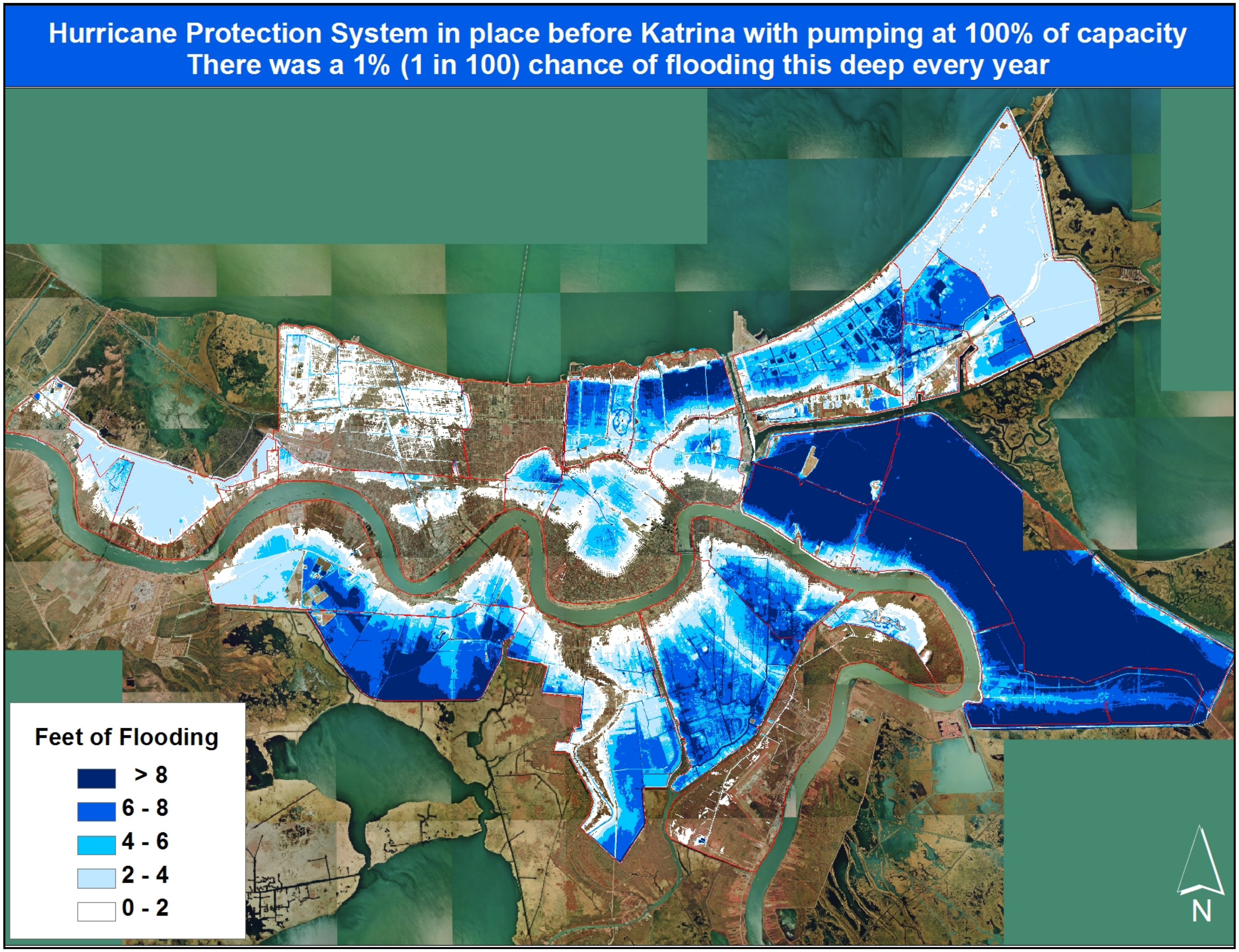

Hurricane Protection System in place in June 2007 with pumping at 50% of capacity
There was a 2% (1 in 50) chance of flooding this deep every year
Feet of Flooding
> 8
6 - 8
4 - 6
2 - 4
0 - 2
N


Hurricane Protection System in place in June 2007 with pumping at 50% of capacity
There was a 1% (1 in 100) chance of flooding this deep every year
Feet of Flooding
> 8
6 - 8
4 - 6
2 - 4
0 - 2
N

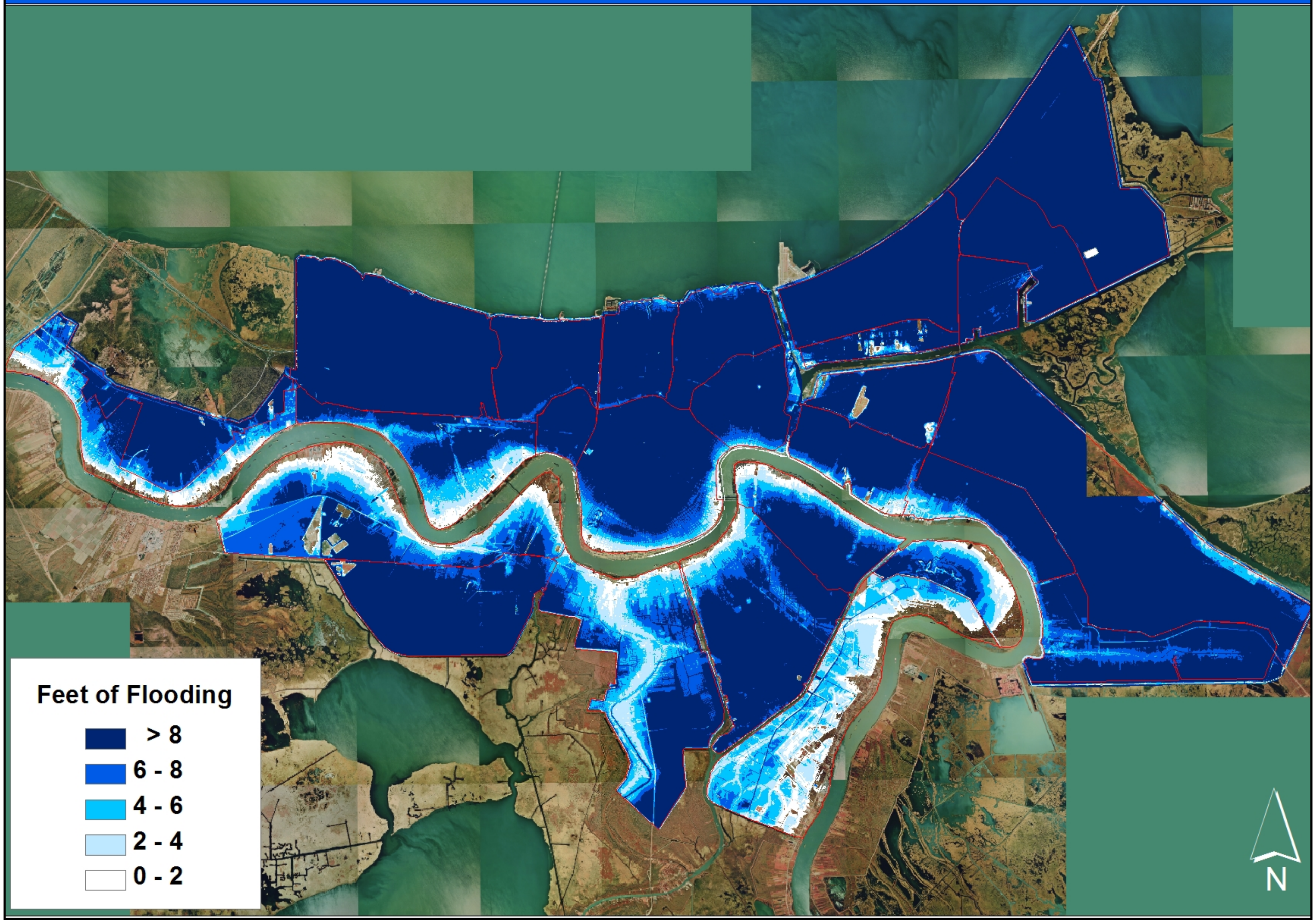

Hurricane Protection System in place in June 2007 with pumping at 50% of capacity
There was a 0.2% (1 in 500) chance of flooding this deep every year
Feet of Flooding
> 8
6 - 8
4 - 6
2 - 4
0 - 2
N

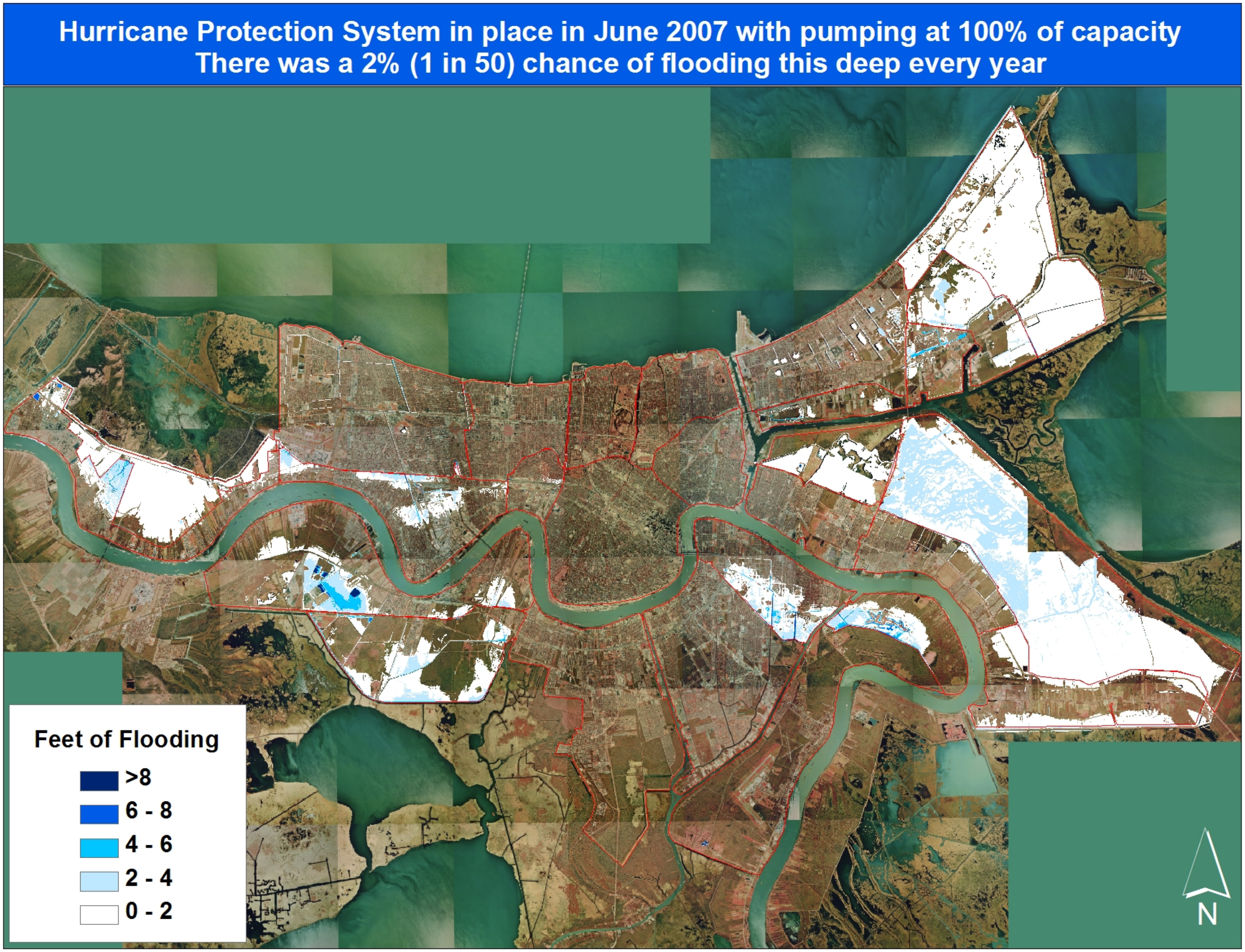


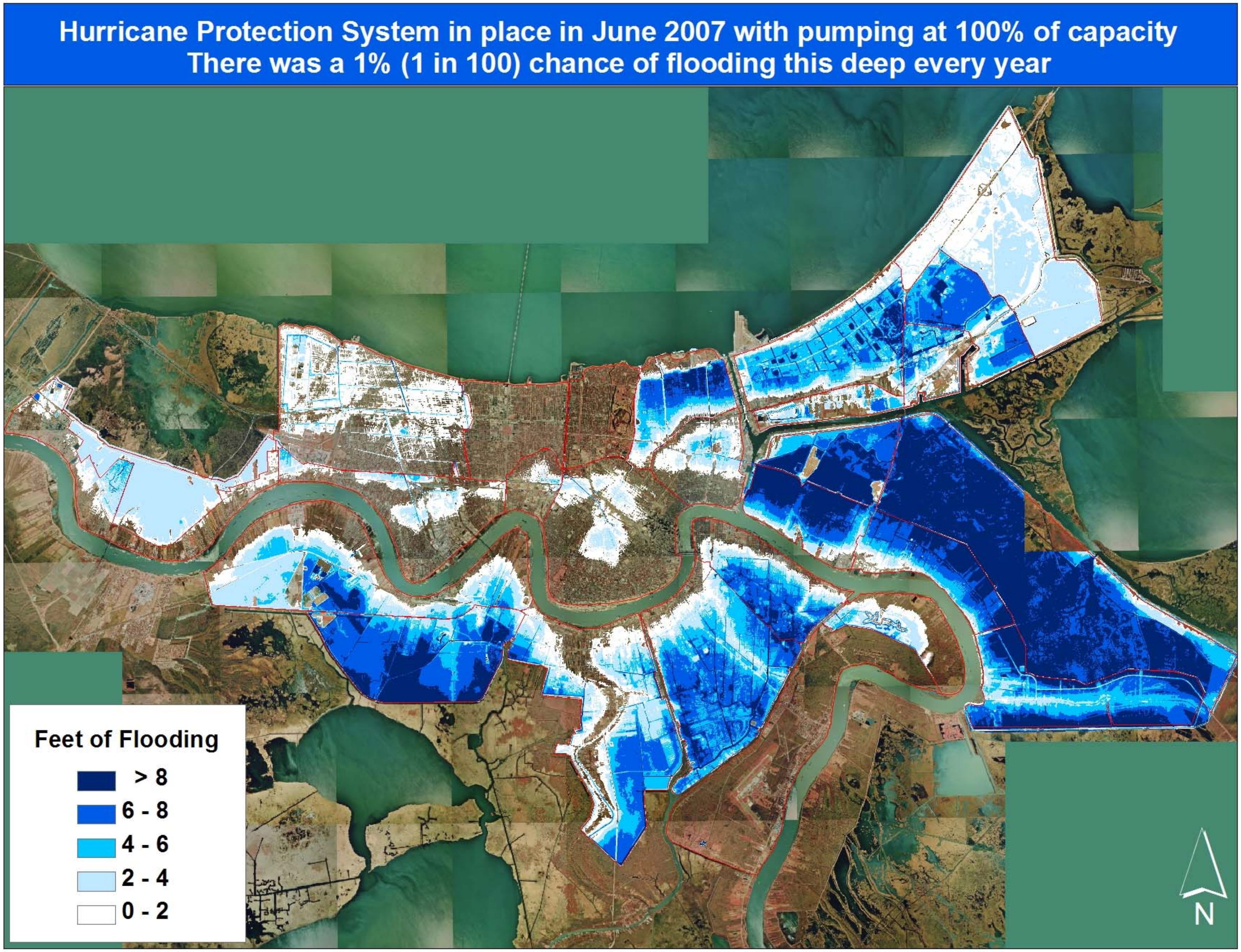
Hurricane Protection System in place before Katrina with pumping at 100% of capacity
There was a 2% (1 in 50) chance of flooding this deep every year
Feet of Flooding
>8
6 - 8
4 - 6
2 - 4
0 - 2
N


Hurricane Protection System in place before Katrina with pumping at 100% of capacity
There was a 1% (1 in 100) chance of flooding this deep every year
Feet of Flooding
> 8
6 - 8
4 - 6
2 - 4
0 - 2
N

Hurricane Protection System in place before Katrina with pumping at 100% of capacity
There was a 0.2% (1 in 500) chance of flooding this deep every year




Hurricane Protection System in place in June 2007 with pumping at 100% of capacity
There was a 2% (1 in 50) chance of flooding this deep every year
Feet of Flooding
>8
6 - 8
4 - 6
2 - 4
0 - 2
N


Hurricane Protection System in place in June 2007 with pumping at 100% of capacity
There was a 1% (1 in 100) chance of flooding this deep every year
Feet of Flooding
> 8
6 - 8
4 - 6
2 - 4
0 - 2
N

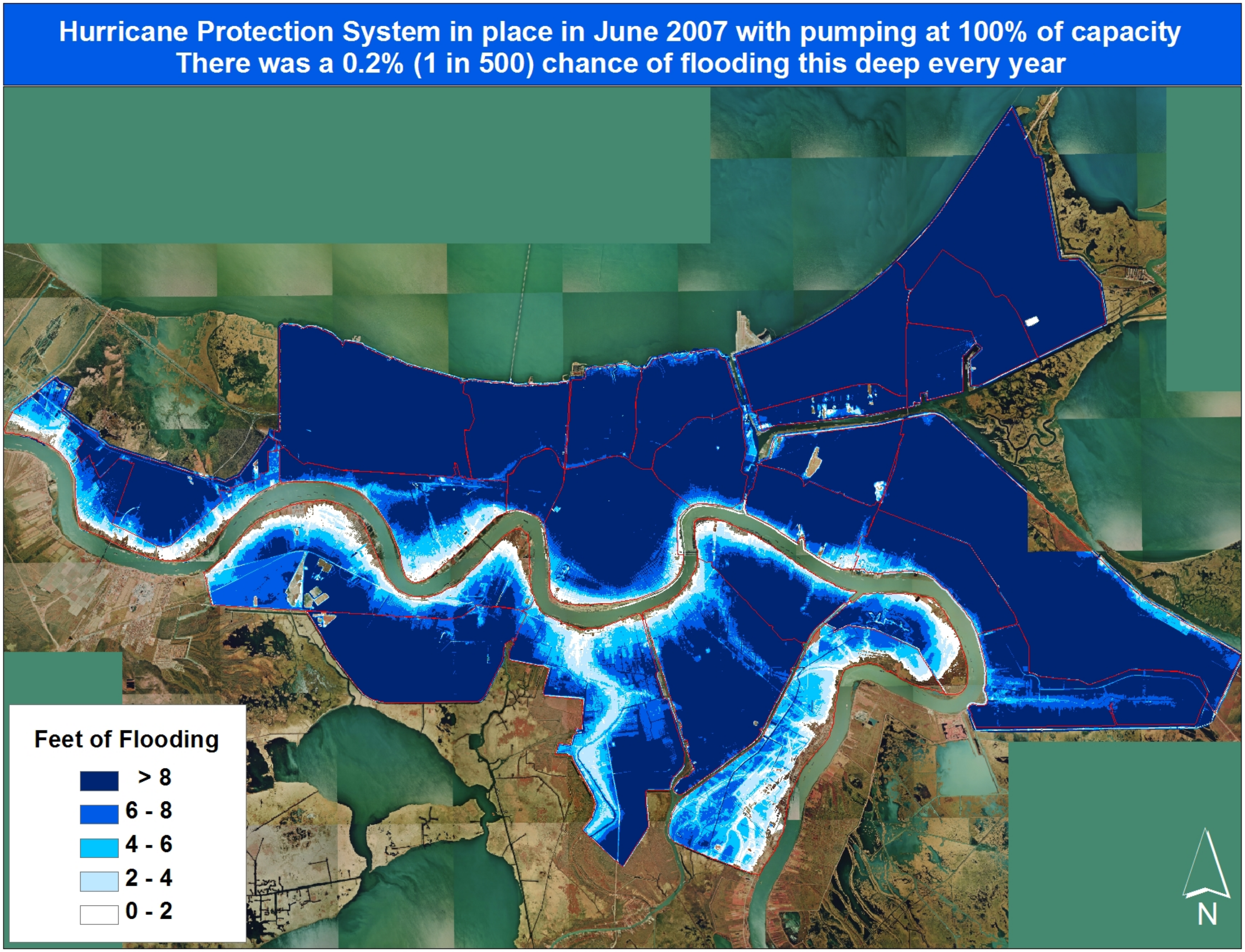
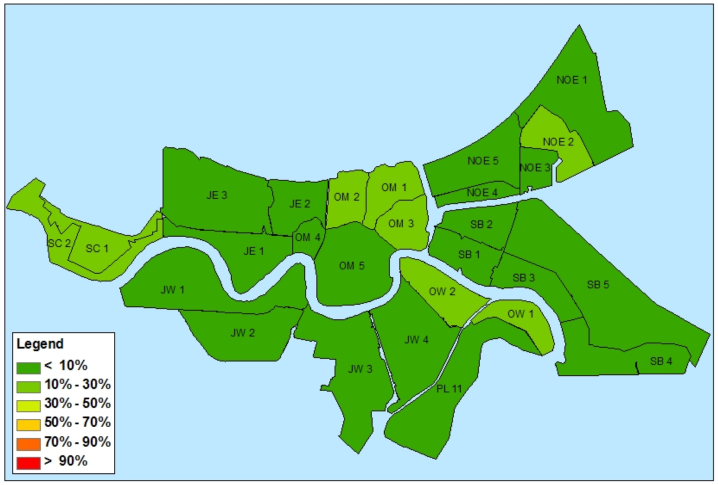
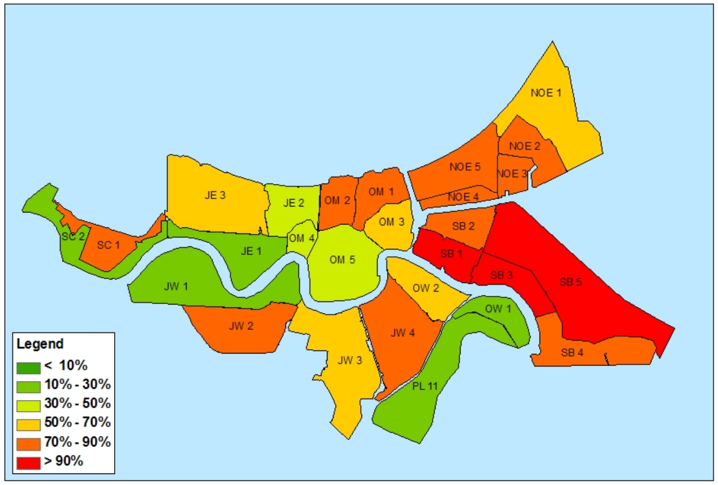

Hurricane Protection System in place in June 2007 with pumping at 100% of capacity
There was a 0.2% (1 in 500) chance of flooding this deep every year
Feet of Flooding
> 8
6 - 8
4 - 6
2 - 4
0 - 2
N

Figure 13-2 Risk Maps

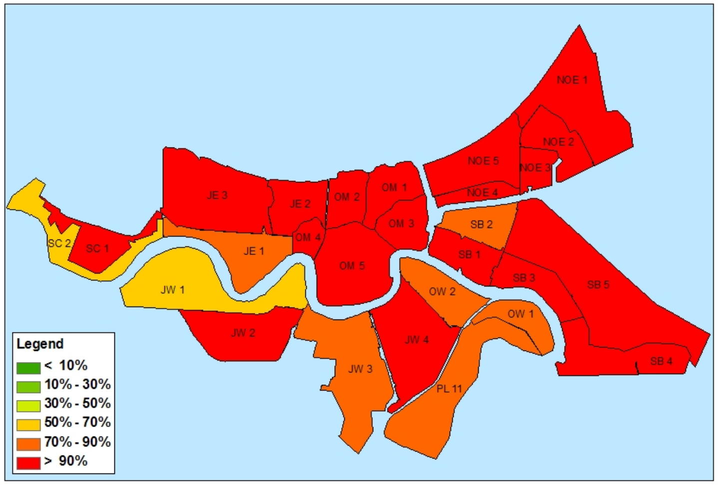
Hurricane Protection System in place before Katrina with no pumping
There was a 2% (1 in 50) chance of this percentage of the total property value being lost



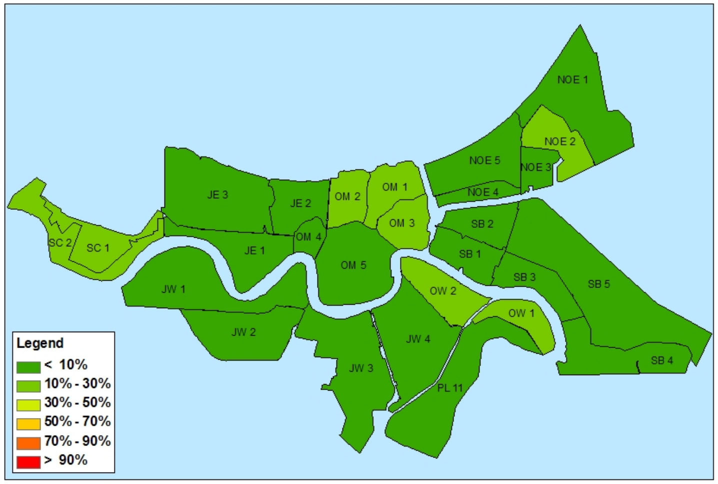
Hurricane Protection System in place before Katrina with no pumping
There was a 1% (1 in 100) chance of this percentage of the total property value being lost



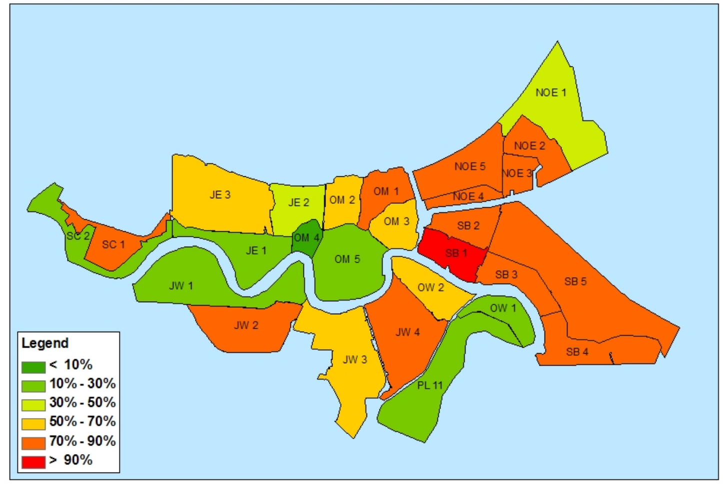
Hurricane Protection System in place before Katrina with no pumping
There was a 0.2% (1 in 500) chance of this percentage of the total property value being lost



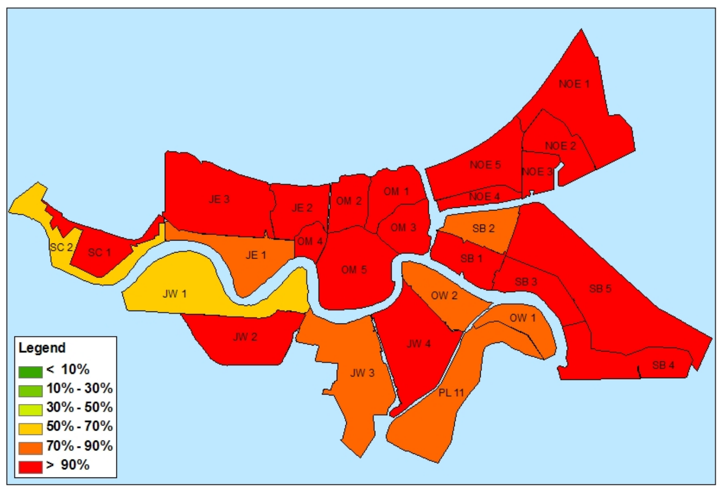
Hurricane Protection System in place in June 2007 with no pumping
There was a 2% (1 in 50) chance of this percentage of the total property value being lost



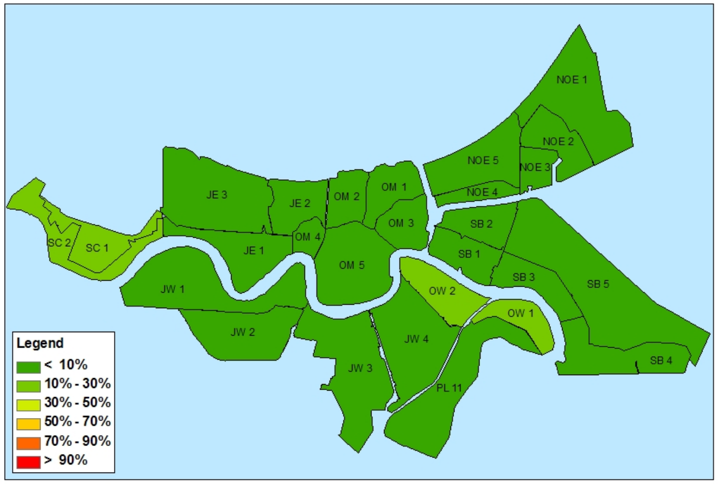
Hurricane Protection System in place in June 2007 with no pumping
There was a 1% (1 in 100) chance of this percentage of the total property value being lost



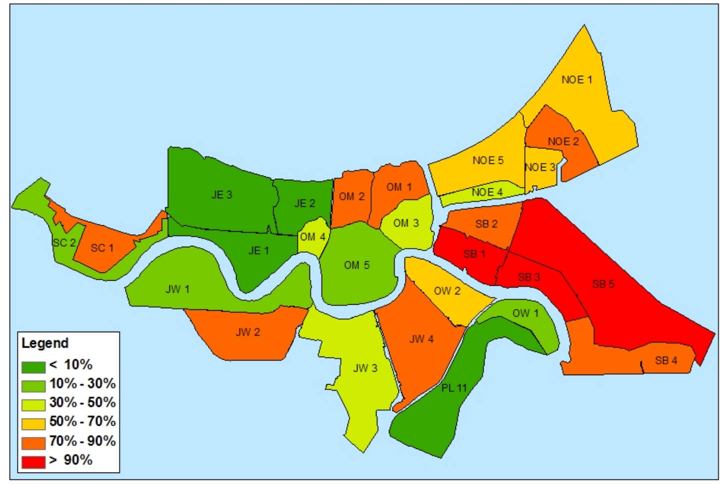
Hurricane Protection System in place in June 2007 with no pumping
There was a 0.2% (1 in 500) chance of this percentage of the total property value being lost



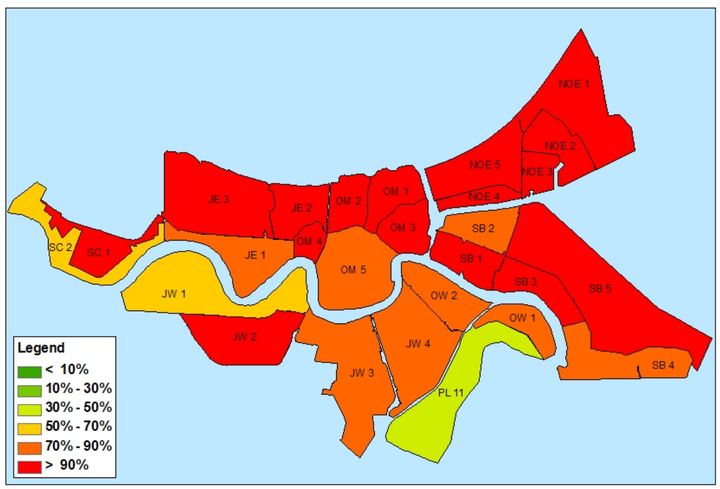
Hurricane Protection System in place before Katrina with pumping at 50% of capacity
There was a 2% (1 in 50) chance of this percentage of the total property value being lost



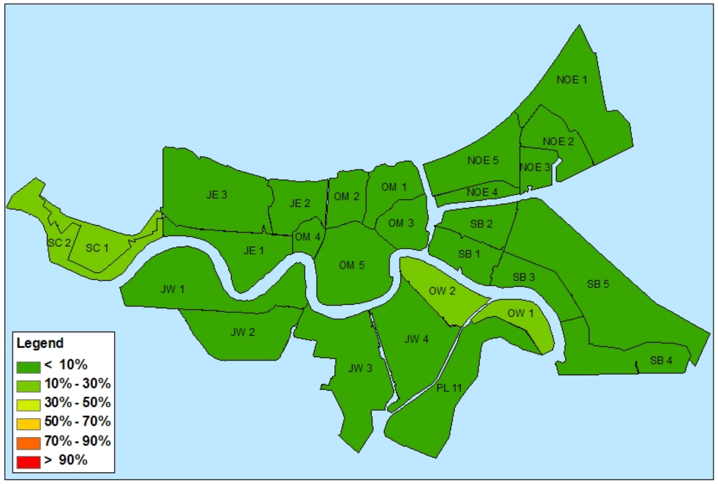
Hurricane Protection System in place before Katrina with pumping at 50% of capacity
There was a 1% (1 in 100) chance of this percentage of the total property value being lost



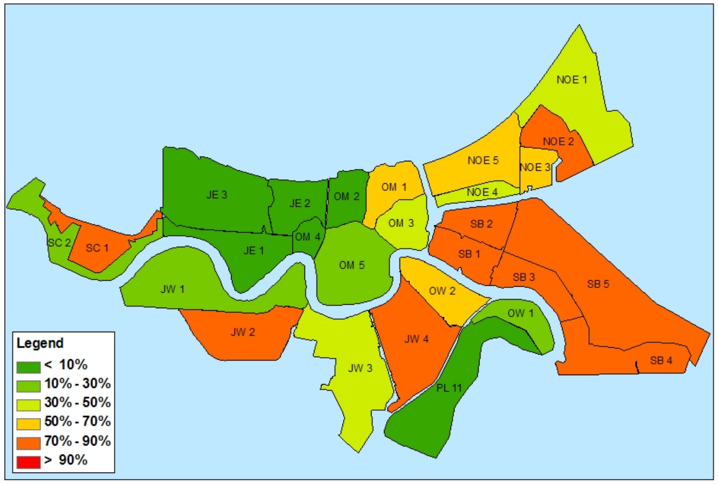
Hurricane Protection System in place before Katrina with pumping at 50% of capacity
There was a 0.2% (1 in 500) chance of this percentage of the total property value being lost



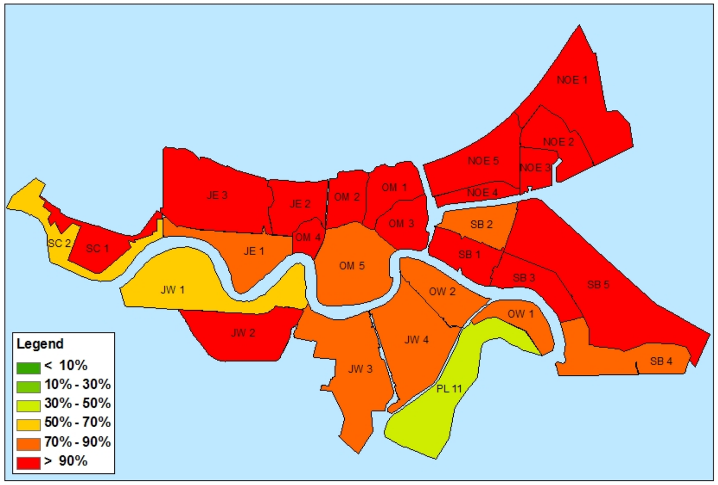
Hurricane Protection System in place in June 2007 with pumping at 50% of capacity
There was a 2% (1 in 50) chance of this percentage of the total property value being lost



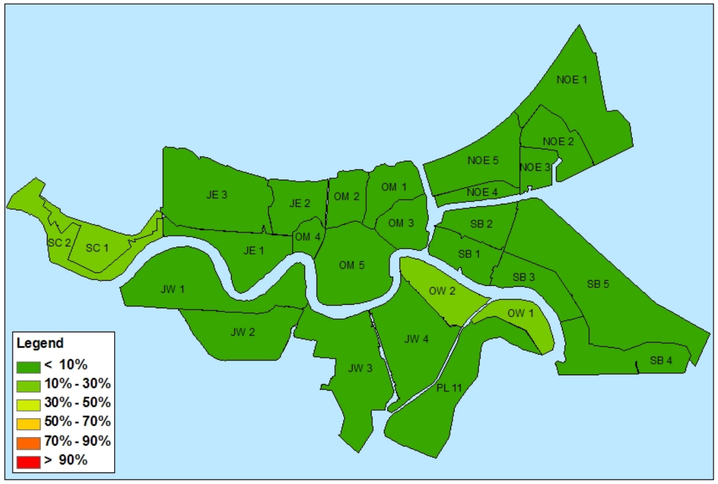
Hurricane Protection System in place in June 2007 with pumping at 50% of capacity
There was a 1% (1 in 100) chance of this percentage of the total property value being lost



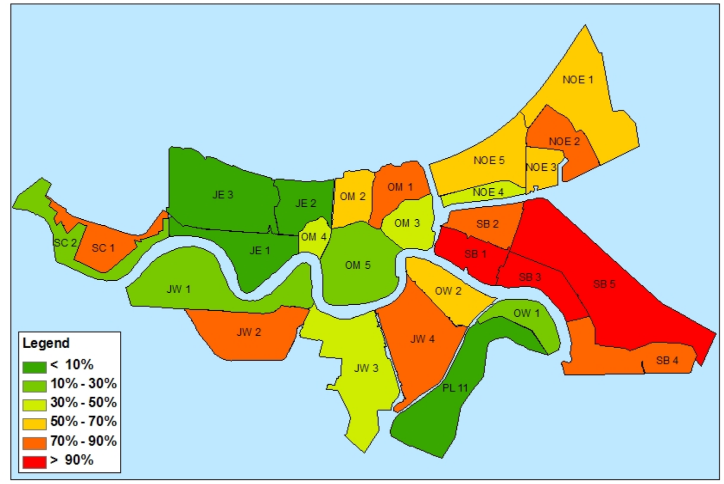
Hurricane Protection System in place in June 2007 with pumping at 50% of capacity
There was a 0.2% (1 in 500) chance of this percentage of the total property value being lost



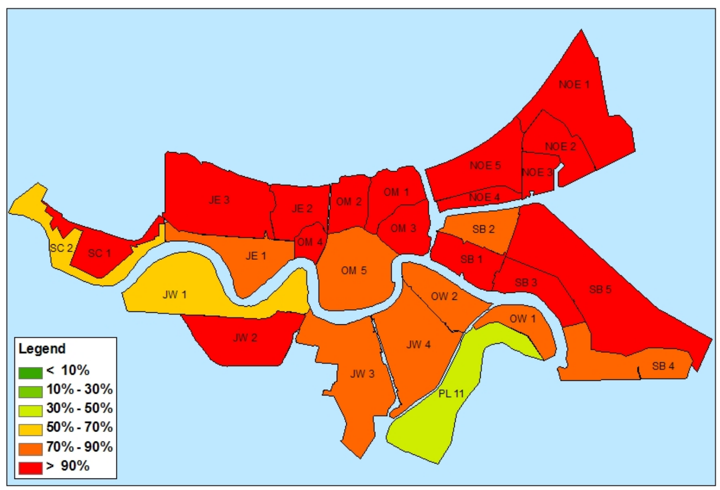
Hurricane Protection System in place before Katrina with pumping at 100% of capacity
There was a 2% (1 in 50) chance of this percentage of the total property value being lost



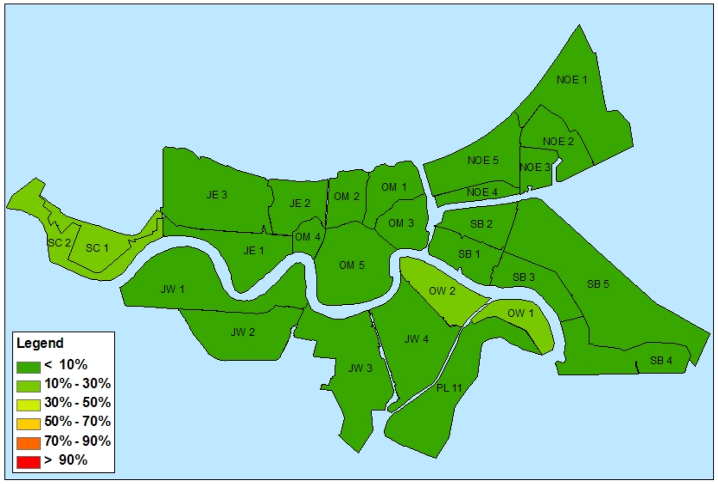
Hurricane Protection System in place before Katrina with pumping at 100% of capacity
There was a 1% (1 in 100) chance of this percentage of the total property value being lost



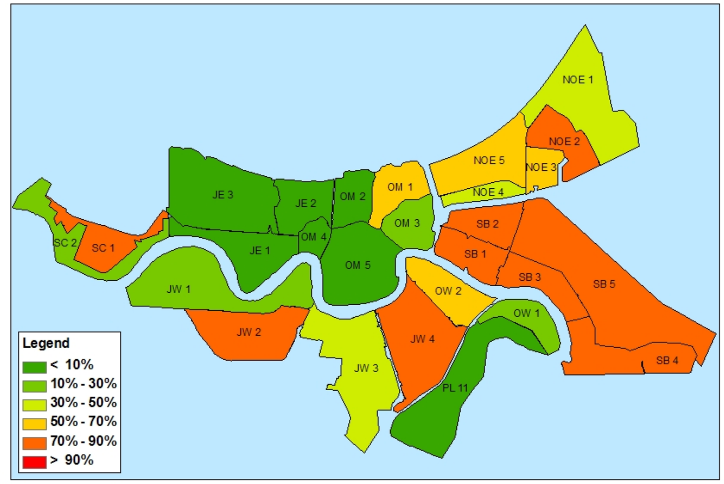
Hurricane Protection System in place before Katrina with pumping at 100% of capacity
There was a 0.2% (1 in 500) chance of this percentage of the total property value being lost



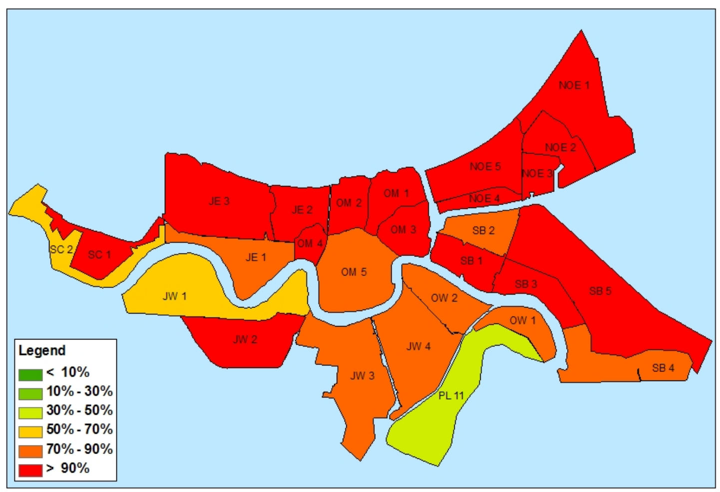
Hurricane Protection System in place in June 2007 with pumping at 100% of capacity
There was a 2% (1 in 50) chance of this percentage of the total property value being lost



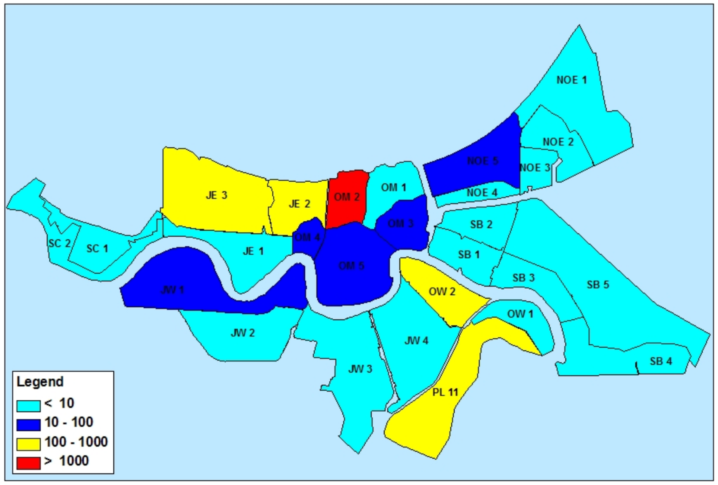
Hurricane Protection System in place in June 2007 with pumping at 100% of capacity
There was a 1% (1 in 100) chance of this percentage of the total property value being lost



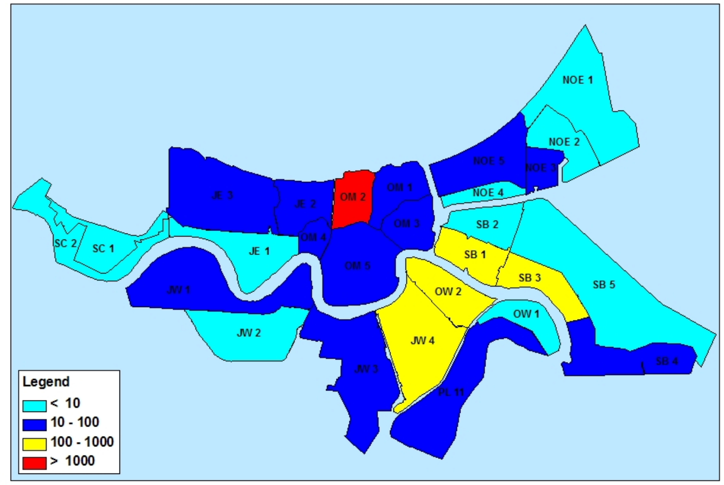
Hurricane Protection System in place in June 2007 with pumping at 100% of capacity
There was a 0.2% (1 in 500) chance of this percentage of the total property value being lost



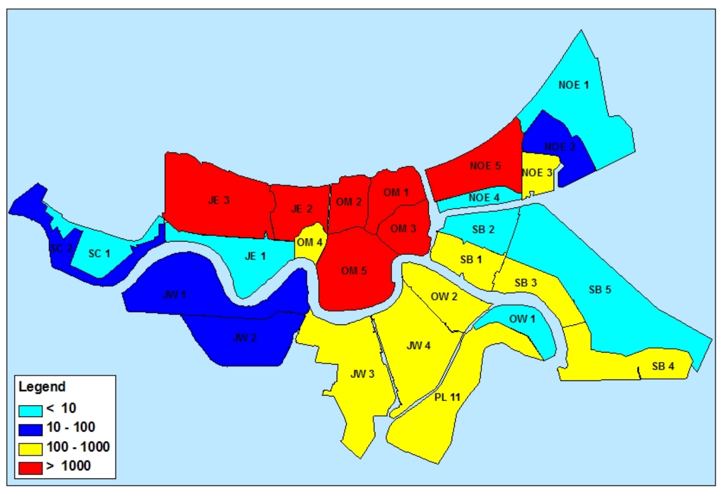
Hurricane Protection System in place before Katrina with no pumping
There was a 2% (1 in 50) chance for this number of fatalities



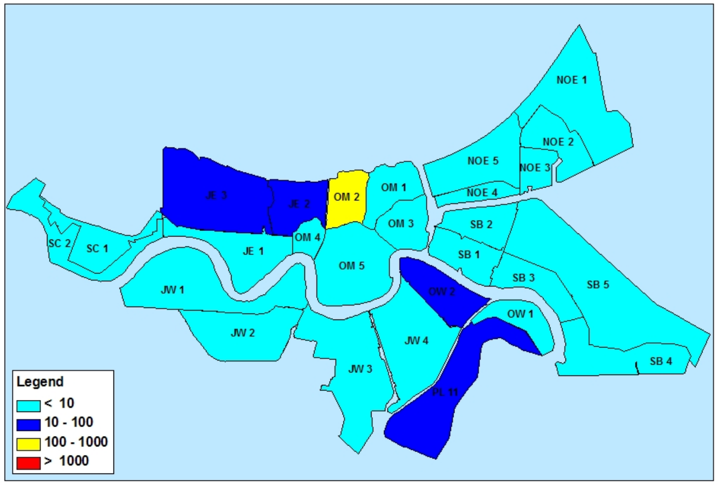
Hurricane Protection System in place before Katrina with no pumping
There was a 1% (1 in 100) chance for this number of fatalities



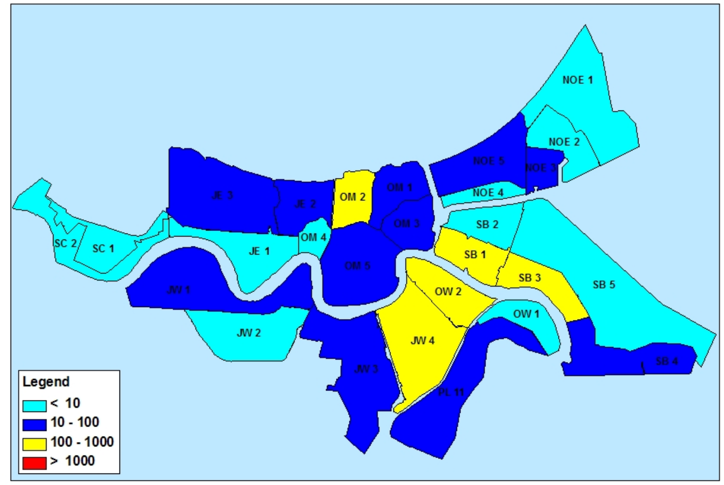
Hurricane Protection System in place before Katrina with no pumping
There was a 0.2% (1 in 500) chance for this number of fatalities



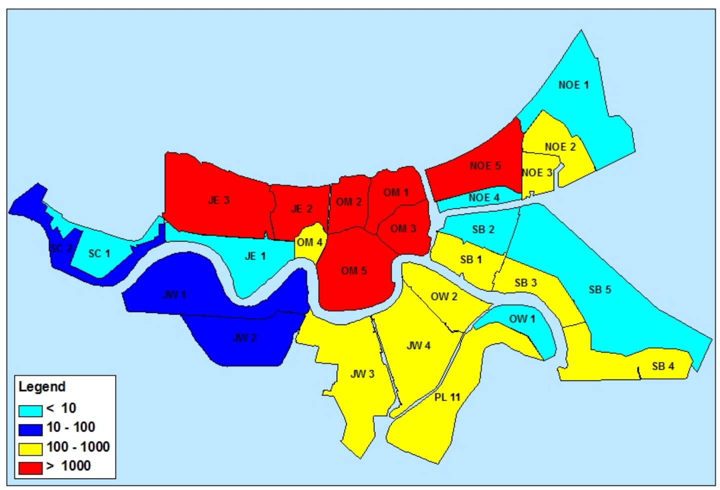
Hurricane Protection System in place in June 2007 with no pumping
There was a 2% (1 in 50) chance for this number of fatalities



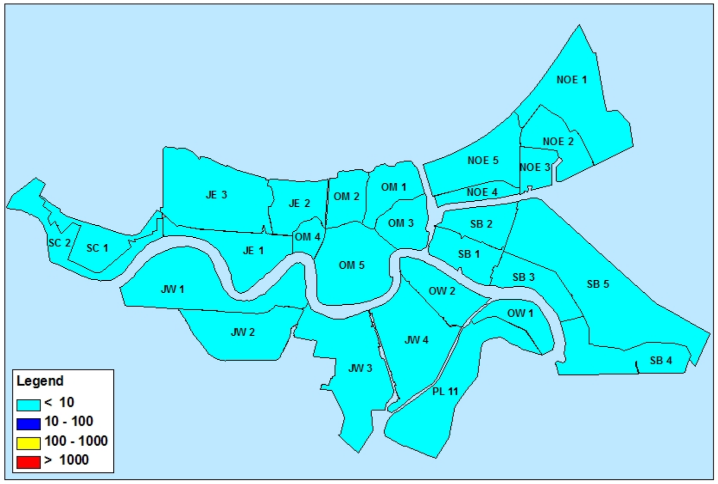
Hurricane Protection System in place in June 2007 with no pumping
There was a 1% (1 in 100) chance for this number of fatalities



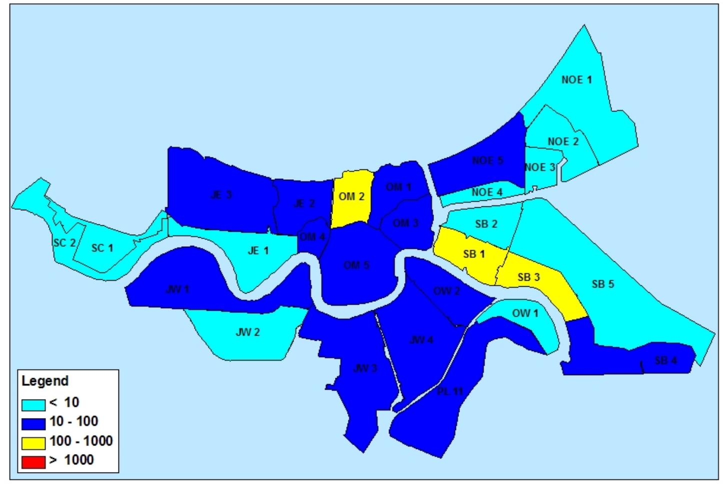
Hurricane Protection System in place in June 2007 with no pumping
There was a 0.2% (1 in 500) chance for this number of fatalities



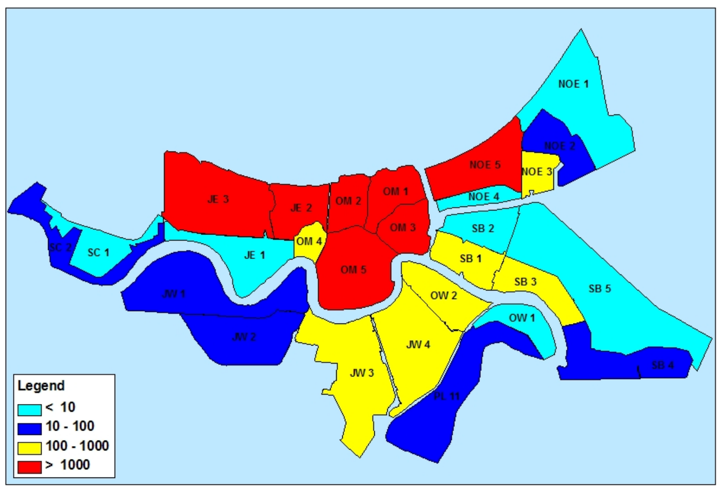
Hurricane Protection System in place before Katrina with pumping at 50% of capacity
There was a 2% (1 in 50) chance for this number of fatalities



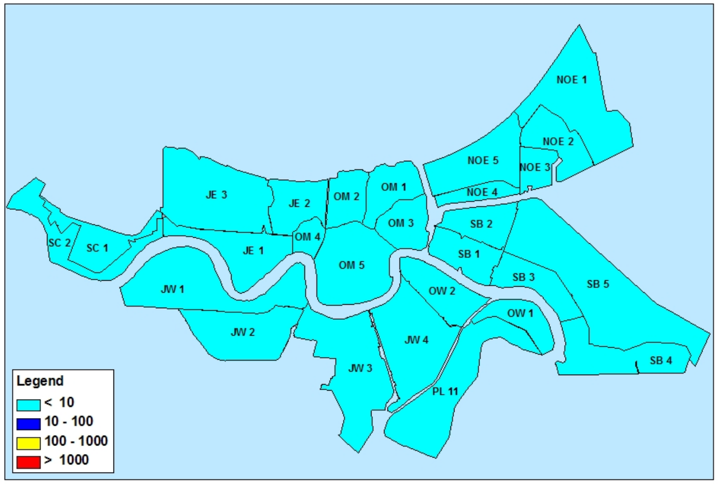
Hurricane Protection System in place before Katrina with pumping at 50% of capacity
There was a 1% (1 in 100) chance for this number of fatalities



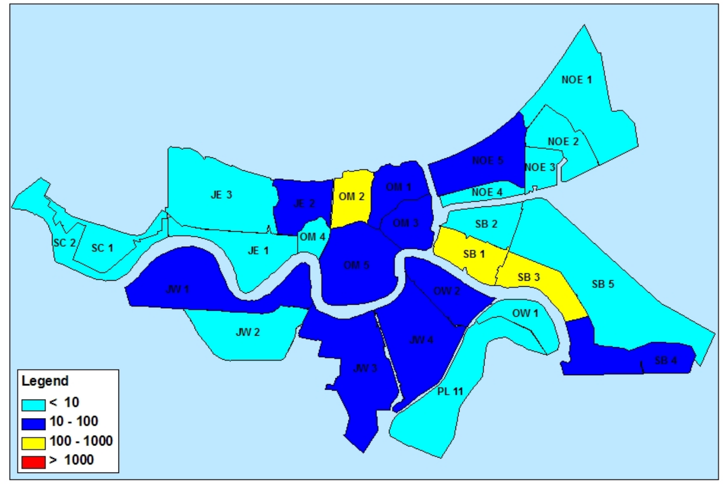
Hurricane Protection System in place before Katrina with pumping at 50% of capacity
There was a 0.2% (1 in 500) chance for this number of fatalities



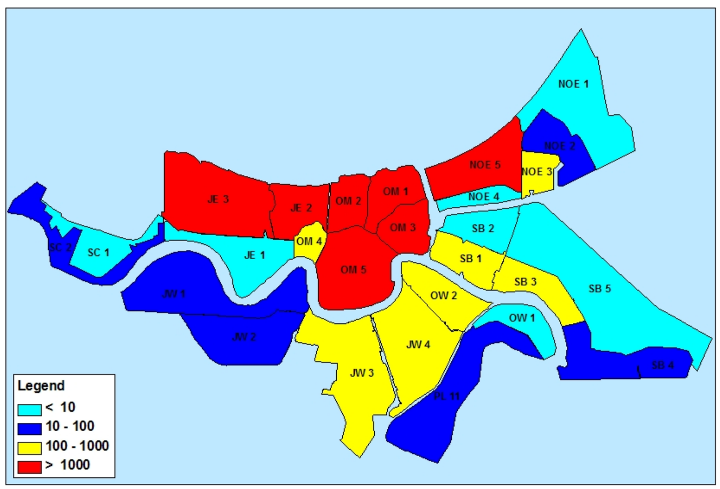
Hurricane Protection System in place in June 2007 with pumping at 50% of capacity
There was a 2% (1 in 50) chance for this number of fatalities



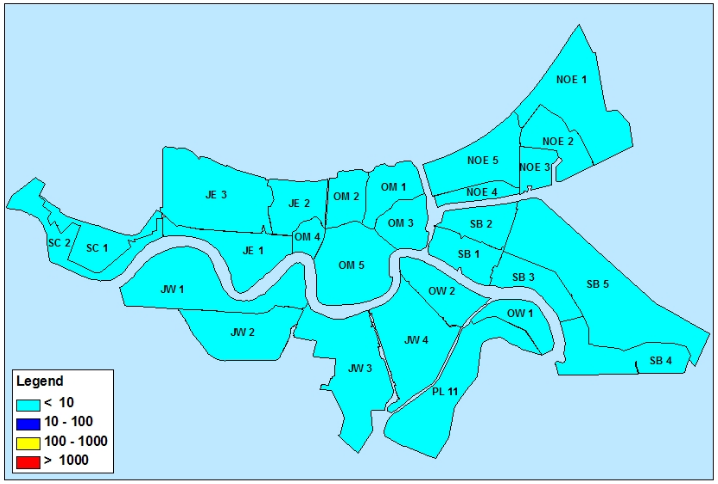
Hurricane Protection System in place in June 2007 with pumping at 50% of capacity
There was a 1% (1 in 100) chance for this number of fatalities



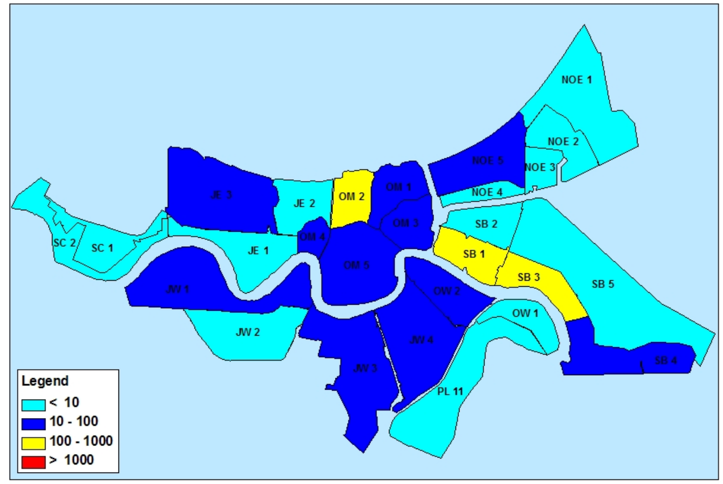
Hurricane Protection System in place in June 2007 with pumping at 50% of capacity
There was a 0.2% (1 in 500) chance for this number of fatalities



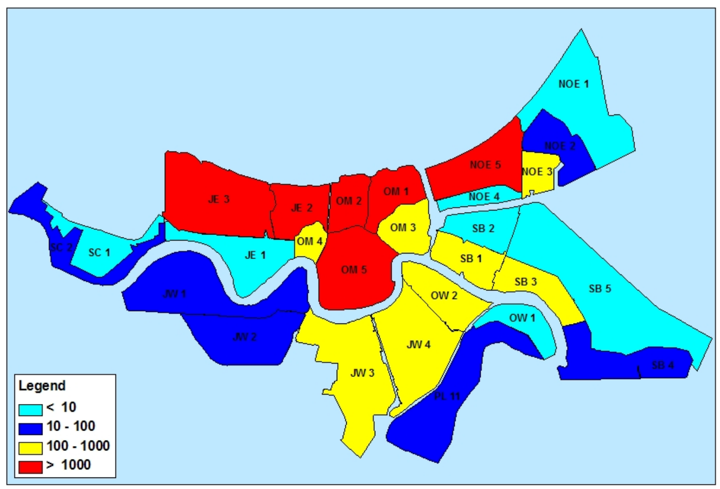
Hurricane Protection System in place before Katrina with pumping at 100% of capacity
There was a 2% (1 in 50) chance for this number of fatalities



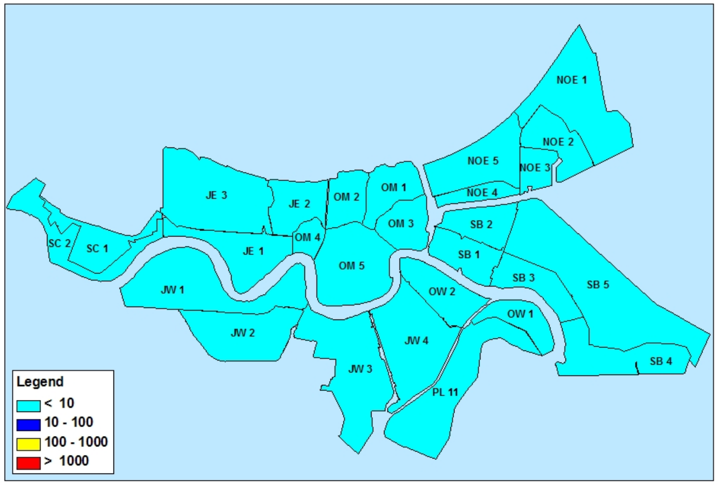
Hurricane Protection System in place before Katrina with pumping at 100% of capacity
There was a 1% (1 in 100) chance for this number of fatalities



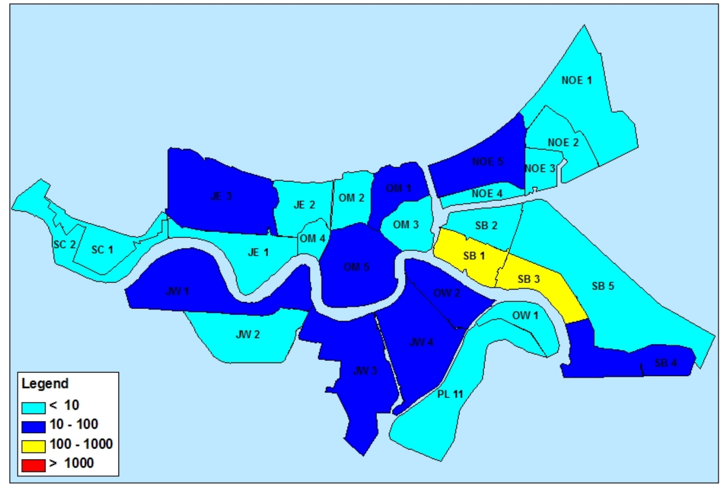
Hurricane Protection System in place before Katrina with pumping at 100% of capacity
There was a 0.2% (1 in 500) chance for this number of fatalities



Hurricane Protection System in place in June 2007 with pumping at 100% of capacity
There was a 2% (1 in 50) chance for this number of fatalities



Hurricane Protection System in place in June 2007 with pumping at 100% of capacity
There was a 1% (1 in 100) chance for this number of fatalities



Hurricane Protection System in place in June 2007 with pumping at 100% of capacity
There was a 0.2% (1 in 500) chance for this number of fatalities

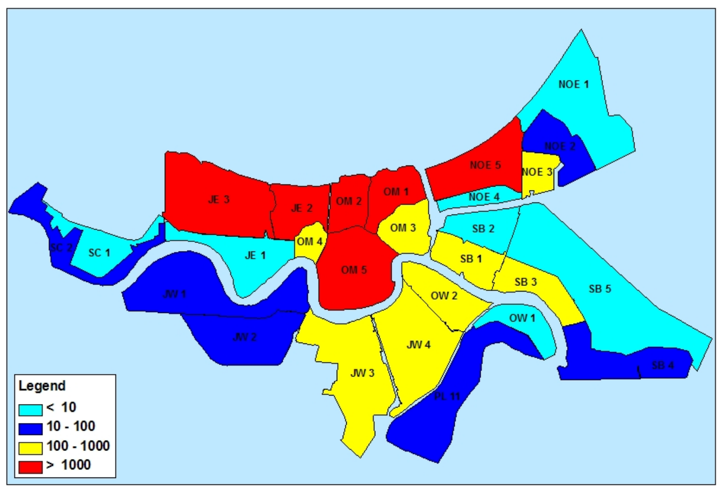


Figure 13-3 Overtopping Vulnerability Maps

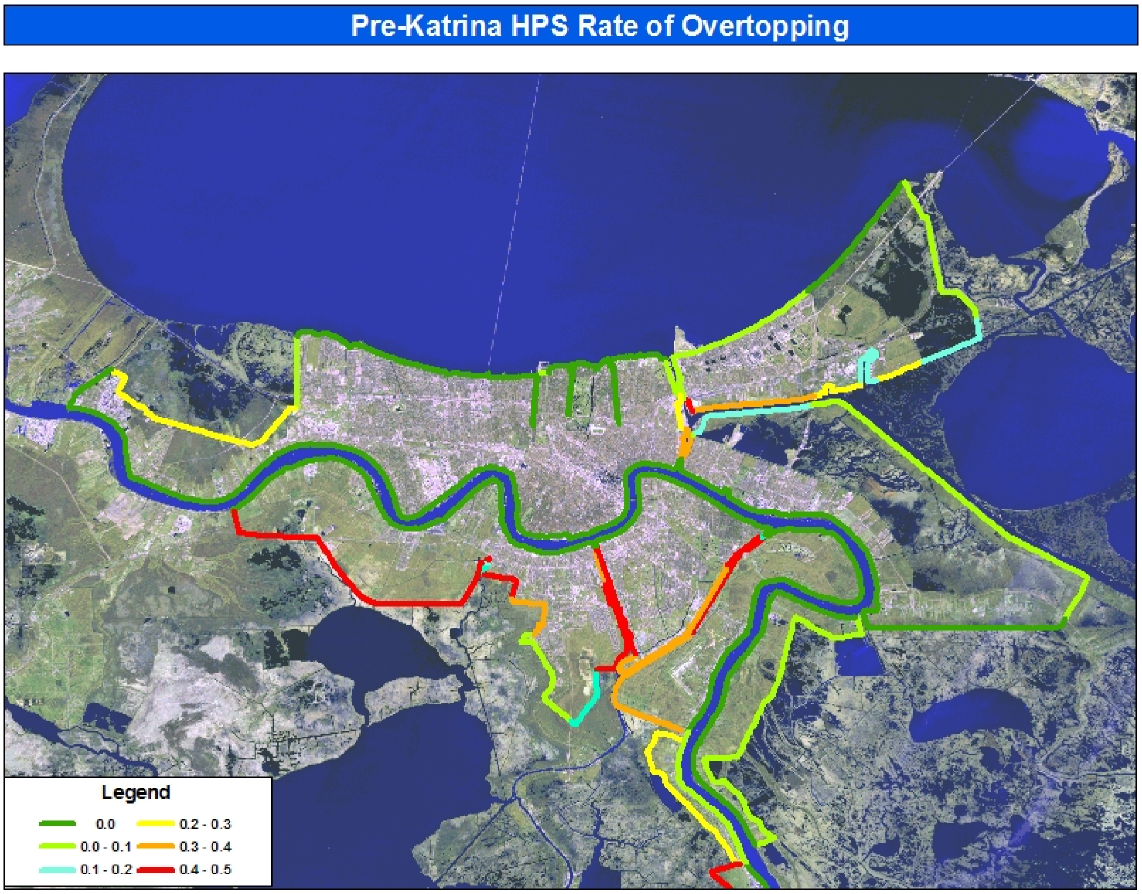


Figure 13-3. Pre-K Overtopping Rates

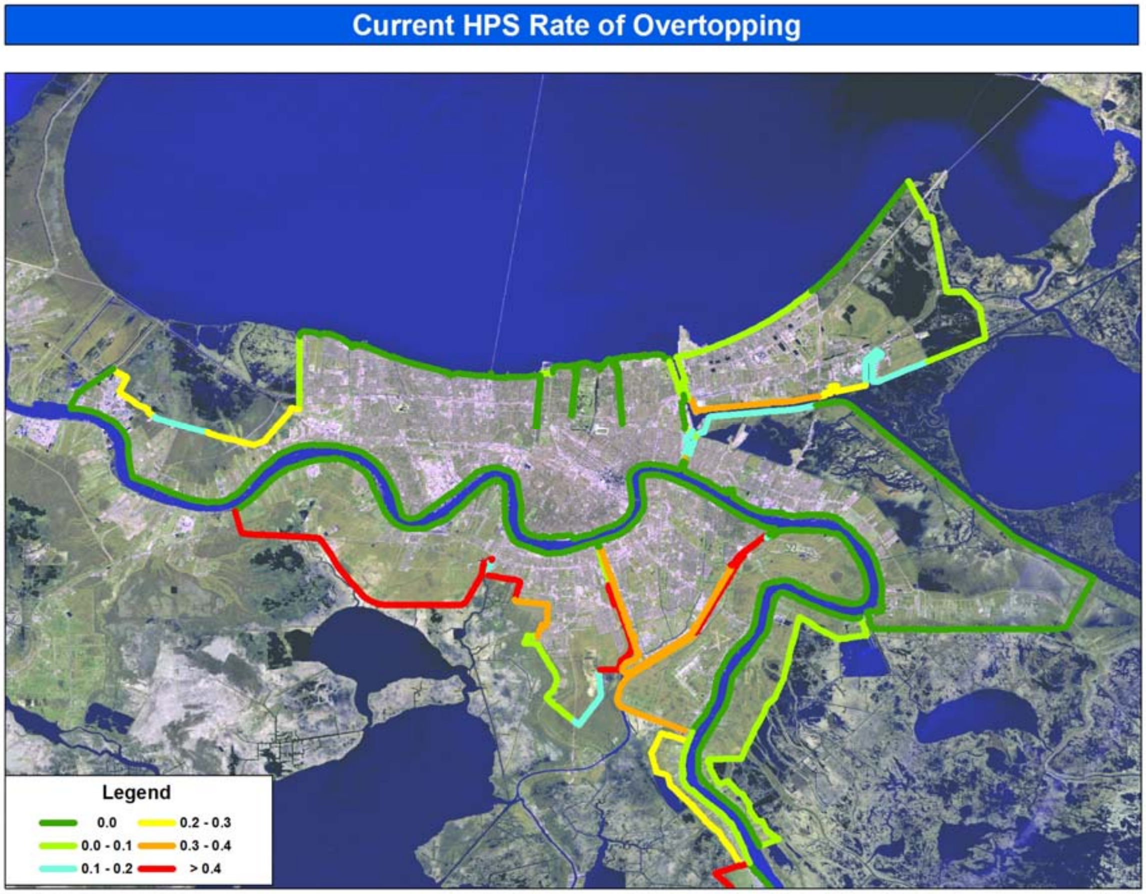


Figure 13-3 Current Overtopping Rates

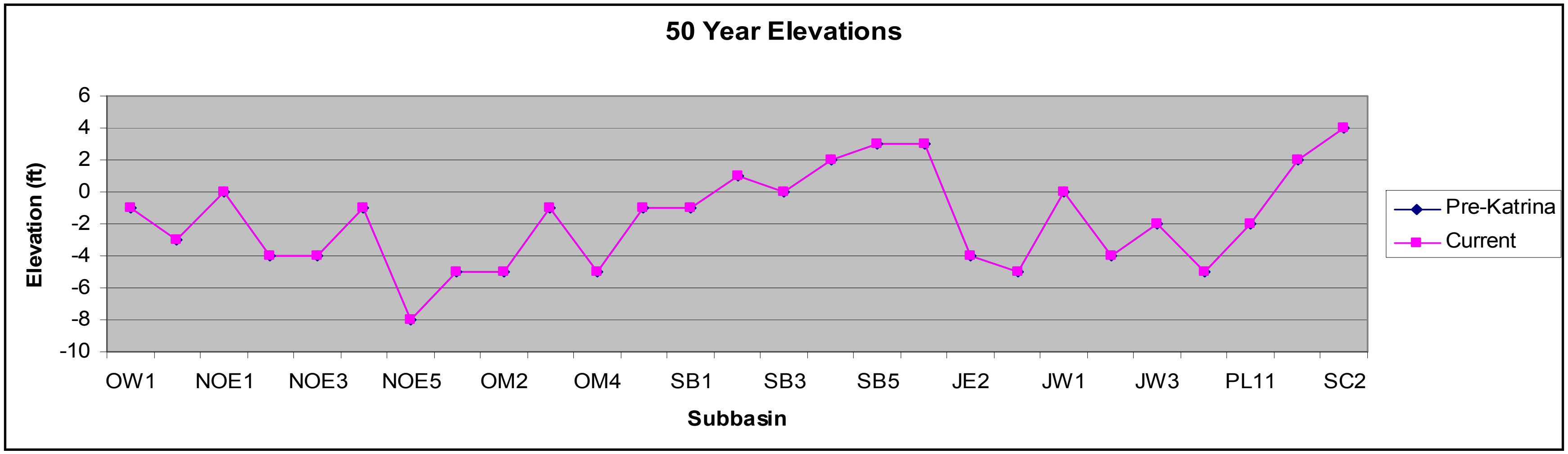


Figure 13-4 – 50-Year Inundation Elevations for Pre-K and June 2007 HPS

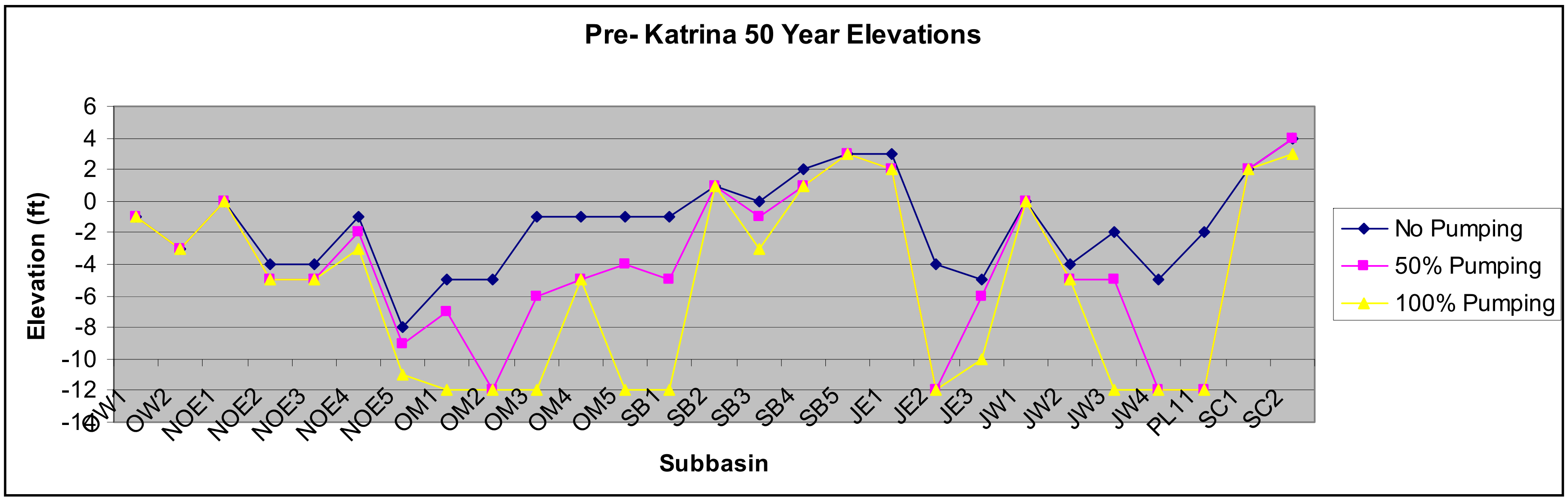


Figure 13-5 – 50-Year Inundation Elevations for Pre-K HPS with Pumping Scenarios

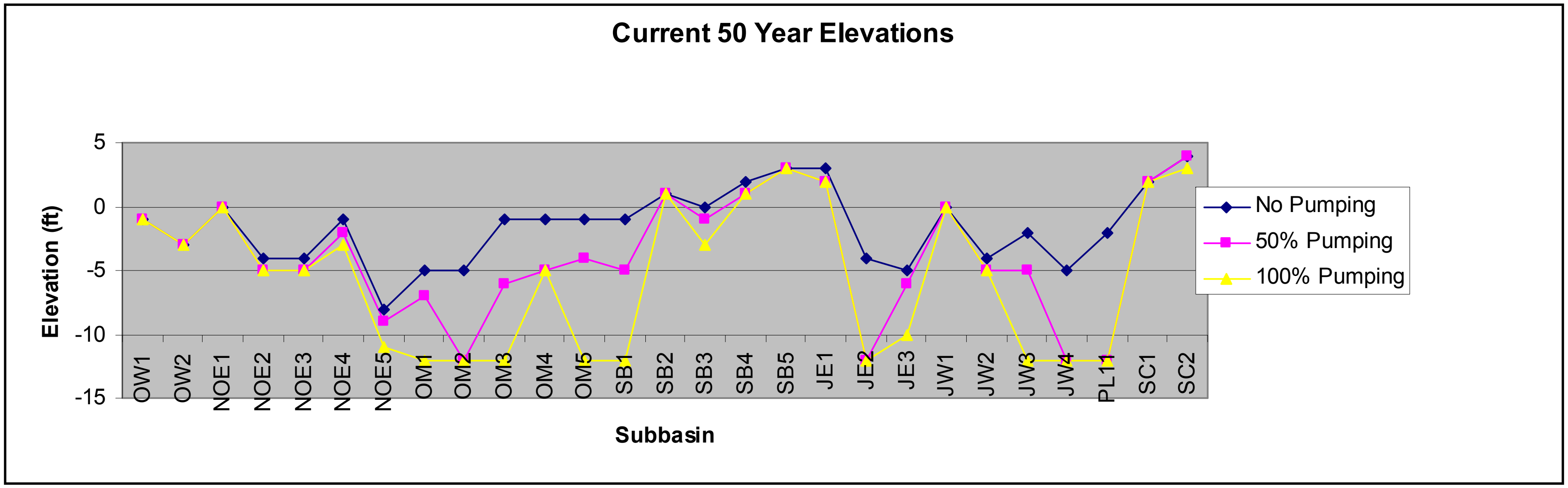


Figure 13-6 – 50-Year Inundation Elevations for June 2007 HPS with Pumping Scenarios

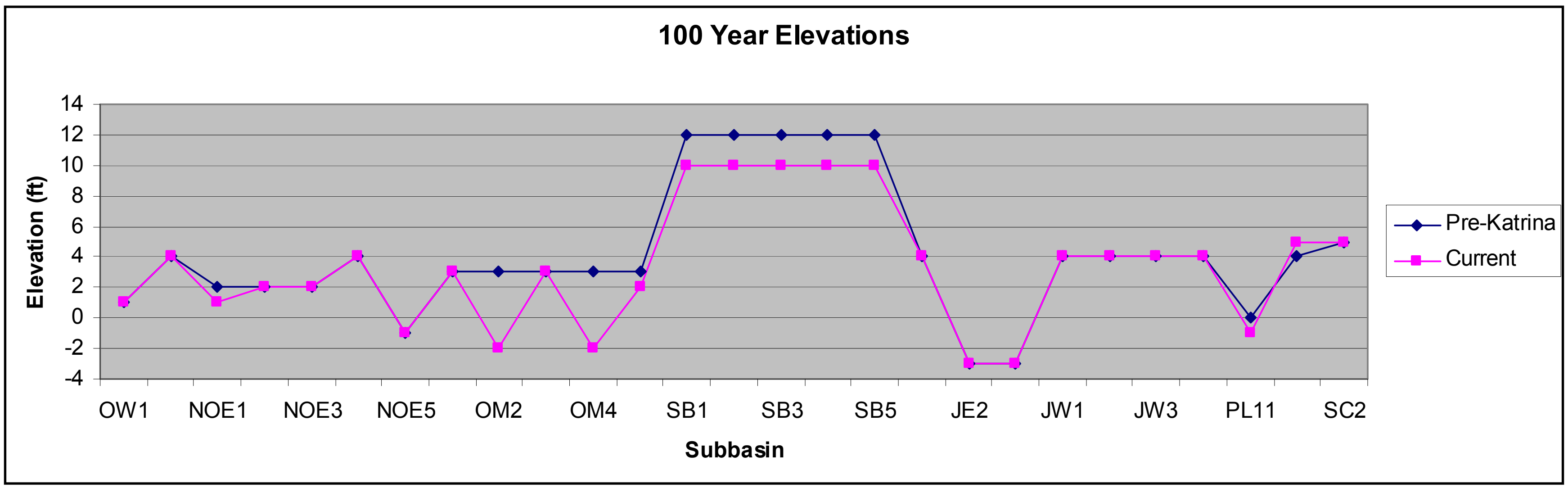


Figure 13-7 – 100-Year Inundation Elevations for Pre-K and June 2007 HPS

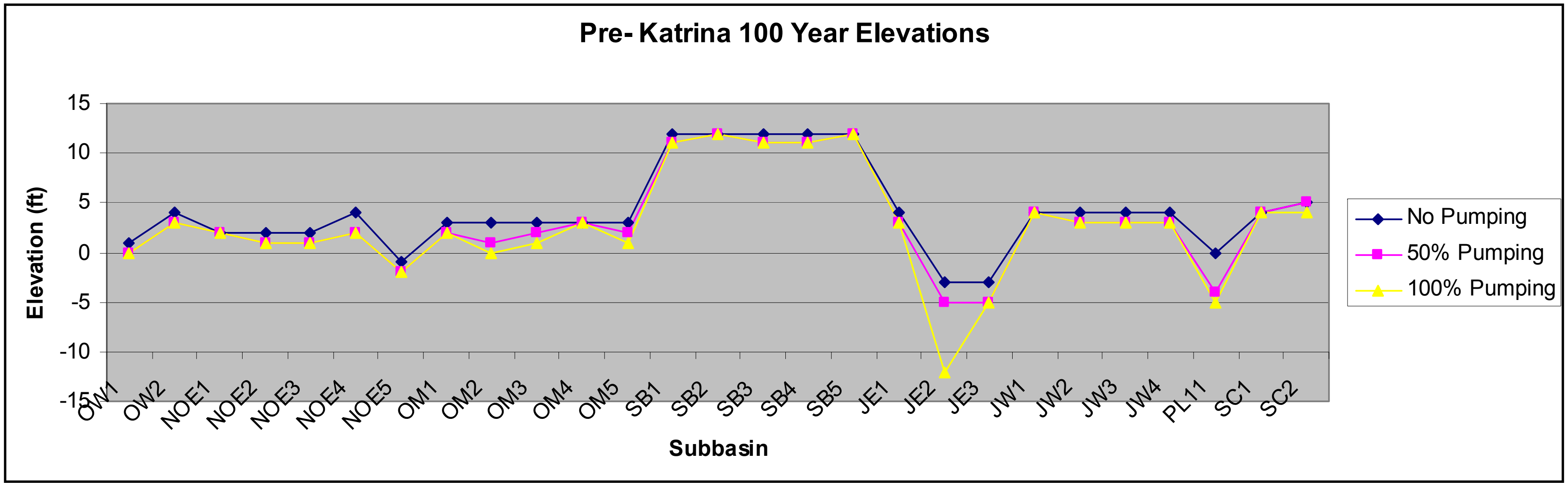


Figure 13-8 – 100-Year Inundation Elevations for Pre-K HPS with Pumping Scenarios

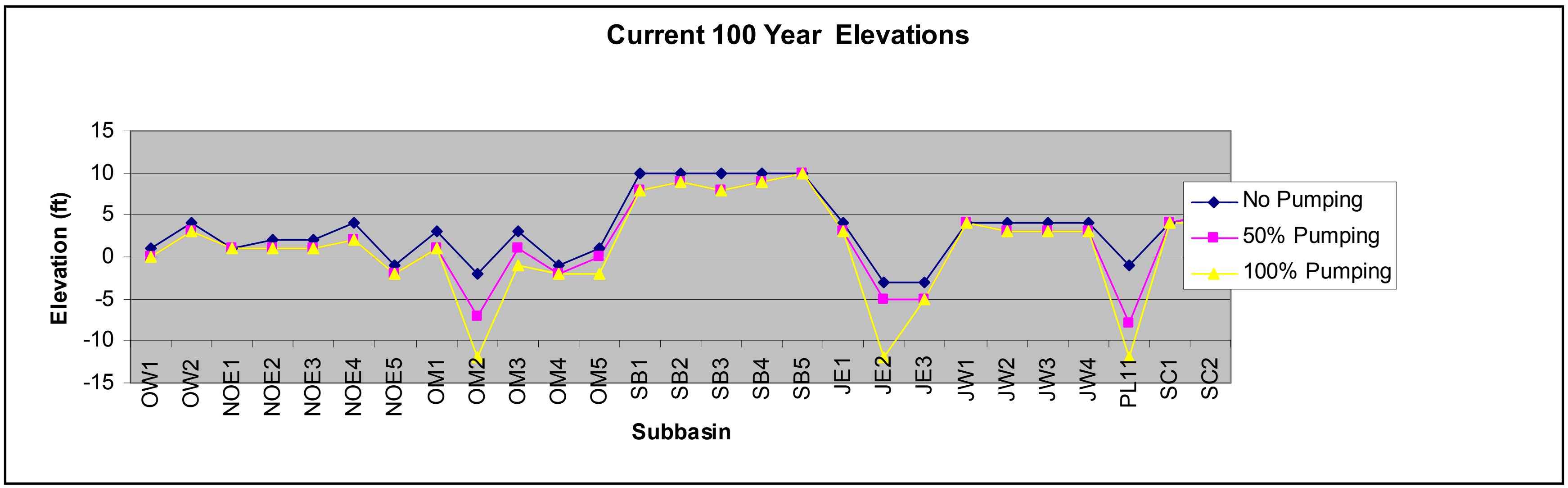


Figure 13-9 – 100-Year Inundation Elevations for June 2007 HPS with Pumping Scenarios

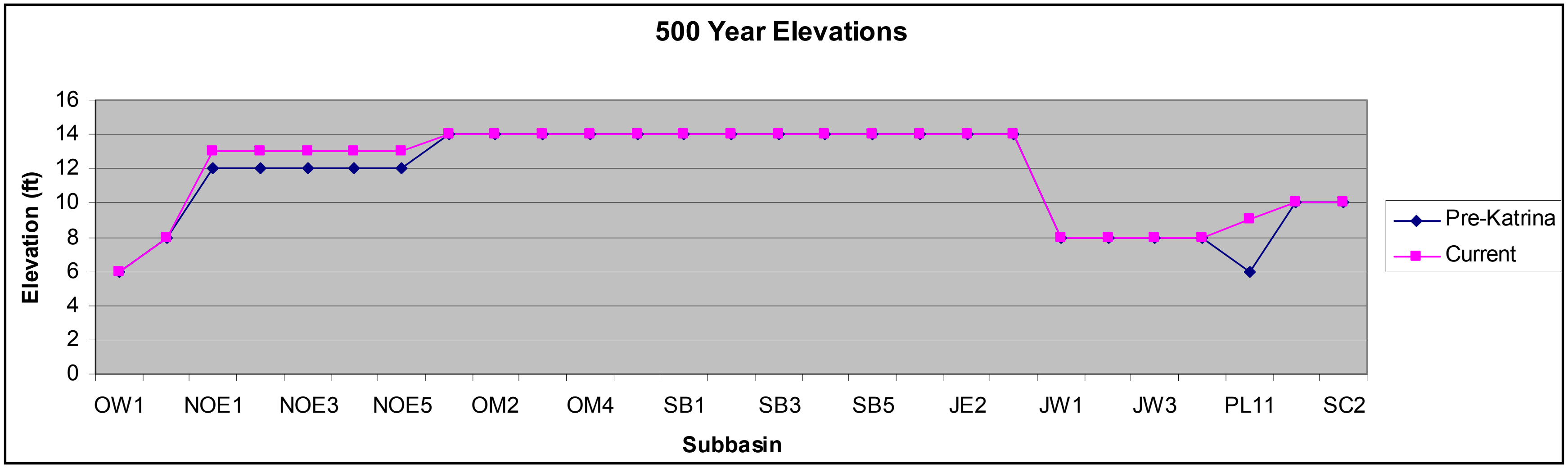


Figure 13-10 – 500-Year Inundation Elevations for Pre-K and June 2007 HPS

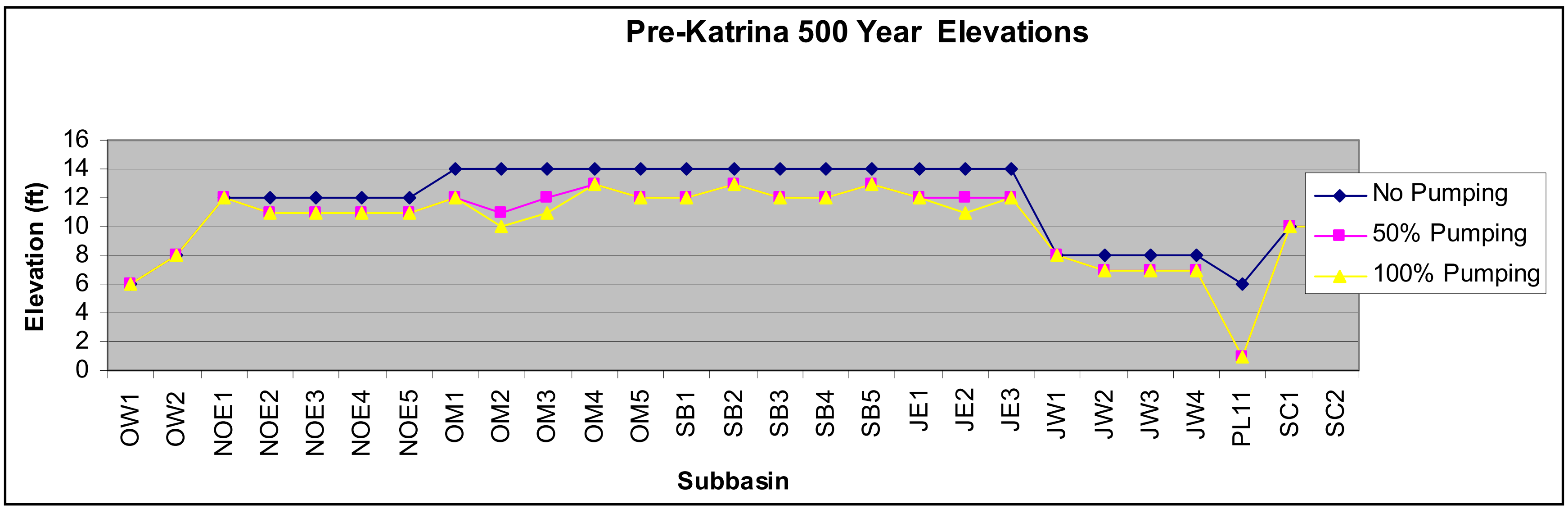


Figure 13-11 – 500-Year Inundation Elevations for Pre-K with Pumping Scenarios

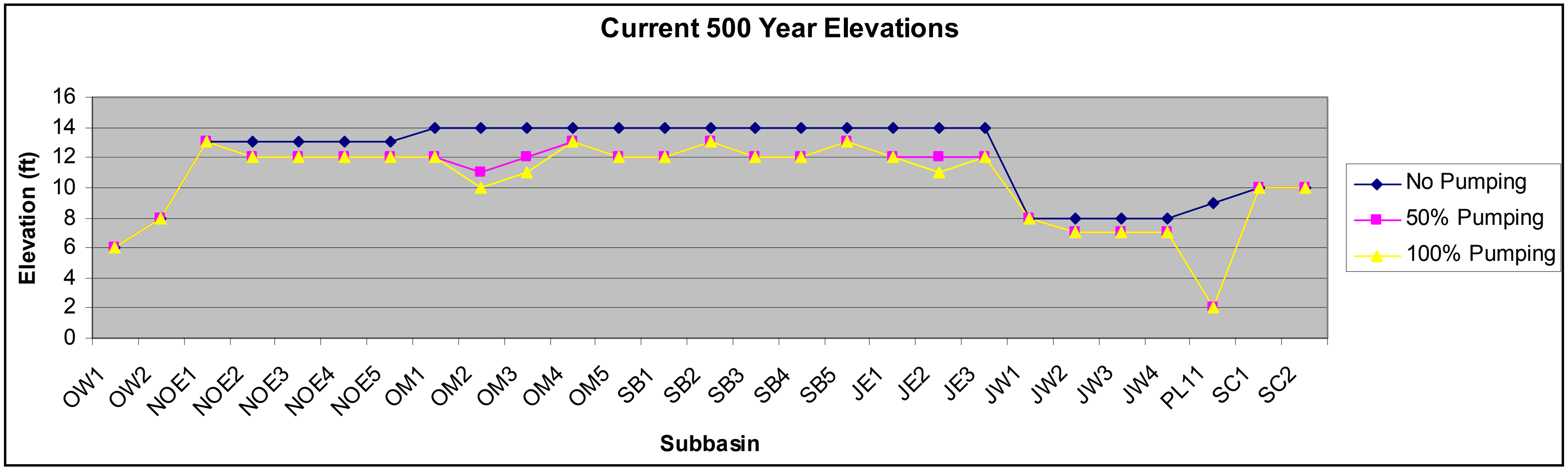


Figure 13-12 – 500-Year Inundation Elevations for June 2007 HPS with Pumping Scenarios

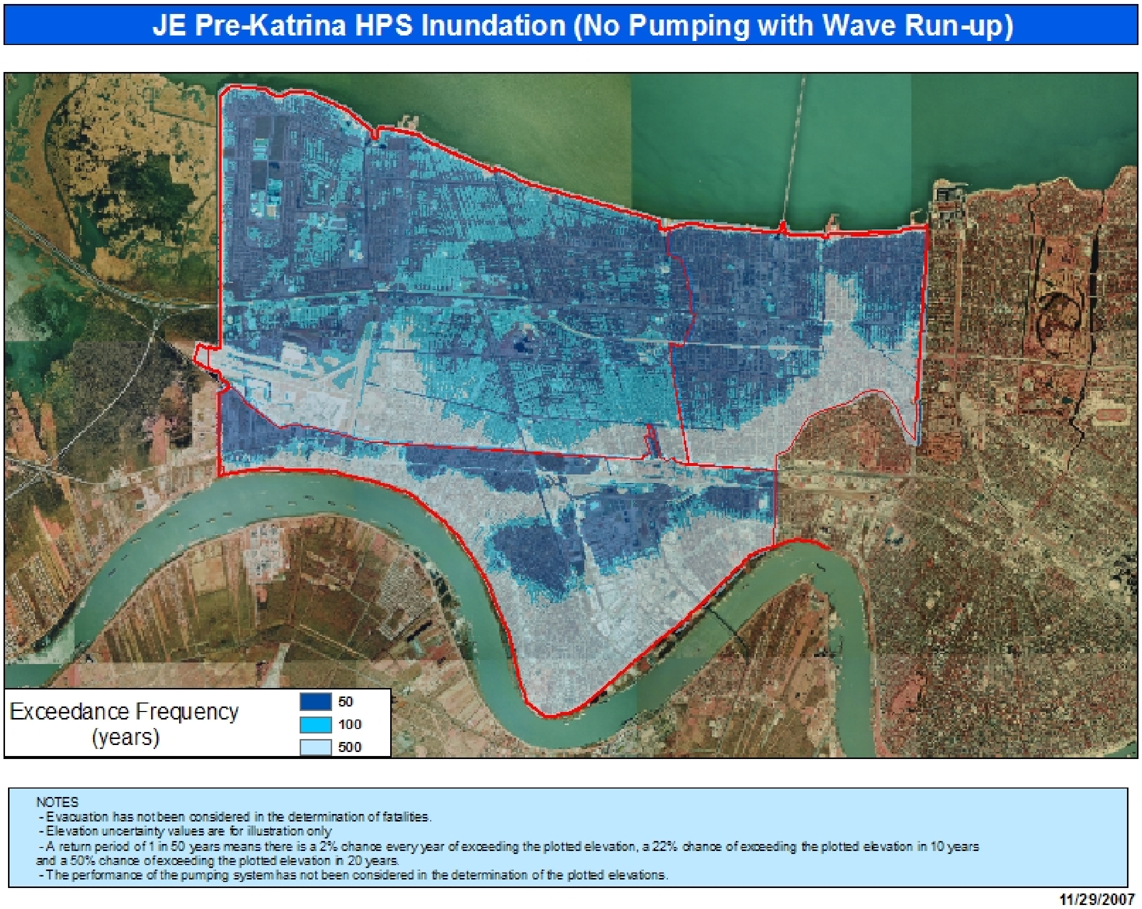


Figure 13-15 – Jefferson East Bank – Pre-Katrina Inundation Risk – No Pumping

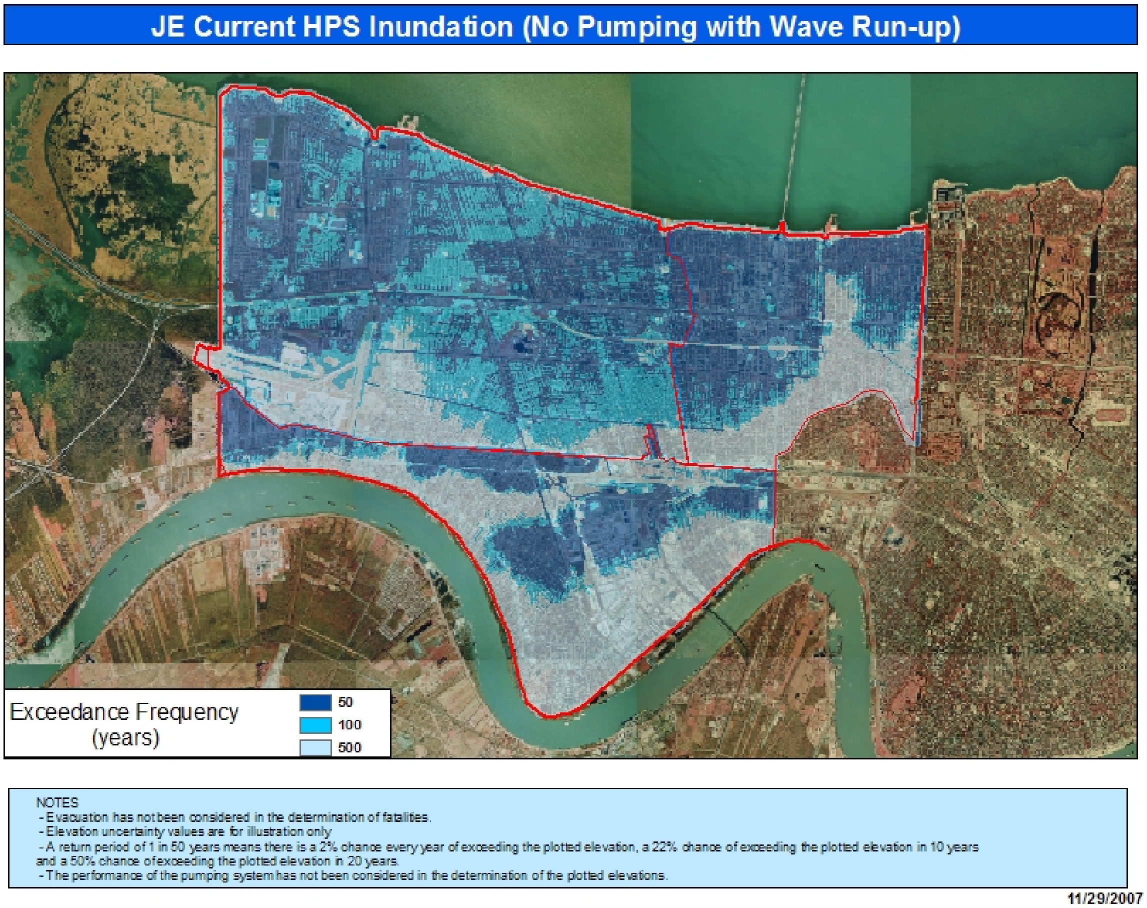
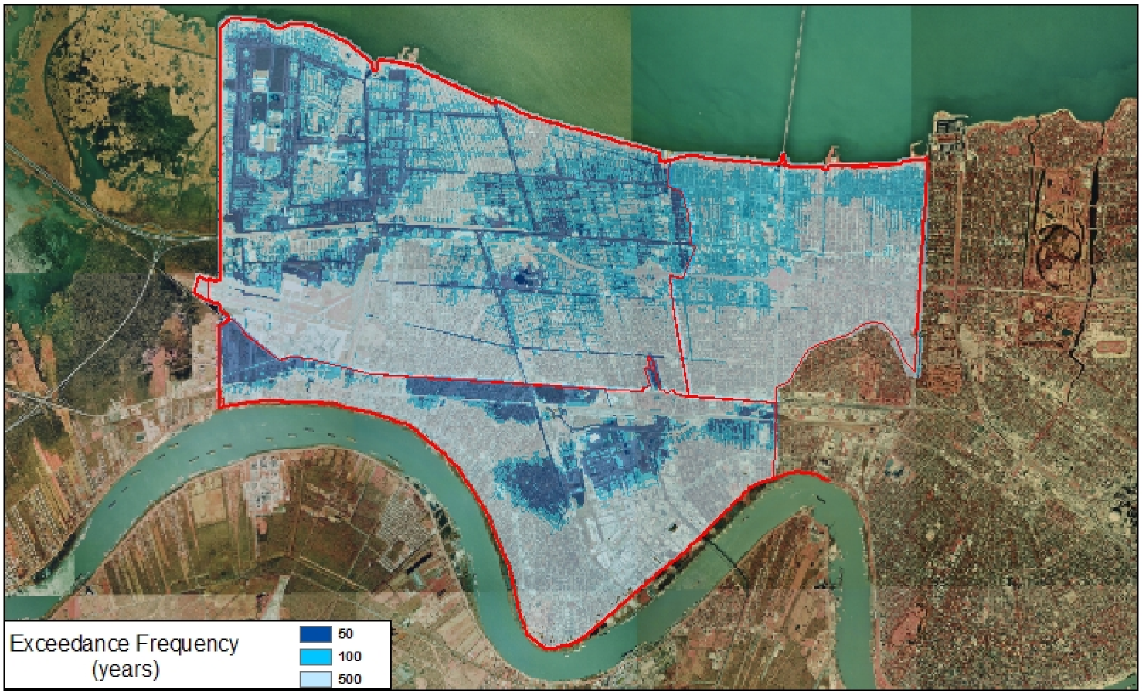


Figure 13-16 – Jefferson East Bank – Current Inundation Risk – No Pumping

JE Pre-Katrina HPS Inundation (50% Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 50% of capacity in the determination of the plotted elevations

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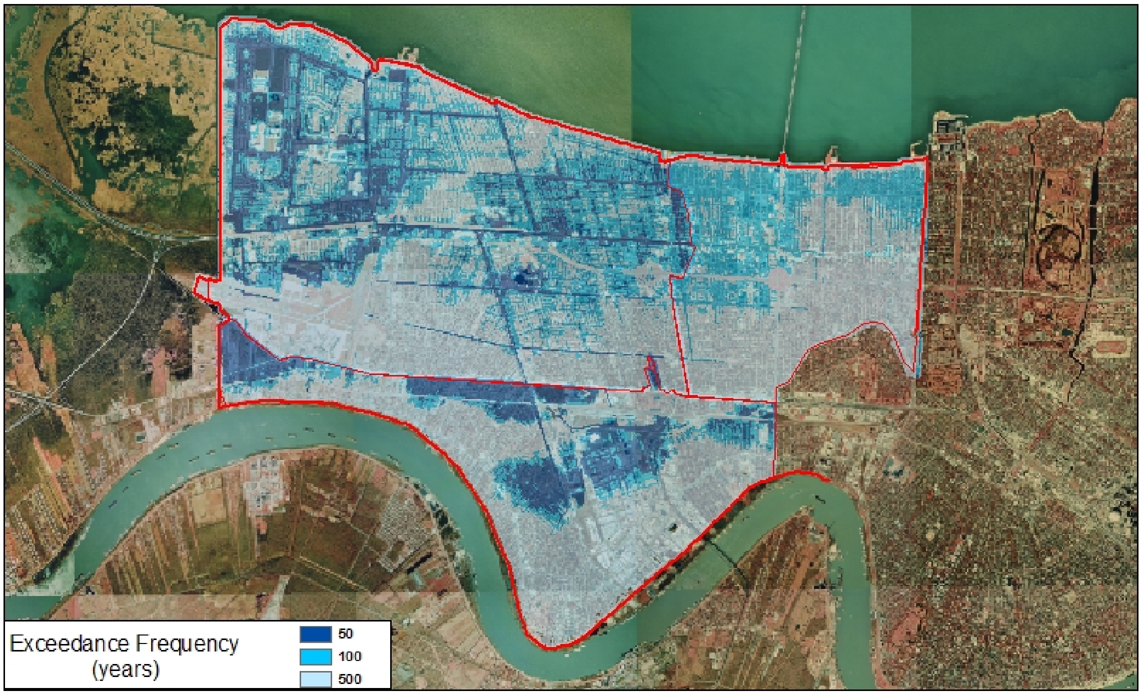
Figure 13-17 – Jefferson East Bank – Pre-Katrina Inundation Risk – 50% Pumping

JE Current HPS Inundation (50% Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalites.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 50% of capacity in the determination of the plotted elevations

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Figure 13-18 – Jefferson East Bank – Current Inundation Risk – 50% Pumping

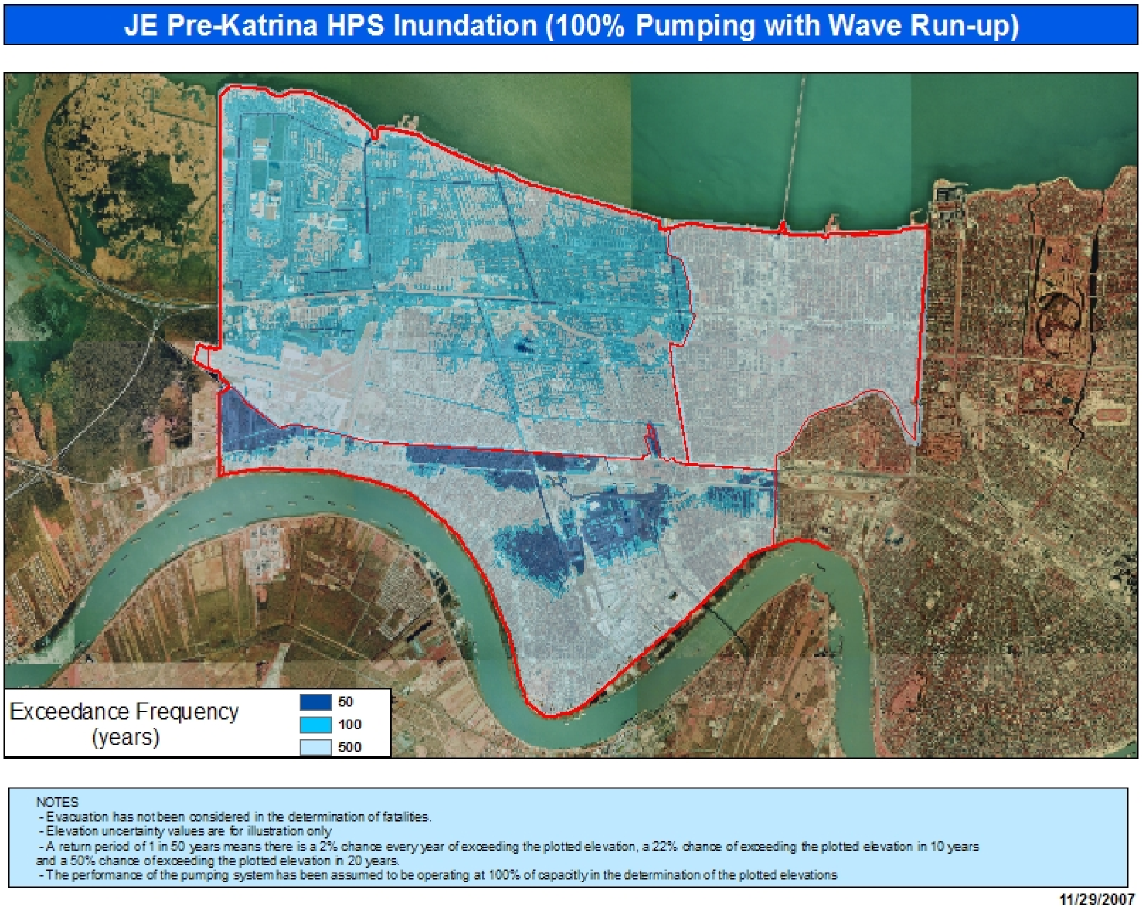
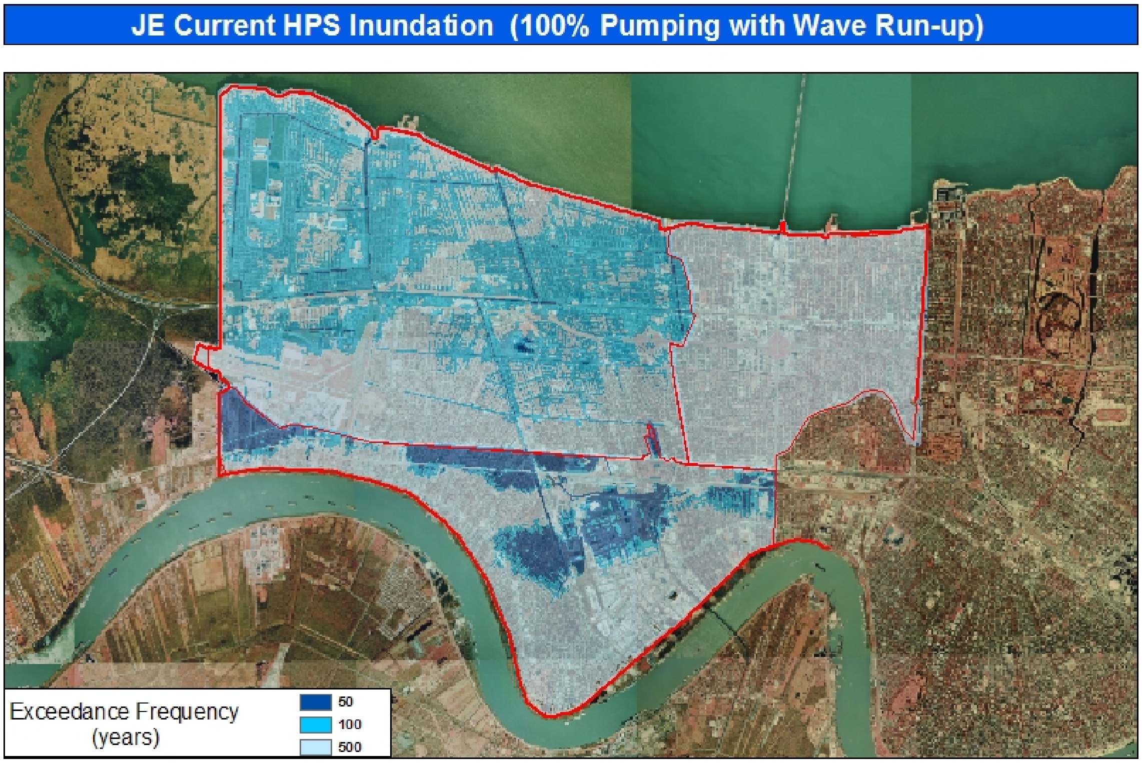


Figure 13-19 – Jefferson East Bank – Pre-Katrina Inundation Risk – 100% Pumping



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 100% of capacity in the determination of the plotted elevations

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Figure 13-20 – Jefferson East Bank – Current Inundation Risk – 100% Pumping

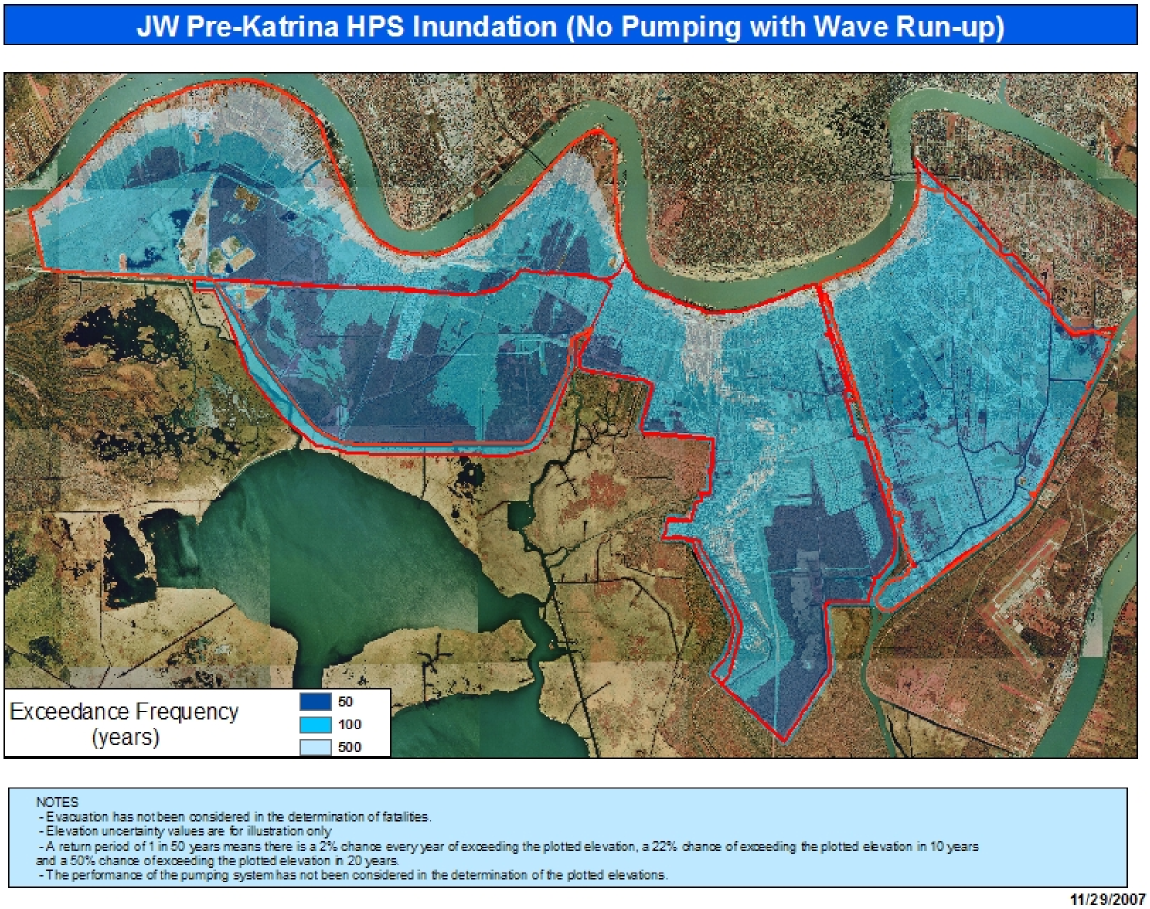
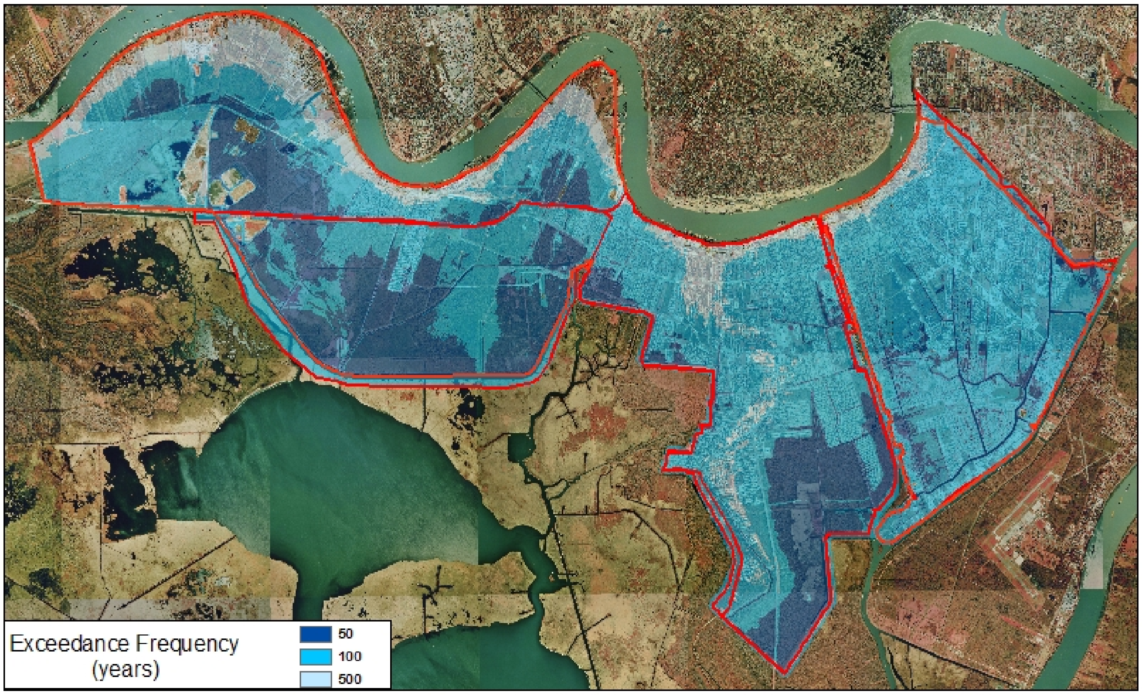


Figure 13-21 – Jefferson West Bank – Pre-Katrina Inundation Risk – No Pumping

JW Current HPS Inundation (No Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has not been considered in the determination of the plotted elevations.

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Figure 13-22 – Jefferson West Bank – Current Inundation Risk- No Pumping

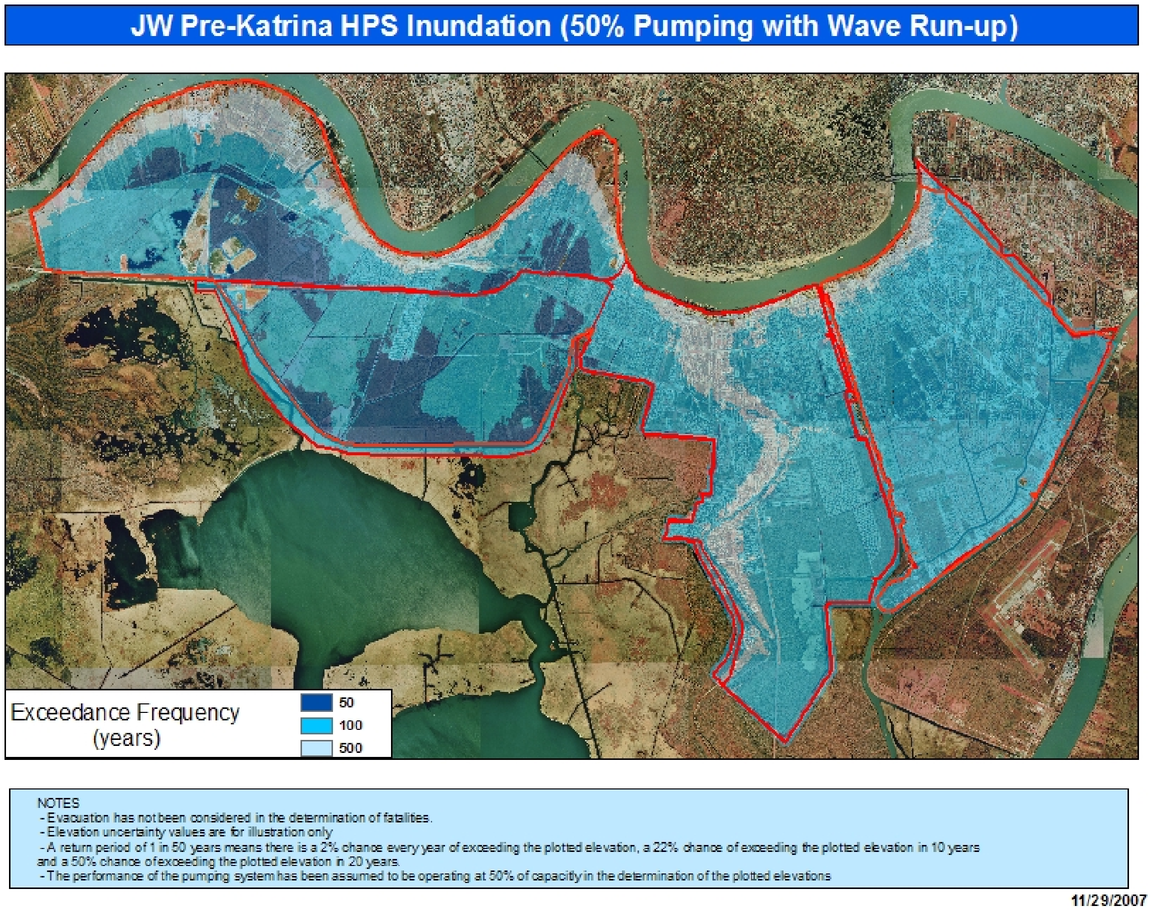


Figure 13-23 – Jefferson West Bank – Pre-Katrina Inundation Risk – 50% Pumping

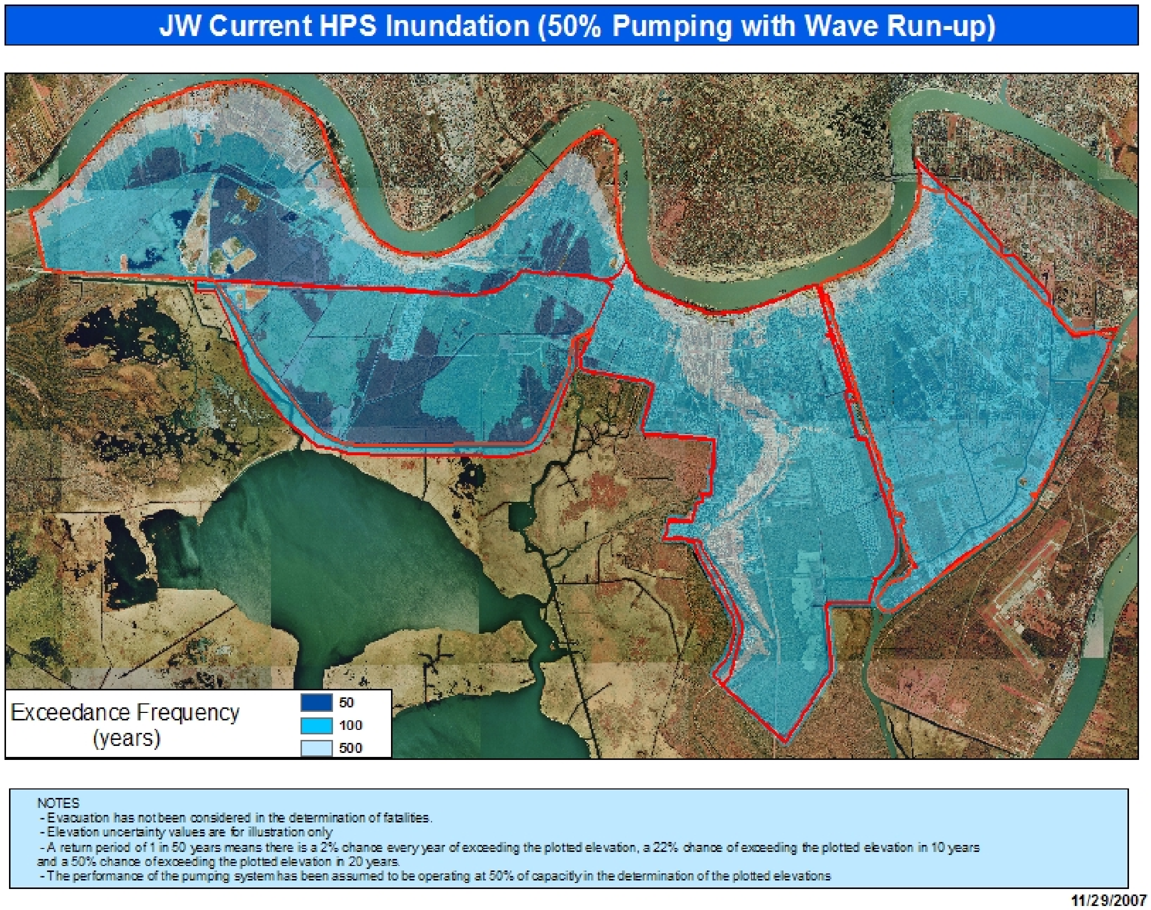
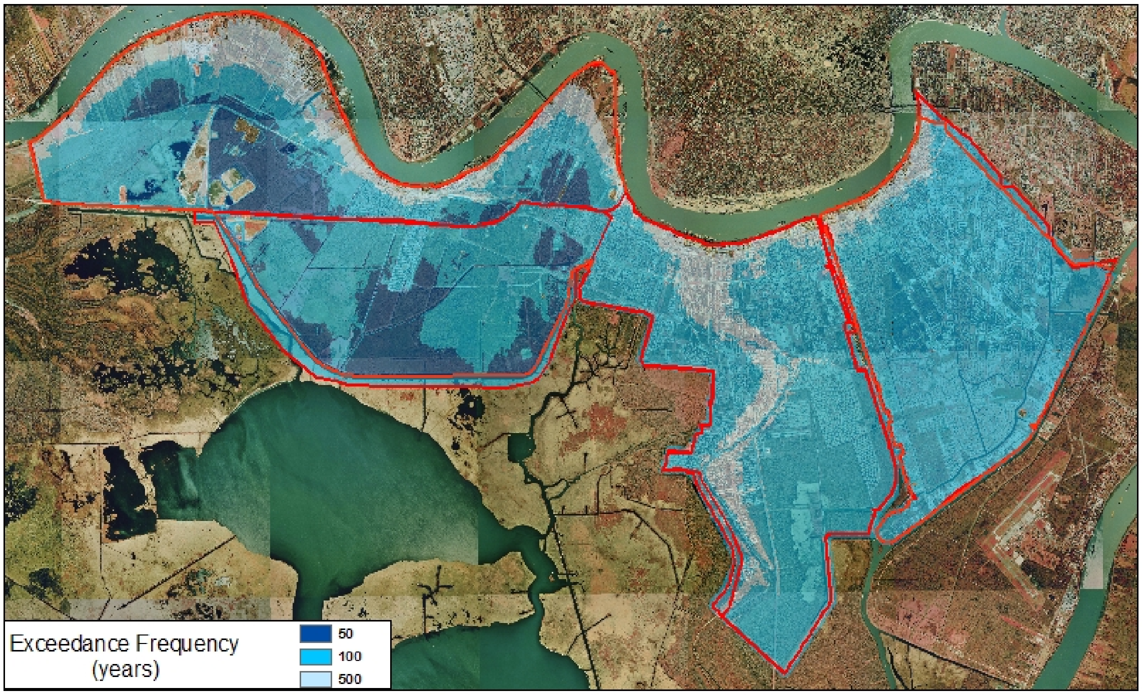


Figure 13-24 – Jefferson West Bank – Current Inundation Risk- 50% Pumping

JW Pre-Katrina HPS Inundation (100% Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 100% of capacity in the determination of the plotted elevations

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Figure 13-25 – Jefferson West Bank – Pre-Katrina Inundation Risk – 100% Pumping

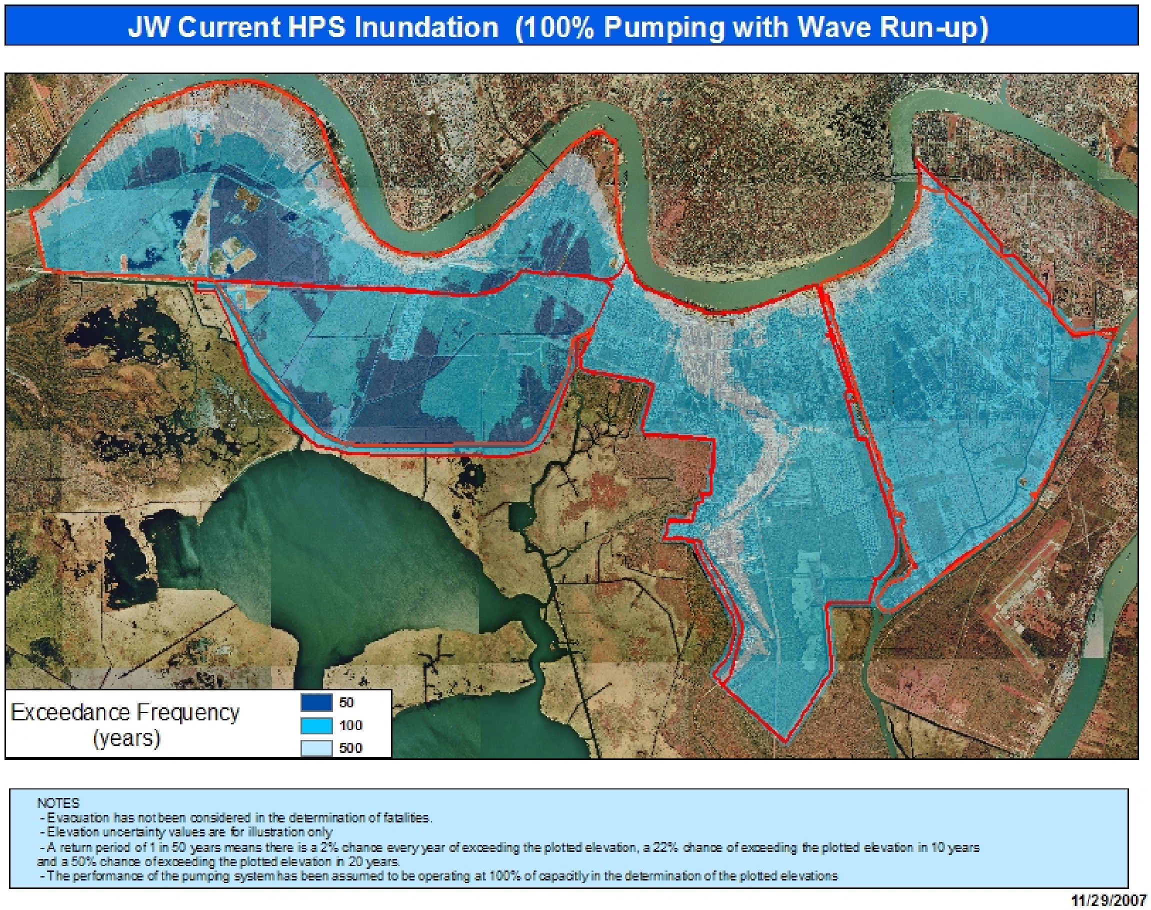


Figure 13-26 – Jefferson West Bank – Current Inundation Risk- 100% Pumping

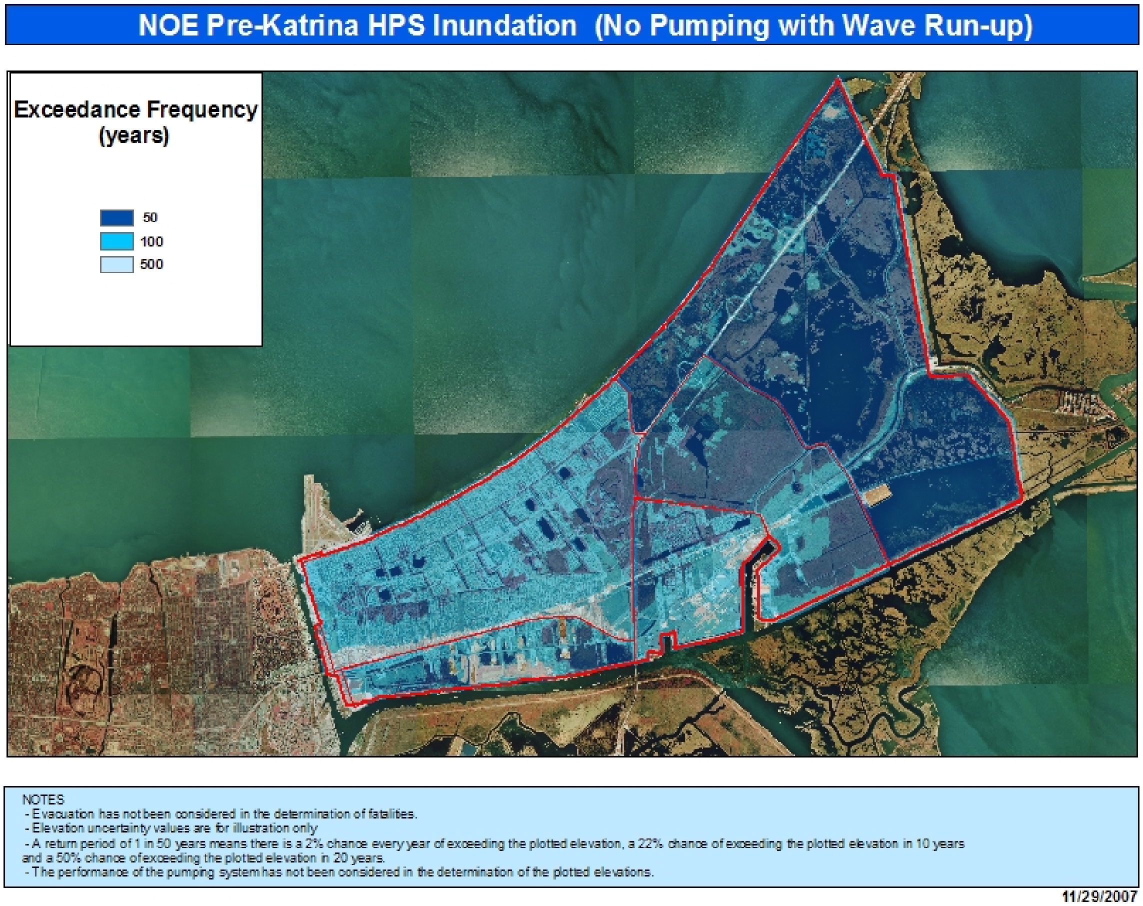


Figure 13-27 – New Orleans East – Pre-Katrina Inundation Risk- No Pumping

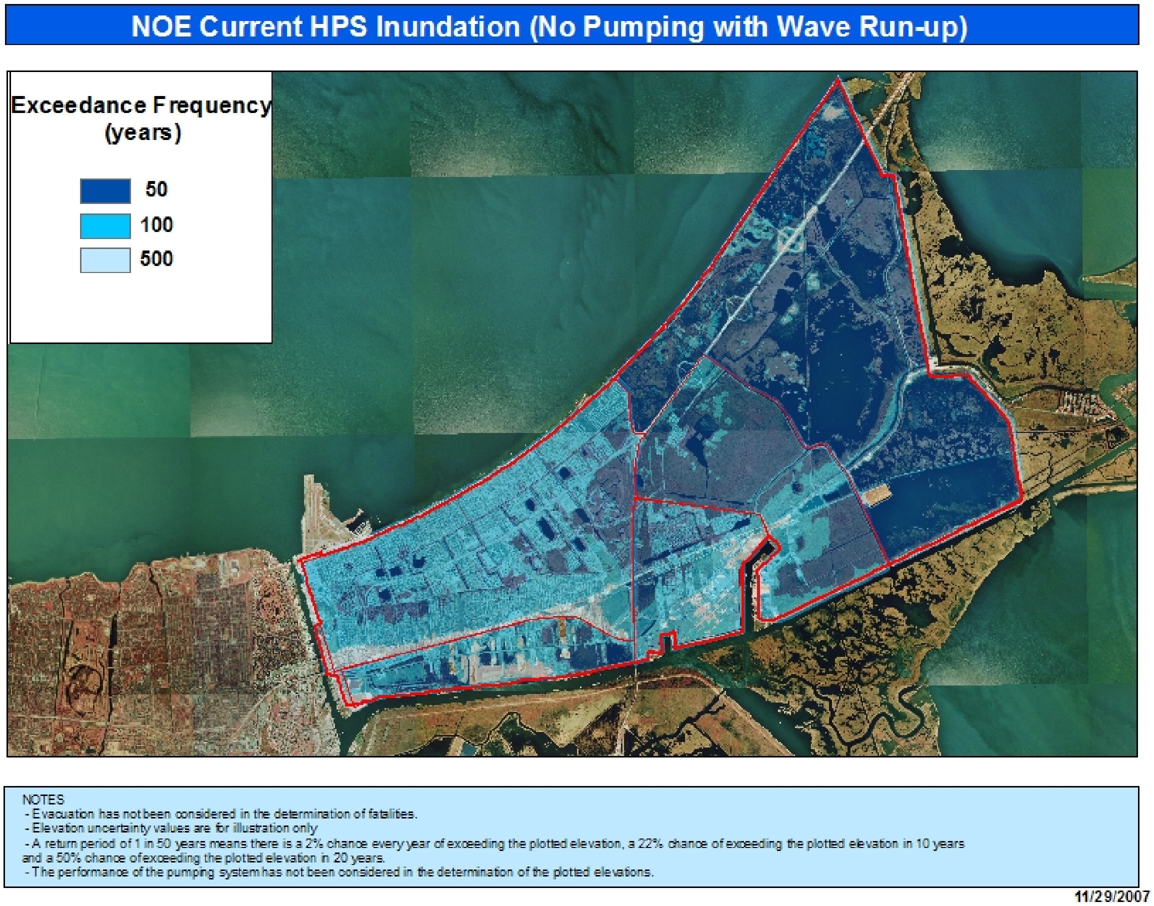


Figure 13-28 – New Orleans East – Current Inundation Risk – No Pumping

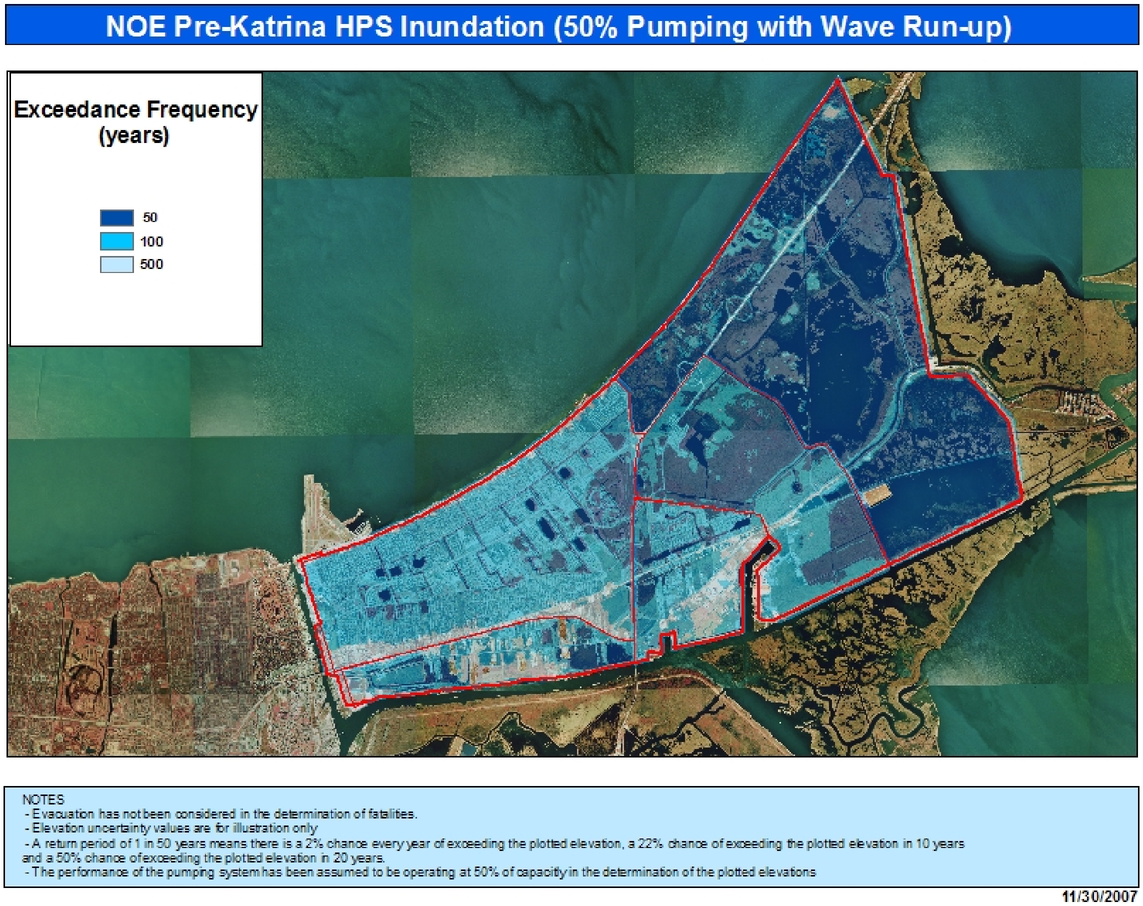


Figure 13-29 – New Orleans East – Pre-Katrina Inundation Risk- 50% Pumping

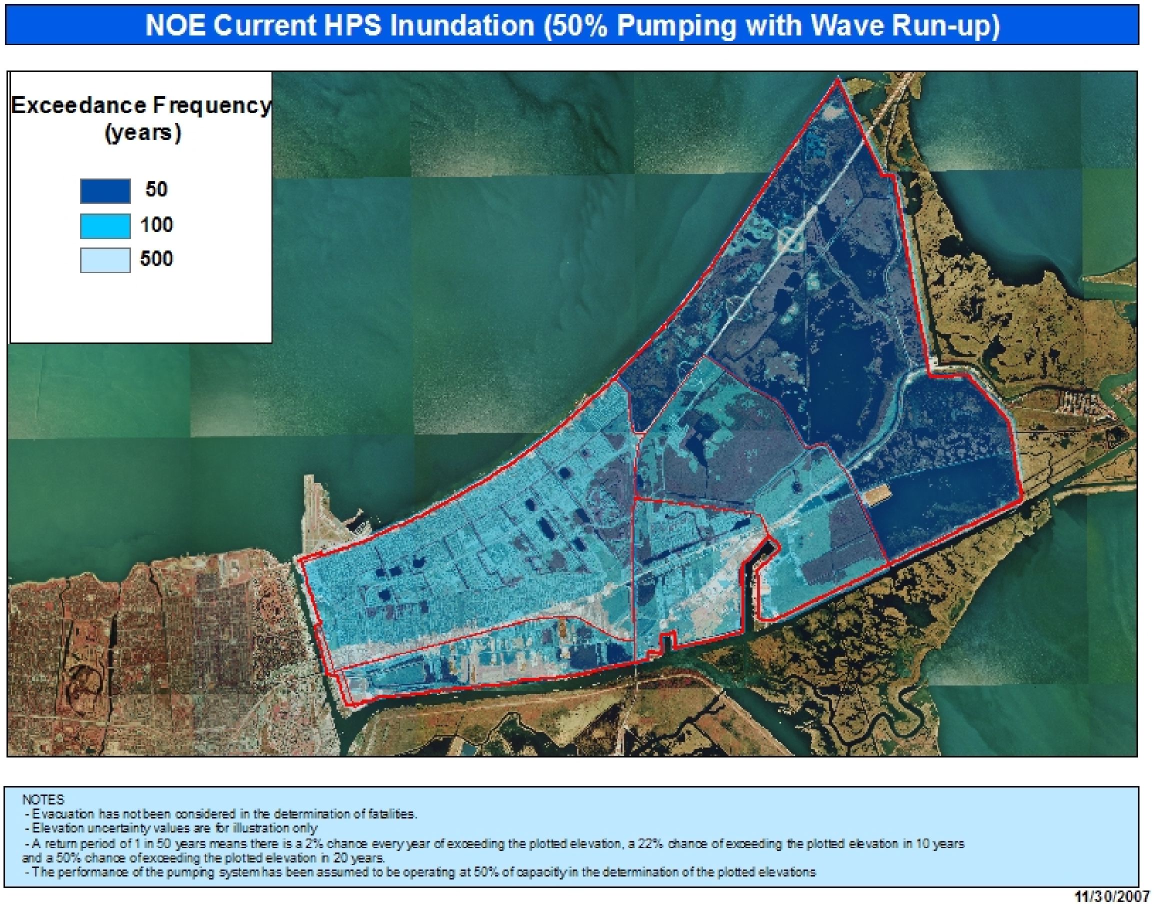


Figure 13-30 – New Orleans East – Current Inundation Risk – 50% Pumping

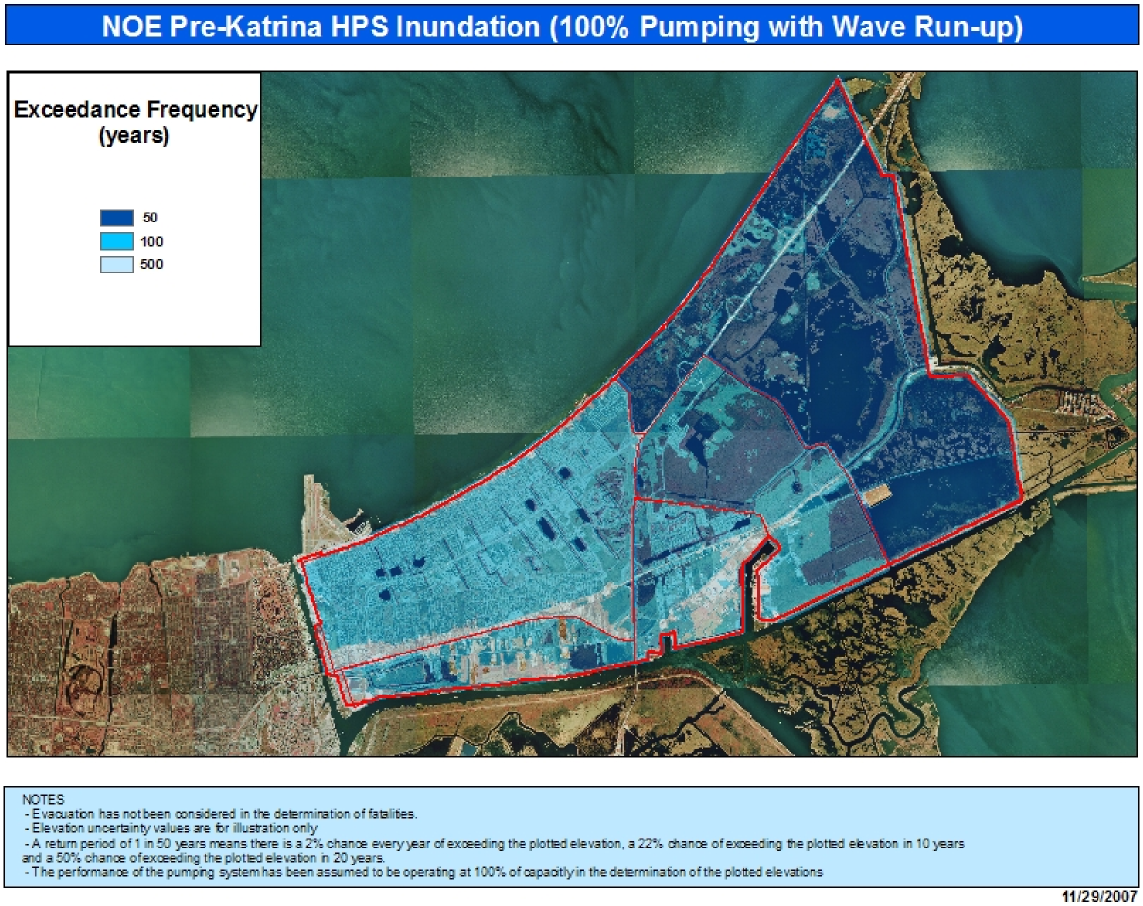
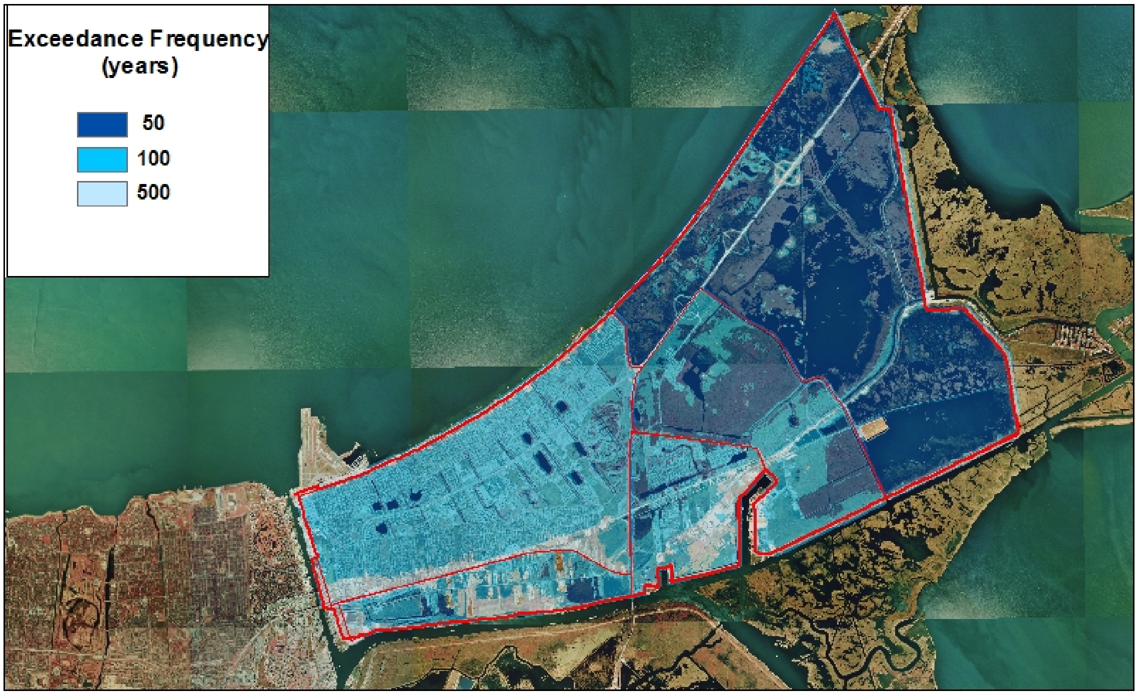


Figure 13-31 – New Orleans East – Pre-Katrina Inundation Risk- 100% Pumping

NOE Current HPS Inundation (100% Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 100% of capacity in the determination of the plotted elevations.

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Figure 13-32 – New Orleans East – Current Inundation Risk – 100% Pumping

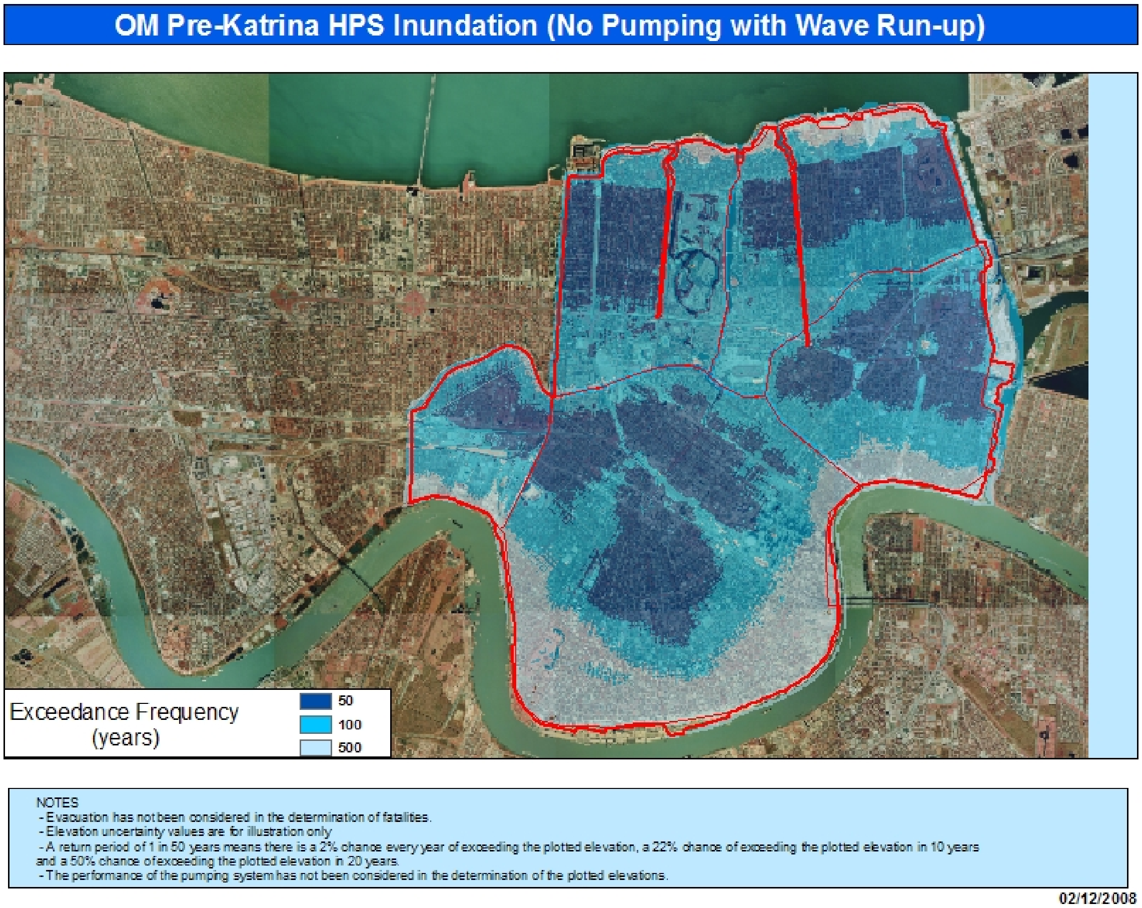
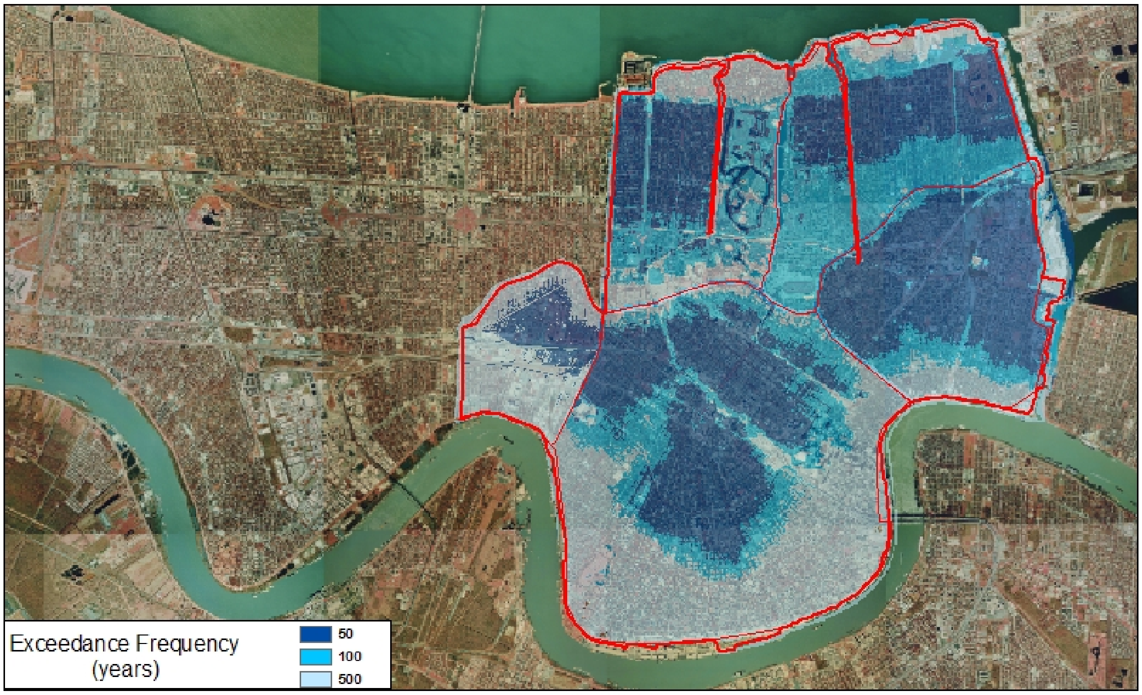


Figure 13-33 – Orleans East Bank – Pre-Katrina Inundation Risk – No Pumping

OM Current HPS Inundation (No Pumping with Wave Run-up)

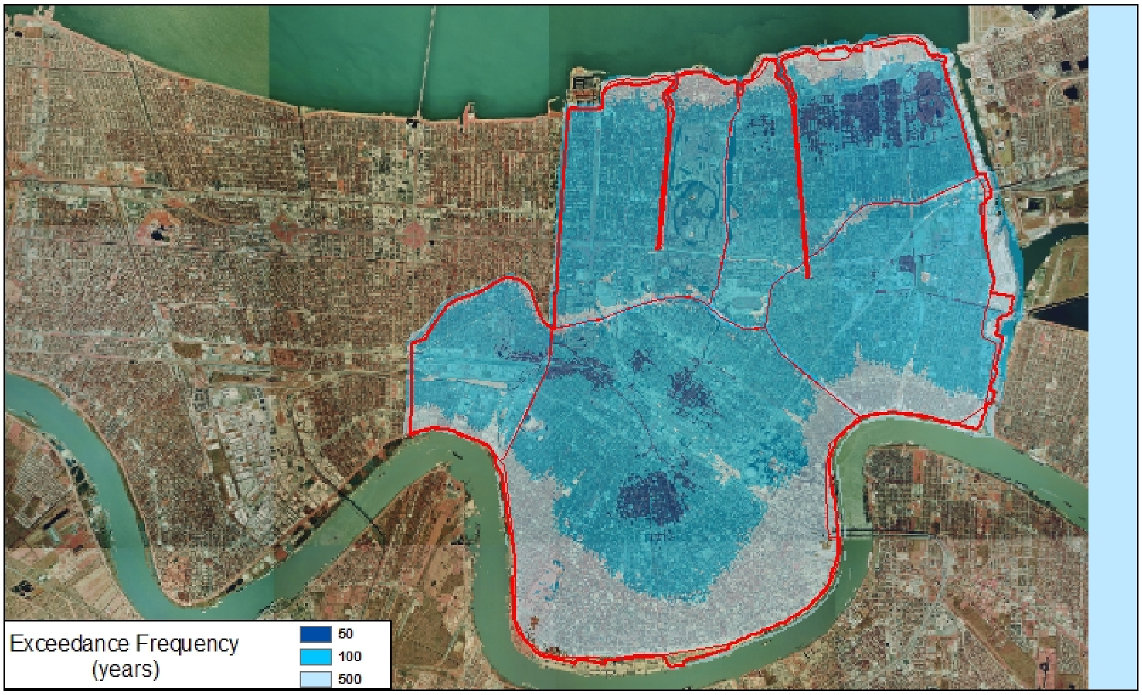


NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has not been considered in the determination of the plotted elevations.

02/19/2008

Figure 13-34 – Orleans East Bank – Current Inundation Risk – No Pumping

OM Pre-Katrina HPS Inundation (50% Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 50% of capacity in the determination of the plotted elevations

11/29/2007

Figure 13-35 – Orleans East Bank – Pre-Katrina Inundation Risk – 50% Pumping

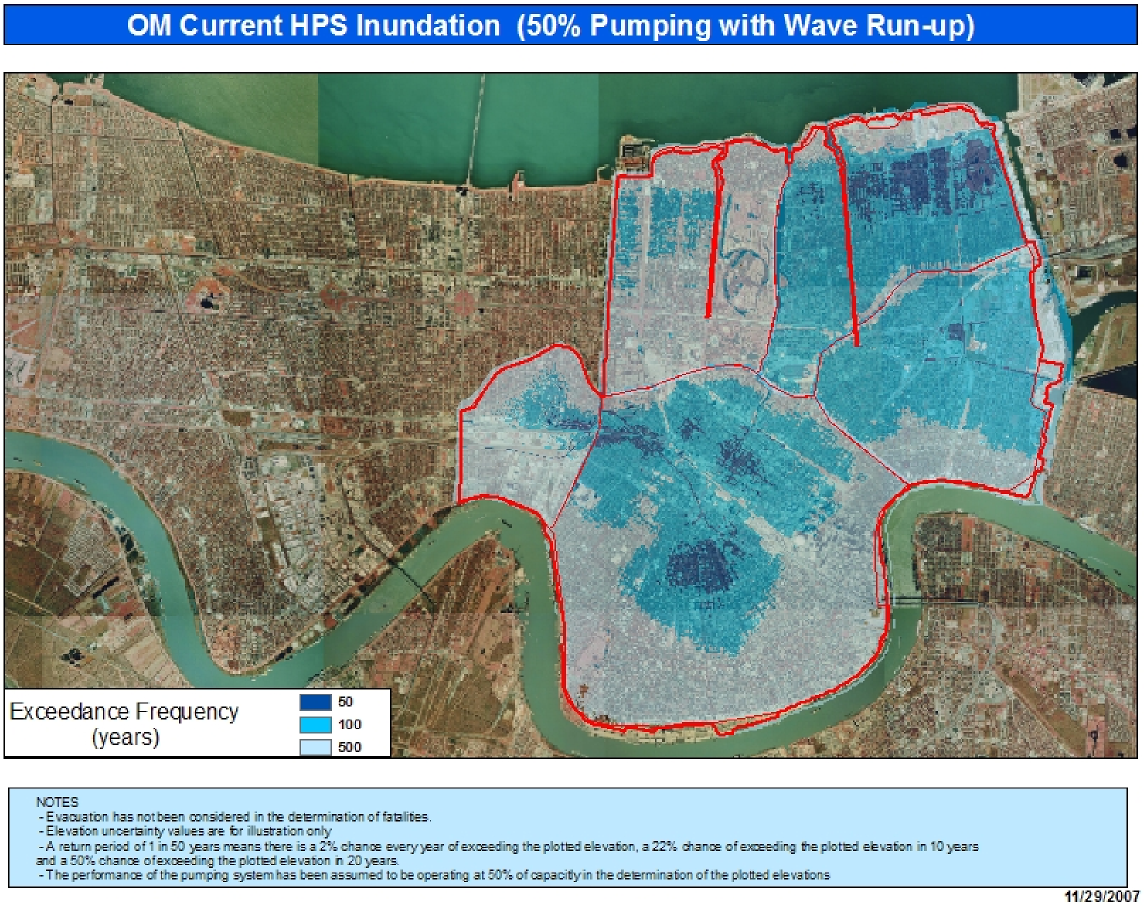
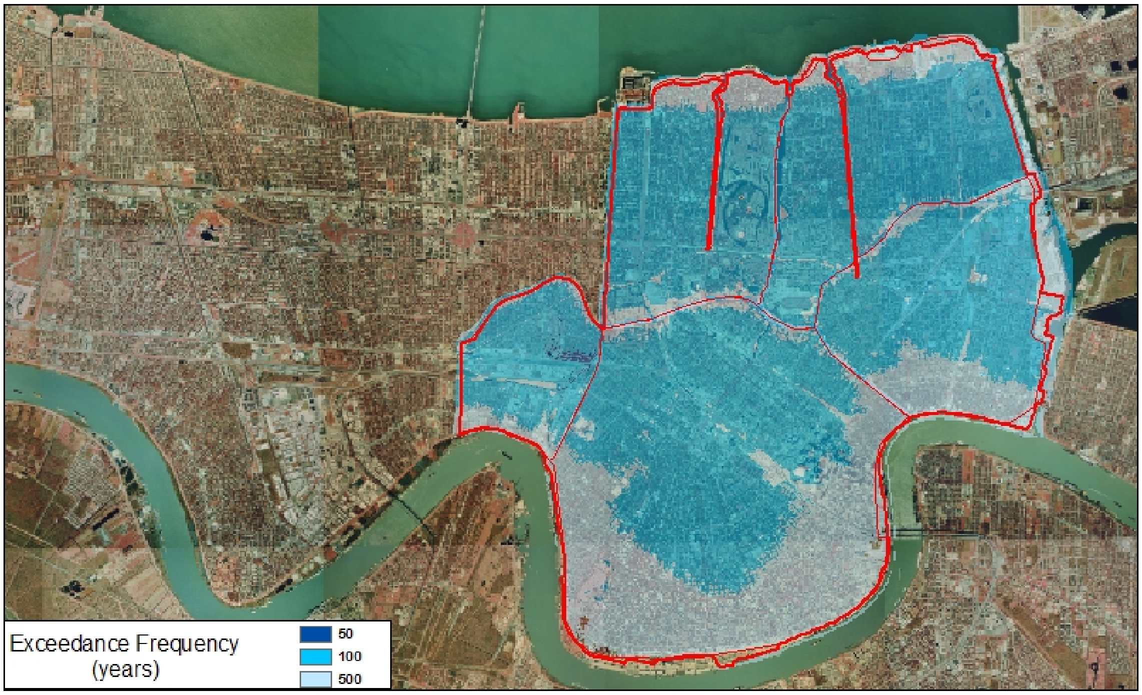


Figure 13-36 – Orleans East Bank – Current Inundation Risk – 50% Pumping

OM Pre-Katrina HPS Inundation (100% Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
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- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 100% of capacity in the determination of the plotted elevations

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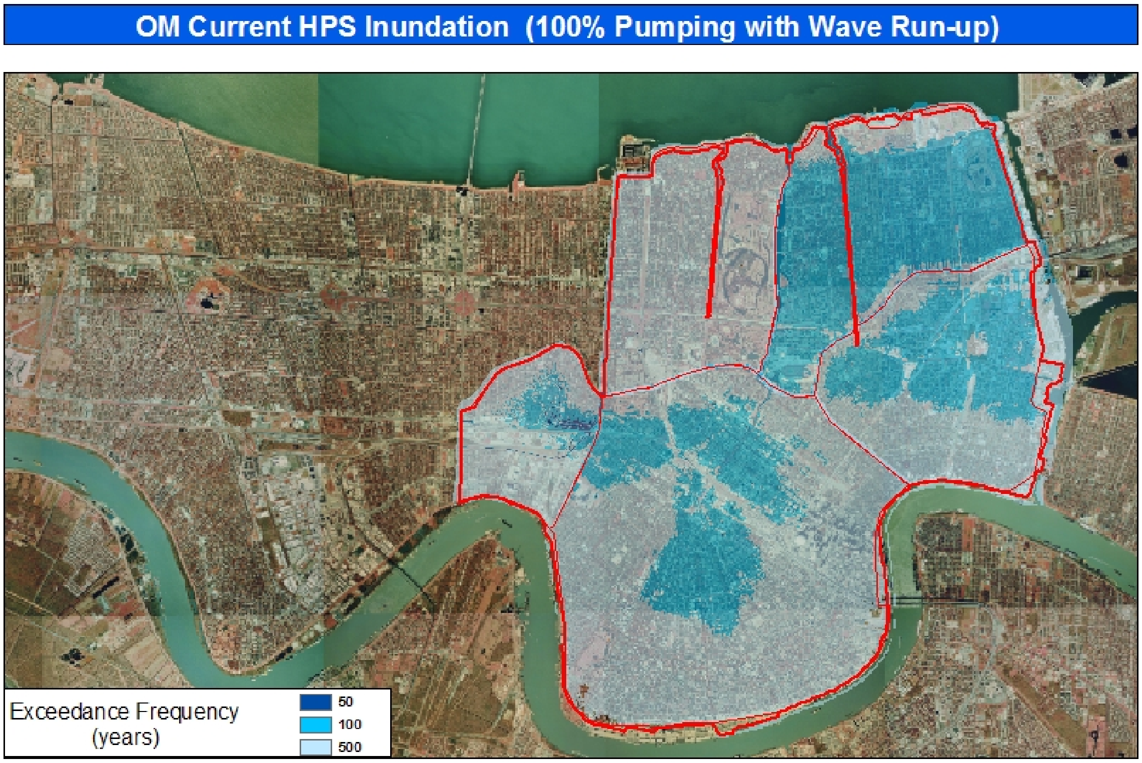
Figure 13-37 – Orleans East Bank – Pre-Katrina Inundation Risk – 100% Pumping



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 100% of capacitly in the determination of the plotted elevations

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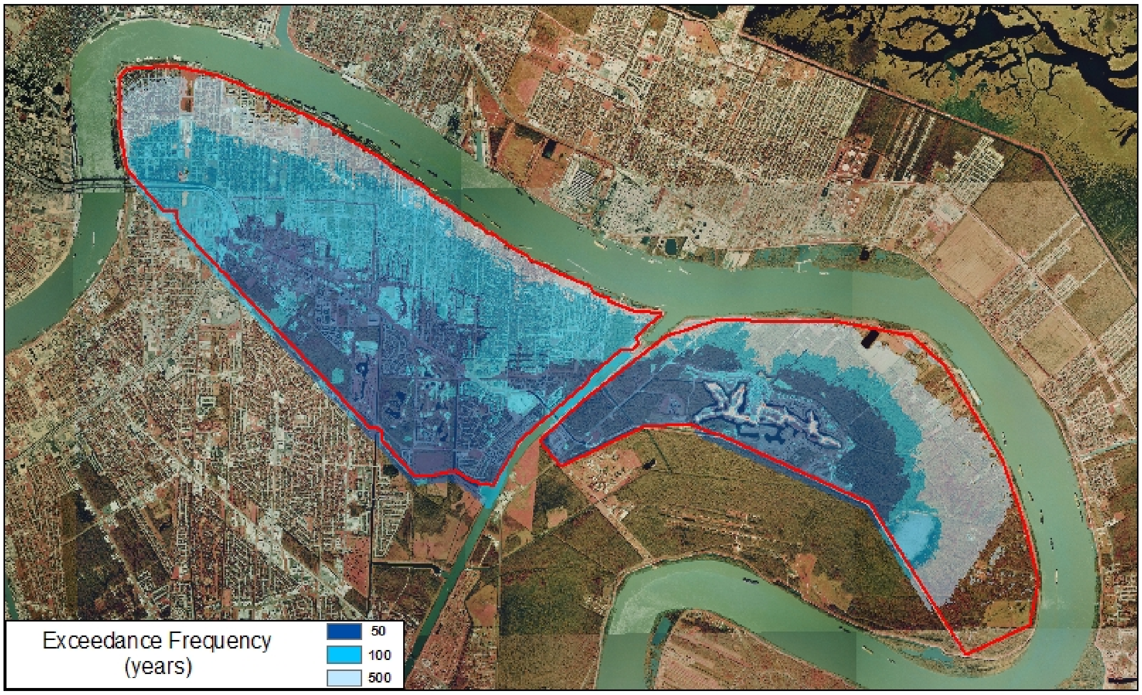
Figure 13-38 – Orleans East Bank – Current Inundation Risk – 100% Pumping

OW Pre-Katrina HPS Inundation (No Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has not been considered in the determination of the plotted elevations.

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Figure13-39 – Orleans West Bank – Pre-Katrina Inundation Risk – No Pumping

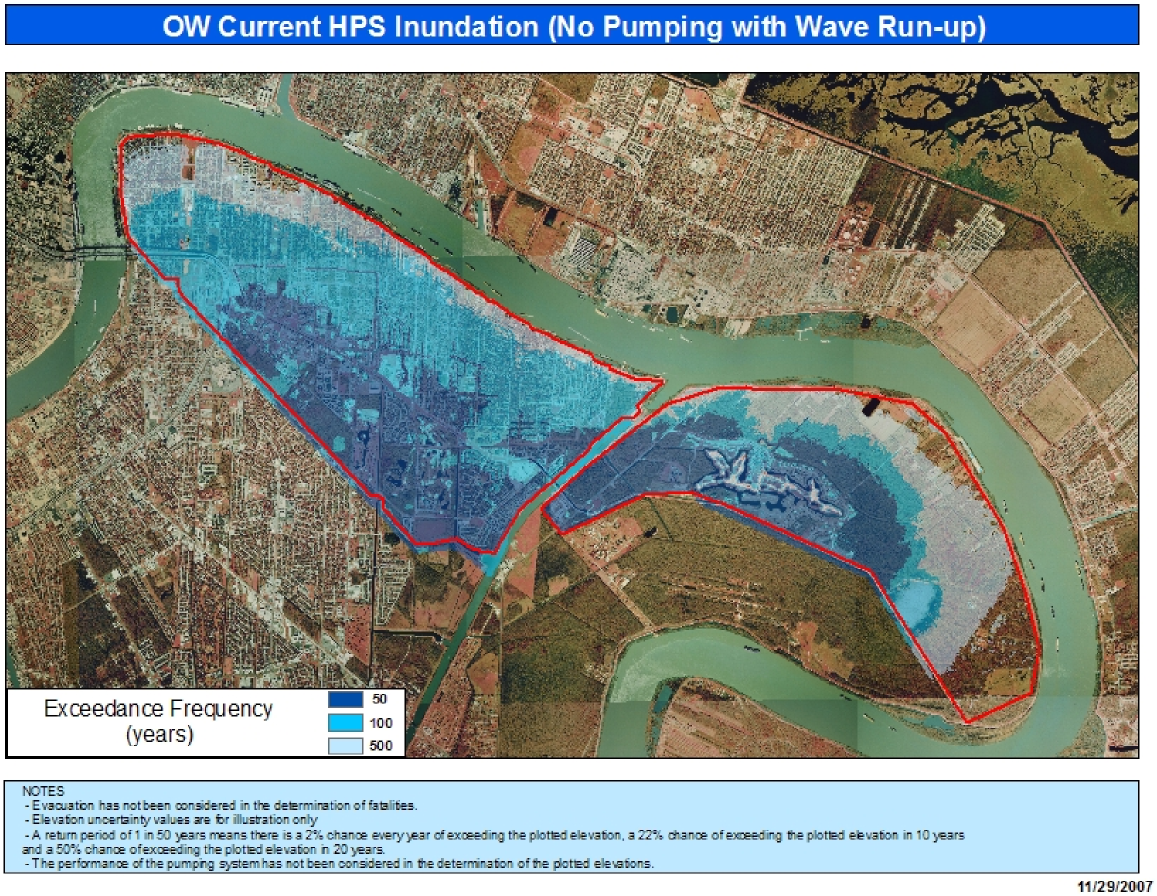
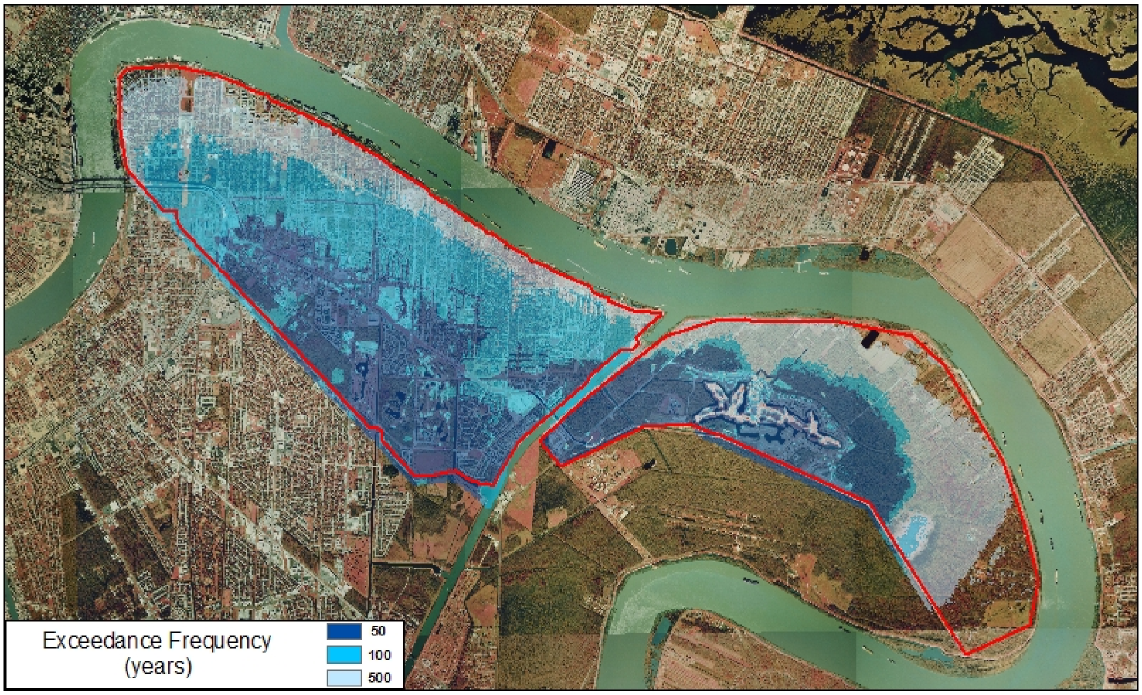


Figure13-40 – Orleans West Bank – Current Inundation Risk – No Pumping

OW Pre-Katrina HPS Inundation - 50% Pumping with Wave Run-up



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 50% of capacity in the determination of the plotted elevations

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Figure13-41 – Orleans West Bank – Pre-Katrina Inundation Risk – 50% Pumping

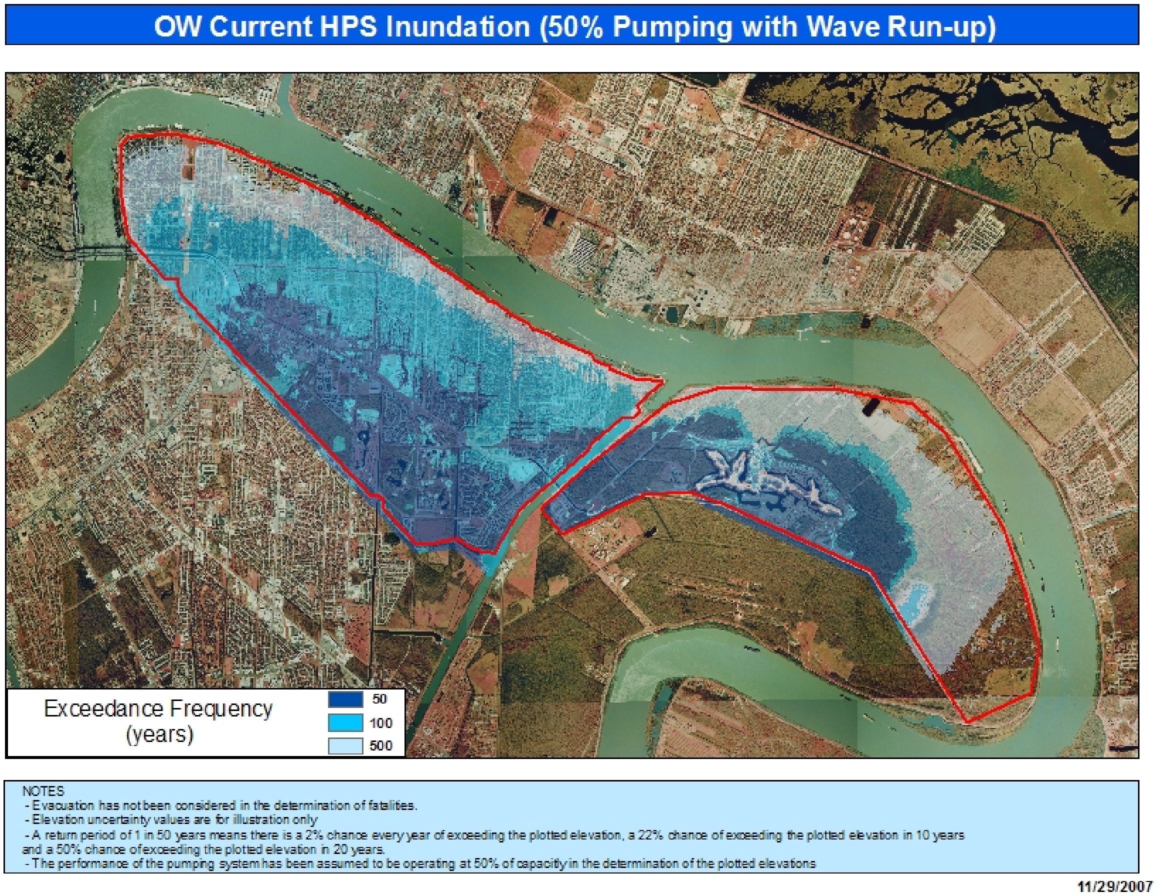
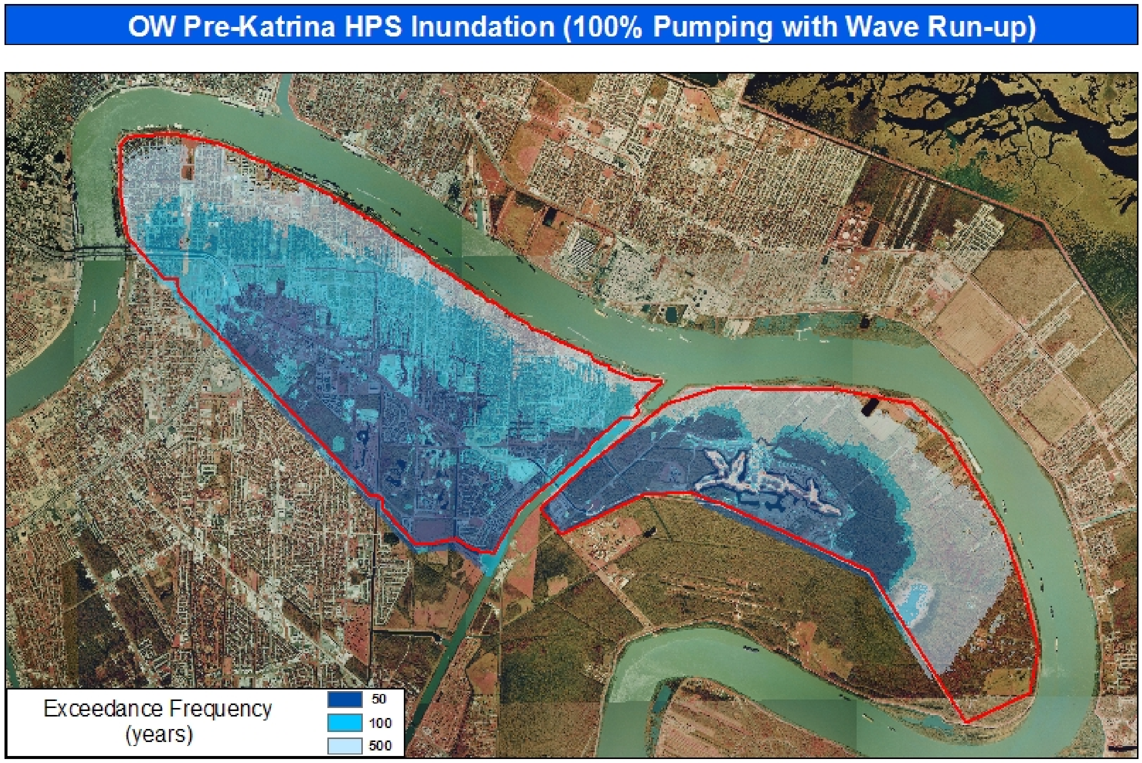


Figure13-42 – Orleans West Bank – Current Inundation Risk – 50% Pumping

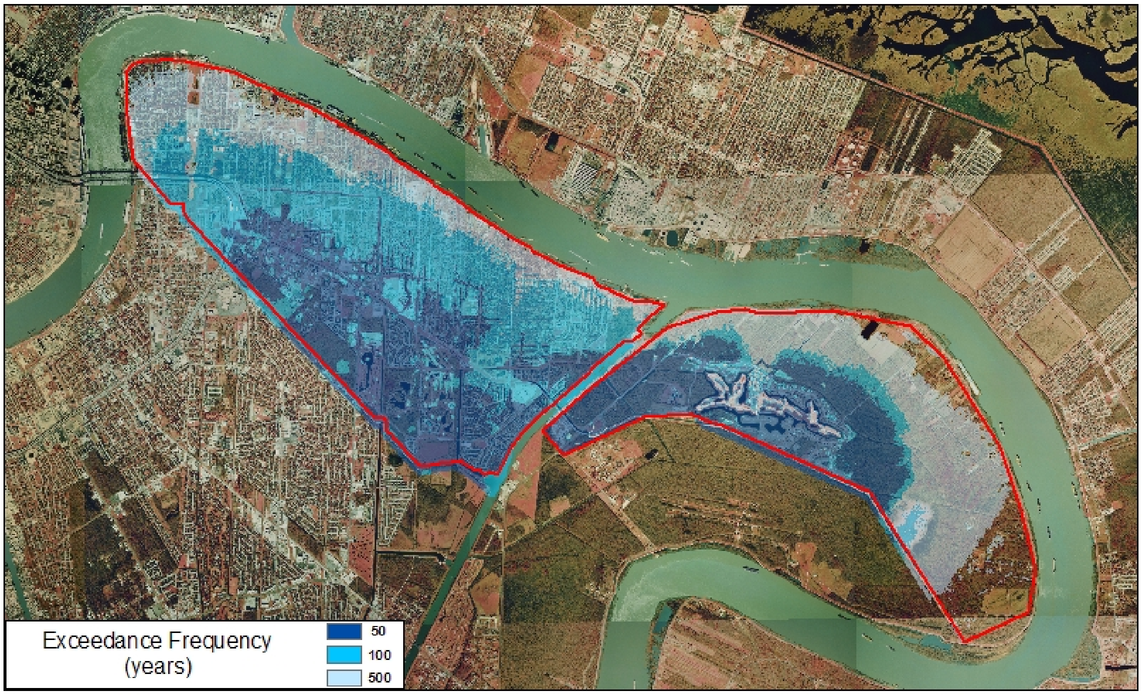


NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 100% of capacity in the determination of the plotted elevations

11/29/2007

Figure13-43 – Orleans West Bank – Pre-Katrina Inundation Risk – 100% Pumping

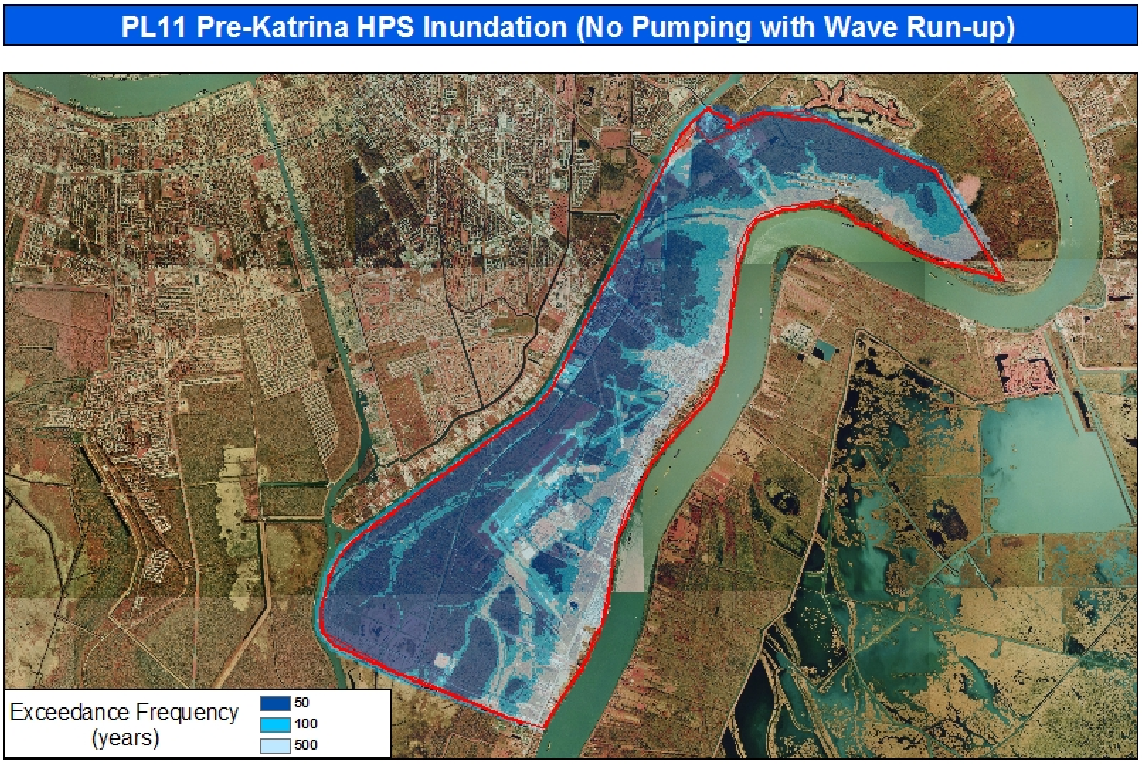
OW Current HPS Inundation (100% Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 100% of capacity in the determination of the plotted elevations

11/29/2007

Figure13-44 – Orleans West Bank – Current Inundation Risk – 100% Pumping



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has not been considered in the determination of the plotted elevations.

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Figure 13-45 – Plaquemines (PL 11) – Pre-Katrina Inundation Risk – No Pumping

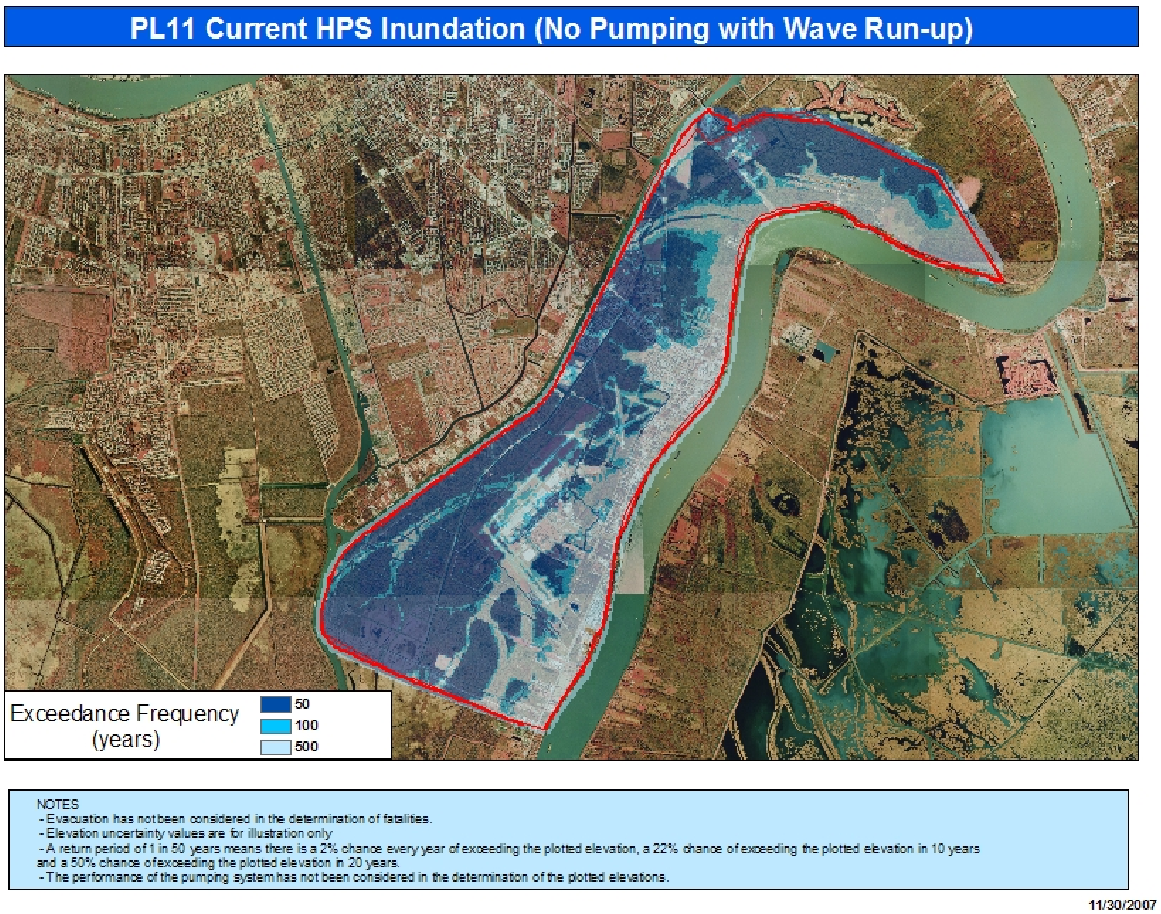


Figure 13-46 – Plaquemines (PL 11)– Current Inundation Risk – No Pumping

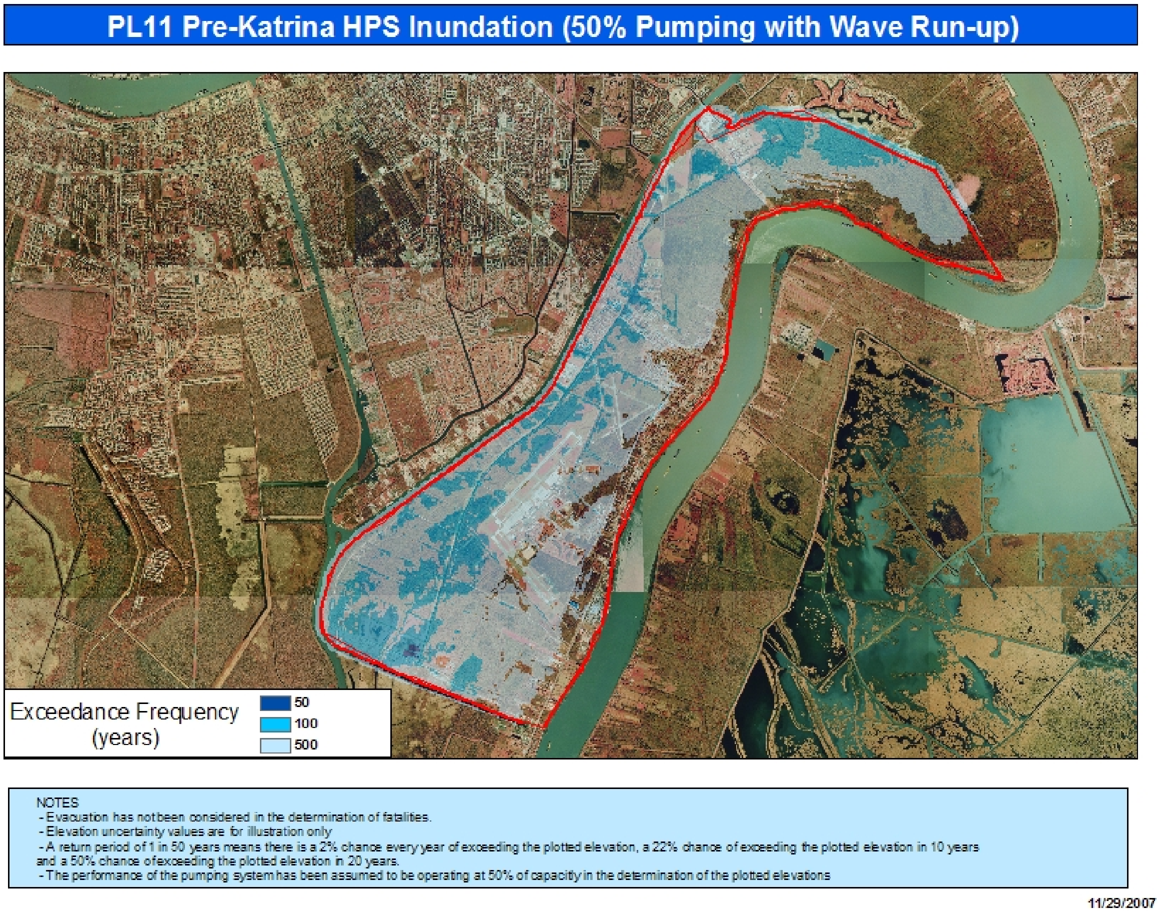
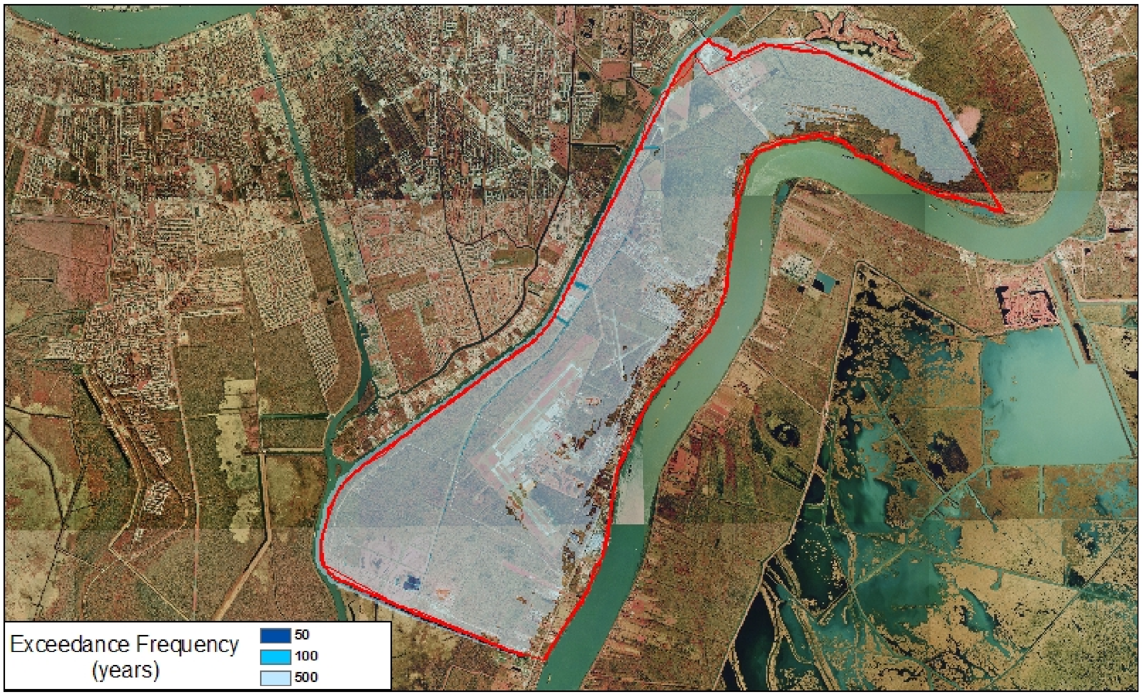


Figure 13-47 – Plaquemines (PL 11) – Pre-Katrina Inundation Risk – 50% Pumping

PL11 Current HPS Inundation (50% Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 50% of capacity in the determination of the plotted elevations

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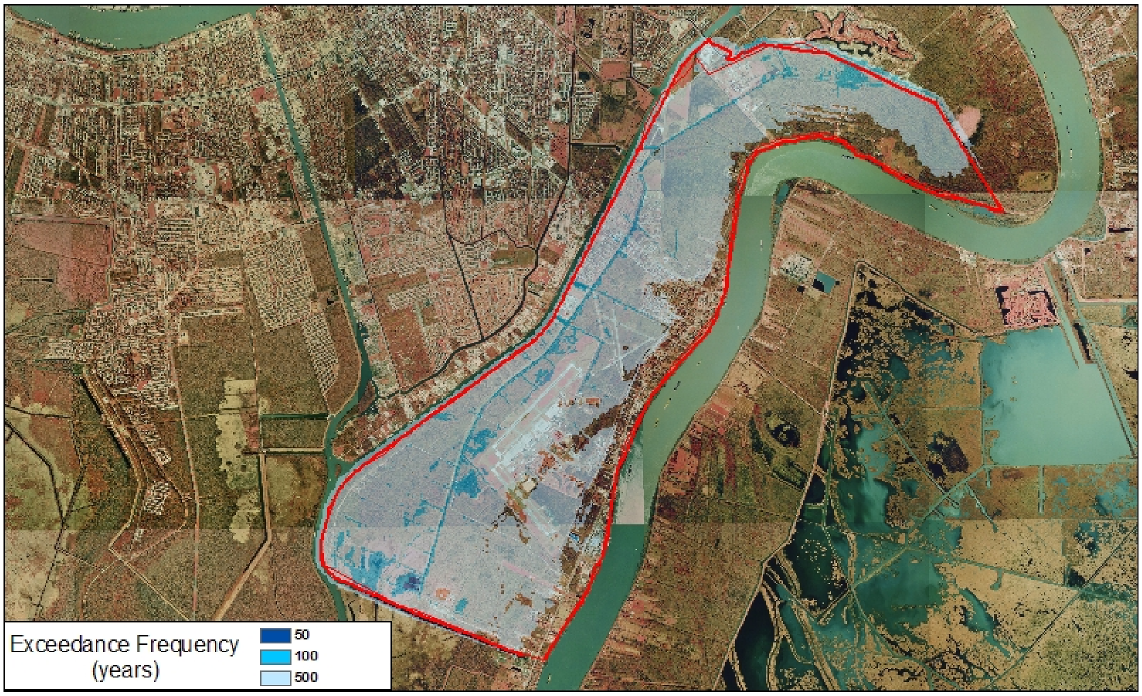
Figure 13-48 – Plaquemines (PL 11) – Current Inundation Risk – 50% Pumping

PL11 Pre-Katrina HPS Inundation (100% Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 100% of capacity in the determination of the plotted elevations

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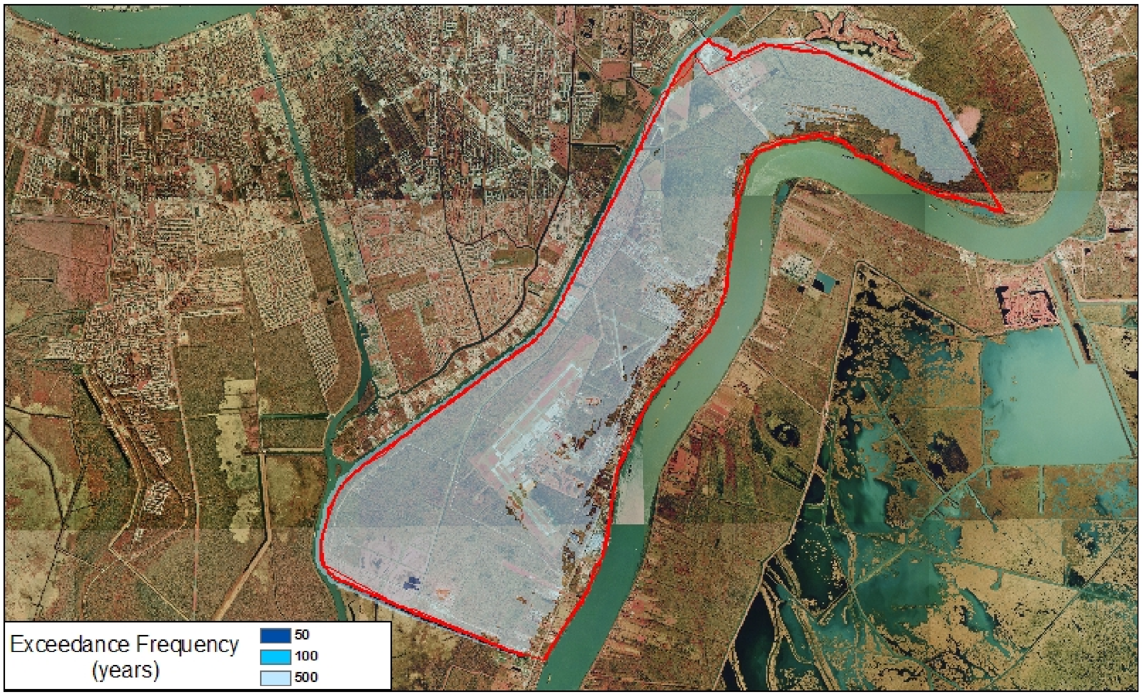
Figure 13-49 – Plaquemines (PL 11) – Pre-Katrina Inundation Risk – 100% Pumping

PL11 Current HPS Inundation (100% Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 100% of capacity in the determination of the plotted elevations

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Figure 13-50 – Plaquemines (PL 11) – Current Inundation Risk – 100% Pumping

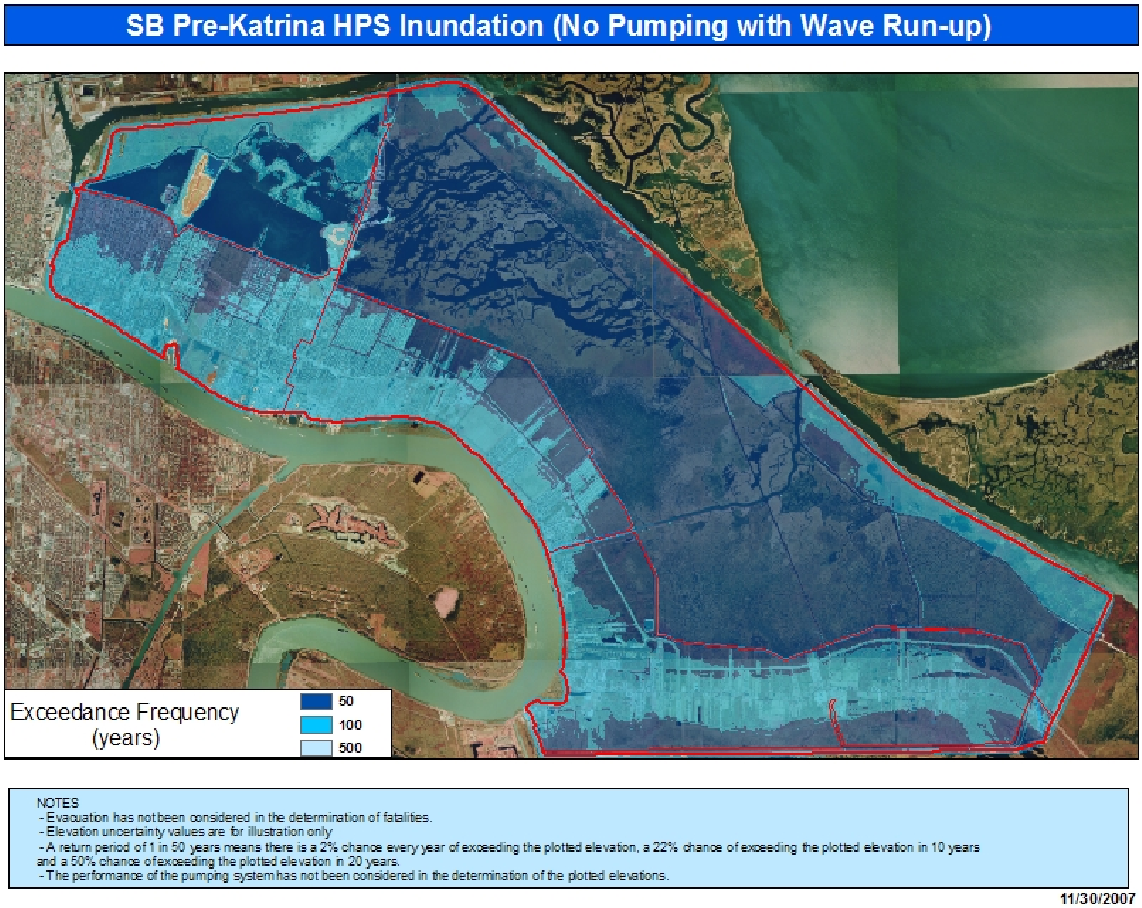


Figure 13-51 – St. Bernard – Pre-Katrina Inundation Risk – No Pumping

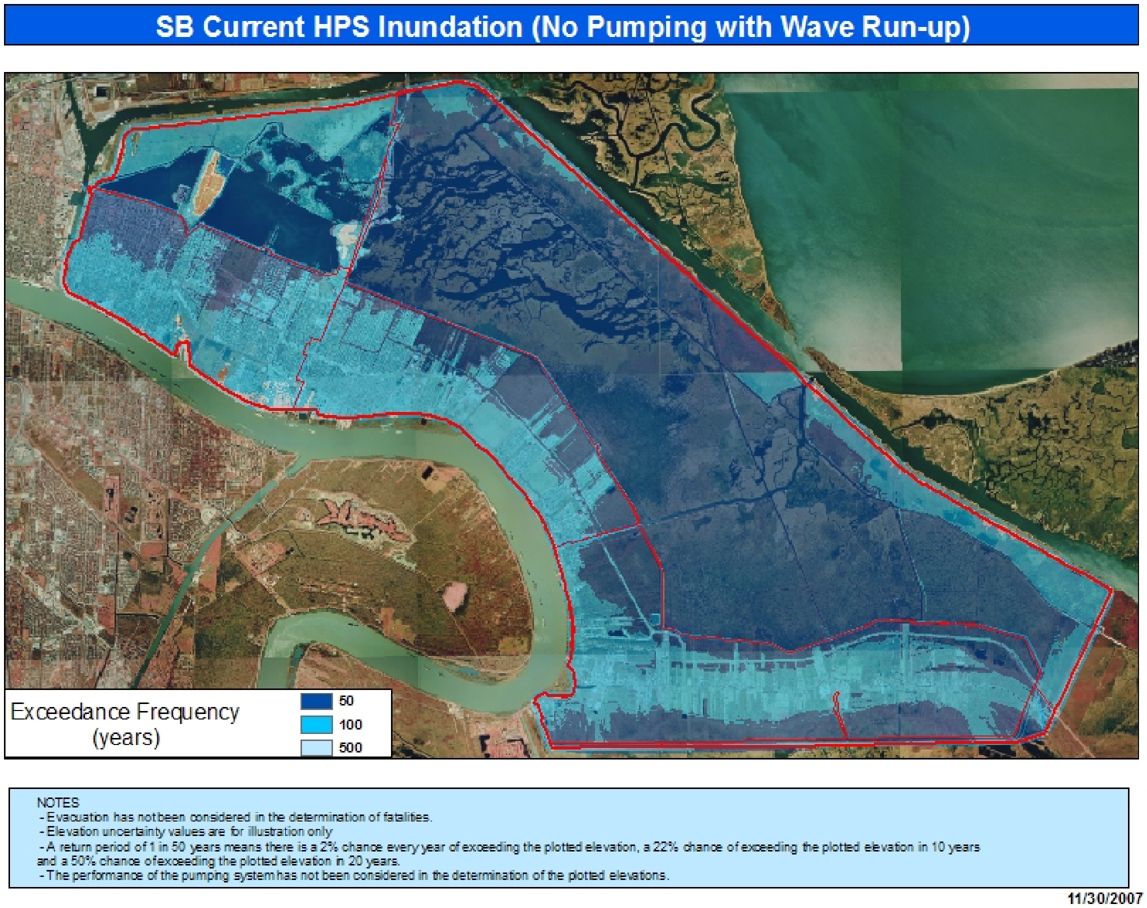
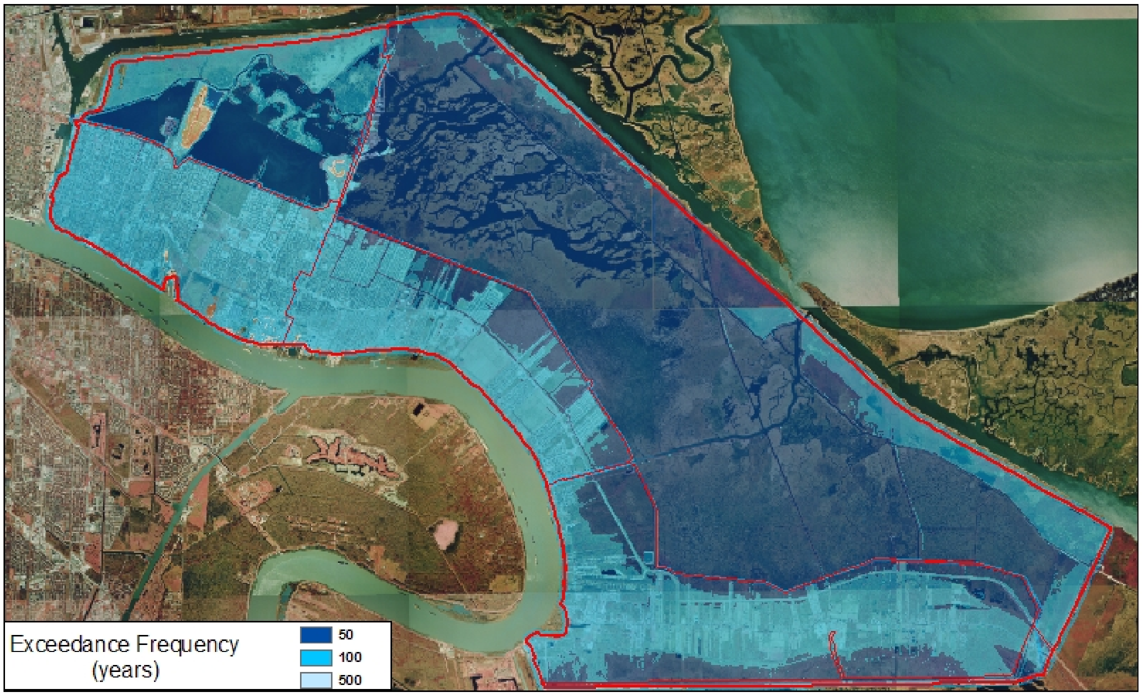


Figure 13-52 – St. Bernard – Current Inundation Risk – No Pumping

SB Pre-Katrina HPS Inundation (50% Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 50% of capacity in the determination of the plotted elevations

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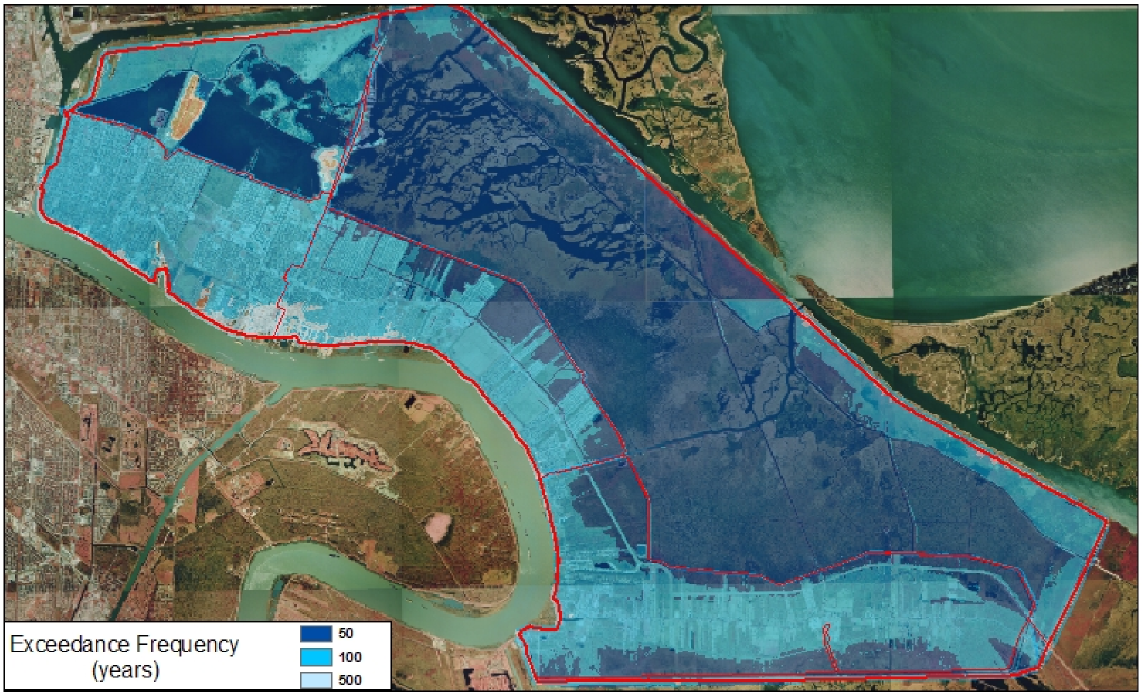
Figure 13-53 – St. Bernard – Pre-Katrina Inundation Risk – 50% Pumping

SB Current HPS Inundation (50% Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 50% of capacity in the determination of the plotted elevations

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Figure 13-54 – St. Bernard – Current Inundation Risk – 50% Pumping

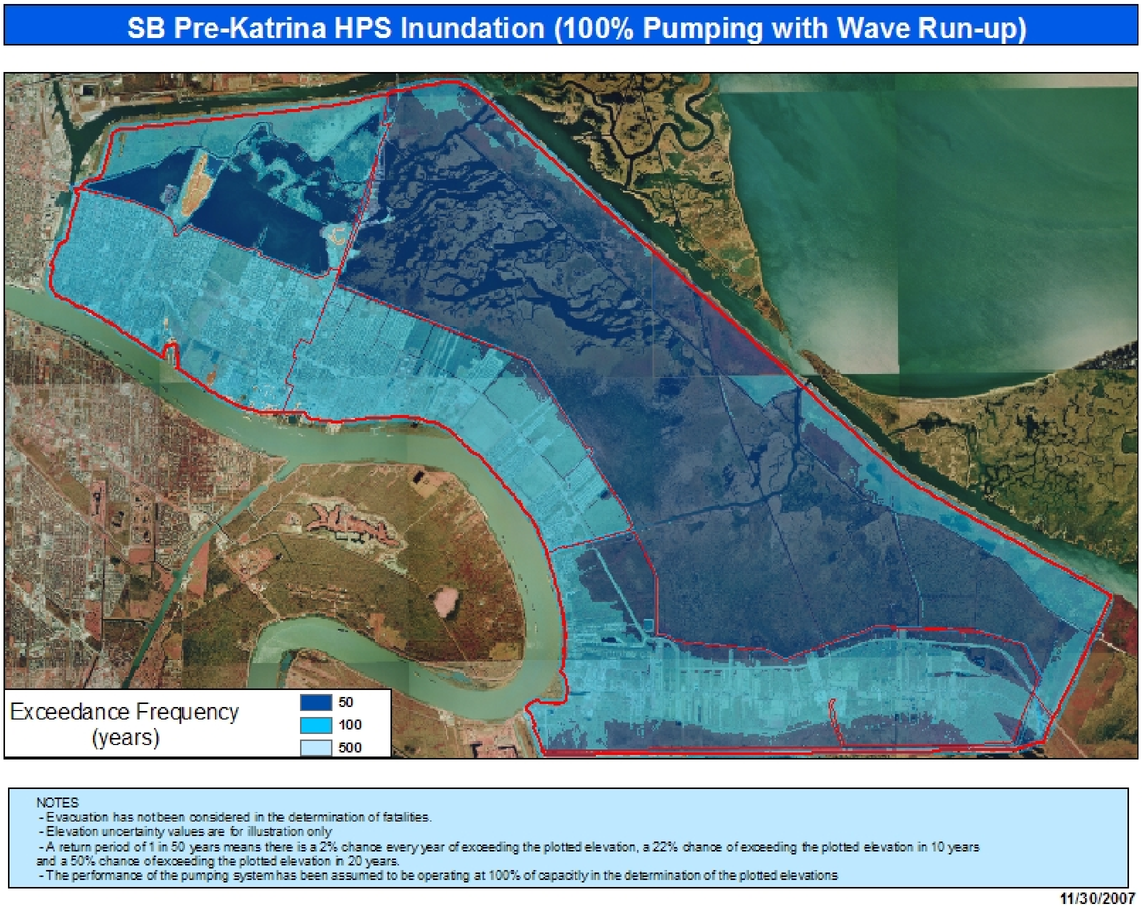


Figure 13-55 – St. Bernard – Pre-Katrina Inundation Risk – 100% Pumping

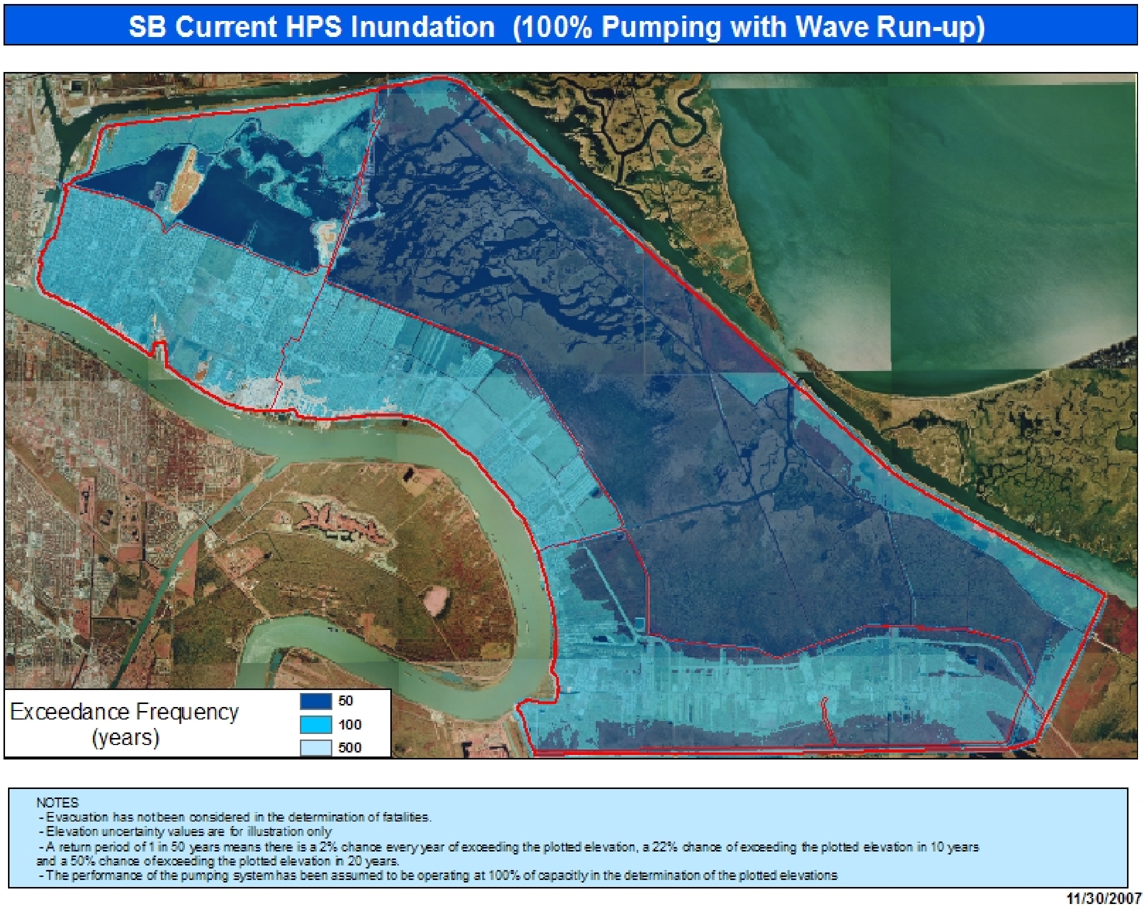
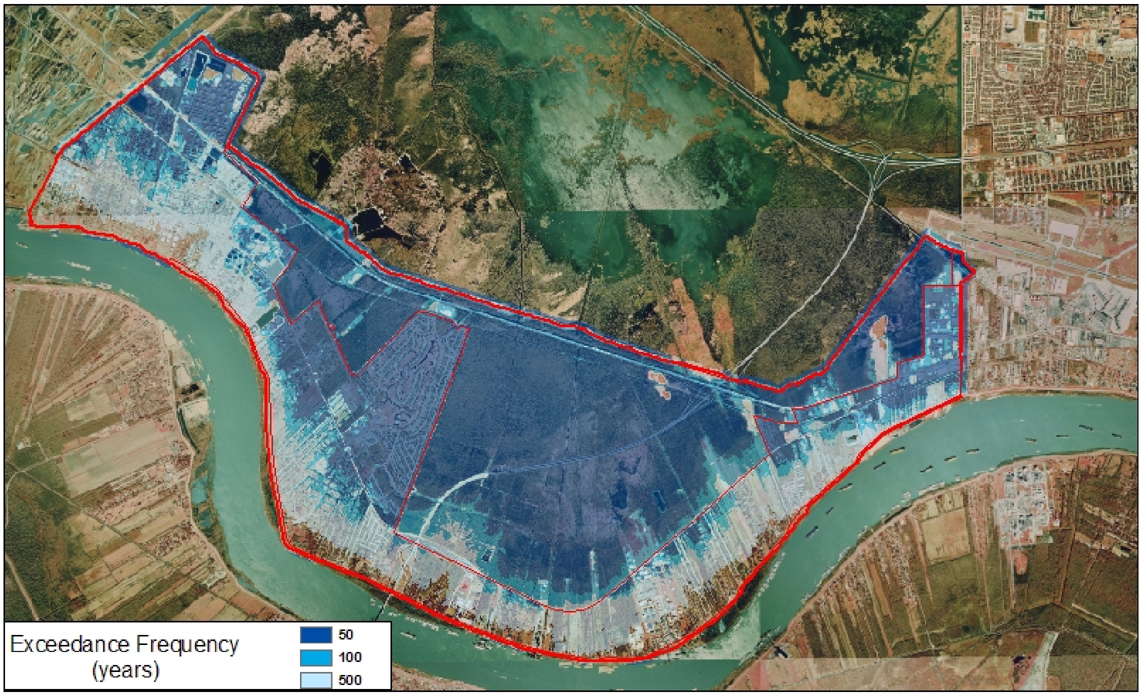


Figure 13-56 – St. Bernard – Current Inundation Risk – 100% Pumping

SC Pre-Katrina HPS Inundation (No Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has not been considered in the determination of the plotted elevations.

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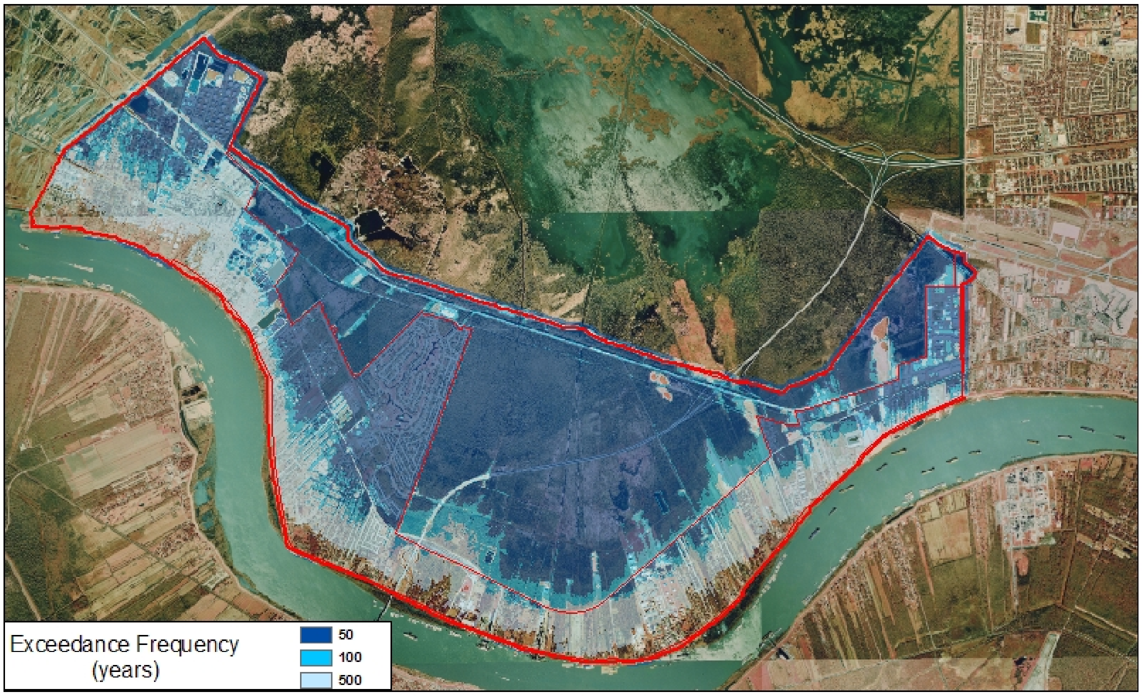
Figure 13-57 – St. Charles – Pre-Katrina Inundation Risk – No Pumping

SC Current HPS Inundation (No Pumping with Wave Run-up)



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has not been considered in the determination of the plotted elevations.

02/14/2008

Figure 13-58 – St. Charles – Current Inundation Risk – No Pumping

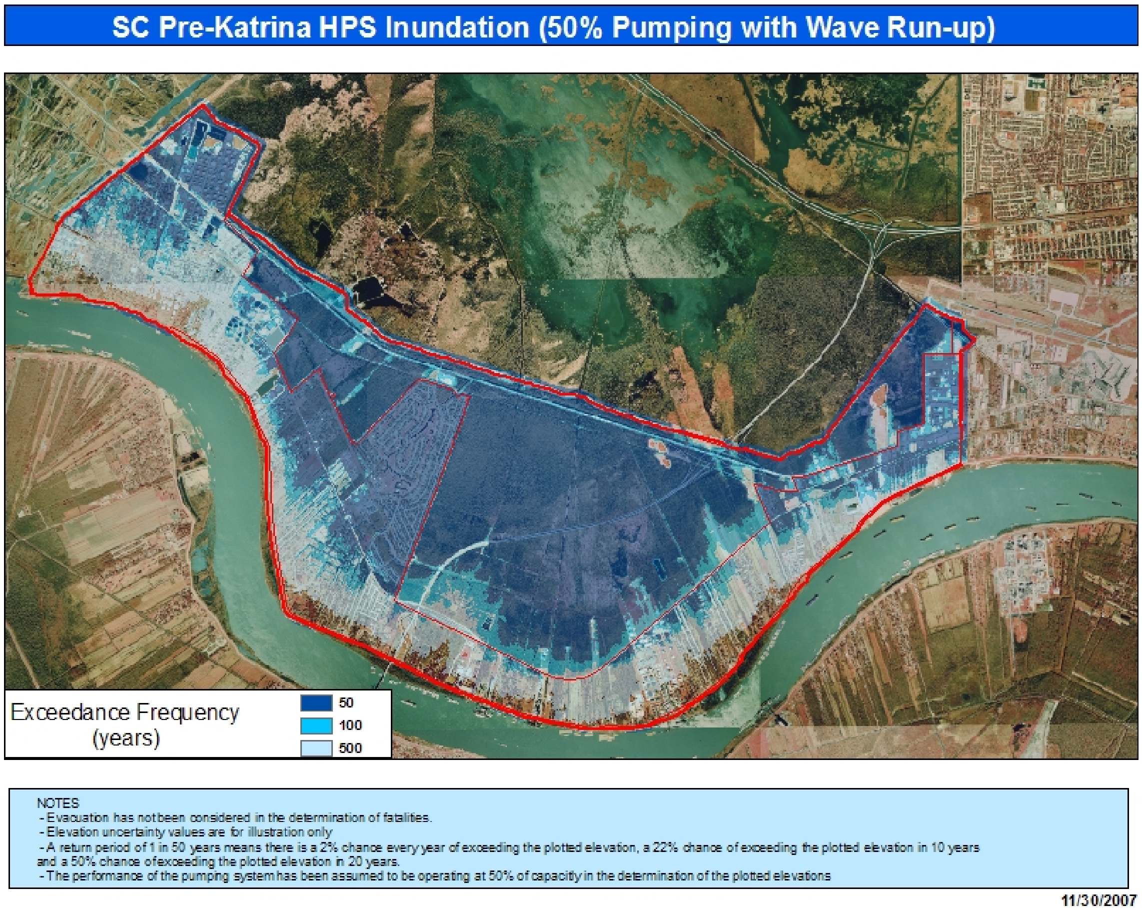
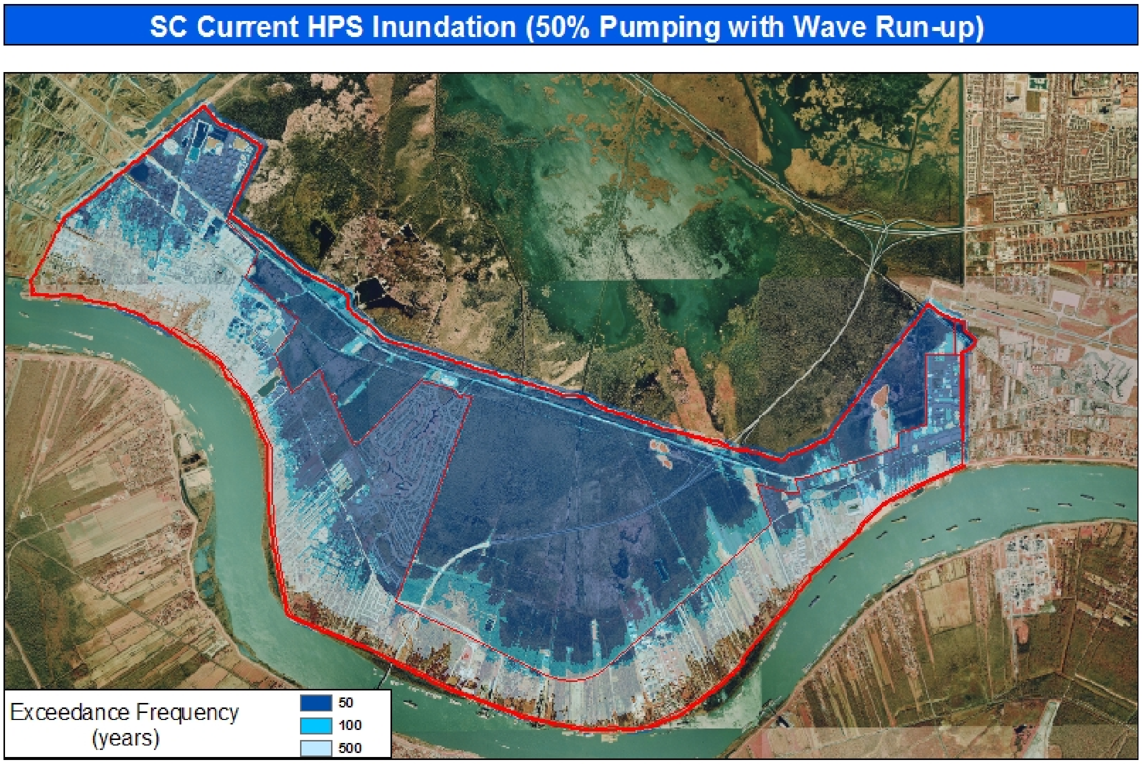


Figure 13-59 – St. Charles – Pre-Katrina Inundation Risk – 50% Pumping



NOTES
- Evacuation has not been considered in the determination of fatalities.
- Elevation uncertainty values are for illustration only
- A return period of 1 in 50 years means there is a 2% chance every year of exceeding the plotted elevation, a 22% chance of exceeding the plotted elevation in 10 years and a 50% chance of exceeding the plotted elevation in 20 years.
- The performance of the pumping system has been assumed to be operating at 50% of capacity in the determination of the plotted elevations

02/14/2008

Figure 13-60– St. Charles – Current Inundation Risk – 50% Pumping

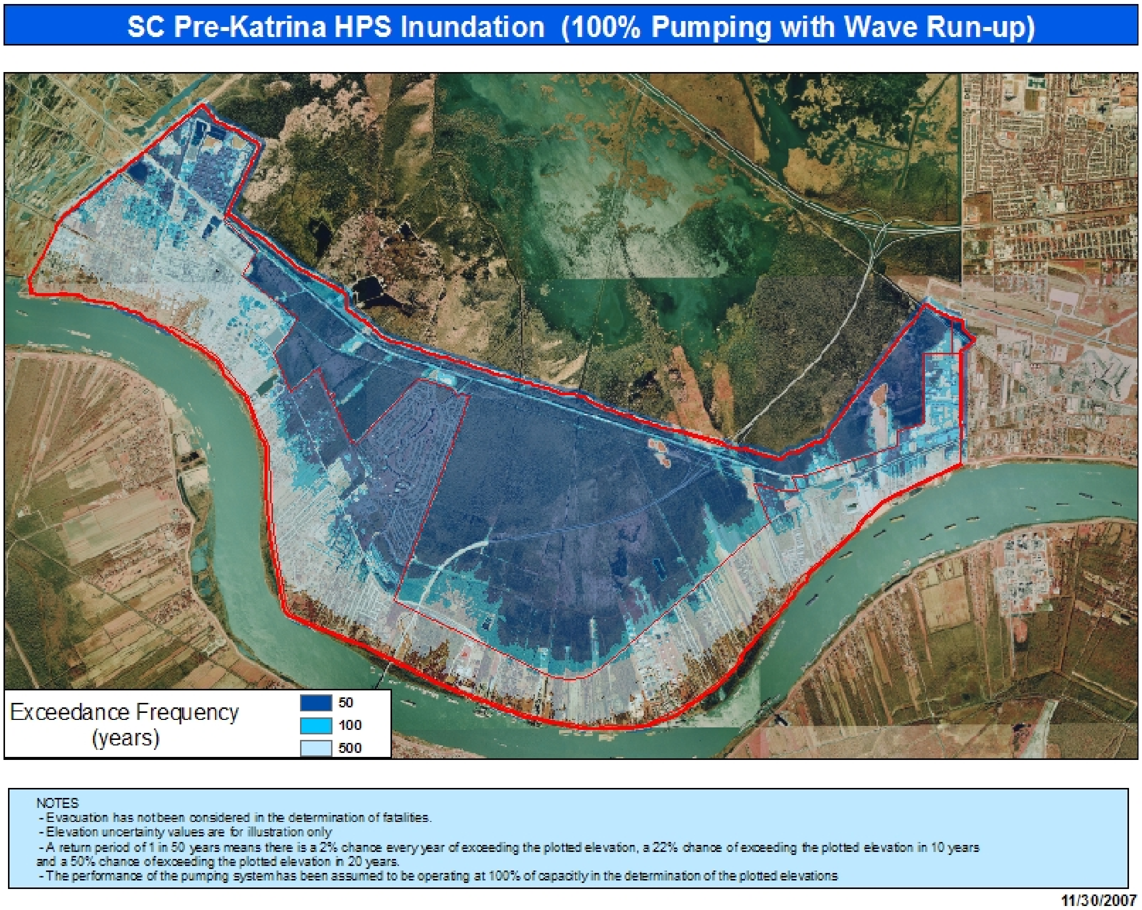


Figure 13-61 – St. Charles – Pre-Katrina Inundation Risk – 100% Pumping

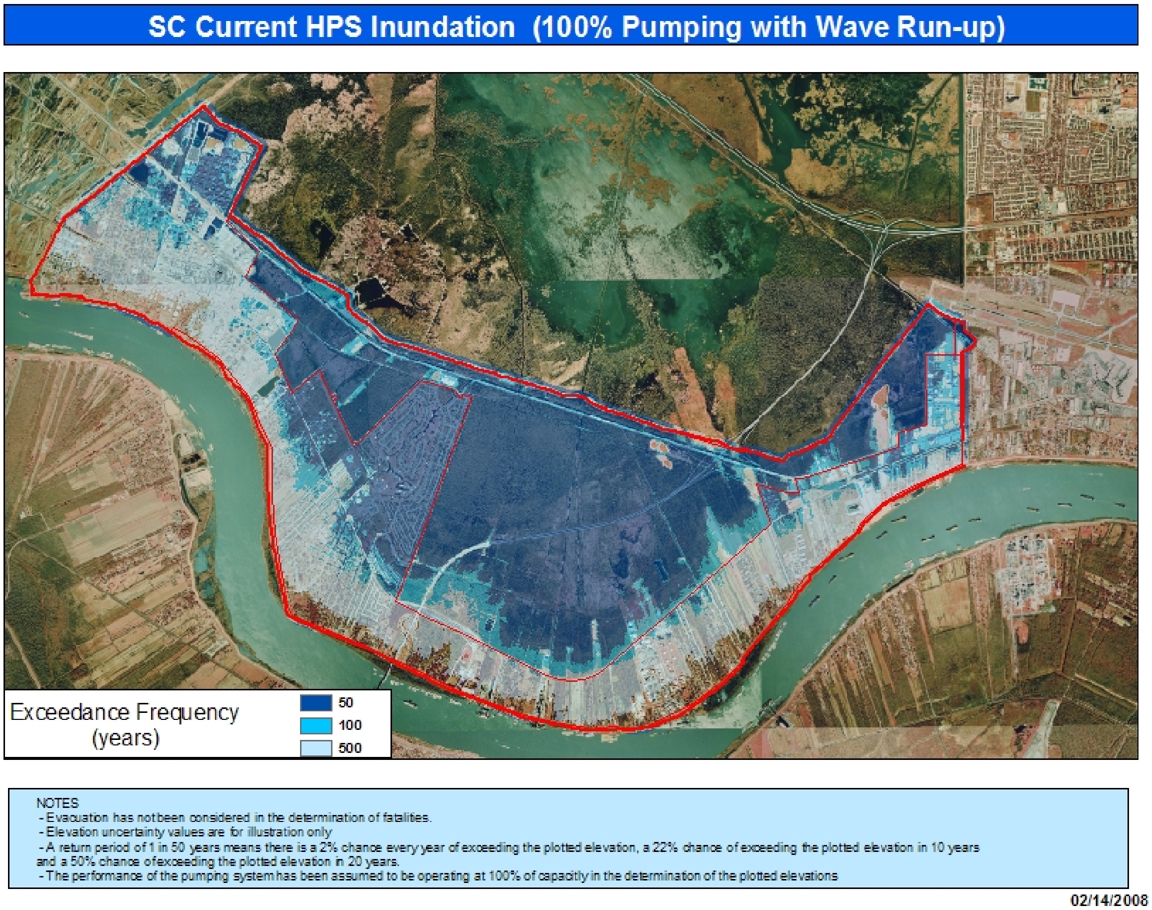


Figure 13-62 – St. Charles – Current Inundation Risk – 100% Pumping