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 Risk Development and Modeling Branch
 Homeland Infrastructure Threat and Risk Analysis Center
 Office of Infrastructure Protection

In Collaboration with

The National Incident Management Systems
 and Advanced Technologies Institute at
 The University of Louisiana at Lafayette

Louisiana Highway 1/Port Fourchon Study

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Homeland
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Executive Summary

Port Fourchon is located at the southern tip of Lafourche Parish, Louisiana, along the coast of the Gulf of Mexico. The port is the southernmost port in Louisiana and centrally located in a large area of the Gulf that is rich in oil and natural gas drilling fields. Shallow water operations are serviced out of many ports along the Gulf Coast, but servicing for deepwater operations is located at select ports due to the use of larger vessels that are required to support deepwater operations. Due to its central location, deep channels, favorable weather conditions, and size, the oil and gas industry has chosen to concentrate its infrastructure for deepwater oil and gas operations support at Port Fourchon. Roughly 270 large supply vessels traverse the channels of Port Fourchon each day. Normally, about 75 percent of these vessels are servicing drilling rigs. Even though there are many more production platforms that require servicing than there are operating drilling rigs, drilling operations require much more material than production requires. The supplies and materials sent to rigs and platforms from Port Fourchon are brought into the port by the 600 eighteen-wheel trucks that travel on Louisiana Highway 1 (LA-1) each day. There is no alternative road access to transport supplies to Fourchon from inland locations. Consequently, a closure of this road effectively closes the port itself.

This study was conducted to provide an assessment of the national consequences of disruptions to LA-1. The study evaluates the reduced ability of the nation to deliver two critical commodities (crude oil and natural gas) to the American public as a result of the loss of LA-1. The study also addresses local, regional and national economic impacts due to a disruption of LA-1 for an extended period of time.

This study has been prepared, in collaboration, by the National Infrastructure Simulation and Analysis Center (NISAC) and the National Incident Management Systems and Advanced Technology (NIMSAT) Institute located at the University of Louisiana Lafayette. NIMSAT's effort was funded by the LA-1 Coalition, a group that is a proponent of enhancing LA-1 to make it less likely to be disrupted. NISAC's effort was funded by the Risk Development and Modeling Branch (RDMB) Department of Homeland Security (DHS) Homeland Infrastructure Threat & Risk Analysis Center (HITRAC). In collaborating in this analysis, NIMSAT defined the disruption scenarios and assessed the likelihood of their occurrence, and analyzed the possible responses of offshore operators to the scenarios. NISAC estimated the economic impacts of the scenarios and the amount of oil and gas production that could be lost due to the scenarios.

Both disruption scenarios considered in this analysis include a 90-day outage of 7.1 miles of LA-1. Two mechanisms of disrupting the road are proposed: a strong storm washing out of the road, and a gradual submersion of the road because of global sea-level rise and regional subsidence of the land surface. This analysis finds that both mechanisms are plausible and sufficiently likely to occur that it is reasonable and prudent to consider the possible impacts of a road closure on the nation's economy and supply of crude oil and natural gas.

Although other ports in the Gulf Coast could substitute for a portion of the service provided by Port Fourchon, this substitution would be costly and could replace only about 25 percent of service normally provided by Fourchon. At this rate of substitution, it is likely that deepwater production of oil and gas could be maintained at normal levels

during a Port Fourchon disruption, but deepwater drilling and maintenance activities could not be provided.

The production capacity of existing oil and gas fields decreases as they mature. In order to offset this natural decrease in production capacity, new deepwater capacity must continually be added by performing maintenance on existing wells, drilling new wells in existing fields, and drilling exploration wells to discover new fields. Port Fourchon plays an important role in each of these activities in the Gulf Coast. Any disruption of these activities due to a closure of the port will result in less oil and gas being produced for many years into the future, all other factors being equal. This analysis used a computer model of off-shore oil and gas production to estimate that a 90-day closure of Port Fourchon would result in a reduction of 120 million barrels of oil, and 250 billion cubic feet of gas produced over the a ten year period starting at the time of the port closure. If the port closure coincided with a major hurricane that damaged offshore facilities, the amounts of lost production due to the unavailability of Port Fourchon alone would increase to 160 million barrels of oil and 320 billion cubic feet of gas.

It is unlikely these levels of reduced Gulf offshore oil and natural gas production would lead to petroleum product or natural gas shortages. A natural gas network model simulation showed that the roughly 4 percent decline in U.S. natural gas supply due to the shut-in Gulf production would likely be offset by a 3 percent increase in domestic production in other areas and imports, as well as a 1 percent decrease in demand. As for petroleum products, the authors believe a combination of withdrawals from storage and the Strategic Petroleum Reserve, along with increased crude oil imports, would be able to compensate for the crude oil production shortfall. Even though there might be temporary restrictions in crude oil supply to some refineries immediately following the storm, this period should be brief and not cause refineries to shut down.

A closure of Port Fourchon would cause loss of business to the many firms in Louisiana and other states that supply goods and services to the petroleum industry. The lost business would cascade through the chains of suppliers for each firm that is directly impacted, thereby spreading the economic impact to regions of the country other than southern Louisiana. This analysis used economic modeling to estimate an upper bound reduction of \$7.8 billion in national gross domestic product (GDP) due a 90-day closure of Port Fourchon. This is an upper bound because sufficient information is not available to determine the fraction of economic activity in industry sectors that support the petroleum industry that can be attributed to offshore activities. Consequently, it was assumed that 100 percent of the activity of these sectors in selected parishes of southern Louisiana would be halted by a Port Fourchon closure. The \$7.8 billion loss is comprised of a \$3.9 billion decrease in GDP for the parishes surrounding Port Fourchon, and a \$2.9 billion loss outside of this region (which includes other parts of Louisiana as well as the United States as a whole). Other Gulf deepwater ports (in Louisiana, Texas, and Alabama) would likely realize a gain in GDP of approximately \$2.6 billion since they could acquire a fraction of the lost Port Fourchon business. If not for this gain, the GDP loss outside of the Port Fourchon region would be \$2.6 billion higher.

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1 Introduction

This Louisiana Highway 1-Port Fourchon Study has been prepared by the National Infrastructure Simulation and Analysis Center (NISAC) in collaboration with the National Incident Management Systems and Advanced Technology (NIMSAT) Institute located at the University of Louisiana Lafayette. NIMSAT's effort was funded by the LA-1 Coalition, a group that supports the mitigation of disruption risk to Louisiana Highway 1 (LA-1). NISAC's effort was funded by the Risk Development and Modeling Branch.

Within the Department of Homeland Security (DHS), the Office of Infrastructure Protection (IP), the Homeland Infrastructure Threat and Risk Analysis Center (HITRAC), and the Risk Development and Modeling Branch (RDMB), NISAC performs critical infrastructure analysis, modeling, and simulation in support of the DHS mission. The NIMSAT Institute is a research institute whose mission is to enhance national resilience against a full range of potential disasters by conducting leading research to innovative tools and applications that empower the homeland security and emergency management community through education, training, outreach, and operational support. The Institute seeks to improve the emergency preparedness, response, recovery and mitigation activities for communities, supply chains and critical infrastructures by establishing best-practice based linkages between the government and industry stakeholders at all levels and across all critical infrastructure sectors.

Port Fourchon (Figure 1–1) is located at the southern tip of Lafourche Parish, Louisiana, on the Gulf of Mexico coast. The port is the southernmost port in Louisiana, centrally located in a large area of the Gulf that is rich in oil and natural gas drilling fields. Shallow water operations are serviced out of many ports along the Gulf Coast, but servicing for deepwater operations must be based at deepwater ports that can accommodate the larger vessels required to support deepwater operations. Due to its central location, deep channels, favorable weather conditions, and size, the oil and gas industry has chosen to concentrate its infrastructure for deepwater oil and gas operations support at Port Fourchon. Even though Port Fourchon has roughly two thirds of the rig crane capacity¹ of all deepwater oil and gas servicing ports in the Gulf of Mexico, it likely provides closer to 90 percent of all Gulf deepwater operations support.² Other ports capable of servicing deepwater operations are Galveston, TX; Harbor Island, TX; Cameron, LA; Venice, LA; and Theodore, AL.

¹ Rig cranes are cranes based at ports that transfer materials to and from vessels. Without rig cranes, a port would not be able to load or unload service vessels. Standard rig crane lifting capacity is 250 tons.

² Estimate of Port Fourchon officials. Accessed August 24, 2010. One reason for this is the reduced travel time due to Port Fourchon's central location. Another is that Port Fourchon has many co-located facilities, which reduce the amount of time a vessel is at the port. (Port Fourchon officials estimate their vessel turn-around time is about 24 hours, versus a turn-around time of around 72 hours at other ports).



Figure 1–1. Locations of Port Fourchon, Louisiana Highway 1, and other ports that could potentially substitute for Port Fourchon

Roughly 270 large supply vessels traverse the channels of Port Fourchon each day.³ Normally, about 75% of these vessels serve drilling rigs. Even though there are many more production platforms that require servicing than there are operating drilling rigs, drilling operations require much more material than production requires. The supplies and materials sent from Port Fourchon to the rigs and platforms each day are brought into the port by both barge and truck. By weight, about half of the cargo is delivered by barge, and half by truck. The cargo is segregated, such that heavy, bulky cargo like drilling mud and diesel fuel is carried by barge and everything else by truck. About 600 eighteen-wheel trucks travel on LA-1 each day to Port Fourchon. There is no alternative road access to Port Fourchon.

Analysts conducted this study to provide an assessment of the national consequences of a potential disruption to LA-1. The study evaluates the reduced ability of the nation to deliver two critical commodities (crude oil and natural gas) to the American public as a result of a possible loss of the use of LA-1. The study also addresses local, regional and national economic impacts resulting from the loss of the LA-1 for an extended period of

³ Physical count was conducted by Greater Lafourche Port Commission Harbor Police.

time. Collaborating in this analysis, NIMSAT defined the disruption scenarios and assessed the likelihood of their occurrence (Section 2.1), and analyzed the possible responses of offshore operators to the scenarios (Section 2.2). NISAC estimated the economic impacts of the scenarios and the amount of oil and gas production that could be lost due to the scenarios (Section 2.3).

1.1 Questions

The study seeks to address local, regional, and national impacts from the loss of use of highway LA-1 for an extended period of time by addressing the following questions:

- How likely is it that LA-1 would be disrupted for an extended period of time?
- How would companies operating out of Port Fourchon deal with an extended outage of LA-1?
- How much would the production of oil and natural gas decrease during and after a closure of LA-1?
- What would be the economic impact of an extended LA-1 outage on regional economies? National economies?

1.2 Assumptions

This analysis uses a scenario approach to estimate the impacts of a disruption to LA-1. Two scenarios were used, and both call for an outage of LA-1. The second scenario also includes a generic Gulf Coast hurricane that damages both LA-1 and offshore oil and gas operations. Because the scenarios are hypothetical events, assumptions are required to represent the scenarios. The following assumptions were used in this analysis:

- The scenario damage to LA-1 would require 90-days to repair.
- Closing highway LA-1 would effectively close Port Fourchon.
- During a shortage of port capacity to service deepwater operations, maintaining current oil and gas production would be a higher priority than drilling new wells or performing maintenance on existing wells.
- During a 90-day closure of Port Fourchon, no deepwater drilling or well maintenance would occur.

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2 Analysis

In order to determine the impact of a closure of the 7.1 miles of LA-1 surface road on Port Fourchon and its operations, on the ability of operators to continue their operations within the Gulf of Mexico, and the impact on the local, state, and national economies, the authors have structured all analyses within this study around two scenarios.

Scenario 1 calls for a sudden, unexpected outage of LA-1, and therefore of Port Fourchon, for a period of 90-days. The purpose of this scenario is to demonstrate the impact to the national economy of a 90-day stoppage of operations from Port Fourchon and to demonstrate the impact (increased cost) of attempting to substitute the functionality provided by Port Fourchon using alternative port facilities within the Gulf of Mexico to sustain day-to-day operations during this period.

Scenario 2 is similar to Scenario 1, but it differs in that it calls for a generic hurricane event whereby LA-1 is severely damaged by a hurricane, which also damages offshore oil and gas operations in the Gulf. The purpose of this scenario is to demonstrate further the cost of substituting alternative port facilities within the Gulf of Mexico to sustain both day-to-day operations during this period and to replicate the role typically played by Port Fourchon in recovery operations which would typically follow this type of event.

The analysis within this study has three main parts:

- Defining the disruption scenarios and evaluating their plausibility and likelihood of occurring
- Surveying operators working in the oil and gas industry to find out how they might alter their operations in response to a closure of Port Fourchon, and
- Estimating the economic impact and the loss of oil and gas production due to the scenario disruptions.

2.1 Likelihood of Scenarios

Both Scenario 1 and Scenario 2 depict a 90-day outage of the 7.1 miles of LA-1 surface road between Golden Meadow and Leeville (Figure 2–1). There exist two conditions which might cause such an outage: First, LA-1 could be inundated as a result of mean sea level rise (MSLR). Second, LA-1 could be washed out by an intense storm. The analysis in this section concludes that both scenarios are highly plausible, and both are highly probable. Scenario 1 will eventually occur, no later than the year 2040. Scenario 2 is highly likely to occur, and is likely to occur before the year 2040.



Figure 2–1. Portion of Louisiana Highway 1 (between Golden Meadow and Leeville) that is closed according to the scenarios considered in this analysis

2.1.1 Scenario 1

Mean sea level rise, as a combination of both subsidence and global sea level rise, has been observed and recorded in the vicinity of the area of LA-1 for over 60 years. Data collected by the National Oceanic and Atmospheric Administration (NOAA) from Grand Isle, Louisiana (just east of Port Fourchon and a few miles south of this section of LA-1) demonstrates a rise in mean sea level of approximately 9.24 millimeters per year since recording first began in the 1940s. See Figure 2–2.

Mean Sea Level Trend 8761724 Grand Isle, Louisiana

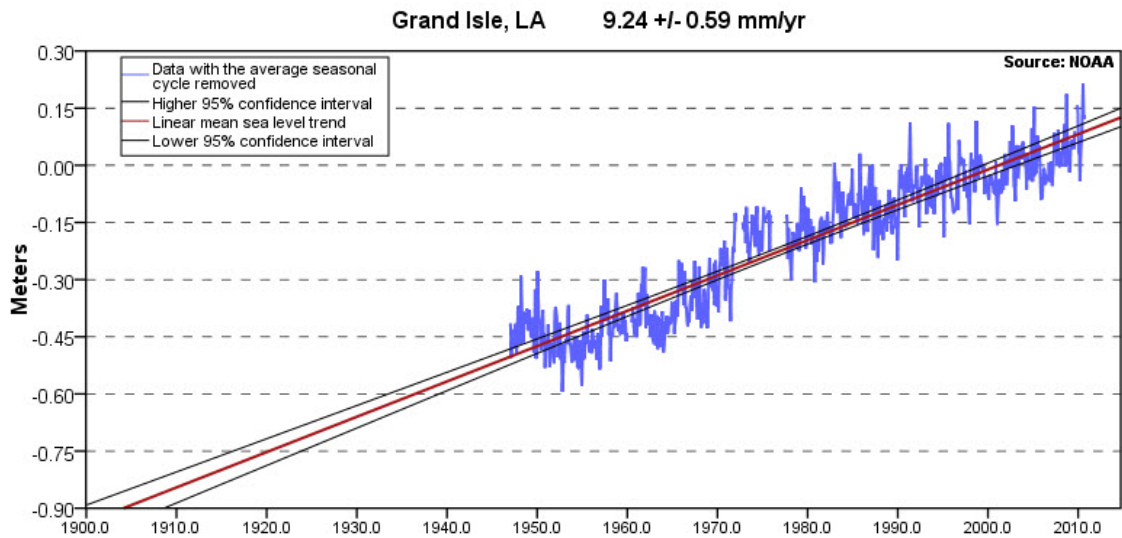


Figure 2–2: Mean Sea Level Trend for Grand Isle, Louisiana

NOAA has stated that this observed rate of mean sea level rise for Grand Isle is also approximately the same throughout the local region, including the area between Golden Meadow and Leeville.⁴

NOAA has further concluded the rate is increasing in this geographic area. They estimate the rate of mean sea level rise for this area will be approximately 11.2 mm per year from 2008 through 2050, and 16.2 mm per year after 2050. See Figure 2–3.⁵

⁴ Email from Tim Osborne, Coastal, Marine, and Physical Scientist; Regional Navigation Manager, NOAA Office of Coast Survey, Eastern Gulf, January 27, 2011.

⁵ Emails from Tim Osborne, Coastal, Marine, and Physical Scientist; Regional Navigation Manager, NOAA Office of Coast Survey, Eastern Gulf, January 24 and January 27, 2011, and email from Stephen Gill, Chief Tidal Analysis Section; Senior Scientist, NOAA/CO-OPS, February 2, 2011

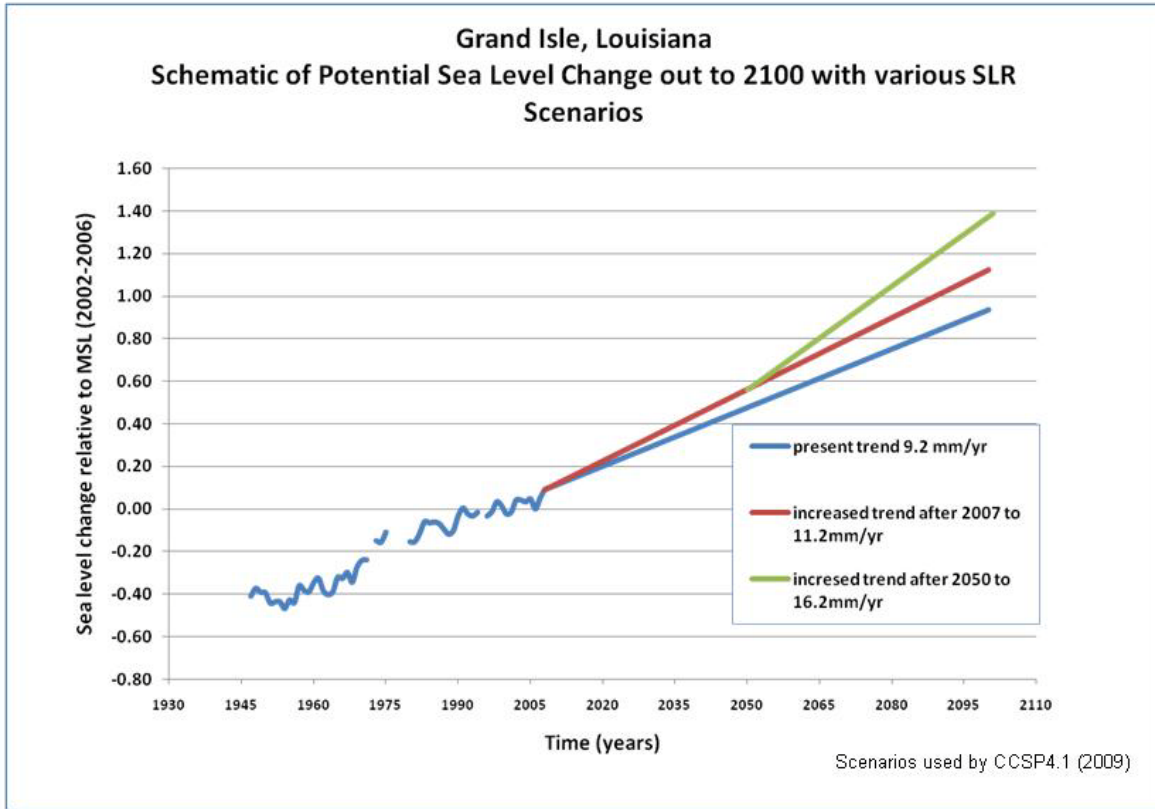


Figure 2-3: Potential Sea Level Change Rates to 2100

The land on which the LA-1 surface road sits is, indeed, sinking into the Gulf of Mexico. What does this mean to our scenario? At these rates of mean sea level rise, how long before the LA-1 surface road is unusable for 90-days?

2.1.1.1 LA-1 Surface Road

Our area of concern is a 7.1 mile stretch of the LA-1 surface road between Golden Meadow and Leeville, Louisiana. Figure 2-4 reflects the elevation of this section of highway, using 2002 elevation data (the latest available).

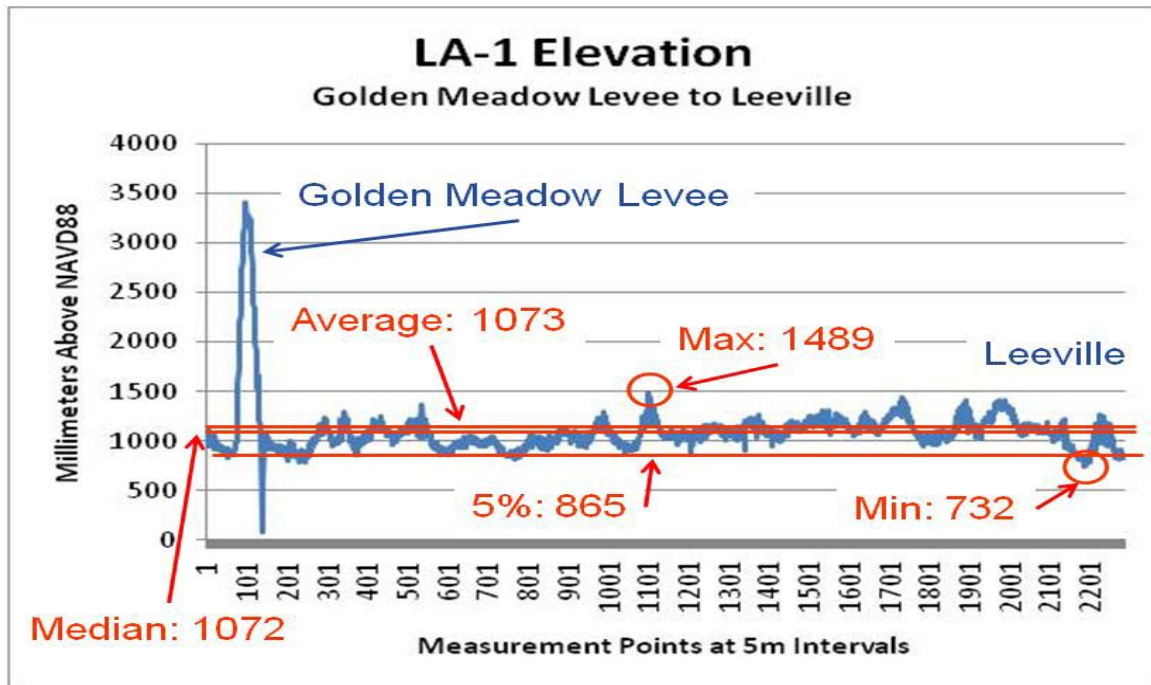


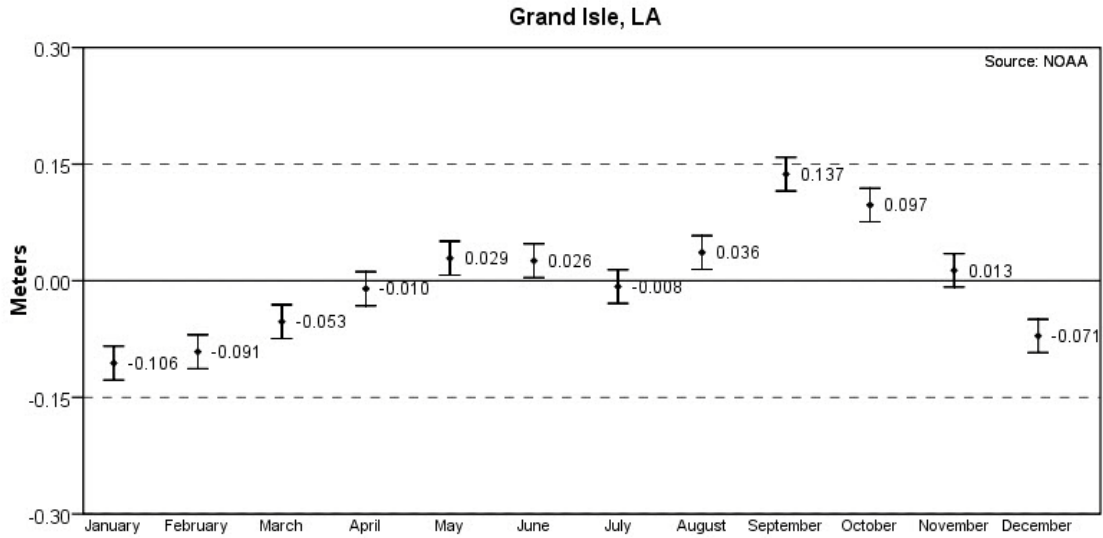
Figure 2–4: Estimated 2010 LA-1 Surface Road Elevations

Between Golden Meadow and Leeville, the surface road elevation varies between a minimum of 732 mm and a maximum of 1489mm, with an average elevation of 1073mm, and a median elevation of 1072mm. Half of the elevation data points (taken every 5 meters) along this 7.1 mile stretch of road, lie below this median point. This figure also shows a line labeled “5%”. Five percent of this section of LA-1 lies below the elevation of 865mm (referred to as the “five percent line” later in the discussion). It is significant in that the Department of Transportation and Development (DOTD) will close this section of LA-1 once five percent of the road is inundated.

2.1.1.2 Seasonal Cycle of Mean Sea Level

Although the authors assign a value to sea level using agreed upon national and international standards, they understand that sea level is, in fact, variable over time. In the simple case, it is clear that sea level changes daily with tides. It is also true that mean sea level, encompassing both high and low tides, is seasonally variable throughout the year. In fact, NOAA data show that sea level varies from mean sea level at Grand Isle from - 0.1m to +0.137m throughout the year. See Figure 2–5.

Average Seasonal Cycle 8761724 Grand Isle, Louisiana



The average seasonal cycle of mean sea level, caused by regular fluctuations in coastal temperatures, salinities, winds, atmospheric pressures, and ocean currents, is shown along with each month's 95% confidence interval.

Figure 2–5: Average Seasonal Cycle of Mean Sea Level for Grand Isle, Louisiana

This Grand Isle average seasonal cycle represents data collected over several years. Figure 2–6 shows an analysis which NOAA conducted of a similar area in 1990.

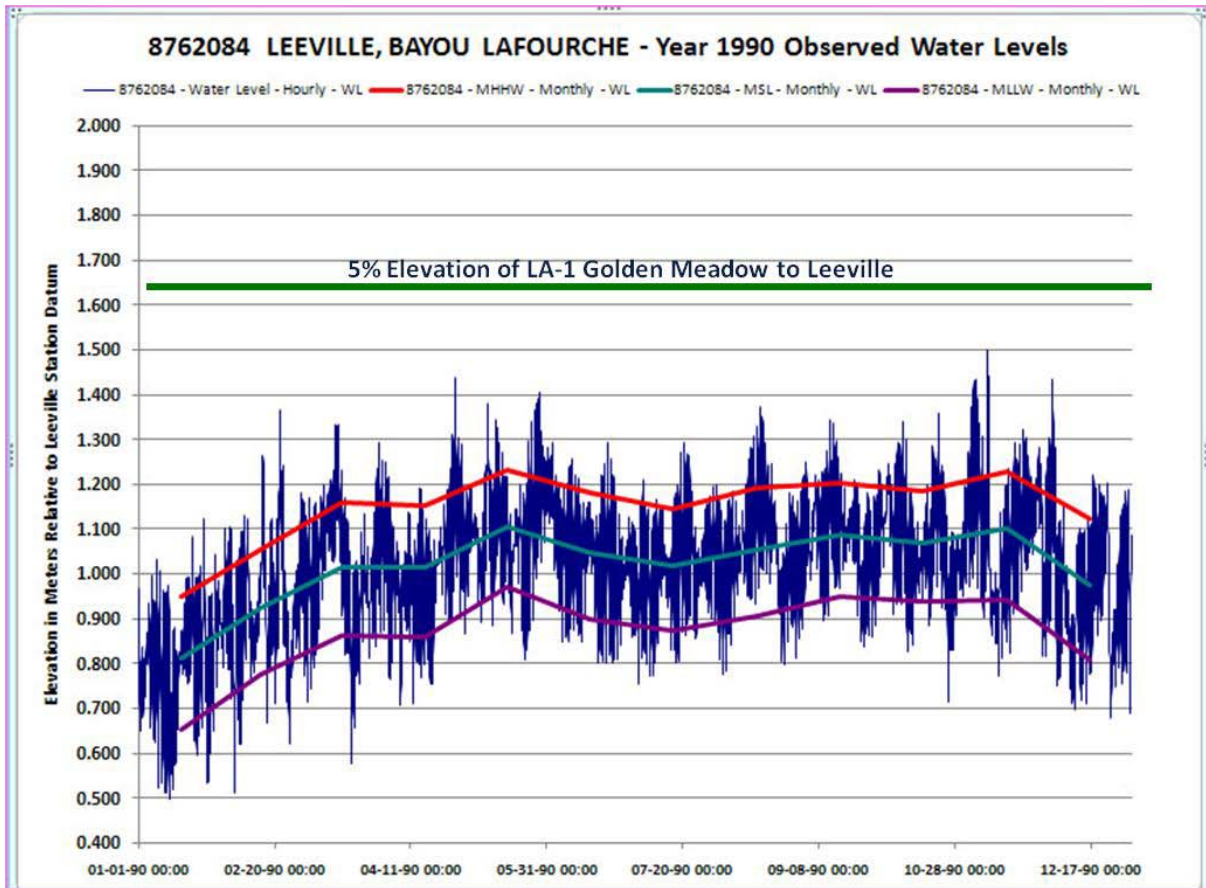


Figure 2–6: 1990 Seasonal Sea Levels for Leeville, Louisiana (Source: NOAA)

The elevations in this figure are relative to the Leeville Station data, though the elevations in Figure 2–2 were relative to the North American Vertical Datum of 1988 (NAVD88). NOAA estimated that in 1990 NAVD88 was approximately 780mm above the Leeville Station Datum. Therefore, the five percent line is on top of this NOAA figure at an elevation of 1645mm (780mm above the 865mm shown in Figure 2–5).

As the LA-1 surface road experiences sea level rise, it will not experience an overnight switch from “above water and completely dry until now” to “submerged forevermore.” . Instead, the lowest points of this surface road will most likely be submerged first during the times of the year with uppermost “high water.” In the Golden Meadow to Leeville area, this would be the months of May/June and November/December. Each year afterwards, this road would experience longer and longer periods of continuous inundation as the mean sea level rise progressed.

2.1.1.3 Analysis

Assuming 1990 represents a very average year, taking the Seasonal Sea Level graph for Leeville in Figure 2–6 above, and lowering the “five percent line” at the rate of 9.24 mm/yr through 2050, one can determine when this five percent line will begin to interact with the graph. See Figure 2–7.

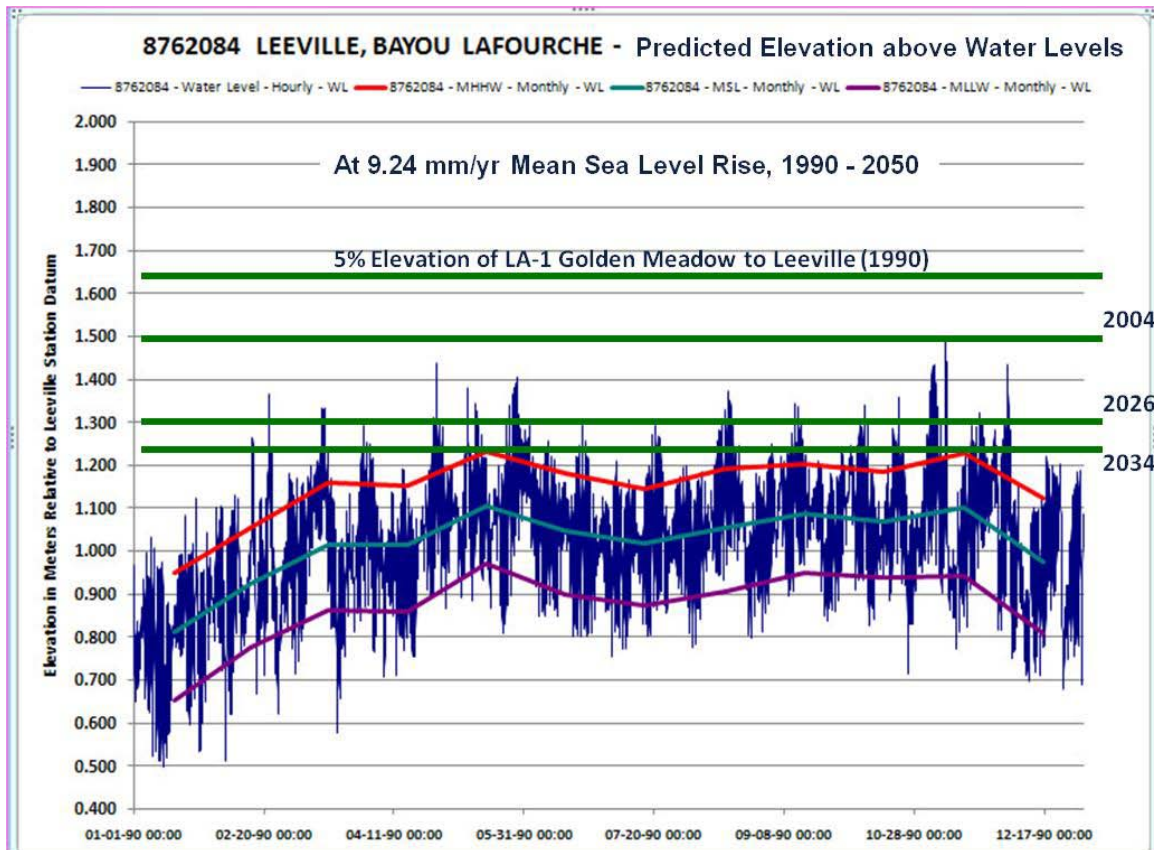


Figure 2–7: Predicted Elevations Above Water Level, 1990-2050

After 2004, analysts “predict” periodic interaction with the graph, meaning periodic inundation of at least five percent of this section of LA-1. The historical record validates this “prediction”. By 2026, this section of LA-1 can expect several five percent inundations each year, and by 2034, the five percent line starts to interact with the average high water line.

During the 15 year period between 2035 and 2048, the 5 percent line moves quickly from two consecutive days beneath the seasonal mean sea level to 302 days, and by 2066, the five percent line will be inundated year round. In 2035, the five percent line has just dipped below the mean high water graph for approximately two days of the year. See Figure 2–8.

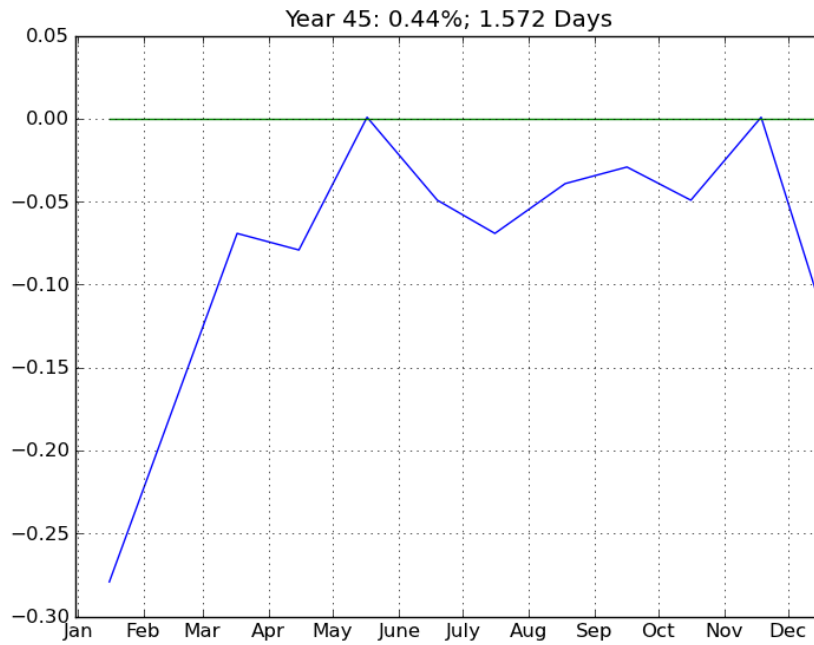


Figure 2-8: Year 45 (2035) 5% LA-1 Elevation versus Mean High Water

By 2037, only two years later, five percent of the surface road will be submerged for more than 30 days of the year (two periods of approximately 19 consecutive days each). See Figure 2-9.

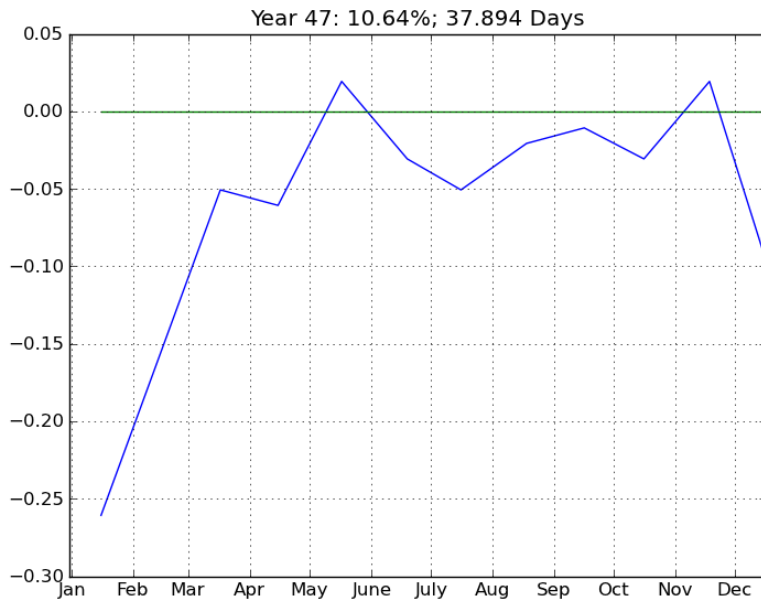


Figure 2–9: Year 47 (2037) 5% LA-1 Elevation versus Mean High Water

And, by 2038, five percent of the surface road will be submerged for almost 60 days (two periods of approximately 28 consecutive days each). See Figure 2–10.

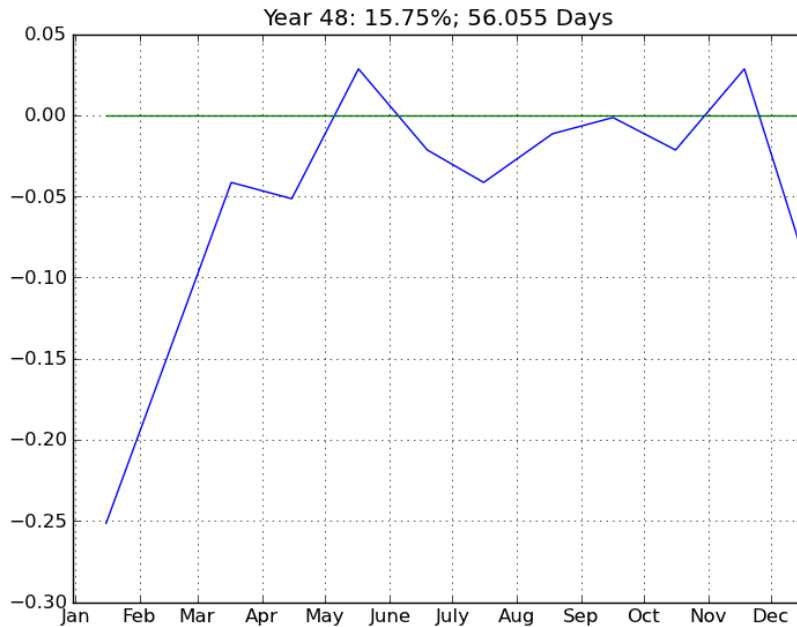


Figure 2–10: Year 48 (2038) 5% LA-1 Elevation versus Mean High Water

By 2040, analysts expect five percent of the road to be submerged for a total of approximately 155 days, (one outage of about 45 days plus another of about 110 days). See Figure 2–11.

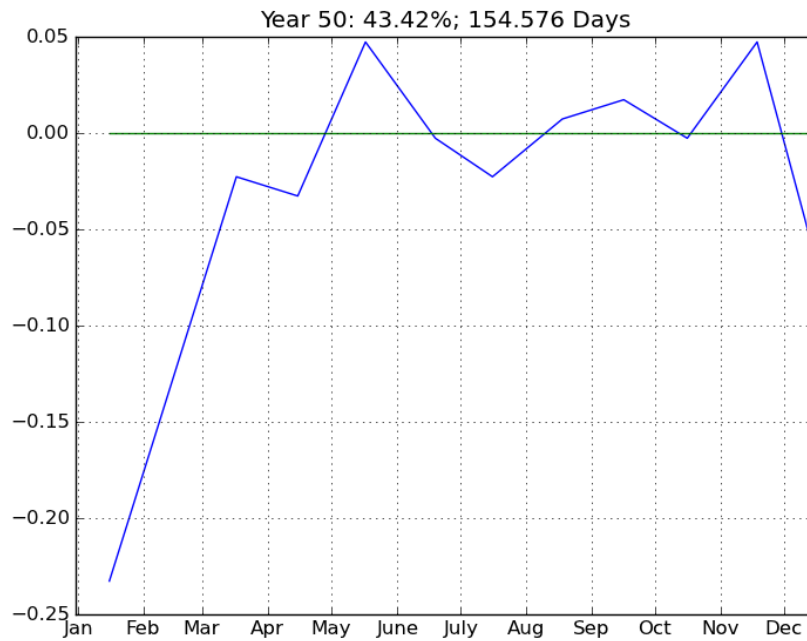


Figure 2–11: Year 48 (2038) 5 Percent of LA-1 Elevation versus Mean High Water

A summary chart of these results highlights the swiftness with which this surface road will succumb to mean sea level rise between the years 2035 and 2066. See Figure 2–12.



Figure 2–12: Consecutive Days of LA-1 Submergence, using 9.24mm/yr

In fact, the slower increase in the curve of this graph after about the year 2044 will likely be an artifact of the estimation model. Further investigation will probably show this model reaching 365 days of submergence significantly earlier than 2065, perhaps as early as 2050.

2.1.1.4 A Worse Case

As mentioned during the discussion of Figure 2–2, NOAA estimated that the rate of Mean Sea Level rise in this geographic area is increasing. Using their predicted rate of 11.2mm/yr from 2007 through 2050, a 90 consecutive day outage could be reached by 2030 or 2031, eight or nine years earlier than when using 9.24mm/yr. See Figure 2–13.

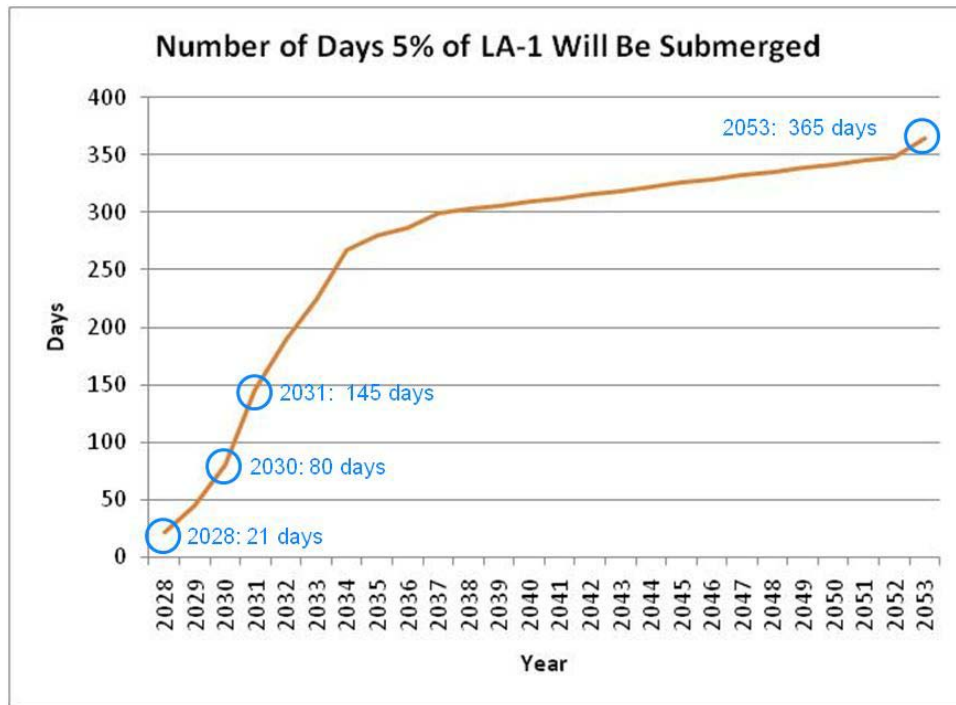


Figure 2–13: Consecutive Days of LA-1 Submergence, Using 11.2mm/yr

2.1.1.5 Likelihood of Scenario 1

There is a near 100 percent probability that Scenario 1, in which Port Fourchon is closed and inoperable for 90-days because the LA-1 surface road is closed, will occur.

Considering mean sea level rise alone, this scenario will most likely occur between the years 2030 and 2040. The length of consecutive days of submergence of the LA-1 surface road will rise swiftly from that point, until somewhere before the year 2066 at least five percent of this road will be submerged year round.

Two factors suggest that the LA-1 surface road will be inoperable to the point of closing Port Fourchon earlier than the worse case projected 90-day outage point of 2031:

First, a severe impact on Port Fourchon operations will be felt long before an outage of the LA-1 surface road for 90-days occurs. The two consecutive day outages projected for the year 2035 in the best case scenario would most likely cause a closure of Port Fourchon, with impacts similar to those resulting from closures for major hurricanes, even assuming no actual storm damage.

Second, Scenario 2, in which a major storm closes the port because of an outage of the LA-1 surface road, is more likely to occur before the year in which Scenario 1, driven by mean sea level rise alone, occurs.

2.1.2 Scenario 2

Scenario 2 assumes that a major hurricane causes both a 90-day outage of the LA-1 surface road, resulting in a 90-day outage of Port Fourchon, and damage to the oil and gas infrastructure in the Gulf of Mexico. This scenario brings up three questions:

1. How likely is a major hurricane to cause a 90-day outage of the LA-1 surface road?
2. How likely is a major hurricane to cause damage to the oil and gas infrastructure in the Gulf of Mexico?
3. How likely is Scenario 2 to happen before the best case projected year in which Scenario 1 would happen by mean sea level rise alone (2040)?

2.1.2.1 Likelihood of a Major Hurricane Causing a 90-Day Outage of LA-1

In 2005, Hurricane Katrina inundated the LA-1 surface road, rendering the road unusable for three days. Several other storms, both before and since Katrina—even those which did not make landfall in Louisiana—have inundated the road, each causing multiple day outages of the road and of Port Fourchon. These are summarized in the following Table 2–1. Figure 2–14 vividly shows the inundation of LA-1 as Hurricane Ike passed through the Gulf of Mexico on the way to landfall in Texas in 2008.

Table 2–1: LA-1 Road Closures from Inundation Since 2001

Month and Year	Event	Days of Road Closure
August 2001	Hurricane Isidore	2
October 2002	Hurricane Lili	2
June 2003	Tropical Storm Bill	2
September 2004	Hurricane Ivan	2
October 2004	Tropical Storm Matthew	2
July 2005	Hurricane Cindy	1
August 2005	Hurricane Katrina	3
September 2005	Hurricane Rita	4
September 2008	Hurricane Gustav	4
September 2008	Hurricane Ike	5



Figure 2–14: Emergency Evacuation of Crew and Equipment From Port Fourchon as Hurricane Ike Storm Surge Flooded the Area

The authors cannot predict what the sequence of hurricanes will be in future years, or predict the intensity or impact of these storms specifically. However, based on historical frequency and impact, and based on the projections above for Scenario 1, the authors can conclude the following:

- Hurricanes in the Gulf of Mexico, even those which do not make landfall in Louisiana, can cause inundation of the LA-1 surface road, resulting in outages of Port Fourchon, and will likely continue to do so in the future.
- These outages, even those of relatively short duration, will close Port Fourchon, causing significant impact on port operations.
- Each year in which major hurricanes in the Gulf of Mexico occur, the actual sea level observations will be higher than the averages used in this study.
- Therefore, as 2040 approaches, each storm has a higher and higher likelihood of producing an outage of the LA-1 surface road of at least 90-days.
- It is also possible that a much earlier storm, though the inundation period might be significantly shorter than 90-days, could cause significant damage during the inundation event itself to cause an outage requiring 90-days to repair.

2.1.2.2 Likelihood of Damage to Oil and Gas Infrastructure by a Major Hurricane

Historically, recent hurricanes have resulted in damage to the off-shore Gulf of Mexico oil and gas infrastructure. According to reports published by the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE, formerly the Minerals Management Service, MMS), Hurricanes Katrina and Rita destroyed 113 offshore oil and gas platforms and seriously damaged 52 others. These hurricanes also damaged 457 oil and gas pipelines, producing 10 inch or greater damage to 101 Federal water large diameter pipelines. BOEMRE also reported that Hurricanes Gustav and Ike destroyed 60

platforms and caused extensive damage to 31 others, while also damaging one oil pipeline and eight gas transmission pipelines.

This damage diverts resources that otherwise would have gone to resumption of production and exploration to the task of repair and restoration. A straightforward conclusion is that future storms on similar tracks will cause similar damage requiring comparable restoration efforts.

2.1.2.3 Likelihood of Scenario 2 Occurring Before 2040

As mentioned above, as 2040 approaches, each storm has a higher and higher likelihood of producing an outage of the LA-1 surface road of at least 90-days, based solely on number of consecutive days the highway will be submerged. We have also observed that a storm before 2040 may result in less than 90-days of submergence, but may require 90-days of repairs from damage caused by the submergence event. However, we cannot discount the possibility that the last few years of the 2030s will be relatively storm-free, or that no significant damage to the road itself occurs. That being said, we can still conclude that a major hurricane in the Gulf of Mexico is likely to cause an outage of the LA-1 surface road of at least 90-days before the year 2040, especially for storms occurring in the late 2030s.

2.1.2.4 Likelihood of Scenario 2

From all of the previous discussion, the authors can see the right storms in the Gulf of Mexico will produce an outage of the LA-1 surface road, with major impacts on Port Fourchon, and with potential damage to the oil and gas infrastructure in the gulf, even if that outage is less than 90-days in duration. As the 2030s approach, each storm is more and more likely to cause such impacts. The authors can also conclude it is highly probable a major hurricane in the late 2030s which does impact the LA-1 surface road would produce the exact scenario.

2.2 Operator Response to Port Closure

The following section details the feedback received from companies that use Port Fourchon to support their Gulf of Mexico (the Gulf) operations when asked how their company would respond under a scenario in which Port Fourchon was shut down for a period of 90-days as a result of LA-1 becoming impassable. A survey entitled, “Port Fourchon Platform Service Survey,” was administered by the NIMSAT Institute and sent to 500 oil and gas professionals who operate out of the Gulf area. (Please see Appendix A for the complete survey.) Survey questions pertained to the effect such a shutdown would have on logistics and operating costs, as well as to whether there were contingency plans for such an event. If their company did have contingency plans, responders were asked to provide insight—to the extent they could—to their plans.

In addition to questions regarding contingencies and effects of a Port Fourchon shutdown, operators were asked why their companies use Port Fourchon to support the majority of their operations as opposed to using other ports located in the Gulf area. To attain greater detail from the responders, phone and in-person interviews were conducted.

Two examples of specific questions asked in the survey and the corresponding responses are given below.

- Question: If Port Fourchon was not accessible for an extended period of time (up to 90-days), how much additional time would be required to continue normal service to the remaining active platforms from either Galveston or Theodore? (Specify expected additional transit time and wait time incurred by using these alternate ports relative to Port Fourchon.)?
 - Answer: If Fourchon were not accessible for up to 90-days, it would have a huge impact on our company because so much equipment is stored at Fourchon. We would need to truck this equipment to another location for loading. This would have a huge impact on our company.⁶
- Question: Based on your estimates in previous questions, how would daily operating costs be affected by the need for additional vessels, personnel; increased transit time, wait time, delays or other expenses caused by a shift of operations to Galveston, Theodore, or operations split between Galveston and Theodore?
 - Answer: Daily operating costs would be greatly affected by the need for additional vessels, personnel, increased transit time, wait delays, and other expenses caused by a shift of operations to Galveston, Theodore, or a split between the two.⁷

In both scenarios for this report Port Fourchon is shut down due to LA-1 being impassable for any reason. The responder to the first question mentioned that equipment would have to be shipped to alternate ports in the event that Fourchon were shut down for 90-days. If LA-1 were impassible, it would be impossible for them to transport equipment by truck. They would be forced to either use barges to transport equipment or to establish temporary contracts with vendors at alternate ports. Either option would significantly affect costs.

The response to the second question above states that daily operating costs would be greatly affected due to additional vessels, personnel, increased transit time, and other factors. These reasons will be analyzed in greater detail later in this report.

Similar responses to the ones above were received from the survey questions and interviews conducted. The majority of operators stated that Port Fourchon was used as a base of operations for multiple reasons, including a central location in the Gulf, an ample amount of bulkhead space available, and a greater level of support services. It was expressed that these factors combine to create an efficiency that is not matched elsewhere in the Gulf. This efficiency leads to shorter round trip times for a support vessel that daily travels from rig to port for servicing, and returns to the rig to deliver supplies. The result is lower overall logistics costs for a project, compared to one using multiple ports for support operations. The operating costs, capabilities, and infrastructure investments at Port Fourchon and alternate ports are discussed in greater detail below.

⁶ Anonymous. "Port Fourchon Platform Service," Survey, Survey Monkey. Accessed October 18, 2010 at www.surveymonkey.com.

⁷ Fontenot, Chuck. "Port Fourchon Platform Service," Survey. Survey Monkey. Accessed October 18, 2010 at www.surveymonkey.com.

2.2.1 Port Fourchon and Alternate Ports Comparison

The following section analyzes the details of Port Fourchon that result in Fourchon being used to service the vast majority of deepwater oil and gas operations in the Gulf. Details include location, support capabilities available at port, and infrastructure investment. These details will be used to compare Fourchon to all alternate ports in the Gulf.

2.2.1.1 Location

The most obvious detail of Port Fourchon that makes it attractive to all survey responders is its central location to operations in the Gulf of Mexico. This central location has attracted a significant amount of infrastructure investment to support oil and gas operations in the Gulf, including a full-service dock and dry dock facilities, drilling fluid (also known as drilling mud) production, rig and heavy lift cranes, and other sundry services. As a result, companies operating out of Port Fourchon are able to receive all-in-one support services to platforms in the Gulf.

The location of Port Fourchon also makes it possible to expand and create the most useable linear feet of bulkhead suitable for offshore production and exploration support. By the end of 2011, Port Fourchon will have a total of 43,000 linear feet of bulkhead suitable for offshore production and exploration support, compared to about 6,000 linear feet of suitable bulkhead available at Galveston, TX and at Theodore, AL combined. According to survey responses, Galveston and Theodore were the ports used to support operations when Fourchon was shut down in the past due to hurricane activity in the Gulf.

2.2.1.2 Support Capabilities

The major capabilities necessary for servicing a vessel supporting rigs involved in shallow or deepwater exploration include ample available bulkhead, rig and heavy lift cranes, and drilling fluid services. As described above, there is more than seven times the amount of bulkhead at Port Fourchon than exists at Galveston and Theodore combined. The ample amount of bulkhead allows for a company to contract with the port to have their own docking facilities if they desire to do so. They are able to equip these facilities in a way that best supports their operations to ensure the most efficient operation possible. Having their own dock space also makes it possible to schedule for their vessels to come into port for servicing, which avoids wasting time waiting for dock space or equipment.

In the “Port Fourchon Platform Service” survey, the following ports were reported most often as options for contingency operations:

- Galveston, TX
- Theodore, AL
- Harbor Island, TX
- Cameron, LA

The total number of available rig cranes for all four alternate ports combined is 35 (compared to 66 available at Port Fourchon). Port Fourchon has nine heavy lift cranes available; the alternate ports combined do not offer any. Due to the fact there are no

heavy lift cranes in any of the alternate ports, these ports are unable to fully support deepwater exploration projects⁸.

Rig cranes are used to lift equipment and supplies on and off of vessels. The maximum rig crane lift capacity is about 250 tons. Heavy lift cranes are necessary to transport anchors, chains, and other equipment necessary for deepwater exploration. Heavy lift cranes available at Port Fourchon have maximum lift capacities ranging from 300 to 800 tons. Other Gulf of Mexico ports with comparable measure to Port Fourchon were not considered as alternatives based on multiple factors such as: insufficient road access, insufficient heavy lift capacity, lack of dock space, and constrained waterways that cause increased traffic and delays.

Theoretically, Lake Charles could be used to offset the absence of Port Fourchon traffic, due to the amount of tonnage that typically goes through the port each year compared to that of the other Gulf of Mexico ports, but it is not actually a good alternative due to multiple factors. First, the type of tonnage that goes through the two ports is quite different; therefore, the support functions of the port, which include but are not limited to dock access, bulkhead, and cranes, are insufficient in Lake Charles.⁹ Second, due to limited maintenance funding, the U.S. Army Corps of Engineers has been unable to maintain 40 feet by 400 feet channel dimensions at all times. Currently, channel dimensions allow one-way traffic only and prevent the passage of some large vessels. Congestion is concentrated along a 15-mile reach of the channel between the Gulf Intracoastal Waterway and Lake Charles. Vessels of 32 feet draft or greater cannot pass side by side on the inland reach of the ship channel, requiring the inbound vessel to wait in the Gulf or outbound vessels to wait upstream until the channel is cleared. The exception is liquefied natural gas (LNG) vessels for which the U.S. Coast Guard mandates a leading safety zone of two miles ahead and one mile behind. With new LNG facilities planned for development or under construction, traffic congestion is expected to worsen.¹⁰

Survey responders stated that if their company were forced to use alternate ports in a situation where Fourchon is unavailable, such as in the 90-day outage scenario in this report, the company would have to make arrangements to have the services they required brought into any alternate port. Contracts with outside vendors who could set up temporary heavy lift crane facilities at the port would have to be established. Some companies, such as Anadarko Petroleum Corporation, have contingency plans that include pre-established contracts with such vendors to provide anything their operations

⁸ Lafont, Daniel, Marketing Manager, C-Logistics. "Port Fourchon Project." Email to: Rawls, Jason. September 28, 2010.

⁹ Lafont, Daniel, Marketing Manager, C-Logistics. "Port of Lake Charles as an Alternative to Port Fourchon." Phone Interview, July 11, 2011.

¹⁰ Louisiana Marine Transportation System Plan, Department of Transportation and Development. September 2007. Accessed at http://www.dotd.la.gov/intermodal/marineandrail/documents/Louisiana_Marine_Transportation_System_Plan.pdf.

might need.¹¹ Based on phone interviews and survey responses, it appears that most companies do not have contingency contracts established to the extent that Anadarko has in place. Without pre-established contracts, the support services would have to be arranged ad hoc which could lead to exorbitant prices and much increased costs.

Having more than seven times the amount of bulkhead, combined with many more rig and heavy lift cranes, means that a much larger number of support vessels are able to be docked and serviced at the same time rather than wait in queue to be serviced. The amount of bulkhead space makes it possible for Fourchon to expand and offer greater facilities and support functions. Other ports are at an inherent disadvantage because they are physically unable to offer what Fourchon can.

Another critical support function for drilling is the availability of drilling fluid, or drilling mud, at a port. Drilling fluids are used in drilling oil and natural gas wells and on exploration drilling rigs. These fluids are also used for much simpler boreholes, such as water wells. The main functions of drilling fluids include providing hydrostatic pressure to prevent formation fluids from entering into the well bore, keeping the drill bit cool and clean during drilling, carrying out drill cuttings, and suspending the drill cuttings while drilling is paused and when the drilling assembly is brought in and out of the hole.¹² Furthermore, deepwater drilling operations are not done without the use of drilling fluids. If a company is going to support their Gulf of Mexico deepwater explorations out of any port other than Port Fourchon, arrangements will have to be made with another company to provide the necessary amount of drilling fluid. This service only exists for exploration companies at an increased cost when compared to what is available at Port Fourchon.

2.2.1.3 Infrastructure Investment

The figures below represent the investments made in the Northern Expansion of Port Fourchon which began in 2007. This expansion will increase the services offered by the port by creating additional large slips and bulkhead. The Actual Cost section represents investments made into Phase 1 of the Northern Expansion. These investments have already occurred. Estimated Cost represents what Port Fourchon will be investing to complete Phase 2 of the Northern Expansion. The total investment of Phase 1 was \$100,363,913. The total estimated cost of Phase 2 is \$113,500,000. Phase 2 is due to be completed by the end of 2011.

2.2.1.4 Actual Cost

- Northern Expansion Phase 1 (Land Creation Only): \$21,300,728
- Northern Expansion Phase 1 (Bulkhead and Dredging): \$72,509,036
- Northern Expansion Phase 1 (Roads and Waterlines): \$6,554,149

¹¹ Aucoin, Stan, Anadarko Petroleum Corporation, “Continuity Planning for Shut down at Port Fourchon Scenario.” Phone Interview, January, 20, 2011.

¹² Como, Casey. “Drilling Fluid Use and Drilling Waste Disposal on HDD Projects,” North American Society for Trenchless Technology, January 11, 2011. Accessed at http://www.nastt.org/store/technical_papersPDF/204.pdf.

2.2.1.5 Estimated Cost

- Northern Expansion Phase 2 (Land Creation Only): \$20,000,000
- Northern Expansion Phase 2 (Bulkhead and Dredging): \$85,000,000
- Northern Expansion Phase 2 (Roads and Waterlines): \$8,500,000

Prior to 2007 and the Northern Expansion, there had been \$87,136,087 invested in the development of bulkhead space at Port Fourchon. That investment resulted in about 12,500 linear feet of bulkhead. By the end of 2011 when the Northern Expansion is complete, Port Fourchon will contain 43,000 linear feet of bulkhead that had been constructed at a cost of \$7,000 per linear foot for a total investment of \$301,000,000.¹³

As illustrated above, there has been and will continue to be significant investment at Port Fourchon to improve the services and capabilities offered. Large investments, such as these, are profitable at Port Fourchon due to the central location of the port. The alternate ports that have been discussed in this report have not had the same degree of investment and do not plan to make the investments necessary to compete directly with Port Fourchon due to a lack of demand.

2.2.2 Operating Costs

Table 2–2 below reflects the daily shore-based operating cost to service a support vessel (which supports a rig or platform via docking at the port and returning to the rig or platform with supplies), as well as the number of rig and heavy lift cranes that are available at each port.¹⁴ The costs below do not include logistic costs such as rental fees for vessels or fuel costs.

Table 2–2: Shore-Based Operating Costs and Crane Capacity by Port

Port	Operating Cost	Rig Cranes	Heavy Lift Cranes
Fourchon, LA	\$1,370	66	9
Galveston, TX	\$1,270	6	0
Theodore, AL	\$1,200	4	0
Harbor Island, TX	\$1,270	3	0
Cameron, LA	\$1,200	22	0

At first glance it appears to be more economical to operate out of the alternate ports than it would be to operate out of Port Fourchon. For example, daily operating costs at Fourchon are \$1,370 per day, but the lowest operating cost for alternate ports is \$1,200 at the port in Cameron, LA. A company could save \$62,050 per vessel, per year by operating daily out of Cameron rather than Fourchon. Shore based operating costs at Port Fourchon are higher than those at alternate ports, but multiple factors cause overall

¹³ Chiasson, Chet, Executive Director, Port Fourchon, “LA-1/Port Fourchon; Infrastructure Questions.” Email to Gibeson, Glenn, October 13, 2010.

¹⁴ Lafont, Daniel, Marketing Manager, C-Logistics, “Port Fourchon Project.” Email to: Rawls, Jason, September 28, 2010.

logistics costs to be higher for a project based at alternate ports. The difference in logistic costs combined with the efficiency at which a company can operate out of Fourchon offset the savings at alternate ports for shore based costs. The major factors that lead to increased overall costs are fuel costs and fees for additional support vessels.

Ronnie Ferguson, Shorebase Coordinator with British Petroleum (BP), expressed that it takes an average of twelve hours for a service vessel to reach Port Fourchon from any of BP's rigs or platforms. Conversely, the same vessel needs 26-32 hours to reach Galveston, TX. In addition to travel time, vessels arriving at Galveston are not able to dock and be serviced immediately due to the smaller port's inability to accommodate them--effectively doubling the time required to service these support vessels compared to Port Fourchon. These delays result in much longer round trip times from the time vessels leave each rig and return to each rig from port. Therefore, operators will need to either increase their fleet size (more vessels) to maintain the current level of support, or decrease their level of support.¹⁵

Therefore, a round trip from rig/platform to Port Fourchon and back, including vessel servicing, could take 36-48 hours (12 hours to port, 12-24 hours in port, 12 hours to return to rig/platform). For a vessel to travel from rig/platform to the Port of Galveston and back would take between 52-64 hours. This does not include the time it would take to service the vessel. In the event Port Fourchon is shut down, Galveston would be operating at capacity, and a vessel would have to wait to be serviced. Port Fourchon officials have estimated that it could be up to 72 hours between the time a vessel docks at an alternate port and receives servicing, and the time it returns to the rig or platform it is supporting.

The number of rigs and heavy lift cranes, sixty-six and nine respectively, combined with the number of slips and support services available at Port Fourchon make it possible for a vessel to spend 12-24 hours in port before it makes the return trip to a rig. If a support vessel is forced to wait for services to become available because a port is operating at capacity, additional vessels may have to be used to ensure that proper support for a rig is provided.

Daniel Lafont, Marketing Manager with C-Logistics, stated that depending on how critical the need, an additional term boat (term of the particular project), a spot hire (solitary vessel roundtrip), or a standby vessel would have to be used to assure optimum service. A term platform supply vessel (PSV) could average around \$26,000 per day. Adding just one additional term vessel can be a significant extra cost. One additional PSV for 90-days would add \$2.3 million to a single project.¹⁶

All of the factors discussed in this section combine to create lower overall logistical costs for a project being serviced out of Port Fourchon. Daily operating costs are slightly higher at Fourchon, but the amount of bulkhead space available, combined with the number of rig and heavy lift cranes and drilling fluid facilities, means more vessels can

¹⁵ Ferguson, Ronnie, Shorebase Coordinator, British Petroleum, "Continuity Planning for Shut Down at Port Fourchon Scenario." Phone Interview, December 16, 2010.

¹⁶ Lafont, Daniel, Marketing Manager, C-Logistics, "Port Fourchon Project." Email to: Rawls, Jason, September 28, 2010.

be serviced daily at Fourchon than at all of the alternate ports combined. The fact that rigs require daily servicing, combined with the need to travel further distances from rig to alternate port, means additional support vessels would be required to assure the same level of support. Without the use of additional vessels, some operations would have to be temporarily shut down until Fourchon was made available again.

2.3 Impacts of 90-Day LA-1 Outage

The objective of the analysis presented in this section is to estimate the impacts of the two disruption scenarios defined for this analysis. Two common measures of impact are estimated, physical availability of goods or services, and economic impact in terms of change in GDP.

Concerning the first measure, the scenarios, assuming all other things are equal, would result in a decrease in the amount of oil and natural gas produced in deepwaters, both during and after the disruption. A large loss of production could result in acute shortages of oil or gas. Smaller losses of production over longer times might not result in shortages, but could reduce revenues to governments or firms, increase retail prices, and increase the amount of oil and gas imported to the United States. Here the authors use computer simulations to estimate the decrease in oil and gas production as a function of time due to the scenarios.

The second impact measure, economic impact to GDP, occurs because the scenarios would result in a loss of business to the many firms in Louisiana and other states that supply goods and services to the petroleum industry. The lost business would cascade through the chains of suppliers for each firm directly impacted, thereby spreading the economic impact beyond southern Louisiana. Changes to GDP that would be caused by the scenarios were estimated using an economic analysis tool based on input-output models.

2.3.1 Impact on the Amount of Oil and Gas Produced

The first step in estimating the impact of the two scenario disruptions on the availability of crude oil and natural gas is to estimate the amount of lost production, with all other factors being equal, due to a 90-day outage of Port Fourchon. Part of Port Fourchon's function is to support exploration and development activities, including deepwater drilling of new exploration and production wells, and maintenance of existing production wells, which are necessary to maintain future production of oil and gas. Consequently, a disruption of these exploration and development activities will impact production long after the disruption period. In this section, the authors estimate the impact on production over a ten year period beginning at the start of the scenario disruption. A key point is that an estimate of the impact of a Port Fourchon closure must consider a long recovery period after a relatively short disruption.

The objective is to estimate the difference in production that is due to Port Fourchon being out of operation for 90-days, with all other factors being equal. This estimated difference in production is a measure of the value added by the port. For Scenario 1, the ten-year production for an undisturbed case is compared to the ten-year production for the case in which Fourchon is disrupted. For scenario 2, the ten-year production for a

hurricane case is compared to the ten-year production for a hurricane case in which Fourchon is also disrupted.

It is neither possible nor necessary to predict the undisturbed or disturbed Gulf production over a ten year period because the difference in production attributed to a 90-day closure of the port is approximately the same for the range of plausible future trends of Gulf production. For example, the 2010 Macondo well accident and the following drilling moratorium will certainly have a long-term impact on Gulf production, but the additional difference in production that would be due to a future port closure would be approximately the same as if the Macondo accident did not occur.

2.3.1.1 Production Calculation Method

NISAC analysts estimated the impact of hypothetical scenario 90-day closure of Port Fourchon by performing a numerical simulation. The simulation sums the additions to production capacity from well workovers, additional production wells in the same plays, and additional production wells from new fields. The simulation also subtracts production declines from mature fields. These additions to and subtractions from the mature deepwater production capacity normally offset each other when production over time is constant; however, if drilling is disrupted, there would be no additions to production capacity to offset the natural decline in capacity.

Figures 2–15, 2–17, and 2–18 below illustrate the structure of the numerical model. Figure 2–15 shows that the total mature deepwater production capacity decreases with time.

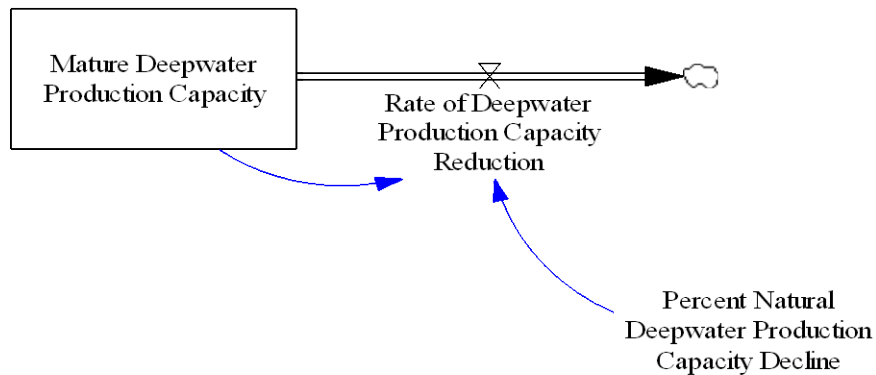


Figure 2–15: Impact of Natural Production Decline on Mature Deepwater Production Capacity

Here, the box represents the accumulated amount of mature deepwater production capacity. The valve on the arrow leading from the box represents the rate of capacity reduction. The rate of capacity reduction is equal to the current mature deepwater production capacity times the natural deepwater production capacity decline. In this example, deepwater production capacity naturally declines at a rate of 16 percent per year. If there were no additions to mature deepwater production capacity, the rate of

decline over time would be 16 percent per year. This is illustrated by the blue line in Figure 2–16 below, which shows that deepwater production capacity would be at about 20 percent of today’s levels in ten years if no capacity additions were made; however, only taking into account the rate of mature field capacity decline does not show the full picture. The additions to deepwater production capacity must also be considered. One source of capacity additions is maintenance. This report defines maintenance as well workovers and drilling new wells in existing fields. In Figure 2–17 this addition to production capacity is represented by the arrow on the left flowing into the stock of production capacity.

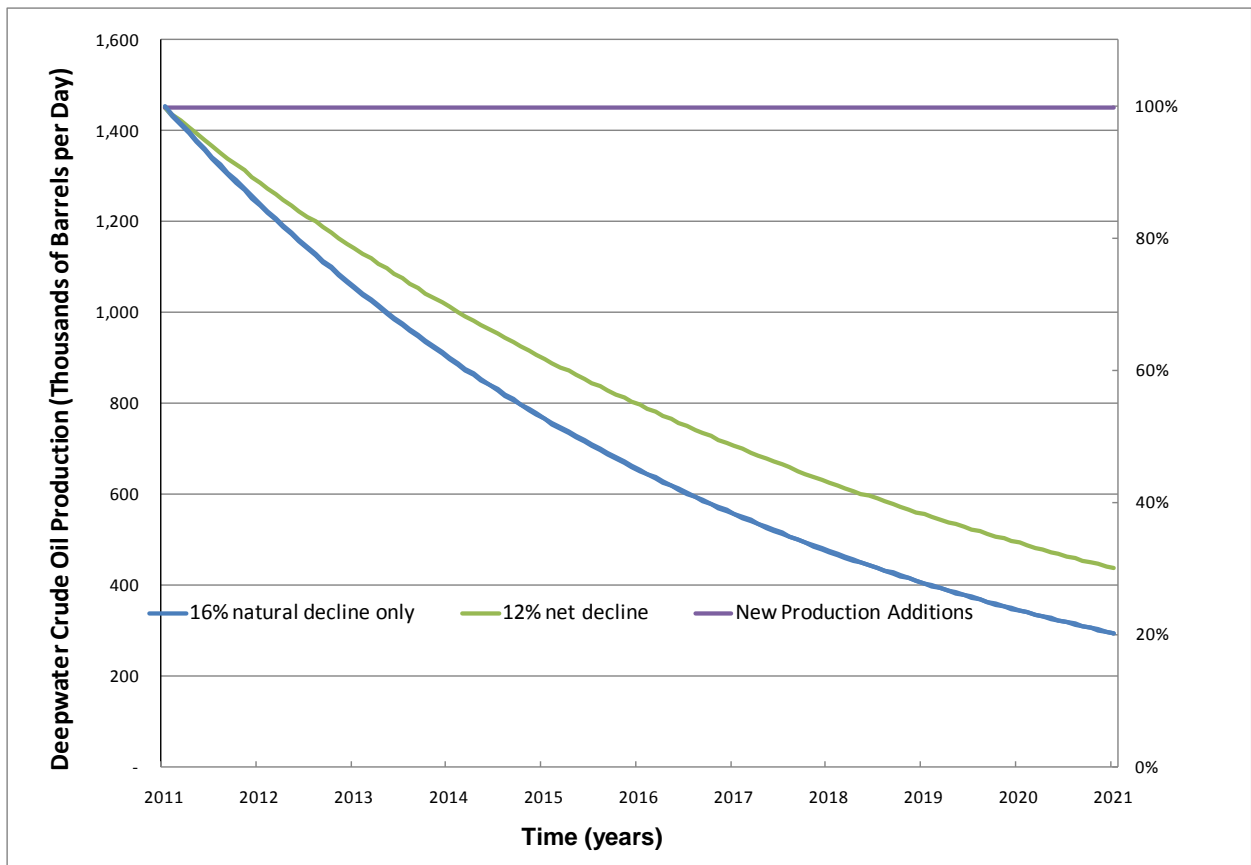


Figure 2–16: Calculated Deepwater Crude Oil Production

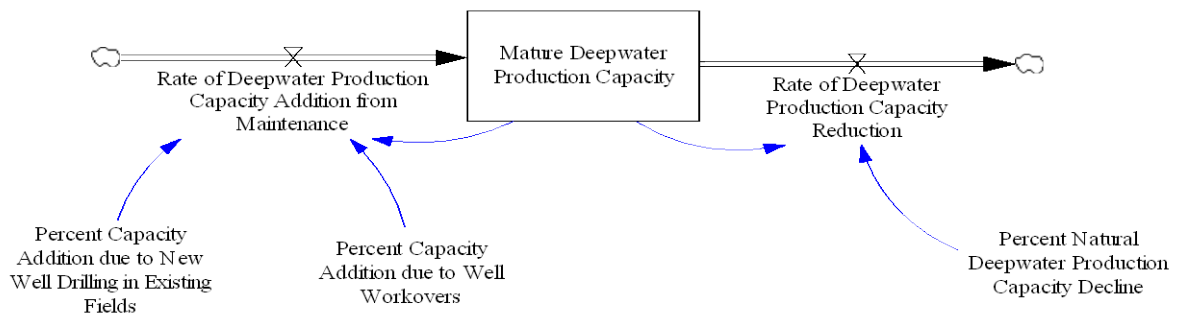


Figure 2–17: Increasing Mature Deepwater Production Capacity by Maintenance

In this example, new well drilling in existing fields increases the mature deepwater production capacity by two percent per year, and well workovers also increase mature deepwater production capacity by two percent per year. Together new development wells and well workovers provide a four percent annual addition to capacity. Since this is offset by a 16 percent annual production capacity decline, there is a net decline of 12 percent per year (green line in Figure 2–16).

There is one more piece to add to the picture. Exploration allows for the discovery of new fields, and establishing production wells in those new fields. If production in the deepwater Gulf is to be kept constant, then most of the replacement of lost capacity due to natural decline must come from new fields. In this example, production wells in new fields add 12 percent per year to mature deepwater production capacity. The complete diagram reflecting new production additions is shown in Figure 2–18. The inflows and outflows, in this example, balance and consequently result in a constant production capacity over time (horizontal purple line in Figure 2–16).

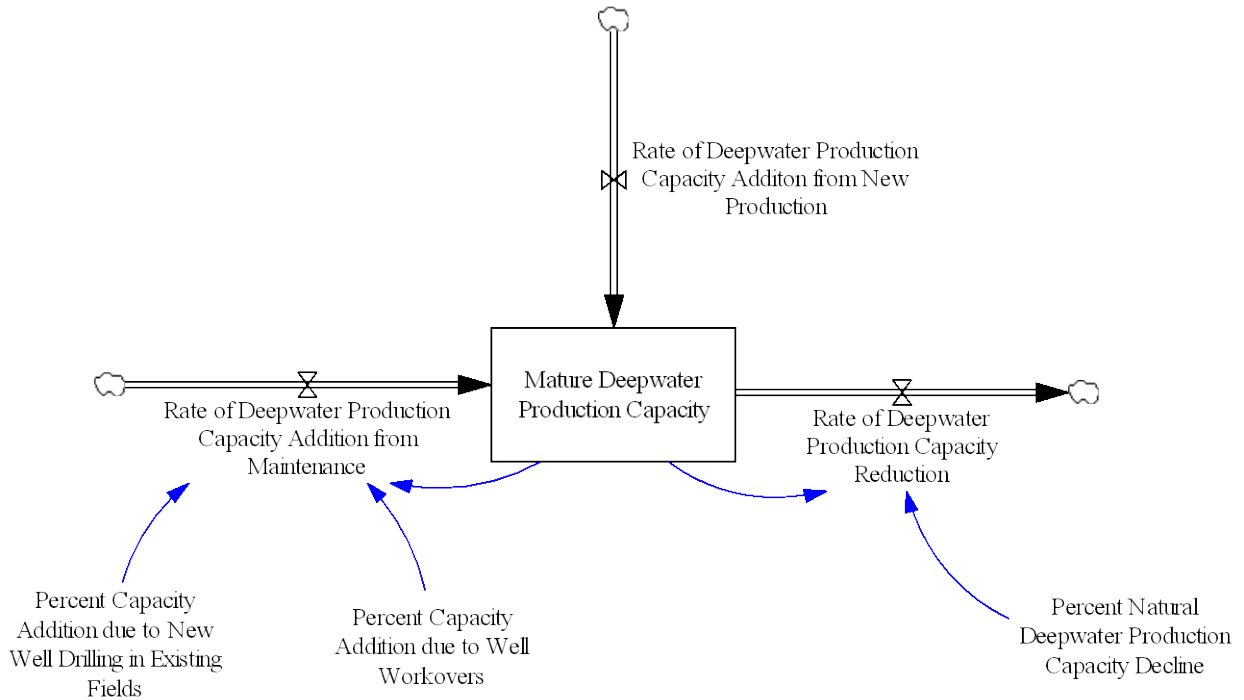


Figure 2–18: Complete Diagram of Additions to and Subtractions from Mature Deepwater Production Capacity

Figure 2–18 summarizes the approach used to estimate Gulf oil and gas production for scenario conditions. In this analysis, undisturbed production is assumed to be constant in the future. As noted above, future undisturbed production is a reference point, and not a prediction. In order to calculate the impacts of the scenarios, two additions to the calculation are required to represent production impacts under disturbed conditions. First, a disruption to Port Fourchon would decrease the rates of the two inflows to the stock of production capacity, from maintenance and from new wells. Second, a hurricane would initially remove a portion of the production capacity of offshore platforms. Some would be damaged, and some would be undamaged but temporarily shut in. In either case, the lost capacity would recover over time.

The actual estimates of the impacts on oil and gas production of a Port Fourchon closure depend on the assumed values for various model parameters. NISAC analysts believe the parameter values used are reasonable, but uncertain. A complete sensitivity analysis of the parameter values is beyond the scope of this study, and not necessary to produce a reasonable estimate of Port Fourchon’s contribution to oil and gas production.

The simulated period of time starts 1 January 2011 and ends 1 January 2021. The scenario 90-day closure of Port Fourchon starts on 1 July, 2011. The scenario hurricane makes landfall on 1 July 2011 in the scenario that includes a hurricane. The simulated start date of the disruptions only matters for calculation of the ability of the U.S. natural gas system to respond to a supply disruption because demand for gas varies seasonally.

The following parameter values describe undisturbed conditions:

- 1) Annual percent change in deepwater production capacity due to natural declines in production from mature deepwater oil and gas fields: -16%
- 2) Annual percent change in deepwater production capacity due to workovers¹⁷ of existing wells: +2%
- 3) Annual percent change in deepwater production capacity due to new production wells in existing plays: +2%
- 4) Annual percent change in deepwater production capacity due to drilling new exploration and production wells in new plays: +12%
- 5) Current Gulf deepwater oil production: 1.45m bbl/day.^{18 19}
- 6) Current Gulf deepwater natural gas production: 2.8 Bcf/day²⁰

The following parameters describe hurricane damage to deepwater platforms and recovery rates:

- 7) Percent of the deepwater Gulf oil and gas production that is shut-in: 90 percent
- 8) Percent of shut-in deepwater production capacity that is damaged: 50 percent
- 9) Percent of shut-in deepwater production capacity that is destroyed: 0 percent
- 10) Time required for damage assessment before undamaged deepwater platforms begin to return to service: one week
- 11) Rate at which undamaged deepwater platforms return to service: five percent of remaining undamaged shut-in capacity per day
- 12) Rate at which damaged deepwater platforms return to service with Port Fourchon open: 0.5 percent of remaining damaged shut-in capacity per day after 3 weeks²¹

¹⁷ Well Workover – “The process of performing major maintenance or remedial treatments on an oil or gas well. In many cases, workover implies the removal and replacement of the production tubing string after the well has been killed and a workover rig has been placed on location.” Oilfield Glossary, Schlumberger. Accessed 15 February 2011 at www.glossary.oilfield.slb.com with a search for the term ‘workover.’

¹⁸ MMS 2009-012, May 2009. The ‘Industry Deepwater Projection’ for 2011 of 1.417 m bbl/day from existing deepwater plays, plus 0.031 m bbl/day from industry-announced discoveries and projected undiscovered resources (Table 2, page 16). This total is roughly 1.45m bbl/day

¹⁹ For comparison, this is close to the Federal Offshore (PADD 3) production number of 1.56 m bbl/day reported by EIA for 2009. Accessed February 15, 2011 at http://www.eia.doe.gov/dnav/pet/pet_crd_crpdn_adc_mbbldpd_a.htm.

²⁰ EIA, “Gulf of Mexico Federal Offshore Production,” accessed February 15, 2011 at http://www.eia.doe.gov/dnav/ng/ng_prod_deep_sl_a.htm. 1,050 Bcf of wet natural gas was extracted from a depth of 200 meters or greater, which equals 2.87 Bcf/day. As extracting the liquids from the 2006 deepwater Gulf natural gas reduced the volume by 2.3%, we subtracted this amount to approximate the volume of dry natural gas extraction in 2007 (which we rounded to 2.8 Bcf/day).

²¹ It is assumed that repair of damaged deepwater production platforms begins three weeks after the hurricane because the primary effort during the three weeks is on assessing damage and restoring non-damaged production to service

The following parameters describe resumption of deepwater activities with Port Fourchon closed:

- 13) Rate at which damaged deepwater platforms return to service with Port Fourchon closed²²: zero
- 14) Rate at which well workovers and new production wells at deepwater existing fields are completed with Port Fourchon closed: zero
- 15) Rate of well completion in new deepwater fields with Port Fourchon closed: zero

The sum of parameters 1), 2), and 3) listed above represents the rate at which production in mature deepwater oil and gas fields is assumed to decline with time in this analysis. The values used for these parameters sum to minus 12 percent, indicating that simulated production in mature deepwater fields declines at a rate of 12 percent per year. This combined rate is based on projections by the former Minerals Management Service²³; however, the relative contributions of the three components are uncertain because only net changes in production rates can actually be observed. The results of this analysis of the impacts of a Port Fourchon closure are not very sensitive to the relative contributions of parameters 1), 2), and 3) because Port Fourchon plays a key role in all activities that maintain or increase deepwater production capacity. In this analysis it is assumed that workovers and drilling of new production wells in existing plays add a modest, but plausible, two percent per year each to production capacity. Larger values of these parameters would increase the calculated impact of a Port Fourchon closure.

Parameters 7), 8), and 9) define the assumed degree that the scenario hurricane impacts deepwater production. Note that the limiting case of assigning each of these parameters a value of zero would make the simulation results equivalent to Scenario 1 in which there is no hurricane. Therefore, the estimated amount of lost oil and gas production due to a closure of Port Fourchon, combined with a scenario hurricane that is less damaging, would be an amount between the values given for Scenario 1 and Scenario 2 in the following section.

Parameters 13), 14), and 15) indicate that no deepwater drilling or well workovers would occur if Port Fourchon is closed for 90-days. Looking at rig crane capacity alone, which was discussed in section 2.2 of this report, one might assume the other ports combined could pick up about 50 percent of Fourchon's normal servicing capacity. Since Fourchon has two thirds of the rig crane capacity, and the other ports have one third, it stands to reason that the other ports could service half the number of vessels Fourchon normally services; however, even by servicing half the number of vessels, it is unlikely the other ports combined could support half the amount of offshore operations. It would take more

²² It is assumed that repair of deepwater does not occur when Port Fourchon is closed because other ports are likely to be used to capacity in returning non-damaged production to service and supporting deepwater production.

²³ Minerals Management Service (U.S. Department of the Interior), "Gulf of Mexico Oil and Gas Production Forecast: 2009 – 2018," MMS 2009-012, May 2009. On page 3, it is stated that "the deepwater oil and gas production estimates ... are assumed to have an effective annual decline rate of 12 percent each year from 2014 through 2018."

time to service offshore installations from the other ports, and this increased time would require an increase in the number of vessels to service the same number of installations. The time to service offshore installations from other ports increases because the travel time to the installations is greater, and also because the vessel servicing times in these ports are greater than at Port Fourchon. In addition, it is not clear how much spare capacity these other deepwater ports would have if Fourchon were unavailable. These ports would not just be sitting completely idle, waiting for a problem at Fourchon—they would be engaged in other work at some fraction of their total rig crane capacity. Therefore, this report estimates the other ports in the Gulf combined could handle roughly 25 percent of the servicing normally performed by Port Fourchon.

Fourchon normally uses about 75 percent of its capacity supporting deepwater drilling operations, and 25 percent of its capacity supporting deepwater production platforms. This analysis assumes, therefore, that the other Gulf deepwater ports combined could take up all of Fourchon’s deepwater production servicing functions,;but in that case, they could assume none of the drilling support functions. Based on this reasoning, the parameters 13), 14), and 15) are assigned a value of zero.

2.3.1.2 Estimated Decline in Production Due to Scenarios

Figure 2–19 below compares undisturbed production at a constant rate of 1.45m bbl/day, with the case of a 90-day closure Port Fourchon.

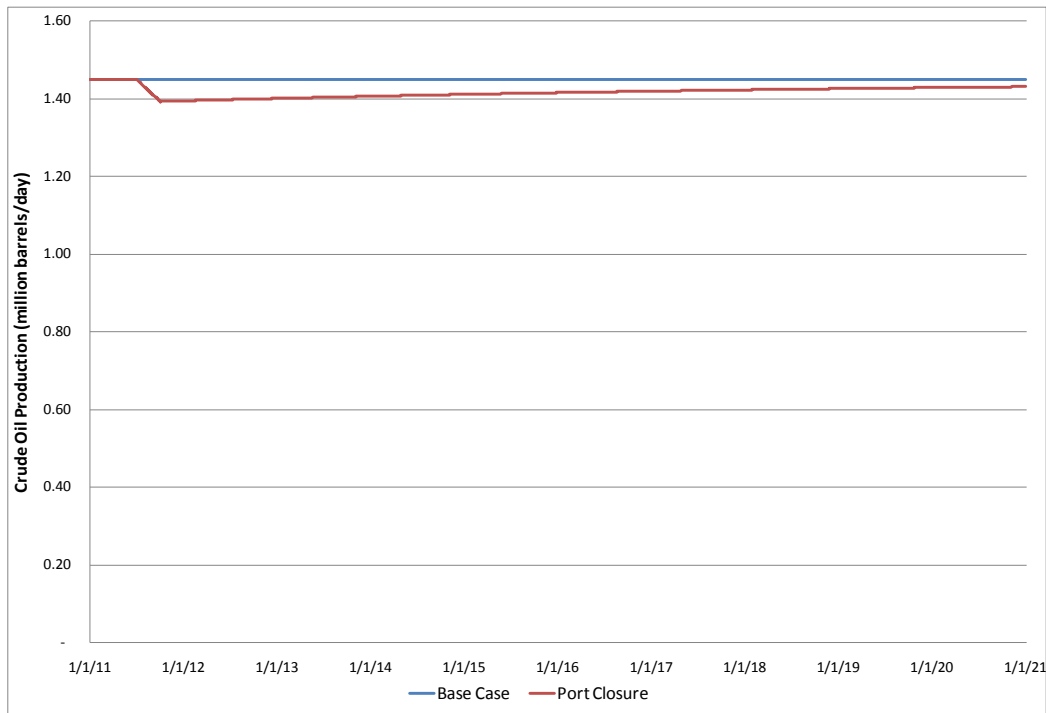


Figure 2–19: Crude Oil Production under Scenario 1 -- Base Case vs. a 90-day Port Fourchon Closure

During the 90-day port disruption, there is a small initial drop in output due to the cessation of all drilling (which includes well workovers, additional production wells at

existing fields, and production wells at new fields). That is, the production curve begins to follow the decline in production capacity shown as the 16 percent decline curve (blue line) shown in Figure 2–16. At the lowest point on the production curve, at the end of the port closure, the production rate is about 3.5 percent below normal. After the port re-opens, the rate of production then comes back very slowly over many years.

Over the ten-year timeframe, 5.22 billion barrels are produced in the undisrupted case, and 5.1 billion barrels are produced in the disrupted case. This means that production in the disrupted case is reduced by 120 million barrels over ten years. This loss is equal to about 83 days of deepwater production at the current production rate.

The graph of natural gas production over time, due to a 90-day port closure (Figure 2–20 below), is similar to the graph for oil.

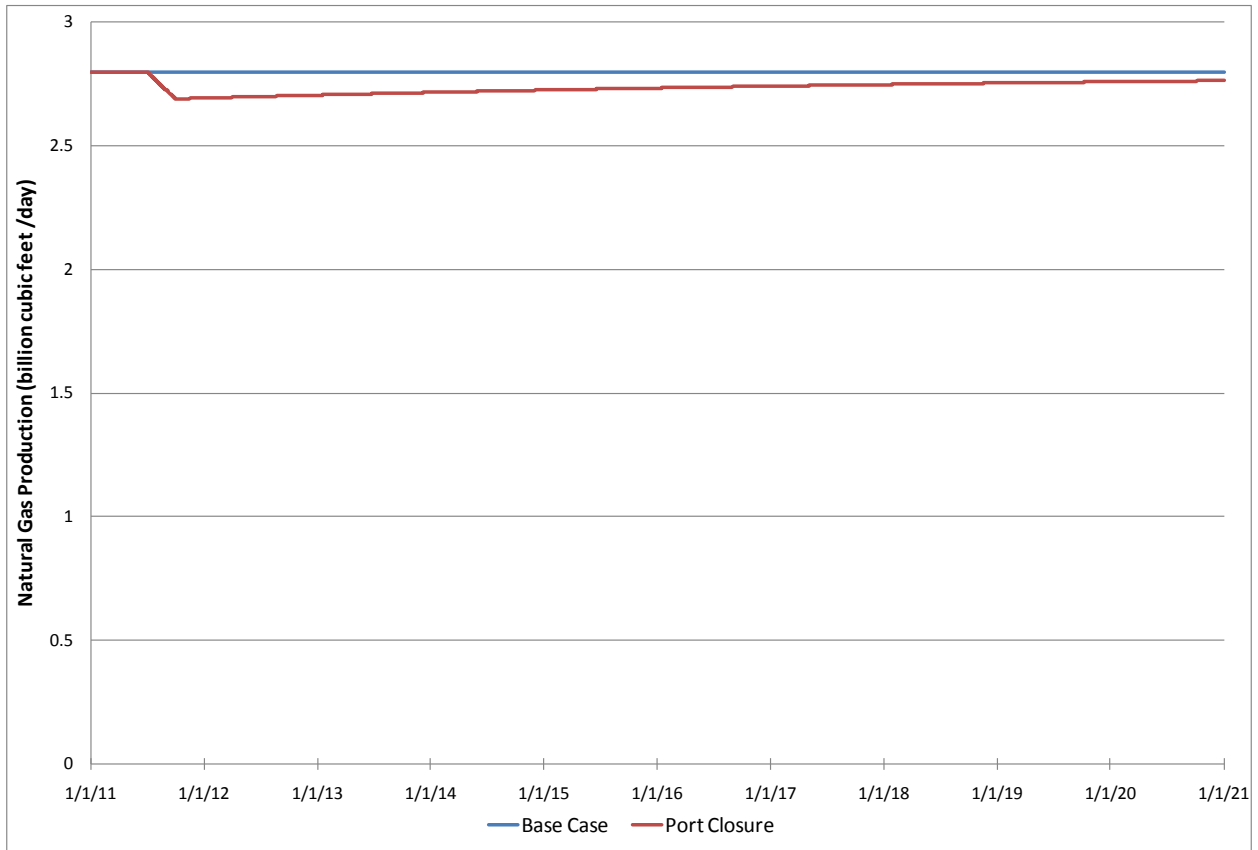


Figure 2–20: Natural Gas Production under Scenario 1 -- Base Case vs. a 90-day Port Fourchon Closure

Over the ten year timeframe, 10.1 trillion cubic feet (Tcf) are produced in the undisrupted case, and 9.85 Tcf are produced in the port-closure case. This means the disruption leads to 250 Bcf of lost production as compared with the undisturbed case.

The following calculations and graphs refer to Scenario 2 in which a hurricane damages offshore oil and gas operations in the Gulf. Production is estimated for two cases, a hurricane with Port Fourchon open, and a hurricane with the port closed. This

comparison is necessary to isolate the role of Port Fourchon from the effects of the hurricane itself.

Figure 2–21 illustrates crude oil production under Scenario 2.

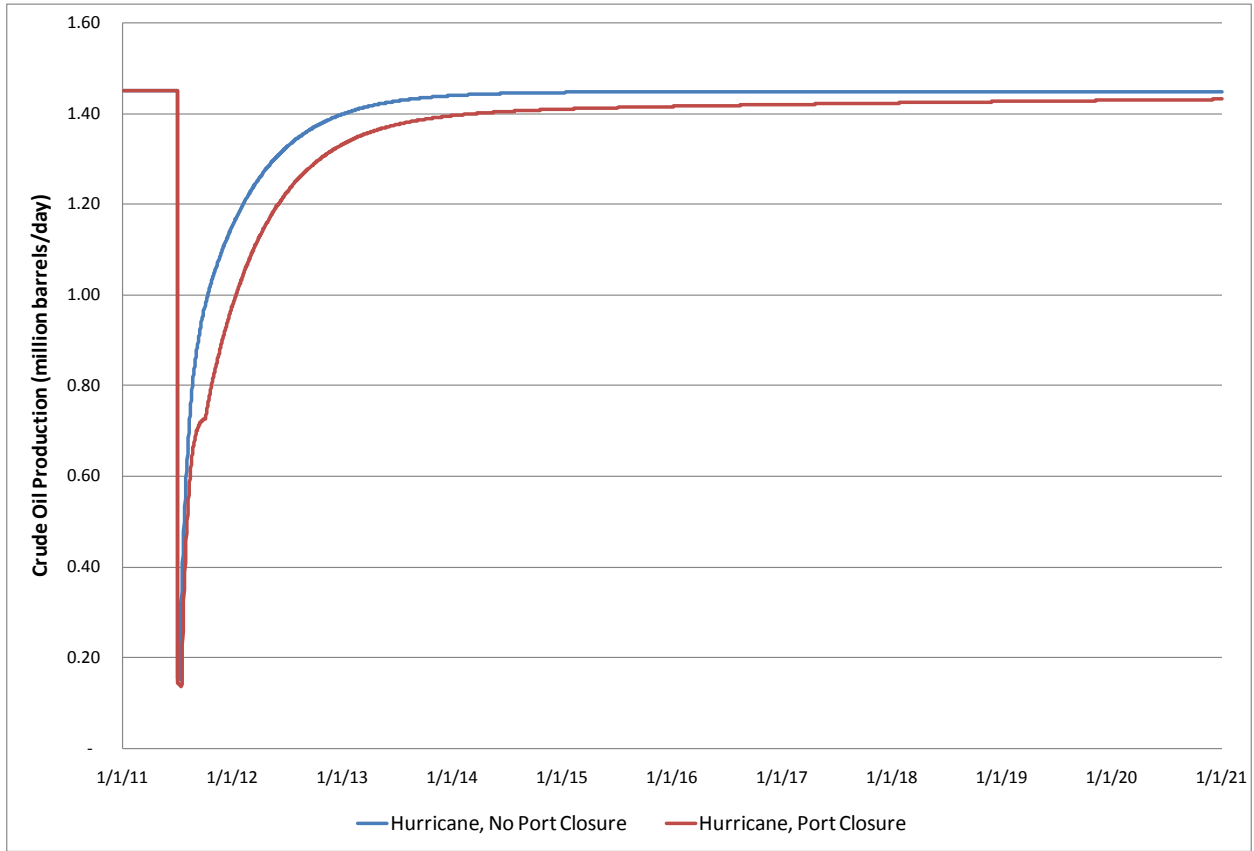


Figure 2–21: Crude Oil Production under Scenario 2 – Hurricane vs. Hurricane along with a 90-day Port Fourchon Outage

Here, the blue line shows the impact of the hurricane on oil production without a Port Fourchon outage, and the red line illustrates the impact of the hurricane together with a 90-day Port Fourchon outage. Not only is the initial recovery slower without the availability of Port Fourchon, but it also takes longer for output to return to normal due to the impact of not drilling for 90-days.

Over the 10-year timeframe, 5.03 billion barrels are produced in the base case (hurricane with Port Fourchon not disrupted), and 4.87 billion barrels are produced in the disrupted case (hurricane with Port Fourchon disrupted for 90-days). This means production is reduced by about 160 million barrels in the disrupted case, or about 40 million barrels more than was estimated for Scenario 1.

Figure 2–22 illustrates deepwater natural gas production under Scenario 2. Natural gas production in the event of a base case hurricane is compared with natural gas production in the event of a hurricane that also results in a 90-day outage of Port Fourchon.

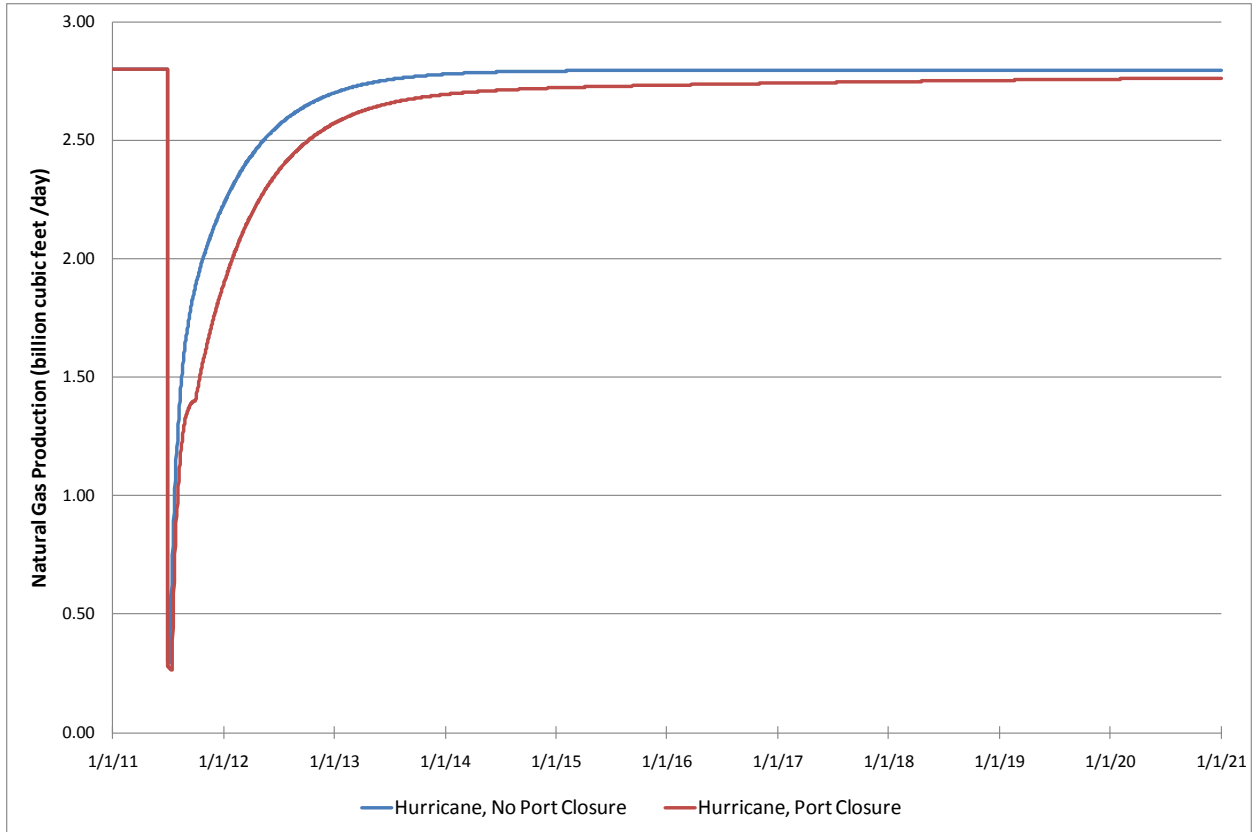


Figure 2–22: Natural Gas Production under Scenario 2 – Hurricane vs. Hurricane along with a 90-day Port Fourchon Outage

The blue line shows the impact of the hurricane on natural gas production without a Port Fourchon outage, and the red line illustrates the impact of the hurricane together with a 90-day Port Fourchon outage. Just as in the case of crude oil production, both recovery from the hurricane and return to normal output over the long term are delayed when Port Fourchon is not available for the 90-days immediately after the hurricane.

Over the 10-year timeframe, 9.72 trillion cubic feet (Tcf) are produced in the base case (hurricane with Port Fourchon not disrupted), and 9.4 Tcf are produced in the disrupted case (hurricane with Port Fourchon disrupted for 90-days). Therefore, the closure of Port Fourchon accounts for about 320 Bcf of lost production. This loss is about 70 Bcf more than the loss attributed to the port closure in Scenario 1.

The lost production of both crude oil and natural gas due to a 90-day shutdown of Port Fourchon is greater for Scenario 2 than for Scenario 1. Whereas Scenario 1 is an indication of Port Fourchon’s contribution to deepwater drilling, Scenario 2 takes into account both Port Fourchon’s drilling function as well as its role in assisting in the recovery from a major hurricane.

2.3.2 Oil and Gas Supply Analysis

The second step in estimating the impact of the two scenario disruptions on the availability of crude oil and natural gas is to evaluate whether the estimated decline in production rates would likely cause natural gas or petroleum product shortages.

2.3.2.1 Natural Gas Supply Analysis

NISAC performed a simulation of Scenario 2, the hurricane plus 90-day closure of Port Fourchon, with the Gas Pipeline Competition Model (GPCM). This model is a network model of the North American natural gas infrastructure. A more detailed discussion of GPCM is contained in Appendix B.

For this simulation, natural gas production from the deepwater Gulf of Mexico was reduced by the schedule outlined in Table 2–3 below. The amounts in the table were a result of the model run discussed under Scenario 2 of the Oil and Gas Production subsection. Figure 2–22 in that subsection illustrates natural gas production under Scenario 2. In that figure, the red line shows the projected natural gas production from the deepwater Gulf of Mexico from the scenario hurricane along with a 90-day Port Fourchon outage.

Combining the effects of the hurricane and of the Port Fourchon closure in this simulation does not allow for isolating the impacts of a Port Fourchon closure alone. However, if the natural gas network is resilient to a shock of this magnitude, then certainly a Port Fourchon closure alone would pose no significant threat to the system.

**Table 2–3: Deepwater Gulf of Mexico
Natural Gas Production Shortfall under Scenario 2**

Month	Production Shortfall (million cu ft/day)
July 2011	2,330
August 2011	1,613
September 2011	1,418
October 2011	1,296
November 2011	1,120
December 2011	976
January 2012	853
February 2012	748
March 2012	658
April 2012	579
May 2012	512
June 2012	454
July 2012	404

Now the results of the model run will be discussed. Here, the results of the Hurricane plus Port Fourchon outage are compared with the base case (operations as usual – no hurricane, no Port Fourchon outage). Gas prices increase, with the price of gas at Henry Hub²⁴ increasing by roughly \$0.80/MMBtu (which is an increase of about 20%) for July, August, and September 2011.

The increase in gas price both increases supply and reduces demand. Supply is increased through additional imports and increased production at other domestic fields. The amount of gas available for consumption in the United States falls by less than 1 percent in the months of July, August, and September 2011. (By comparison, if the 2,330 million cf/day of production in July 2011 were simply lost and additional supplies had not been brought to market, this would have been a reduction in gas available for consumption of around 4 percent for the United States as a whole.²⁵) Demand drops to equal the amount of gas available; therefore, gas shortages do not develop.²⁶

Since the reduction in deepwater Gulf production is greatest in July 2011, and since this gas comes on shore in Louisiana, it makes sense to look at how the gas flows from production basins to Louisiana customers differ in Scenario 2 versus the base case of no disruption. Table 2–4 below illustrates the volume of gas that would likely flow from each production basin to customers in Louisiana if spot prices alone dictated the flows. These numbers are a result of the natural gas network model runs discussed above.

²⁴ Henry Hub is a key natural gas market point that interconnects with multiple pipelines, and is located in Louisiana. It is the pricing point for natural gas futures contracts on the New York Mercantile Exchange (NYMEX).

²⁵ The base case model run projects 56.9 Bcf/day of gas available for consumption in the U.S. in July 2011. The amount of deepwater Gulf of Mexico natural gas production loss we project due to the hurricane and Port Fourchon closure for July 2011 is 2.3 Bcf/day, which represents 4% of the gas normally available (56.9 Bcf/day).

²⁶ To clarify, we define a gas shortage as an event where a customer willing to pay the spot price for gas cannot obtain that gas.

Table 2—4: Simulated Gas Flows from Production Basin to Louisiana for July 2011 (in MMcf/day) Source: GPCM model runs

Production Basin	Scenario 2 Flows to LA	Base Case Flows to LA
Arkla-East Texas	1,669	1,759
East Gulf Onshore	56	-
Gulf – Deep	38	556
Gulf – Shallow	971	747
LNG	122	115
Midcontinent	434	290
Southern LA onshore	96	22
Texas Gulf Onshore	1	-
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TOTAL	3,387	3,490

As can be seen, the overall shortfall to Louisiana in Scenario 2 versus the base case is about 100 million cf/day (or about a 3 percent reduction) in July 2011. There is, as one might expect, a large loss (of around 500 million cft/day) in deepwater Gulf supplies to Louisiana customers.²⁷ Much of this loss is compensated for by increased flows to Louisiana from the following basins: East Gulf Onshore, Shallow Gulf, Midcontinent, and Southern Louisiana Onshore.

In summary, it seems unlikely that the drop in natural gas supply brought about by the combination of a powerful hurricane combined with a 90-day outage of Port Fourchon would lead to a shortage of natural gas. The spot price of natural gas will almost certainly jump in the months following the hurricane; however, this tends to happen when there are powerful hurricanes in the Gulf, even when Port Fourchon is available to assist in platform and undersea pipeline repairs. The difference here is the added delay in returning damaged platforms to operation, as well as a small reduction in production capacity due to the 90-day hiatus in deep sea drilling (from the Port Fourchon shutdown), which increases spot prices over a longer duration than a hurricane alone would.

2.3.2.2 Crude Oil Supply Analysis

NISAC also analyzed the potential impact of a reduction in crude oil production caused by the hurricane and Port Fourchon 90-day outage scenario. Table 2–5 below depicts the loss in crude oil production by month used in the analysis. These numbers were obtained from the model run discussed in the Oil and Gas Production section of this report, and are shown graphically in Figure 2–21 of that section.

²⁷ To be clear, the production drop in July 2011 from the deepwater gulf is 2,300 cf/day. However, here we are examining the flow of gas from source to destination. Instead of the 556 million cuft/day that Louisiana customers would normally receive from the deepwater Gulf in July 2011, they receive only 38 million cf/day.

Table 2–5: Deepwater Gulf of Mexico Crude Oil Production Shortfall under Scenario 2

Month	Production Shortfall (thousand barrels/day)
July 2011	1,207
August 2011	835
September 2011	734
October 2011	671
November 2011	580
December 2011	505
January 2012	442
February 2012	387
March 2012	340
April 2012	300
May 2012	265
June 2012	235
July 2012	209

The United States consumed about 19 million bbl/day of petroleum products in 2009. That same year, the United States had net refined product imports of about 1m bbl/day (roughly 3m bbl/day was imported, while about 2m bbl/day was exported).²⁸ And about 1m bbl/day was consumed in the form of natural gas liquids (propane, ethane, etc.). The remaining 17m bbl/day was refined in the United States from crude oil.²⁹

The projected loss of 1.2 million bbl/day of production in July 2011, due to the scenario hurricane and Port Fourchon closure, amounts to a loss of about seven percent of the U.S. crude oil supply (or 6 percent of the overall U.S. fuel supply). This is a significant amount, and would almost certainly impact world oil prices and retail fuel prices in the United States. The question then becomes whether refined product shortages could result from the levels of shortfall projected in Table 2–5.

In order to answer this question, a clarification is in order for some facts about the crude oil network in the United States, as well as about the scenario under consideration. First, most of the Gulf Coast refineries are connected by a common network of crude oil pipelines. It is unlikely, therefore, that any shortfall would impact a few refineries disproportionately. Instead, the shortfall would likely be distributed fairly evenly across

²⁸EIA, “Oil: Crude and Petroleum Products Explained,” last updated on 19 November 2010. Accessed on 14 February 2011 at: http://www.eia.doe.gov/energyexplained/index.cfm?page=oil_imports

²⁹ NISAC analysts rounded the EIA figures on natural gas liquids and finished petroleum products. The source data can be found at: http://www.eia.doe.gov/dnav/pet/pet_sum_snd_d_nus_mbbldpd_a_cur.htm, accessed 14 February 2011.

Gulf refineries, which comprise 43 percent of the U.S. total refining capacity.³⁰ Second, the Strategic Petroleum Reserve (SPR) and crude oil import terminals in the Gulf are connected to this Gulf Coast refinery supply network, just as are pipelines bringing oil produced in the Gulf onshore. Therefore, the SPR can be drawn down to replace the crude oil production shortfall. And if there is additional import capacity available, crude imports into the Gulf region can also be increased.

In addition, there are multiple locations where crude oil is stored in the transportation network. Excluding the SPR, the Gulf Coast (PADD 3)³¹ has about 167 million barrels of working storage capacity, and the Midwest plus Oklahoma (PADD 2) has about 79 million barrels of working storage capacity (of which 46 million barrels are at Cushing, Oklahoma).³² Refineries also typically have several days of crude inventory in storage on site. This means that even without additional imports or withdrawals from SPR, the system does have crude oil in storage that it can use. Finally, the authors assume this scenario would have no impact on the ability of the Louisiana Offshore Oil Port (LOOP) to import oil. While the LOOP booster station (which is located at Port Fourchon) could lose power for a few days following the hurricane or be damaged by the hurricane, this would not likely have an impact on normal LOOP operations. This is because most of LOOP's pumping capacity is at its Clovelly Dome Storage Terminal, located 25 miles inland near Galliano, LA³³. The booster station increases the facility's maximum offloading capacity from 75,000 bbl/hour (or 1.8m bbl/day) to 100,000 bbl/hour (or 2.4m bbl/day), whereas LOOP normally imports about 1m bbl/day.³⁴

The authors contend that the losses in production depicted in Table 2–5 would lead to fuel shortages anywhere in the United States. This is because a combination of withdrawals from working storage and SPR, along with increased crude oil imports, would be able to handle the production shortfall. While there may be temporary restrictions in crude oil supply to some refineries immediately following the storm (until stocks in storage and the SPR can be used, or imports increased), this period should be brief and should not cause refineries to shut down.

One may ask why this analysis is not projecting fuel shortages, when in fact fuel shortages did materialize in the wake of Hurricane Katrina (which was of a similar magnitude and took a path similar to the hurricane envisioned by this scenario). The main reason is that Hurricane Katrina cut power to multiple pumping stations along Colonial and Plantation refined product pipelines, causing these pipelines to shut down for several

³⁰ EIA, "Gulf of Mexico Fact Sheet," updated 30 December 2010. Accessed on 14 February 2011 at http://www.eia.doe.gov/special/gulf_of_mexico/index.cfm.

³¹ PADD (Petroleum Administration for Defense Districts) were delineated during WWII to facilitate oil allocation. Data on crude oil and petroleum products published by the Energy Information Administration (EIA) are typically aggregated by PADD.

³² EIA, "Working and Net Available Shell Storage Capacity as of September 30, 2010."

³³ Location of Clovelly Dome Storage Facility from the Louisiana Dept. of Transportation and Development's web site, accessed February 14, 2011 at http://www.dotd.louisiana.gov/programs_grants/loop/.

³⁴ LOOP hourly capacity, as well as LOOP average daily import rate, provided by LOOP representatives in an August 24, 2010 meeting.

days. The Southeast (not including Florida) is highly dependent on these product pipelines, and currently does not have any viable alternate supply.³⁵ Once these pipelines were shut down, the Southeast only had as much fuel as was in distribution tankage along the pipeline at the time.

The scenario posited in this analysis does not include a power outage impacting multiple pumping stations along Colonial and Plantation pipelines. This is because the objective the scenario used in this analysis was to examine the role of Port Fourchon in restoring offshore Gulf oil and gas production in the aftermath of a hurricane. Whether a hurricane takes a path on land that results in a loss of power for product pipeline pumping stations is not relevant to Port Fourchon's role. The likelihood of a product pipeline pumping stations losing power or the the time required to restore normal operations do not, depend on the status of Port Fourchon.

2.3.3 Economic Impact of Ninety-Day Closure of LA-1

This analysis estimates economic impact to GDP due to the loss of business to the many firms in Louisiana and other states that supply goods and services to the petroleum industry. The lost business would cascade through the chains of suppliers for each firm that is directly impacted, thereby spreading the economic impact to regions of the country other than southern Louisiana. This analysis applies to both of the disruption scenarios because the loss of business is due to the closure of the port, rather than to the impact of hurricane damage to offshore facilities.

Two estimates, or cases, are presented. The first assumes that other ports in the Gulf region are not able to substitute for the lost capacity at Port Fourchon. The second case more realistically assumes a portion of Port Fourchon's normal workload could be performed at other ports.

2.3.3.1 Background Discussion

Gulf Coast states, particularly Louisiana and Texas, are important to the effective functioning of the near-shore and off-shore oil and natural gas industry. Recent trends in discovery of on-shore natural gas fields in the United States make the off-shore natural gas component less important nationally than the petroleum component. Nevertheless, this segment of the industry is regionally important to Gulf Coast states due to the concentration of chemical plants in the area requiring crude petroleum and natural gas for refining and further processing into a variety of transportation fuels and feedstock chemicals. Because of declining domestic U.S. production of crude petroleum, outer continental shelf (OCS) crude petroleum exploration and production in the Gulf Coast area is vitally important to U.S. national economic interest. Every barrel of crude petroleum produced domestically displaces a barrel that would otherwise be imported—a boost to the U.S trade balance that is persistently in deficit, not to mention the economic boost that domestic production entails. Accordingly, maintenance of business-as-usual conditions in the Gulf Coast oil and gas industry is important.

³⁵ Florida is an exception because it receives refined product by barge and tanker. There are no pipelines that deliver refined product to Florida.

As mature fields peak and begin to decline in production, discovery of new fields is important to maintain the industry. Exploration and development activities are supported by on-shore facilities important to transportation of materials, supplies, and personnel needed for continued activity. As previously discussed, Port Fourchon, connected to in-shore areas and the regional transportation networks by LA-1, as the only supply route to the interior of the U.S, plays an important role in that continuity. It would follow then that southern Louisiana should be an important component to the continued effective functioning of the OCS industry.

2.3.3.2 Literature Review

Doubts regarding the veracity of this supposition that the state of Louisiana benefits greatly from the presence of the oil and gas industry exist in the literature. Former Louisiana Department of Natural Resources Secretary Scott Angelle stated in an interview in response to the question, “With regard to continuing on-shore and off-shore oil and gas development, how important is the industry to the state today?”³⁶

When talking about the importance of the oil and gas industry to the economy of the state, there are two distinct regions – within state boundaries and in the OCS (federal Outer Continental Shelf waters). The predominant economic contribution comes from that activity from within the boundaries of the state, not that in the federal waters beyond the state’s 3-mile (5-km) offshore boundary. To a large extent the infrastructure burdens placed on Louisiana by the OCS are practically unrecoverable from a taxation perspective since a huge portion of the workers and most of the companies operating in the OCS are beyond the state’s taxing authority. Although they work in federal OCS area, many OCS workers live and pay taxes in areas far remote from Louisiana’s taxing authority. Past efforts to find out where OCS workers live revealed that huge numbers (more than 60% by some estimates) commute from Texas, Arkansas, Mississippi, Alabama, Georgia, Tennessee, Florida and other states, as well as foreign countries such as Venezuela and Mexico. The 7-day-on, 7-day-off, 14-day-on, 14-day-off and similar schedules for offshore workers facilitate long distance commuting. Workers mostly pay taxes where they live, buy homes and cars, shop, etc. For large numbers of OCS workers, that is not in Louisiana. Additionally, the production, equipment, property, profits, etc., of OCS companies and operations are in federal waters, beyond the taxing jurisdiction of the state of Louisiana, other than the incomes of employees and the few small companies headquartered in Louisiana.

A further indication that areas outside the immediate vicinity of Port Fourchon are important to servicing the OCS industry is contained in an economic impact study

³⁶ “Louisiana: Proud Past, Promising Future” Supplement to *Oil and Gas Investor E&P*, Hart Energy

performed by members of the Coastal Marine Institute at the Louisiana State University. The authors are careful to allocate expenditures and income based on survey data reflecting their geographic location for particular phases of oil field development and production and on the income flows that result from that development. They state,

*The allocation of activities or expenditures to onshore areas is probably one of the more important factors for determining the region-specific economic impacts associated with offshore activities. These breakouts are important, because there are tendencies for certain onshore support activities to be concentrated in particular geographic areas. This concentration has tended to occur in Louisiana and Texas and has continued despite the movement of offshore activities into deeper water and into the Central-Eastern portions of the Gulf of Mexico.*³⁷

These comments indicate that a wider selection of Louisiana Parishes than had originally been planned to be included in the analysis would be prudent.

Further indication of the desirability of including a larger set of parishes is provided by a study of the economic impacts of coastal erosion in southern Louisiana.³⁸ The map shown in Figure 2–23 identifies the coastal parishes included in their analysis (green) and what the authors refer to as the adjacent parishes (yellow). This study examined the possible economic impacts of a continual coastal erosion that is due to a variety of factors, among them oil and gas exploration and production; control of flows on the Mississippi River; and Midwestern agricultural practices.

“What If” scenarios are constructed by the authors for the major industries in the southern Louisiana area that could be affected by erosion-caused disruptions together with storm activity. Oil and gas pipelines could be disrupted, transportation on the Mississippi River and the Gulf Inter-coastal Waterway could be disrupted, and commercial fishing and recreational activity could also be affected by erosion and storm activity. Each of these scenarios is specified by an extent and duration, and economic impacts are determined for each.

This study reports the economic impacts in terms of reductions in sales, earnings, and employment rather than GDP. The report also includes reductions in employment for an assumed five-week disruption in oil and gas pipelines that results in the loss of around 1400 jobs in Louisiana. Direct job losses are the basis for indirect job loss calculations

³⁷ Dismukes, D.E., W.O. Olatubi, D.V. Mesyanzhinov, and A.G. Pulsipher. 2003. Modeling the Economic Impacts of Offshore Oil and Gas Activities in the Gulf of Mexico: Methods and Applications. Prepared by the Center for Energy Studies, Louisiana State University, Baton Rouge, La. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-018. 88 pp.

³⁸ Richardson, Dr. James A., and Dr. Loren C. Scott, “The Economic Impact of Coastal Erosion in Louisiana on State, Regional, and National Economies.” Prepared for the Department of Natural Resources, State of Louisiana. April 2004.

³⁹ Ibid.

that result in a calculated 54,000 jobs nationally. These two studies form a good foundation on which to base the present analysis.

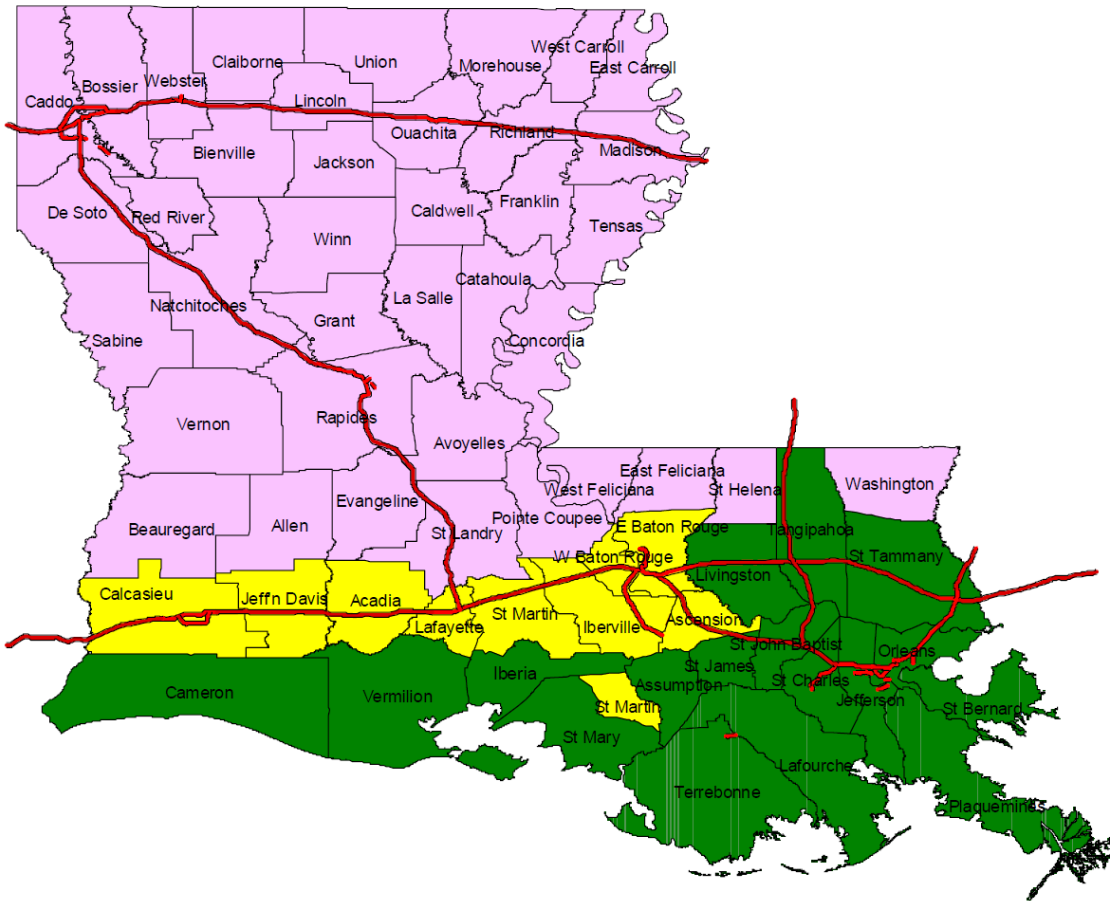


Figure 2–23: Louisiana Parishes Included in the Coastal Erosion Study³⁹

2.3.3.3 Defining Regions for This Study

Two significant ports along the Louisiana coast support the oil and gas industry in the OCS—Ports Fourchon and Cameron. Port Fourchon is the principal facility through which much of the material and equipment flows. It has nine heavy lift cranes that are absolutely required for some types of OCS activities. No other port along the Louisiana, Texas, or Alabama coasts has this type of lifting capability. However, our examinations indicated that Port Cameron is also significant, particularly in terms of its rig crane capacity. While our initial inclination was to assume all activity supporting the OCS rigs flowed through Port Fourchon, closer examination indicated that assumption would likely overstate its activity level. Accordingly, a two-region grouping of the Parishes in southern Louisiana was adopted for this study.

Oil and gas activity in the five western Parishes surrounding Port Cameron is assumed to use Port Cameron while all of the remaining parishes to the east along the coast are

³⁹ Ibid.

assumed to use Port Fourchon. The two-region grouping just described is presented in the colored map shown in Figure 2–24. Combined, the two-Parish grouping includes the same Parishes identified as pertinent in the coastal erosion study conducted by Richardson. Inclusion of these Parishes was verified by the authors of this study based on an analysis of 2007 Bureau of Economic Analysis employment data for the sectors of the economy pertinent to the oil and gas industry. In Figure 2–24 the green area is the tributary area for the Case 1 assumptions in which Port Fourchon is completely shut down for 90-days. The 4 tan areas along the Gulf coast identify the areas to which some of the servicing activity would shift under the Case 2 assumptions.



Figure 2–24: Map Showing Pertinent Economic Impact Analysis Areas

The authors are aware that it is possible—probably likely—that this assumption is approximate at best; oil and gas industry supported activity could originate in the eastern coastal regions and use Port Cameron and vice versa. In other words, “cross-hauling” is possible, if not likely. There is not data available to verify the correctness of the assumption. Nevertheless, it is likely that cost-minimizing firms will utilize the most economical routes, other things equal. Logistics therefore dictates that firms located in the western five-parish region will use the closer of the two ports (Cameron) as long as

their cargo can be handled in this port; vice versa for Port Fourchon. Whatever the origin-destination distribution of cargo, the equilibrium apportionment will be determined by a combination of distance and port capacity. Port Fourchon is clearly the port with the highest capacity and will therefore handle most of the cargo. Given this, closure of Port Fourchon as hypothesized would result in the largest impact.⁴⁰ The assumption of no cross-hauling, if inappropriate, has insignificant effects on the results. Table 2–6 lists the parishes in each regional grouping.

Table 2–6: Parish Regional Groupings

Eastern Louisiana Parishes		Western Louisiana Parishes
Ascension	St. Bernard	Acadia
Assumption	St. Charles	Calcasieu
East Baton Rouge	St. James	Cameron
Iberia	St. John the Baptist	Jefferson Davis
Iberville	St. Martin	Vermilion
Jefferson	St. Mary	
Lafayette	St. Tammany	
Lafourche	Tangipahoa	
Livingston	Terrebonne	
Orleans	West Baton Rouge	
Plaquemines		

2.3.3.4 Industry Sector Identification

Industry sectors directly involved in the oil and gas industry were identified using the North American Industry Classification System (NAICS) industry listing. The identified sector names and their NAICS classification numbers are shown in Table 2–7.

⁴⁰ Note also the comments of Mr. Gene Forte, Terminals Contract Manager, Upstream Americas, Fourchon Terminal that, for Shell, 95% of drilling mud and fuel shipments arrive at Fourchon by truck and 5% from Galveston. Similarly, Shell’s post-damage assessment is conducted 95% from Fourchon and 5% from Galves⁴⁰ton. With Port Fourchon out of service, Shell would attempt to obtain support from Cameron, Sabine Pass, Mobile, and Pascagoula as alternative.

Table 2–7: Oil and Gas Industry Sector Identification

Industry Sector Name	NAICS Classification Number
Drilling Oil and Gas Wells	213111
Support Activities for Oil and Gas Operations	213112
Heavy and Civil Engineering Construction	237
Petroleum and Coal Products Manufacturing	324
Machinery Manufacturing	333
Ship and Boat Building	3366
Non-Scheduled Air Transportation	4812
Deep Sea, Coastal, and Great Lakes Water Transportation	4831
Specialized Freight Trucking	4842
Pipeline Transportation	486
Special food Services	7223

The Bureau of Economic Analysis (BEA) and the County Business Patterns (CBP)⁴¹ establishment and employment data for each of the sectors directly related to business in or servicing of the oil and gas industry in each of the parishes identified was used to support a determination that each sector/parish combination had sufficient economic activity to be included in the impact analysis. Note that the classification numbers include sectors with between 3-digit- and 6-digit-classification numbers. In general, the more digits the more disaggregated the industry sector.

These data are accumulated for each industry based on a formalized, regular reporting process. They are among the most carefully assembled and recorded data available at this much disaggregated economic and geographic level. However, their use involves issues and problems. Among the most significant issues for this study is the fact that the industry sectors identified include some that support both the land-based and water-based segments of the oil and gas industry. Yet the information is not accessible to make a split between activities in a given sector that support the land-based industry as distinct from the portion of that sector’s activities that support the offshore segment. For some sectors the distinction is clear; for example, Ship and Boat Building, Non-Scheduled Air Transportation, and Special Food Services all support predominantly the off-shore industry. Most of the remaining sectors support both segments. Data representing the onshore-offshore apportionment do support our assumption. The 2010 Louisiana Department of Natural Resources data show that approximately 88% of the crude petroleum and condensate production came from the Federal OCS region while 43% of

⁴¹ CBP data is collected by the Census Bureau, an agency of the Department of Commerce of the U.S. Government; the BEA is also an agency within the Department of Commerce⁴² Source: <http://www.loga.la/oil-gas-statistics.html>

the wet gas production came from the Federal OCS region.⁴² Nevertheless it is not clear whether the sector-by-sector oil and gas servicing economic activity scales with the relative amount of production or with the quantity of labor servicing off-shore production and drilling rigs versus land-based and near shore activities. The effect of our assumption is to somewhat overstate the economic impact of the shutdown of Port Fourchon, but the authors cannot determine by how much this assumption overstates the “true” impact. Nevertheless it is the authors’ informed judgment that the overstatement is not gross.

The Louisiana Offshore Oil Port (LOOP) has pumping stations located at Port Fourchon but is not dependent on Port Fourchon for its functionality. Thus, it is assumed that LOOP will continue its operations although perhaps not at full capacity. If the LOOP is relatively undamaged and continues in operation, oil tankers bringing in foreign crude oil could continue.

In shuttering the entire industry in these parishes, one could claim overshooting, as some economic activity would likely continue to support these in-shore and land-based activities. If there is excess capacity in the industry at present then it is possible that, after a resumption of exploration and production, some of the losses could be made up by extending work schedules and applying more resources. Whether this is possible is conjecture. The current state of the industry has not been investigated in sufficient detail to make a determination on this issue.

2.3.3.5 Description of the Scenarios

As previously discussed, the agreed scenario involves the following assumptions:

- Access highway to Port Fourchon is disrupted for 90-days; no truck traffic.
- Two Cases:
 1. No substitution of servicing activity from Fourchon to other ports; and
 2. Partial substitution from other Gulf Coast ports.
 - a. Natural gas and crude oil production continue during the highway disruption.
 - b. Under normal business conditions, servicing activity is level across the year.

2.3.3.6 Economic Impact Calculation Methodology

An economic analysis tool called REAcct (for Regional Economic Accounting) was employed in the calculation of economic impacts of closure of Port Fourchon. This tool is particularly useful for rapidly calculating approximate economic impacts for disruptions due to natural or man-made events. It is based on and derived from the well-known and extensively documented input-output modeling technique initially presented by Leontief and more recently further developed by numerous contributors. It provides county level economic impact estimates in terms of gross domestic product (GDP) and employment for any area in the United States. The process for using REAcct incorporates geo-spatial computational tools and site-specific economic data permitting the identification of geographical impact zones that allow differential magnitude and duration estimates to be specified for regions affected by a simulated or actual event. Using this as input to

⁴² Source: <http://www.loga.la/oil-gas-statistics.html>

REAcct, the number of employees for 23 industry sectors directly affected are calculated and aggregated to provide direct impact estimates. Indirect estimates are then calculated using RIMS II multipliers. The interdependent relationships between critical infrastructures, industries, and markets are captured by the relationships embedded in the input-output modeling structure.

2.3.3.7 Economic Impact Calculation Results: Case 1, No Substitution Scenario

The assumptions that define the scenario effectively shut down southern Louisiana’s main economic activity for a period of three months—one quarter of a year—so a significant impact to the region is expected. Results bear out that expectation. The total economic impact of the stoppage of the industry amounts to, in round numbers, a \$10.4 billion reduction in total GDP for the United States. This total GDP reduction is comprised of an approximately \$3.9 billion reduction in the parishes directly supporting the oil and gas industry while the remaining approximately \$6.5 billion is the economic impact in the wider national economy that would be affected by the disruption.

The industries that directly sustained the largest reduction in GDP include Support Activities for Oil and Gas Operations at \$1.0 billion, Petroleum and Coal Products Manufacturing at \$1.0 billion, and Heavy and Civil Engineering Construction at slightly over \$0.5 billion. The remaining industry sectors had direct impacts below \$0.5 billion. Table 2–8 displays the direct GDP reductions by industry sector.

Table 2–8: Direct GDP Reduction by Sector in Eastern Parishes

Industry Sector	Direct GDP Reduction (billion \$)
Drilling Oil and Gas Wells	0.2
Support Activities for Oil and Gas Operations	1.0
Heavy and Civil Engineering Construction	0.5
Petroleum and Coal Products Manufacturing	1.0
Machinery Manufacturing	0.2
Ship and Boat Building	0.4
Non-Scheduled Air Transportation	0.0
Deep Sea, Coastal, and Great Lakes Water Transportation	0.3
Specialized Freight Trucking	0.1
Pipeline Transportation	0.1
Special food Services	0.0
Total	3.9

Parishes experiencing the largest direct GDP reductions included Lafayette at \$0.67 billion, East Baton Rouge at \$0.5 billion and Jefferson at \$0.4 billion. St. Mary, Terrebonne, and Lafourche each sustained GDP reductions of between \$0.2 and \$0.3

billion, while the remaining parishes sustained impacts below \$0.2 billion. Table 2–9 shows the direct GDP reductions by Parish.

Table 2–9: Direct GDP Reduction by Parish

Parish	Direct GDP Reduction (billion \$)	Parish	Direct GDP Reduction (billion \$)
Ascension	0.04	St. Bernard	0.15
Assumption	0.02	St. Charles	0.25
East Baton Rouge	0.49	St. James	0.14
Iberia	0.13	St. John the Baptist	0.15
Iberville	0.02	St. Martin	0.04
Jefferson	0.43	St. Mary	0.29
Lafayette	0.67	St. Tammany	0.06
Lafourche	0.25	Tangipahoa	0.03
Livingston	0.01	Terrebonne	0.31
Orleans	0.17	West Baton Rouge	0.09
Plaquemines	0.15		

Figure 2–25 portrays the Parish location and sector-by-sector reductions in direct GDP as a result of the port shutdown.

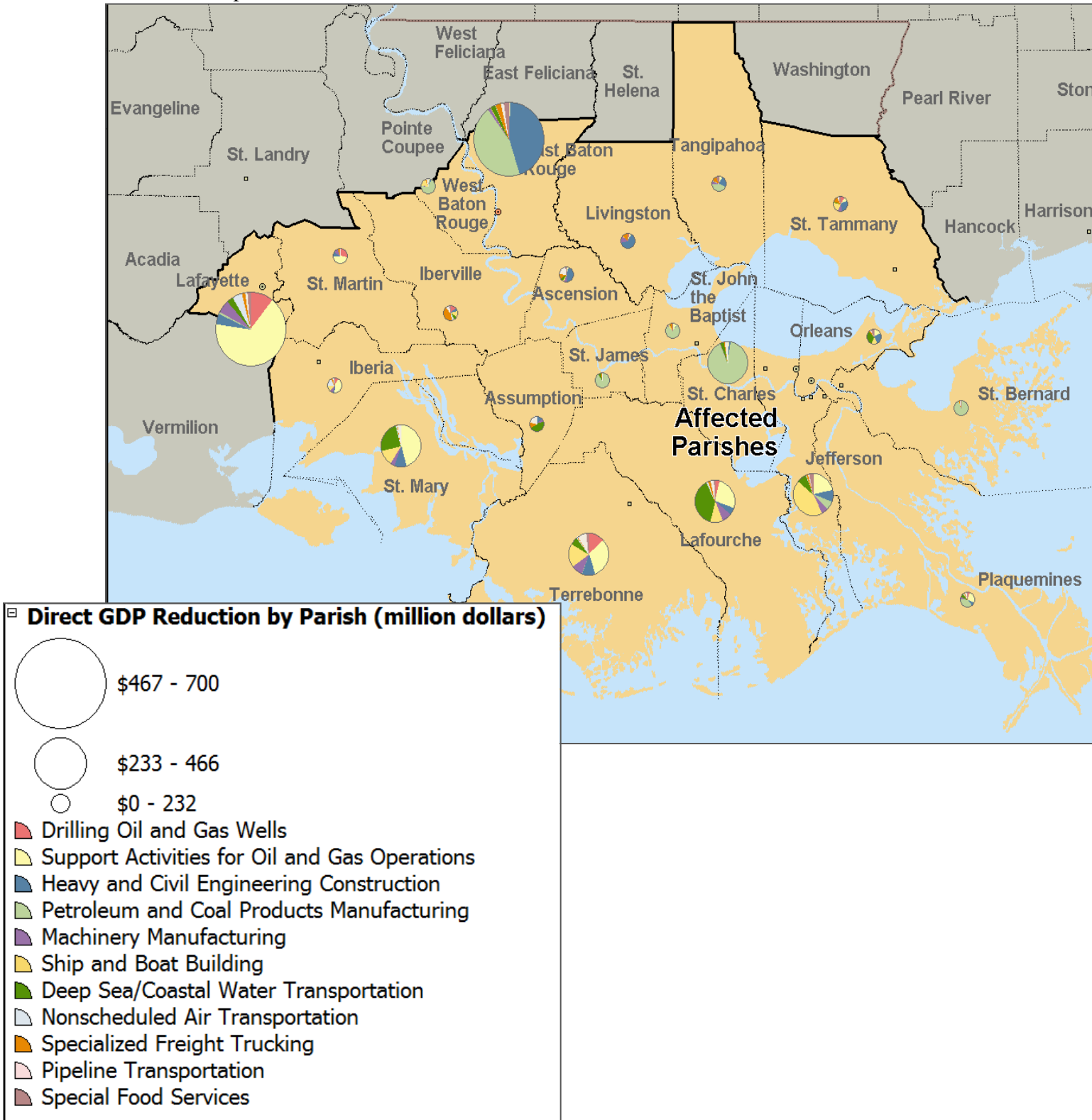


Figure 2–25: Direct GDP reduction by Parish and Oil and Gas Servicing Sector

2.3.3.8 Economic Impact Calculation Results: Case 2, Substitution Scenario

A more plausible scenario is that some of the OCS rig service work that under normal conditions would be supported out of Port Fourchon shifts to other, still available locations. The question then becomes: Which ports could substitute and how much of the servicing could be performed out of these other facilities? This would reduce the national economic impact of the loss of the use of Port Fourchon. But which other ports could serve these functions? Oil field servicing logistics suggest that the limiting factor on such servicing capability is available crane capacity. In order to identify other ports that could substitute for Port Fourchon, data was obtained on Port Fourchon crane servicing capacity along with crane capacity in four other Gulf Coast oil servicing ports: Cameron, LA; Theodore, AL; Galveston, TX; and Harbor Island, TX. The information obtained on rig crane capability by port is shown in Table 2-2.

Substitution reduces the national economic impact of the scenario because some of the oil and gas servicing activity originally lost from the Port Fourchon tributary area (the green Parishes in Figure 2-24) is now recovered in other states/parishes/counties. This shift of economic activity assumes not only that the port facilities in these other areas have the capacity to perform the functions, but also that they are available for use. In other words, the implicit assumption is that before the disruption activity at the ports of Harbor Island, Galveston, Cameron, and Theodore is below the rated capacity of the ports.

The national total GDP reduction for Case 2 is now \$7.8 billion. Thus, Port Fourchon, and the parishes' tributary to it, still suffers the \$3.9 billion total GDP reduction it did in Case 1 with the same oil and gas sector and parish distribution of GDP reductions; however, in Case 2 oil and gas servicing activity and general economic activity increase in certain regions of Texas and Alabama as well as in Louisiana. The increase in economic activity in these other regions of Louisiana, Texas, and Alabama totals \$2.6 billion in GDP. This total GDP increase is distributed among the four areas as follows: Port Cameron, \$1.7 billion; Galveston, \$521 million; Theodore, \$261 million; and Harbor Island, \$130 million. Thus, the five-parish region surrounding Port Cameron gains the most as the result of the loss of Port Fourchon.

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3 Conclusion

Both disruption scenarios considered in this analysis include a 90-day outage of 7.1 miles of the surface road (Louisiana Highway 1) that provides an essential land-based connection between Port Fourchon and the rest of the Louisiana road and highway network. Consequently, a closure of this road effectively closes the port itself. Two mechanisms of disrupting the road are proposed: a strong storm washing out the road, and a gradual submersion of the road because of global sea level rise and regional subsidence of the land surface. This analysis finds that both mechanisms are plausible and sufficiently likely to occur, and that it is reasonable and prudent to consider the possible impacts of a road closure to the nation's economy and supply of crude oil and natural gas. Scenario 1 will eventually occur, no later than the year 2040. Scenario 2 is highly likely to occur, and is likely to occur before the year 2040.

Although other ports in the Gulf Coast could substitute for a portion of the service provided by Port Fourchon, this substitution would be costly and could replace only about 25 percent of service normally provided by Fourchon. At this rate of substitution, it is likely that deepwater production of oil and gas could be maintained at normal levels during a Port Fourchon disruption, but deepwater drilling and maintenance activities could not be provided.

The production capacity of existing oil and gas fields decrease as they mature. In order to offset this natural decrease in production capacity, new deepwater capacity must continually be added through the activities of drilling new wells in existing fields, workovers of existing wells, and drilling of exploration wells to discover new fields. Port Fourchon plays an important role in each of these activities in the Gulf Coast. Any disruption of these activities due to a closure of the port will result in less oil and gas being produced many years into the future, all other factors being equal. This analysis used a computer model of off-shore oil and gas production to estimate that a 90-day closure of Port Fourchon would result in a reduction of 120 million barrels of oil, and 250 billion cubic feet of gas produced over a ten year period starting at the time of the port closure. If the port closure coincided with a major hurricane that damaged offshore facilities, the amounts of lost production, due to the unavailability of Port Fourchon alone, increase to 160 million barrels of oil and 320 billion cubic feet of gas.

It is unlikely these levels of reduced Gulf offshore oil and natural gas production would lead to petroleum product or natural gas shortages. A natural gas network model was used to examine how the natural gas infrastructure might respond to a strong hurricane shutting in wells in the Gulf combined with a 90-day closure of Port Fourchon (which would delay the repair of damaged wells and undersea pipelines). The roughly four percent decline in U.S. natural gas supply due to the shut-in Gulf production would likely be offset by a three percent increase in domestic production in other areas and imports, as well as a one percent decrease in demand. And, as for petroleum products, the authors believe that a combination of withdrawals from working storage and the Strategic Petroleum Reserve (SPR), along with increased crude oil imports, would compensate for the crude oil production shortfall. While there may be temporary restrictions in crude oil supply to some refineries immediately following the storm (until stocks in storage and the

SPR can be used, or imports increased), this period should be brief and should not cause refineries to shut down.

A closure of Port Fourchon would cause loss of business to the many firms in Louisiana and other states that supply goods and services to the petroleum industry. The lost business would cascade through the chains of suppliers for each firm directly impacted, thereby spreading the economic impact to regions of the country other than southern Louisiana.

This analysis used economic modeling to calculate an upper bound of \$10.4 billion national GDP reduction, assuming no port substitution, and \$7.8 billion if substitution of other ports for Port Fourchon is permitted for a 90-day closure of Port Fourchon. This is an upper bound because sufficient information is not available to determine the fraction of economic activity in industry sectors that support the petroleum industry which can be attributed to offshore activities. However, based on examination of offshore versus onshore production data for oil and gas in Louisiana, it is considered unlikely this assumption would have an inordinately large impact on the results.

In the considered judgment of the authors it is likely the assumptions adopted to perform the economic analysis capture the eighty percent solution. In our judgment the assumptions would cause no more than a 20% deviation from that stated “worst case.” Thus, total economic impacts would likely be in the range of \$8 billion for the no port substitution case and \$6.2 billion for the port substitution case. The \$7.8 billion loss is comprised of a \$3.9 billion decrease in GDP for the parishes surrounding Port Fourchon, and a \$2.9 billion loss outside of this region (which includes other parts of Louisiana as well as the United States as a whole).

Other Gulf deepwater ports (in Louisiana, Texas, and Alabama) would likely realize a gain in GDP of approximately \$2.6 billion since they could acquire a fraction of the lost Port Fourchon business. If not for this gain, the GDP loss outside of the Port Fourchon region would be \$2.6 billion higher.

Acronyms and Abbreviations

Acronym	Description
BEA	Bureau of Economic Analysis
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement
Bbl/day	Barrels per Day
Bcf/day	Billion Cubic Feet per Day
CBP	Country Business Patterns
DHS	Department of Homeland Security
DOTD	Department of Transportation and Development
EIA	Energy Information Administration
GDP	Gross Domestic Product
The Gulf	Gulf of Mexico
GPCM	Gas Pipeline Competition Model
HITRAC	Homeland Infrastructure Threat and Risk Analysis Center
IP	Office of Infrastructure Protection
LOOP	Louisiana Offshore Oil Port
LA-1	Louisiana Highway 1
LNG	liquefied natural gas
MMBtu	Million British Thermal Units
MMS	Minerals Management Service
MSLR	Mean Sea Level Rise
NAICS	National American Industry Classification System
NAVD88	North American Vertical Datum of 1988
NIMSAT	National Incident Management Systems and Advanced Technologies
NISAC	National Infrastructure Simulation and Analysis Center
NOAA	National Oceanic and Atmospheric Administration
OCS	Outer Continental Shelf
PADD	Petroleum Administration for Defense Districts
PSV	Platform Supply Vessel
RDMB	Risk Development and Modeling Branch
SPR	Strategic Petroleum Reserve
REAcct	Regional Economic Accounting
Tcf	Trillion Cubic Feet

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Glossary

Term	Description
Henry Hub	A key natural gas market point that interconnects with multiple pipelines, and is located in Louisiana. It is the pricing point for natural gas futures contracts on the New York Mercantile Exchange (NYMEX).
Louisiana Highway 1	This state highway runs from the northern to southern ends of the state. For the purposes of this study, however, the authors are interested in the 7.1 mile section between Golden Meadow and Leeville, in southern Lafourche Parish, the only surface road access to Port Fourchon. This section of LA-1 is referred to in this paper as the LA-1 Surface Road.
Mean Sea Level (MSL)	Measure of the average height of the ocean's surface (such as the halfway point between the mean high tide and the mean low tide); used as a standard in reckoning land elevation.
Mean Sea Level Rise (MSLR)	Combination of both subsidence and global sea level rise
PADD (Petroleum Administration for Defense Districts)	PADDs were delineated during WWII to facilitate oil allocation. Data on crude oil and petroleum products published by the Energy Information Administration (EIA) are typically aggregated by PADD.
Port Fourchon	Louisiana's southernmost port, located on the southern tip of Lafourche Parish, Louisiana, on the Gulf of Mexico. It is a sea port, with significant petroleum industry traffic from offshore Gulf oil platforms and drilling rigs as well as the Louisiana Offshore Oil Port pipeline. Fourchon's primary service markets are domestic deepwater oil and gas exploration, drilling, and production in the Gulf of Mexico. Port Fourchon currently services over 90% of the Gulf of Mexico's deepwater oil production.
Shutting-in	To intentionally stop production of a well.
Well Workover	The process of performing major maintenance or remedial treatments on an oil or gas well. In many cases, workover implies the removal and replacement of the production tubing string after the well has been killed and a workover rig has been placed on location.

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Appendix A: Port Fourchon Platform Service Survey

This survey is part of an ongoing study to accurately describe the national importance of Port Fourchon, and consequently the importance of LA-1 Highway as the only land access to and from the port:

We understand that some recipients of this survey may be more familiar with certain parts of the industry than others. Therefore, please answer the questions that pertain to your area of expertise and omit the ones with which you are unfamiliar. Additionally, it would be greatly appreciated if you could refer this survey to others within your company or organization that may be able to provide answers to any questions you are uncertain of or cannot answer.

Please answer the following questions as diligently as possible. The more detail that you are able to provide, the more comprehensive the study will be, and the more weight its conclusions will carry. Thank you very much for participating.

1. Please provide a list of every platform that your company manages/services out of Port Fourchon. Note that in order for this information to be useful, we require any two (2) of the following pieces of information for each platform on your list: Platform_ID, Complex_ID, grid location, Latitude/Longitude and/or Installation Date.
2. On average how often does a platform require servicing by ship (Include routine service such as resupply and non-routine service such as unscheduled repairs)?
3. What methods are used to transport oil/gas from the production platforms to shore facilities (e.g. barge, ship, pipeline, or specify other method)? Please include approximate percentages and names of pipelines where possible.
4. After leaving the production platform which facilities do you use to store or process your oil/gas (Please include specific storage and processing locations and approximate percentages)?
5. If Port Fourchon was not accessible for an extended period of time (up to 90-days) what percentage of your platforms could be maintained from other ports with your current infrastructure, pipelines and shore facilities (Specify which, if any, platforms would be operated at reduced capacity or shut down during this period and why)?
6. If Port Fourchon was not accessible for an extended period of time (up to 90-days), how much additional time would be required to continue normal service to the remaining active platforms from either Galveston or Theodore (Specify expected additional transit time and wait time incurred by using these alternate ports relative to Port Fourchon)?
7. What is your company's operating costs out of Port Fourchon? Are these costs typically expressed as daily, weekly, monthly, annually, or some other unit of measure?

8. Based on your estimates in previous questions, how would daily operating costs be affected by the need for additional vessels, personnel; increased transit time, wait time, delays or other expenses caused by a shift of operations to Galveston, Theodore or operations split between Galveston and Theodore?

9. Please describe which services, special equipment or infrastructure (if any) that are available at Port Fourchon that cannot be found or effectively replicated at Galveston or Theodore in the 90-day timeframe described here.

10. Please provide contact information if you would be willing to discuss follow up questions with the study team (name, company, email address, telephone number).

Appendix B: Gas Pipeline Competition Model (GPCM)

The Gas Pipeline Competition Model or GPCM was developed by Dr. Robert Brooks of RBAC, Inc.⁴³ GPCM represents the natural gas infrastructure in the United States and Canada⁴⁴. It is not possible to analyze the consequences of disruptions to U.S. natural gas infrastructure without considering Canada because the natural gas systems of these two countries are highly interconnected and participate in a single natural gas market.

GPCM is a network model, which represents major transmission pipelines as individual links (arcs) in the network. Transmission pipelines are large pipelines, available to all shippers of natural gas, which move gas between different regions of the U.S. and Canada. The many thousands of smaller pipelines that move natural gas from gas fields to the transmission pipelines (gathering system), or offload gas from the transmission pipelines for distribution to customers (distribution system) are not represented in GPCM as individual entities.

GPCM also represents sites where natural gas is stored in underground caverns or reservoirs. During normal times, natural gas storage is used to balance seasonal differences between gas production and gas consumption. Specifically, winter consumption rates exceed North American production capacity; gas is put into storage during other seasons of the year and withdrawn from storage for consumption during the winter. During times of disruption, gas storage can add to the system's capacity to decrease consequences by making stored gas available to consumers. However, withdrawals of gas that exceed the typical amount for a given season can result in tighter gas markets in later months.

Simulated flows of gas from one point on the transmission network to another are driven by gradients of price. That is, gas flows occur where the simulated gas price at a distant point is sufficiently larger than the local price to offset any transportation costs. Prices at various locations in the network are estimated using a partial-equilibrium economics model contained within GPCM.

⁴³ Brooks, R.E., 2001, "The Theory and Practice of Modeling with GPCM," RBAC, Inc., 10 pp

⁴⁴ The United States exports approximately one billion cubic feet of natural gas per day to Mexico; this flow volume doesn't materially change in the various scenarios.

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