GROUNDWATER FOR POWER PLANTS: A BIG RISK TO NEW ORLEANS EAST

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Louisiana Public Health Institute

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Introduction

For nearly 60 years, New Orleans was home to Michoud, a large natural gas power plant. The Michoud generating facility was a steam turbine power plant comprised of three generating units fueled primarily by natural gas. Unit 1 came online in 1957, followed by Units 2 and 3 in 1963 and 1967 (U.S. Environmental Protection Agency [EPA], 2016b). Originally built to burn either natural gas or fuel oil, Michoud ran only on natural gas in its final years. The three units together provided a total of 959.2 megawatts of capacity to New Orleans, first through New Orleans Public Service, Inc., and later through Entergy New Orleans, Inc. (ENO). Michoud offered baseload and load following capacity, filling a large percentage of New Orleans' power needs for nearly 60 years.

After an extensive cost analysis of needed upgrades and repairs in 2014, ENO and the New Orleans City Council decided that decommissioning the plant was in the best interest of ratepayers. The units were decommissioned on June 1st, 2016. ENO has proposed to build a new natural gas combustion turbine (CT) plant at the same site as Michoud in New Orleans East. According to ENO's proposal, the CT plant would fill a gap in energy services of New Orleans, principally during the hot summer months when energy demand is the highest.

The Louisiana Public Health Institute (LPHI) and the Alliance for Affordable Energy (AAE) conducted a health impact assessment (HIA) on the plan to build the proposed CT plant in New Orleans East. This project was supported by a grant from the Health Impact Project, a collaboration of the Robert Wood Johnson Foundation and The Pew Charitable Trusts.[1]

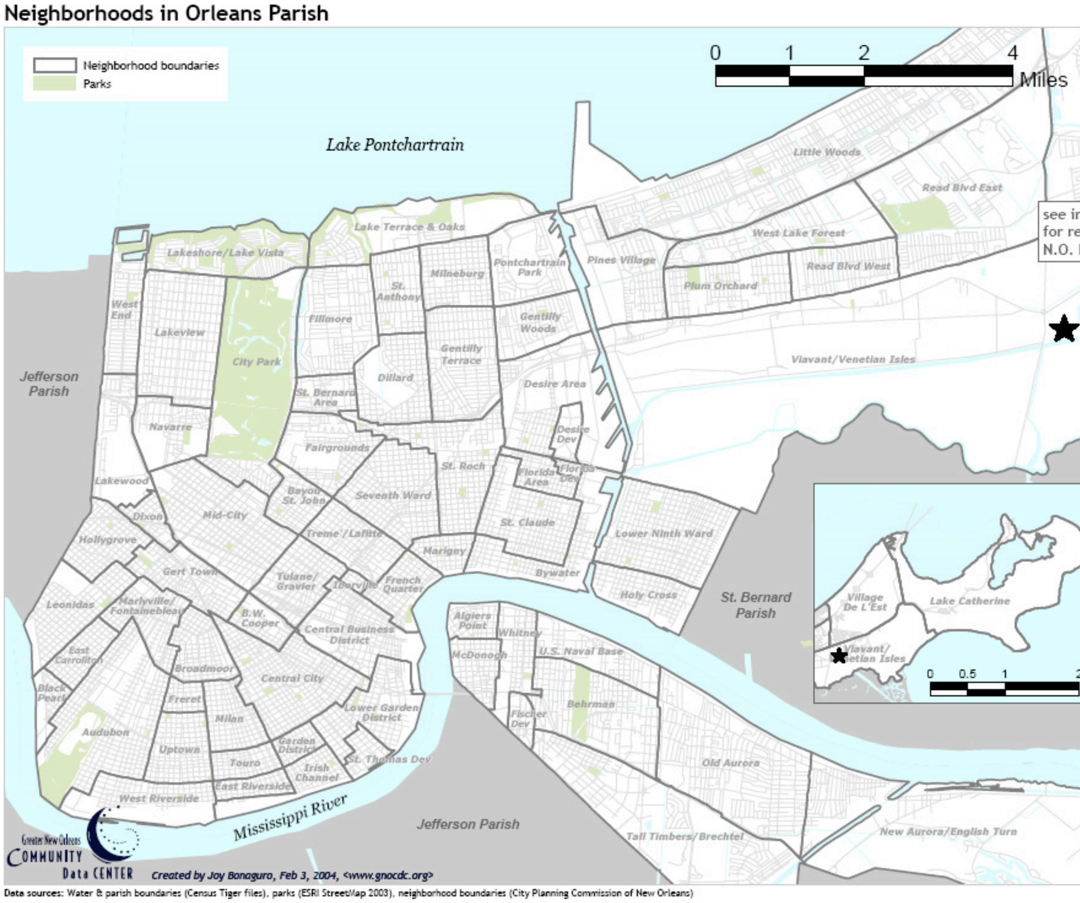
While the HIA focused on eight topics, some of the most concerning and pressing findings centered on Michoud's impact on subsidence. Subsidence is an extremely relevant and important issue, as New Orleans East, and New Orleans overall, are very vulnerable to extreme weather events and flood risk. As a result, this report further investigates Michoud's historic use of groundwater and Michoud and the proposed CT plant's impacts on subsidence.

New Orleans East Neighborhoods

Michoud is in an area locally known as New Orleans East, which is made up of several neighborhoods. The boundaries of New Orleans East are the Industrial Canal to the west (where there were multiple breaches during Hurricane Katrina), the Intracoastal Waterway to the south, the St. Tammany Parish line to the east, and Lake Pontchartrain to the north. Michoud and the site of the proposed CT plant are located at the intersection of Old Gentilly and Paris Roads, within the Viavant/Venetian Isles neighborhood, close to the Village de L'Est, Read East, Read West, West Lake Forest, Little Woods, Plum Orchard, and Pines Village neighborhoods of New Orleans East.

[1]The views expressed in this HIA are those of the authors and do not necessarily reflect the views of the Health Impact Project, The Pew Charitable Trusts, or the Robert Wood Johnson Foundation.

Figure 1: Map of New Orleans neighborhoods



Note: black star to the far right of the map is the location of Michoud and the proposed CT plant

Source: The Data Center, 2004

New Orleans East makes up over 60% of the geographical land area of New Orleans. Following Katrina, the area has experienced substantial rebuilding and new construction, including Joe Brown Memorial Park, South Shore Harbor Marina, the Lakefront Airport, 7th District Police Station, and New Orleans East Hospital. New Orleans East is home to many large companies and industries including NASA, Air Products, Folgers, Blade Dynamics, Textron, and the U.S. National Finance Center.

Energy Resilience and Lessons from Recent History

New Orleans East is particularly vulnerable to hurricane damage because of its location, low elevation, rate of subsidence, and both natural and human-caused coastal wetland erosion (Nelson, 2012). The five most destructive storms to hit New Orleans have occurred since 2005; these included Hurricanes Katrina, Rita, Gustav, Ike, and Isaac (Schleifstein, 2012).

Hurricane Katrina made landfall on August 29th, 2005. The 15-foot storm surge that entered the Industrial Canal overtopped floodwalls and breached critical levees along the Industrial Canal. Flooding in New Orleans East, St. Claude, St. Roch, and the 7th Ward neighborhoods was severe. Shortly after, a second 11-foot storm surge hit Lake Pontchartrain causing levee failures at the London Avenue Canal and 17th Street Canal. In total, water quickly covered over 80% of New Orleans and directly led to 1,500 deaths (Nelson, 2012).

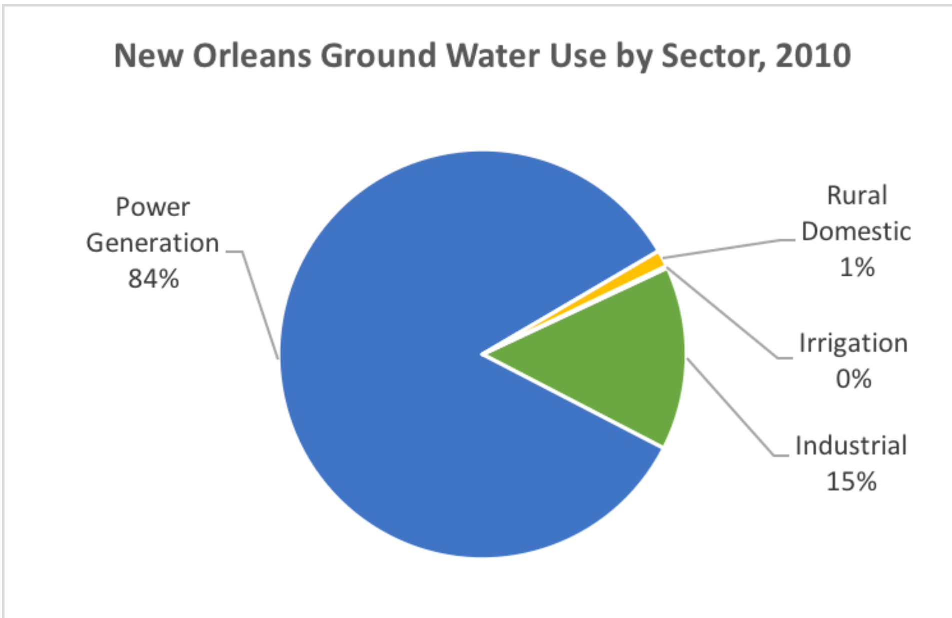
During Katrina, Michoud and Patterson (another energy generation facility located in New Orleans East) were both taken offline well before the hurricane made landfall for safety reasons. They both experienced severe flooding and the Patterson plant never came back online (Javetski, 2006). Following Katrina, Unit I, the oldest of the Michoud units, was officially retired. Michoud Units 2 and 3 had extensive damage from six feet of salt water flooding. Michoud required $17 million in repairs and Unit 2 came back into service in April 2006, eight months after the plant flooded (ENO, 2006). Unit 3 returned to service later in 2006. New Orleans East was most severely impacted by the outages following Katrina and took the longest to receive service again, although Michoud was located in that area of the city.

Groundwater Usage by Michoud

Generating electricity with traditional fossil fuel power plants requires the use of millions of gallons of water each day. The average natural gas plant uses around three gallons of water per kilowatt-hour generated (Union of Concerned Scientists, 2011).

Since the late 1950s, power generation has been the largest user of groundwater in New Orleans. In 2010, 84% of daily groundwater withdrawals in Orleans Parish were used for energy generation (Figure 2). A handful of very small residential wells drew a total of 0.17 million gallons daily in Orleans. The remaining groundwater usage in the parish was industrial, also predominantly located in New Orleans East (United States Geological Survey [USGS], 2014).

Figure 2: New Orleans groundwater use by sector, 2010



Note: other reporting sectors using zero groundwater included public supply and livestock
Source: USGS, 2014

Michoud has historically been one of the largest users of groundwater in Orleans Parish. Michoud used around 464 million gallons of water per day in 2010, of which an average of 10.87 million gallons was withdrawn from the Gonzalez-New Orleans Aquifer via the operation of deep wells 631-645 feet (LDNR, 1958-1982) below the plant (Figure 3; Table 1) (P. Sargent, email communication, June 6, 2016). The remaining 450+ million gallons of water used at the plant was drawn daily from the Gulf Intracoastal Waterway, a canal that runs alongside the plant (USGS, 2014).

Figure 3: Michoud water wells

Note: shown are the high yield water wells (green dots, with yield in gallons per minute), U.S. Army Corps of Engineers water level gauge 76040 (black circle with yellow cross), and benchmarks with names (magenta circles with black crosses)
Source: Dokka, 2011

Table 1: Groundwater use for energy generation

Year	Total daily Orleans groundwater use (million gallons)*	Total daily Orleans groundwater use for power generation (million gallons)*	Total daily Michoud facility groundwater use (million gallons)**	% of total daily Orleans groundwater use for energy*	Total daily Louisiana groundwater use for power (million gallons)*	% of total daily Louisiana groundwater use for power generation in Orleans*
1965	34.26	9.15		27%	27.44	33%
1970	43.40	19.44		45%	35.82	54%
1975	35.82	16.40		45%	31.04	53%
1980	35.50	20.70		58%	47.10	44%
1985	30.88	15.90	10.10	51%	35.73	45%
1990	21.99	19.06	12.49	87%	40.57	47%
1995	12.89	10.36	6.85	80%	31.17	33%
2000	5.56[2]	12.97	10.22		42.58	30%
2005	5.04[2]	12.20	6.59		28.85	42%
2010	12.95	10.87	10.87	84%	41.02	26%

Note: see Appendix I for annual reported Michoud facility usage, 1985-2009

*Source: USGS Lower Mississippi-Gulf Water Science Center[3]

** Source: P. Sargent, email communication, June 6, 2016

In 2010, 41.02 million gallons of groundwater were withdrawn per day for power generation in Louisiana; Michoud accounted for 26% of that water use while only providing about 2% of the total electricity generated in Louisiana. Since reporting began in the 1960s, power generation in Orleans Parish has accounted for up to 54% of the entire state's groundwater use for power generation (Louisiana Department of Transportation and Development, 2012; USGS Lower Mississippi-Gulf Water Science Center).

It is not clear why the Michoud plant has extracted so much groundwater for power generation. Nationally, an average of 0.9-1% of water used for electricity generation comes from groundwater; the vast majority of water for electricity generation comes from surface sources (Kenny et al., 2009). Most power plants that are situated near surface water rely on rivers, lakes, or waterways for their needs, instead of tapping aquifers (Union of Concerned Scientists, 2011).

[2] Values in the table represent the best estimate of what was known at the time of data collection. Revisions in water use data may be made by the Louisiana Water Use Program in order to correct errors.

[3] The data in this table comes from the United States Geological Survey Lower Mississippi-Gulf Water Science Center water use chart data and are conservative estimates.

Subsidence in New Orleans East

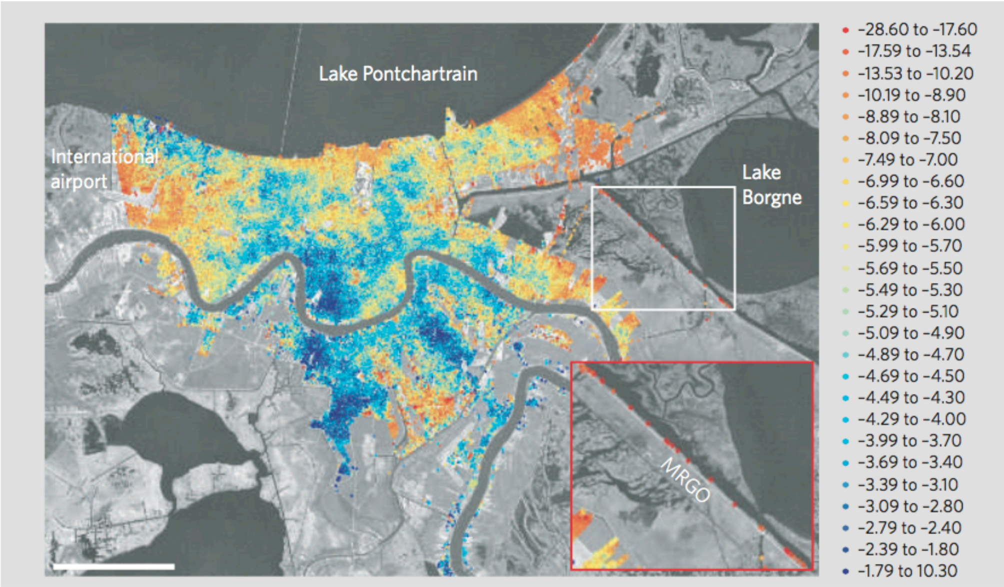
New Orleans has a very high water table; the water in the soil and aquifers is partly responsible for maintaining the land's elevation. When water is removed from underground, the soil compacts and subsides.

Subsidence: gradual sinking of land, as a result of factors ranging from underground extraction and storm water pumping to deep fault movements.

Recent research shows that subsidence in New Orleans East, specifically at and around Michoud, is occurring at a faster rate than the rest of the city (Jones et al., 2016). Water level gauges at the Paris Road Bridge that runs alongside Michoud and over the Gulf Intracoastal Waterway showed subsidence of around 80 centimeters (almost three feet) in the first 40 years of Michoud power production (Dokka, 2011), and research conducted in 2014 shows this area subsiding between 1-1.3 inches per year (Jones et al., 2016). This bridge crosses a protective levee that was breached during Katrina, and runs alongside the four deep groundwater wells for Michoud. It appears that the greatest subsidence in New Orleans Parish coincides with the largest yield water wells (Dokka, 2011).

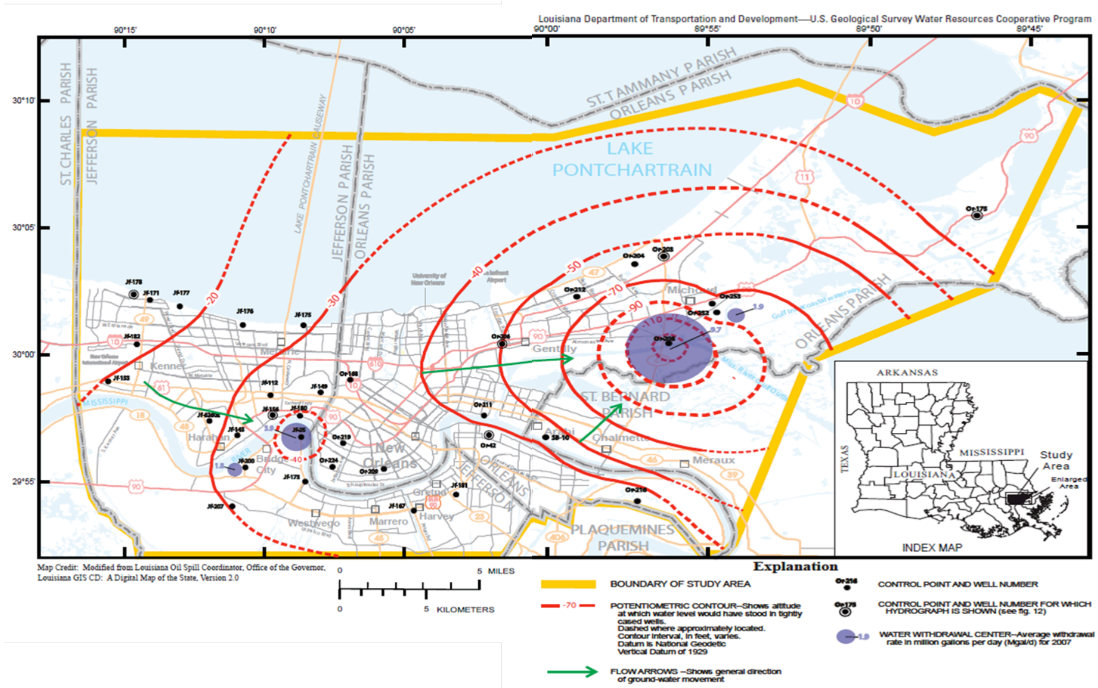
Comparing the subsidence maps developed by the University of Miami (Figure 4) with the pumping map of Orleans Parish (Figure 5), a center of maximum subsidence in Orleans Parish is at Michoud at the Paris Road Bridge, and the subsidence affects levees in every direction. A recent NASA research study also found the highest rates of subsidence in Orleans Parish at Michoud, with up to two inches of sinking per year (NASA, 2016).

Figure 4: Subsidence rates of Orleans Parish



Note: the red and orange areas are those with the highest rates of subsidence
Source: Dixon et al., 2006, p. 587

Figure 5: Pumping legend, New Orleans



Note: Michoud and the proposed CT plant are located in the center of the largest purple circle
Source: Louisiana Department of Transportation and Development, 2012, p. 20-21

There is significant evidence that the groundwater extraction at Michoud is linked with this accelerated subsidence rate, making New Orleans East more vulnerable to sea level rise and flood risk from major storm events. Throughout the U.S., groundwater pumping accounts for more than 80% of subsidence (USGS, 2014). A recent study identified a correlation between subsidence and groundwater depletion, and found short-term subsidence rates as a result of groundwater depletion are double the long-term geologic rates between Virginia and South Carolina (Karegar, Dixon, & Engelhart, 2016). In fact, groundwater withdrawal was determined to be a causative agent in New Orleans East subsidence as early as 2011 (Dokka, 2011). NASA (2016) directly links subsidence to groundwater withdrawal in New Orleans East, stating,

"Subsidence rates in 2009–2012 support the conclusion that groundwater withdrawal is the primary subsidence driver in areas with major industry around New Orleans, particularly in Norco and Michoud."

Groundwater withdrawals for Michoud operations over the last six decades averaged 12 million gallons per day (Dokka, 2011). Because of these groundwater withdrawals, there have been reduced water levels in wellheads around the city. The decrease in wellhead levels has contributed to the subsidence seen across Orleans Parish, and most acutely in New Orleans East (Dokka, 2011).

Other factors that lead to subsidence are storm water pumping (dewatering), hydrocarbon withdrawals (such as oil and gas extraction), and tectonic shifts. However, there is evidence that the severity of deep subsidence in New Orleans is too large to be explained by these other causes alone and points to large groundwater extraction as a major cause (Dokka, 2011).

The amount of groundwater withdrawals in Orleans Parish peaked in 1970, at around 43 million gallons per day (approximately 19 million of which were used for power generation). Since then, water levels in individual wells have somewhat rebounded. In fact, following Katrina, well water levels in New Orleans East rose abruptly, about 18 feet (USGS, 2014). Likewise, the aforementioned study of subsidence along the Atlantic coastal plain (Virginia to South Carolina) suggests that changes in groundwater management in the last 10 years have shown a reduction in compaction (Karegar, Dixon, & Engelhart, 2016). This does not immediately equate to releveling of subsided areas, as deep subsidence does not instantly correct itself once well levels recharge, and the withdrawal of groundwater is one of a few anthropogenic activities that lead to subsidence.

Salt water intrusion into drinking water aquifers is another consequence of groundwater pumping. According to research done for the New Orleans Urban Water Plan, salt water intrusion is currently happening in New Orleans East (R. Stuurman, personal communication, July 22, 2015). The ensuing subsidence, lower wellhead levels, and salt water intrusion lead to further soil compaction. This compaction can cause shallow surface deformations and activate the fault line that runs through New Orleans East (Zou et al., 2016).

Impacts of Subsidence on Flooding

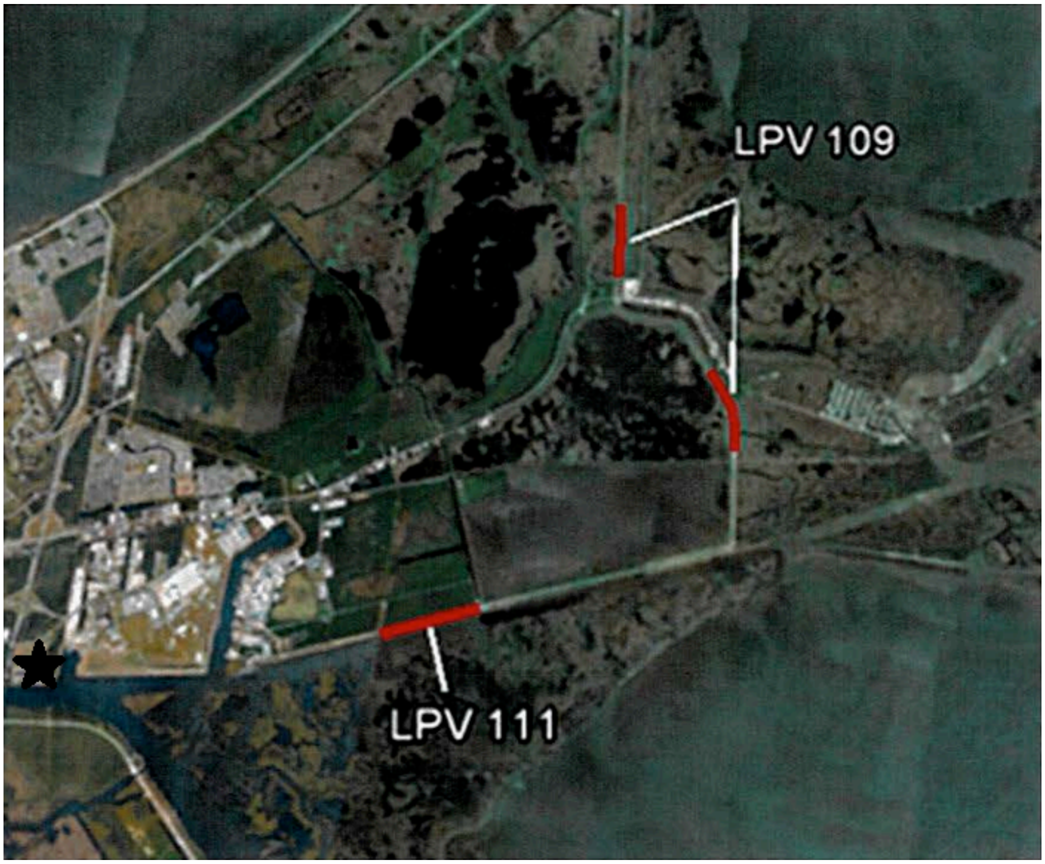
Levees, along with storm surge protection measures, require sturdy land in order to protect New Orleans neighborhoods. As subsidence continues to push New Orleans even farther below sea level, levees follow suit, causing increased risk for the entire city. Subsidence resulting from single facilities can, in fact, impact flood control infrastructure a number of kilometers away (Jones, 2016).

According to Dixon et al. (2006, p.588), flooding associated with Katrina in the area around the Mississippi River Gulf Outlet Canal (to the immediate southeast of Michoud)

"could be explained by the correlation we observe between the location of the breach points and the high rate of subsidence beneath these levee sections."

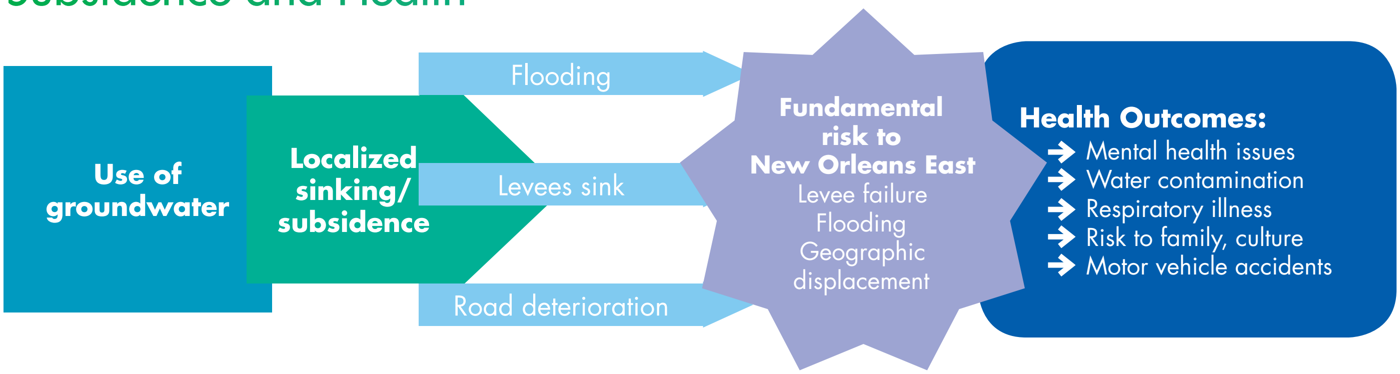
At a March 2016 meeting of the Coastal Protection and Restoration Authority of Louisiana, Robert Turner of the Southeast Louisiana Flood Protection Authority described the levee walls between Lake Borgne, New Orleans East, and St. Bernard Parish as being "more prone to flooding than before Katrina," and in need of "levee lifts in the near future" (Turner, 2016). These levees are directly impacted by the rate of subsidence of the land on which they are built. As of August, 2016, a levee approximately two miles from the Michoud facility is in the application process through the U.S. Army Corps of Engineers for lifting (U.S. Army Corp of Engineers, 2016).

Figure 6: Levee lift project locations



Note: black star to the left of the map is the location of Michoud and the proposed CT plant
Source: U.S. Army Corps of Engineers (2016)

Subsidence and Health



Subsidence has been shown to lead to degradation of infrastructure, like roads and home foundations, due to surface level fracturing (Yuill, Lavoie, & Reed, 2009). Subsidence that undermines the effectiveness of levees and floodwalls is a damaging outcome for an already vulnerable population.

Levees protecting New Orleans East were fortified after Katrina, but continued sea level rise, sinking land, and reduced protections from coastal wetlands continue to put homes and infrastructure in this community at risk for extreme flooding (EPA, 2016a). The effects are not limited to New Orleans East, and also include the Lower Ninth Ward and St. Bernard Parish. Health outcomes that result from extreme flooding include stress, depression, and post-traumatic stress disorder (PTSD) stemming from geographic displacement and homelessness. Mold and humidity exposure can lead to respiratory illness (Rhodes & Chan, 2010).

If the proposed CT plant continues to use groundwater, it is very likely that subsidence will continue. This would lead to increased vulnerability to flooding in New Orleans, especially New Orleans East, the Lower Ninth Ward, and St. Bernard Parish, all of which have large percentages of low-income individuals and children. Flooding and subsiding roads would lead to a number of serious health effects.

Table 2: Subsidence pathway

Potential Determinant	Potential Health Effect	Increased/ Decreased Effect	Certainty	Magnitude	Vulnerable Populations
Geographic displacement	PTSD, depression	↑	Likely	Medium	Minorities, low-income, seniors, children with existing conditions, isolated individuals, marginalized populations
Homes and businesses exposed to flood water	Respiratory disease, drowning	↑	Likely	Medium	Respiratory, immune deficient, seniors, children, and pregnant women
Decline in road quality	Motor vehicle accidents and injuries	↑	Very likely	Low	

Recommendations:

- ENO must immediately cease groundwater withdrawals at Michoud and must use surface water for any future projects until the full scope of the impact on sinking is understood.
- The City of New Orleans, through its Resilient NOLA programming, could conduct an analysis of groundwater removal and its impact on subsidence in New Orleans East.
- The City Council and the Mayor's Office should develop equitable and responsible water rights protection for the city. Groundwater use should be reported and regulated, as in the Capital Area Groundwater Conservation Commission in Baton Rouge (see http://www.cagwcc.com/site2015/laws-regs/title56-part_v.pdf).
- ENO should be engaged in all discussions with regards to subsidence, including with city and state agencies, regional levee boards, the Coastal Protection and Restoration Authority, the Army Corps of Engineers, and the Federal Emergency Management Agency (FEMA).

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Appendix 1: Michoud power plant groundwater usage

Year	Million gallons per day
1985	10.1
1988	12.9
1989	11.46
1990	12.49
1991	6.7
1992	5.07
1993	9.23
1994	7.34
1995	6.85
1996	10.22
1997	10.22
1998	10.22
1999	9.95
2000	10.22
2001	10.22
2002	10.09
2003	10.09
2004	10.22
2005	6.59
2006	6.98
2007	9.69
2008	8.24
2009	10.87

Source: P. Sargent, email communication, June 6, 2016

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