HEAVY MOVABLE STRUCTURES, INC.
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Inspection and Repair of Louisiana Movable Bridges Damaged by Hurricanes Katrina and Rita

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DOUBLETREE HOTEL AT THE ENTRANCE TO UNIVERSAL ORLANDO
ORLANDO, FLORIDA

Introduction:

Hurricane Katrina:

In the early morning hours of August 29, 2005, hurricane Katrina approached the extreme southeastern portion of the State of Louisiana with winds exceeding 160 mph – a major category 5 storm. However, an incursion of dry air into the storm's southwest quadrant created a disruption in the storm's organization which began a rapid decrease in its sustained wind speed. By landfall later that morning at the Mississippi River Delta, the maximum sustained winds had decreased to 135 mph. As the storm approached the Mississippi and Alabama Gulf Coasts, the sustained winds had decreased to 125 mph. The storm was quickly diminishing in strength.

The hurricane experts tell us that the diminished wind speed may have spared Louisiana, Mississippi, and Alabama some wind damage, however, the storm surge, the bulge of water pushed inland by the northerly winds on the eastern side of the storm, the element of the storm that historically produces the most destruction, does not fluctuate so quickly. Generated during the approach of the hurricane, the storm surge that impacted the Louisiana, Mississippi, and Alabama Gulf Coast was that of a Category 5 hurricane. In some places, the storm surge recorded was in excess of 25 feet.

Hurricane Rita:

Less than one month later, in the early morning hours of September 24, 2005, hurricane Rita impacted the extreme southwest portion of the state of Louisiana with sustained winds in excess of 120 mph – a strong category 3 hurricane. Many of the Louisiana citizens that evacuated the Lake Charles area because of the approach of Rita were New Orleans area residents that had earlier evacuated to Lake Charles to avoid Katrina. Although not quite as strong as Katrina, Rita was still a major hurricane. Because its approach to the shoreline of Louisiana was relatively shallow, the storm surge flooded homes in Terrebonne Parish, about 100 miles east of where the storm made landfall.

Purpose of Paper:

When I started writing this paper, I realized that there were many issues related to the flooding of New Orleans that were hard to understand from the national news reports… even for local residents with a strong understanding of the geography and layout of the city. I began to think that had this natural disaster happened somewhere else, I would have been very interested in getting an explanation of what happened from the perspective of one of the locals. I therefore decided to add a brief discussion of "what happened" from my point of view.

In addition to this, the paper will investigate the following items:

- The Louisiana Department of Transportation and Development's (LA DOTD) methodology for inspecting the storm damage to our movable bridges.
- Types of damage and repairs performed.
- New design changes to help minimize damage to movable bridges from future storms.

Hurricanes 101:

Everyone who was raised either on the East Coast or the Gulf Coast becomes an “expert” at understanding hurricane terminology and predicting hurricane behavior and movement… at least in our own minds. For those who lead a more sedate and boring life away from the coast with only tornadoes, earthquakes, blizzards, and volcanic eruptions to worry about, the following are some basic hurricane facts and terminology that may help you understand some of the discussions later in the paper.

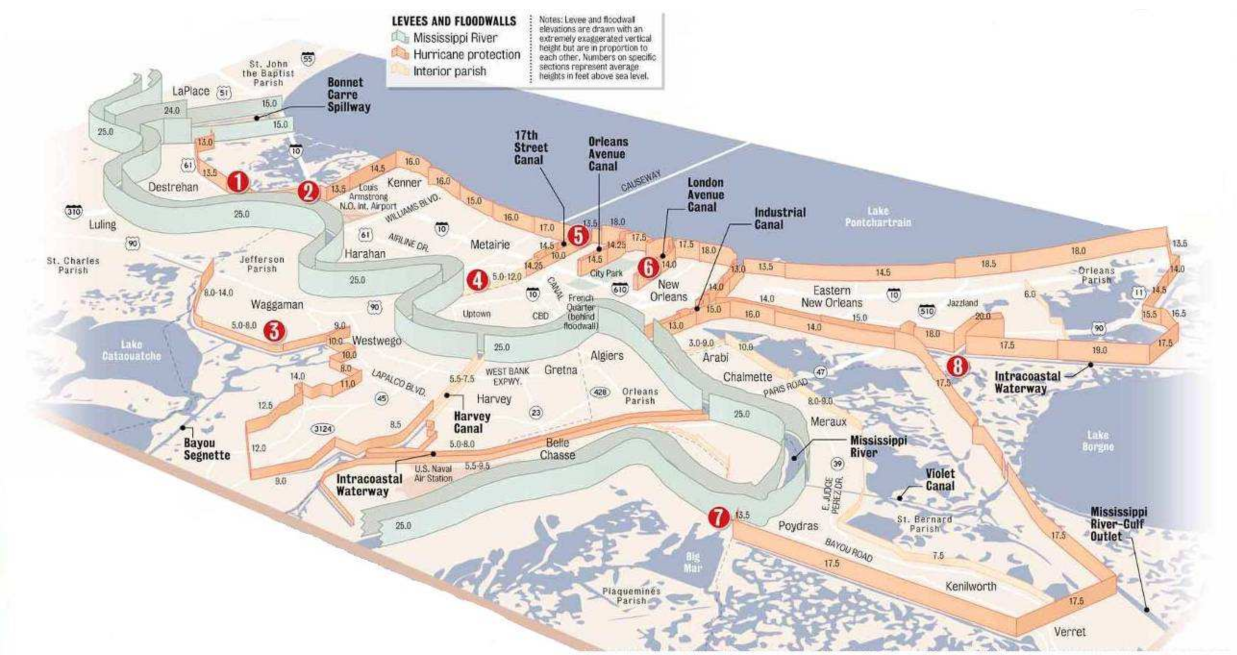
- A Hurricane is an intense low-pressure weather system with enclosed circulation in which the central core is warmer than the surrounding atmosphere. It must have sustained winds of at least 74 mph. In the northern Hemisphere of the globe, it has a counterclockwise rotation.
- Because of the counterclockwise rotation and the forward movement of the storm, the quadrant to the right of the forward motion is usually the strongest and most dangerous. This is usually the northeastern quadrant for storms that make landfall on the East or Gulf Coasts with a northerly or northwesterly heading. Often, areas just 50 miles to the left of the path of the storm, receive minimal damage. This is mainly because the storm surge that is pushed ahead of the storm by the winds on the right side of the storm inflicts more damage than the wind itself. Also, the wind on the left side of the storm at landfall is usually weaker than on the right side because it has already traveled over land.
- The Saffir-Simpson Hurricane Scale:

Category 1	**Category 2**	**Category 3**	**Category 4**	**Category 5**
74-95 mph	96-110 mph	111-130 mph	131-155 mph	156+ mph
4’-5’ Surge	6’-8’ Surge	9’-12’ Surge	13’-18’ Surge	18’+ Surge

Hurricane Katrina – What Happened to New Orleans?

For years, residents of Louisiana have been hearing reports from hurricane experts stating that if a hurricane was strong enough (category 4 or 5), and came inland at just the right angle, New Orleans would be under 15 feet of water. Hurricane Katrina was not that storm, but it may have been close enough.

A discussion of "what happened" must first begin with a discussion of the geographic location of New Orleans, and what flood control measures the state and local parishes have implemented to protect these areas. These are depicted in the following graphic.



Greater New Orleans Area: Levee System

To the west of the City of New Orleans is the Mississippi River and miles of land. New Orleans has no storm surge vulnerability to the west.

To the south is about 40 miles of coastal marshes and solid land (at least as solid as it gets in south Louisiana). A storm surge from any size hurricane approaching from this direction would likely be dissipated before reaching New Orleans. Even if it did, New Orleans is bordered on the south by the Mississippi River. These levees are 25 feet high and would stop any remaining surge that had approached from the south. That is not to say that there aren't many small communities to the south of New Orleans that could be devastated by a major storm surge approaching from this direction, but the city of New Orleans itself has no storm surge vulnerability to the south.

To the east, the areas known as the Lower 9th Ward, New Orleans East, and St. Bernard Parish are protected by the Intracoastal Waterway and the Mississippi River Gulf Outlet (Mr. GO) levees. The city of New Orleans proper is protected to the east by the levee bordering the Inner Harbor Navigation Canal known locally as the Industrial Canal. These levees are not as high as the Mississippi River levees, only 13-14 feet in some places, and are a point of vulnerability to these areas from the east.

To the north is Lake Pontchartrain. Levees that border the normally stable lake and associated drainage canals are similar in height (13-14 feet in some places) to those along the Intracoastal Waterway and Mississippi River Gulf Outlet that protect areas to the east. Again these levees are not as high as the Mississippi River levees. They were only designed to contain a category 3 storm surge, and they represent a weak point in the levee system protecting New Orleans.

The hypothetical storm that the experts predicted could flood New Orleans would have made landfall with a northwest heading and would have passed just south and west of New Orleans. This would have pushed the maximum storm surge from the Gulf, through Lake Borgne, and into Lake Pontchartrain. The levees protecting New Orleans on the east side and north side (lake side) of the city would be overtopped. The design height of these levees was only intended to contain the storm surge of a category 3 hurricane that followed the path described.

Katrina made landfall with a due north heading and passed about 20 miles east of the city. Even though Katrina was pushing a category 5 storm surge on her eastern side as described in the introduction of the paper, the heading of the storm did not allow the full effect of that surge to approach New Orleans either from the east or the north.

So what happened? If Katrina was not the storm the experts warned us about, why did New Orleans flood?

Basically, New Orleans was hit by two (2) different storm surges from hurricane Katrina. One (1) surge that approached through Lake Borgne from the east, and another surge that approached through Lake Pontchartrain from the north.

The storm surge that approached from the east was the equivalent of a category 4 storm, between 13-18 feet. This was high enough to overtop the Intracoastal Waterway, the Mississippi River Gulf Outlet, and the Industrial Canal levees, and it did so in many places. The real flooding in these areas, however, occurred from the failure of these levees after they were overtopped. These levees were not supposed to fail even though they were overtopped. This is a point of great concern especially since the failures happened in many locations, and were not just one or two isolated events. If the overtopped levees had not failed, it is very likely the storm surge would have dropped below the level of the levees quickly enough to prevent a major portion of the flooding in the eastern areas of the city.

The storm surge that approached from the north (Lake Pontchartrain) was only the equivalent of a category 3 storm, between 9-12 feet. This level was not high enough to overtop the Lake Pontchartrain, 17th Street Canal, or London Canal levees. However, one (1) levee failure on the 17th Street Canal and two (2) levee failures on the London Canal allowed a large portion of the city to flood. This was of great concern because these failures occurred before the surge water reached the levees design capacity.

So why did New Orleans flood? Simply put, the levees failed. Some failed before they were overtopped, and some failed because they were overtopped. However, none were supposed to fail even if they were overtopped.

New Orleans had survived the passing of Katrina with relatively minimal damage. Yes, part of the Superdome roof was torn off by the wind. Yes, many high rise buildings downtown had blown out windows. Yes, the city had no power, roofs were damaged, and trees were blown down. But those are all relatively minor issues that the city could have recovered from in a reasonably short period of time. The main thing is that the streets would have been mostly dry. Flooding from the overtopped Industrial Canal levees would have been relatively minor. New Orleans’ legendary pumping capacity was more than a match for the rainfall associated with the storm. The storm surge level in Lake Pontchartrain had not exceeded the design capacity of its levees.

That is not to say there would have been no flooding in the area. Other municipalities to the south and east of New Orleans that were more directly in the path of the storm such as Venice, Buras, Empire, Yscloskey, and Slidell were devastated by Katrina's storm surge. However, these communities knew how vulnerable they were, and all but the most extremely hard headed (this is the kindest way I can think of to describe them) of the residents evacuated ahead of the storm. While there was a large amount of property damage, very few lives were lost in these areas. In addition, if New Orleans had remained a functioning city, support and rescue for those areas could have come much more quickly. As it was, most of the support for the recovery was based out of Baton Rouge, sixty (60) miles up river, which made things much more difficult.

Many news reports are now implying that New Orleans shouldn't be rebuilt in its present location. They claim that its location and elevation renders the city perpetually susceptible to hurricane storm surge and wind damage. Let's look at each of these issues.

New Orleans' Elevation: Many residents in the New Orleans area are being prevented from repairing their flooded homes while government officials decide if the homes must first be raised above sea level. If the levees fail again or are overtopped by a larger storm surge, it won't matter if your house is 3 feet below sea level or 3 feet above sea level, it will still flood. Remember, some houses in the New Orleans area were completely submerged where even the roofs could no longer be seen. If the elevation of New Orleans is the problem, then the elevation of the entire city needs to be raised about 20 feet. This may sound crazy (and it is), but it still makes more sense than having everyone raise their houses an amount that won't keep them from flooding simply because it sounds bad that the city is below sea level.

New Orleans' Levees: So how should New Orleans be protected from hurricane storm surges? Some argue that since the levees failed, the levees can't protect New Orleans. I grew up 1½ miles from the Mississippi River near New Orleans. Every year during the spring thaw, the Mississippi River level rises and tests its levees, and they never fail. Why? Because these are serious levees built for a serious purpose. The Mississippi River levees are massive earth and concrete structures 25 feet high. If they needed to be 30 feet high to contain the Mississippi, they would be. Otherwise, New Orleans and many many other communities along the Mississippi River could not exist. River levels in New Orleans often reach twenty (20) feet with no threat of levee failure. Occasionally, when the river threatens to exceed this level, the Bonnet Carre Spillway is opened to allow excess water to bleed into Lake Pontchartrain before it reaches New Orleans. Sixty (60) miles up river in Baton Rouge, the levees often see thirty (30) foot levels that are of no consequence (the record high in Baton Rouge is 47 feet). If the same effort was put into the levees that border Lake Pontchartrain to the North, they would not fail and they would not be overtopped by any storm surge. That is not to say that this would not be a huge undertaking, but it would not be as huge as the original Mississippi River levees, and it certainly wouldn't be as difficult as relocating the city. It can be done, and it needs to be done to prevent another disaster like Katrina. In fact, some would say that there has already been enough money allocated to levee projects in the New Orleans area to build category 5 levees… but that's another story.

Wind Damage: What about wind damage due to the city's close proximity to the coast? Some building codes have been strengthened in recent years (particularly after Hurricane Andrew in 1992) that should allow houses/buildings near the coast to survive against higher wind loads. Even still, if a major storm makes a direct hit on New Orleans, there is going to be a large amount of wind damage. This, however, can be said about many other coastal cities including Galveston, Biloxi, Mobile, Miami, and Jacksonville.

Unless we are prepared to make a federal law that prohibits the location of any city within 100 miles of the coast, I don’t see why New Orleans should be singled out.

Damage Inspection of Louisiana Movable Bridges:

In my 15 years with the Department, we have not had an event that even came close to inflicting the amount of damage delivered by hurricanes Katrina and Rita. Even hurricane Andrew which was a category 4 hurricane as it approached landfall, and directly hit the central Louisiana Gulf Coast in 1992, produced much less damage than either Katrina or Rita.

In the past, damage to our movable bridges from hurricanes was less significant and on a much smaller scale. Our district maintenance forces could either effect repairs themselves, or hire a Contractor on force account to make the repairs. If the area was declared a Federal Disaster Area, the Federal Government would assist with repair funds. The LA DOTD Headquarters and our Bridge Design Section were mostly not involved.

When Katrina hit, the severity and scale of the damage made it obvious that inspection and repairs of the movable bridges would have to be organized at the Headquarters level. Since the entire southeastern portion of the state was declared a Federal Disaster Area, the Federal Highway Administration (FHWA) and the Federal Emergency Management Agency (FEMA) were to provide repair funds. FHWA was responsible for all Federal Aid Routes and a representative from FHWA had to perform/verify the inspection of each damaged bridge on these routes. FEMA was responsible for all other routes, and a representative from FEMA was to perform an inspection of each damaged bridge on these routes.

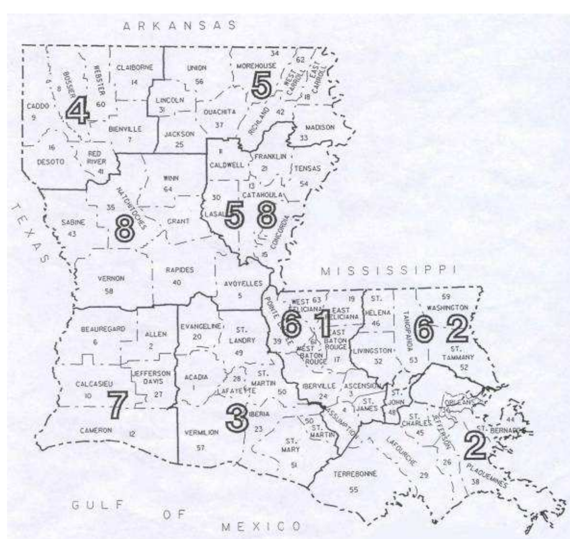
FEMA had no inspectors that were qualified to inspect movable bridges so they requested the FHWA inspectors to inspect the non-federal aid route bridges also.

In the days following Katrina, we assembled two (2) movable bridge inspection teams. Each team was comprised of the following members:

- **Structural Design Engineer:** LA DOTD Bridge Design Section
- **Mechanical Design Engineer:** LA DOTD Bridge Design Section
- **Electrical Design Engineer:** LA DOTD Bridge Design Section
- **Statewide Bridge Maintenance Engineer:** LA DOTD Statewide Maintenance Section
- **FHWA Representative**

The LA DOTD has divided the state into nine (9) Districts as shown to the right for construction and maintenance purposes. Hurricane Katrina damaged bridges in two (2) Districts, District 02 and District 62. Hurricane Rita damaged bridges in three (3) Districts, District 07, District 03, and District 02.

Our first step after Katrina passed was to locate all the movable bridges in the hurricane affected Districts, both on-system (state owned) and off-system (parish owned), and develop a plan between the two teams to inspect them all. This was a fairly large task. The LA DOTD has 47 movable bridges in the two districts affected by Katrina, along with another 31 off-system bridges.



LA DOTD Districts

During the inspections for Katrina, we sent out two teams a day. These teams did not always have the exact same people, but they always had the specialties listed above. Our intention was to have as many qualified personnel as possible become experienced with making these inspections. Also, we tried to keep the two teams in the same area. Each team would be tasked with different bridges to inspect, but they were to keep in contact with each other to monitor progress and render assistance if needed.

Based on reports from the Districts, we decided to inspect the bridges that had the easiest access first. This did not always mean the bridges that were the least damaged. The first area inspected was St. Tammany Parish on the northeast shore of Lake Pontchartrain. This area was hit very hard by Katrina's storm surge, but the surge waters receded quickly allowing us access.

The first day the inspection teams entered a District, they would have a meeting with the local District Maintenance Engineer. Since the district maintenance personnel had already visited all the bridge sites in the district at this point, the Maintenance Engineer could tell us which bridges received no damage and did not need to be inspected. District bridge maintenance personnel would then accompany the teams on the inspections to give information about conditions that existed before the storm; conditions that were not storm related damage. On some of our older structures, this was not always easily determined.

For Katrina, the system that worked best was to spend two days on the road making inspections, then one day in the office writing reports and recuperating. On inspection days, the teams would leave from Baton Rouge at dawn and would not return until near sundown. While in the field, the teams had to be careful about the time. Some of the areas inspected had curfews that prohibited movement after dark.

Communication in the field was difficult. Our vehicles did not have radios. Most areas had no cell phone coverage at all. In areas that still had a cell phone signal, attempted calls usually resulted in a recording stating that all circuits were busy. However, with perseverance, calls would eventually get through from these areas.

The Katrina inspections took about two weeks to complete, but the teams did not start their inspections until almost a week after the storm. With unfettered access to all the bridges, the inspections may have been completed in a week and a half. However, access in and out of some of the affected areas, as well as some security concerns, hampered our progress at times. We spent the fourth week after Katrina reviewing and modifying the inspection reports, initiating and organizing repairs to the bridges, regrouping a little bit, and watching in disbelief as hurricane Rita bore down on Louisiana's western coast.

Two days after Rita made land fall, the inspection teams were in the field. Reports from the Districts indicated that storm damage occurred as far east as Terrebonne Parish in District 02. Since there were many experienced inspection personnel at this point, the decision was made form three (3) inspection teams. Each team was assigned one of the affected Districts. This time, having experienced inspection teams, an established methodology, easier access, and fewer bridges to inspect (there are fewer movable bridges in the western part of the state), the inspections were completed in three (3) days.

Types of Damage and Repairs Performed:

There were two main types of damage encountered during the inspections. Storm surge damage and/or wind damage. Surge damage became very predictable. After a while, when you came upon a swing span that had been submerged by the storm surge, you knew exactly what damage had been done. Wind damage was a little less predictable. Sometimes barrier gates were blown down, sometimes they weren't. Sometimes the operator's house windows were blown out, sometimes they weren't. But for the most part, and as might be expected, wind damage to the structures was less significant than storm surge damage.

Wind Damage and Repairs:

The following pictures show examples of wind damage:

Company Canal Bridge: Vertical Lift, Houma, LA

Lapalco Blvd. Bridge: Harvey Canal, Jefferson Parish, Off-System, Semi Hi-Level, Double Leaf Bascule

Harvey Canal Bridge: Jefferson Parish, Double Leaf Bascule

<u>Repairs:</u> The repairs performed to fix wind damage are fairly straight forward and self explanatory. Whatever was blown down, blown out, or blown away was repaired or replaced.

Storm Surge Damage and Repairs to Swing Span Bridges:

Swing span bridges in Hurricane Katrina affected area.

Since the drive machinery, wedge machinery, and a good portion of the electrical system is located under the span on swing span bridges, they were particularly vulnerable to damage from storm surge.

Swing Span High Water Marks:

East Pearl River: St. Tammany Parish

Chef Menteur Pass: Orleans Parish

The picture to the left shows a water bottle that was caught in the bridge guard rail as the storm surge receded. The picture on the right shows the marsh grasses caught on the approach span. We estimated that the storm surge came just over the roadway on this bridge.

Bayou Bonfouca: St. Tammany Parish, High Water Mark

Many of the swing span bridges that were inundated by the storm surge had many parts of their mechanical and electrical systems submerged. This was of particular concern because, unlike normal flood water due to excess rain, storm surge water is salt water.

Swing Span Electric Motors:

Chef Menteur Pass Bridge: Electric Motor

Bayou Dulac Bridge (Houma): Electric Motor

Rigolets Pass Bridge: Electric Motor

Rigolets Pass Bridge: After Motor Repairs

Repairs: Because of the salt water, the decision was made that all electric motors that were submerged by storm surge would be rewound, not just reconditioned, and the bearings would be replaced. We were afraid that the motor windings might test OK now, and the bearings might look OK now, but would continue to corrode with time even though they had been cleaned.

The picture to the right shows how one district maintenance crew prevented damage to the span electric motor. At the Houma Navigation Canal Bridge, the district maintenance crew disconnected and raised the motor prior to the storm making landfall. This is a tricky proposition, however, because the bridge must remain operable until conditions deteriorate to the point that the operator is dismissed from duty.

Houma Navigation Canal:

Swing Span Gear Boxes:

Chef Menteur Pass Bridge: Submerged gear box

Rigolets Pass Bridge: Submerged gear box

East Pearl River Bridge: Gear set with cover

East Pearl River Bridge: Inside cover

Repairs: All submerged gear boxes were inspected for infiltration. If it was found that surge water had infiltrated the gear box, it was sent to a shop for cleaning and bearing replacement.

Swing Span Pivot Bearings:

Chef Menteur Pass Bridge: Pivot bearing - obvious evidence of submersion.

Bayou Bonfouca Bridge: Pivot bearing - obvious evidence of submersion.

Mermentau River Bridge: Pivot bearing - marsh grass, water, sediment, and rust are visible.

Rigolets Pass Bridge: Pivot bearing - marsh grass, water, sediment, and rust is visible

Repairs: All swing span bridges that that were submerged by storm surge were jacked and the pivot bearings were cleaned and inspected. Pivot bearings that were not damaged were cleaned and re-lubricated onsite. We recommended not opening the spans until this could be accomplished. However, out of necessity, some submerged spans were operated before the pivot bearings could be cleaned. Some bearings showed signs of damage, and were brought to a local machine shop to have a new surface cut. Although Louisiana has about 10 swing span bridges with spherical roller pivot bearings, all spans that were submerged were of the disk bearing type.

Swing Span Submarine Cables:

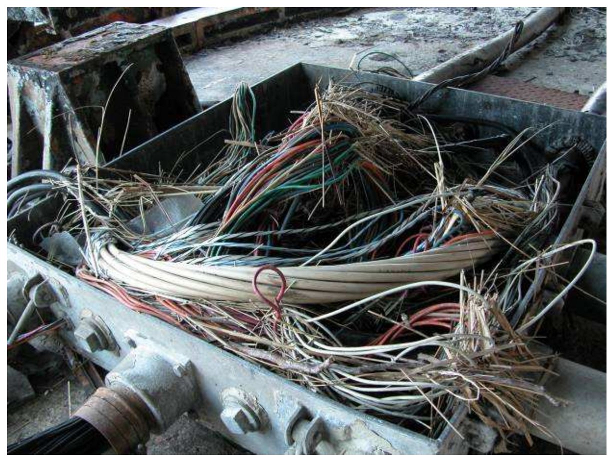
Chef Menteur Pass Bridge: Storm surge current pulled submarine cables from brackets.

Rigolets Pass Bridge: Storm surge current pulled submarine cables from junction boxes.

Repairs: Broken submarine cable brackets were replaced. Submarine cables that were pulled from junction boxes were assumed to be damaged and were replaced.

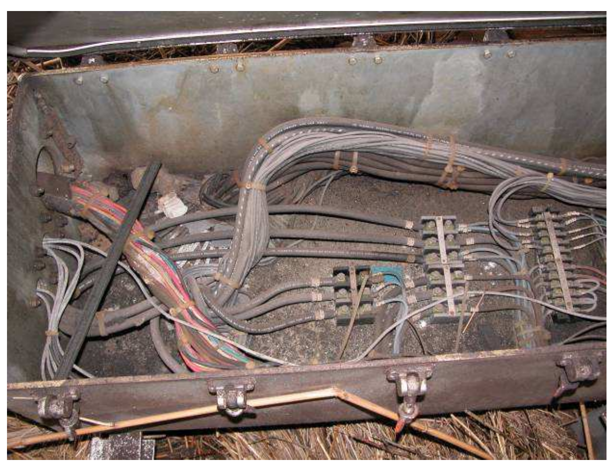
Swing Span Junction Boxes:

Chef Menteur Pass Bridge: Junction box.



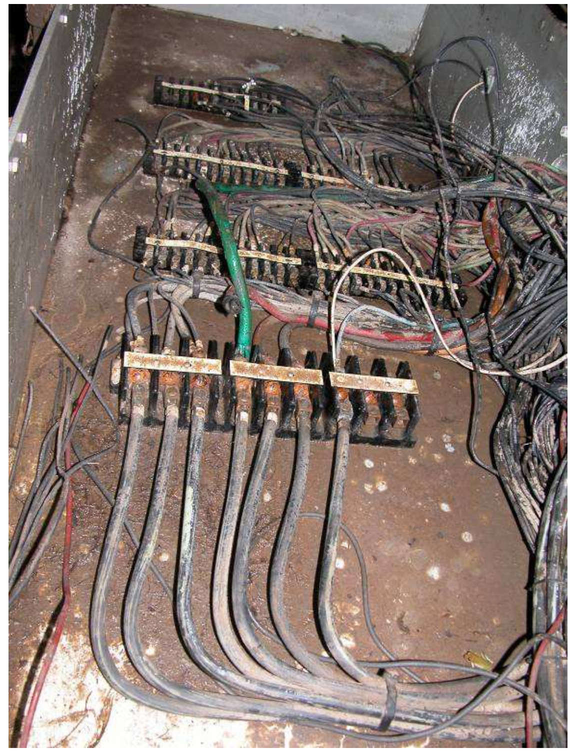
Rigolets Pass Bridge: Junction box.

East Pearl River Bridge: Junction box.



Bayou Dulac Bridge (Houma): Junction box.

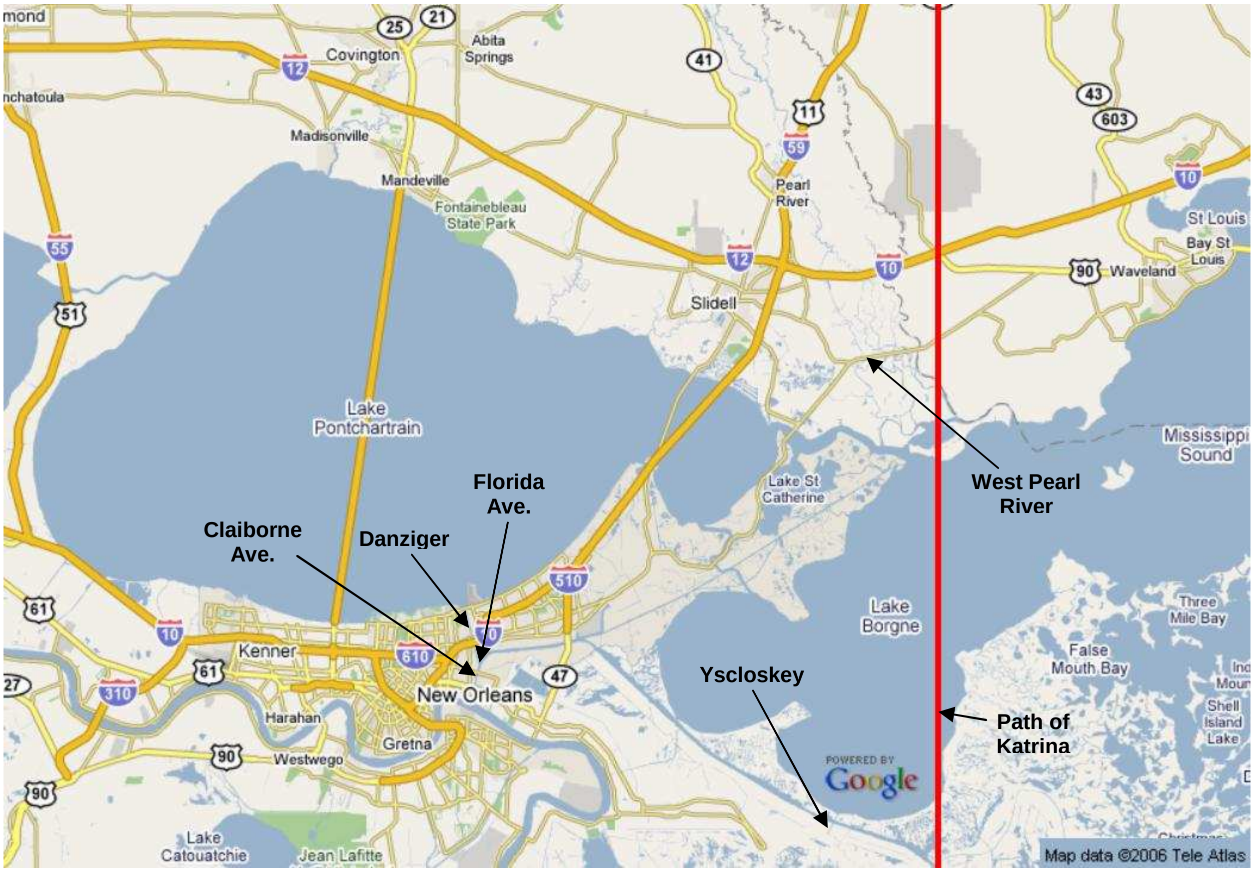
Houma Navigation Canal: Junction box.



Madisonville Bridge: Junction box.

Repairs: All submerged junction boxes were repaired as follows. Boxes were thoroughly cleaned onsite. All terminal blocks were replaced. All wires that terminated in the junction box were re-pulled and replaced. If submarine cables terminated in junction box, but were not pulled from junction box, they were cleaned and reused.

Storm Surge Damage and Repairs to Vertical Lift Bridges:



Vertical lift bridges in Hurricane Katrina affected area.

In general, the vertical lift bridges in the hurricane affected areas handled the storm surge well. Usually, just the span locks and some control limit switches were submerged and needed to be cleaned/repaired/replaced. One interesting discovery was that the counterweight ropes of all the vertical lift bridges were in effect "pressure washed" clean of all lubricating grease. By the time we made our inspections, they were already rusting significantly.

Yscloskey Bridge: Counterweight ropes

The one vertical lift span that suffered significant damage is the Yscloskey (pronounced "why closkey") vertical lift bridge. The town of Yscloskey is located in St. Bernard Parish, very close to the path of Katrina. This community bore the full brunt of Katrina's storm surge because it is located outside of the protective levee system.

The following information will focus on the damage to this vertical lift bridge.

Ycloskey Vertical Lift Bridge:

Yscloskey Vertical Lift Bridge:

Yscloskey: Span pushed up by storm surge.

Yscloskey: Skewed counterweight.

Yscloskey: Span locks tied back.

The Yscloskey Bridge is a small vertical lift span over Bayou LaLoutre built in 1956. Problems with the span locks at some time in the past had caused the district maintenance personnel to remove the span locks from the operation sequence, and tie the locks back with rope (middle right). This allowed the storm surge to float the span up and slip the counterweight ropes on the sheaves.

Yscloskey: Operator's House.

Yscloskey: Inside Operator's House.

Katrina's Storm Surge completely devastated the operator's house and the electrical system of the Yscloskey Bridge. Surge waters near the top of the house blew out the door and all the windows, knocked down the electrical switchboard, and flipped over the control desk. Marsh grass and storm debris filled the inside of the house.

Yscloskey: Generator and sewage treatment plant platform.

Yscloskey: We found the generator, but not the sewage treatment plant.

The picture on the left shows the platform that once held the backup generator and the sewage treatment plant for the bridge. Katrina's storm surge wiped it clean. After a little looking around, we did locate the generator about 75 feet away mixed in with other storm debris.

Repairs: Currently, the Yscloskey bridge is the only on-system (state owned) movable bridge in Louisiana still under repair. In fact, at the writing of this paper, no repairs have been made to this bridge at all. There are two reasons for this. First, the town of Yscloskey was so decimated by the storm that the population now is practically zero. Therefore, there is very little pressure to get the bridge back in operation. Second, the damage to this bridge was so extensive that, unlike the repairs to the other damaged bridges which were performed under force account, it was decided that the repairs to this bridge should be competitively bid. The contract was recently let, and the repairs will begin soon.

Virtually the entire electrical system will be replaced including switchboard, control desk, backup generator, wires and conduit, and limit switches. Believe it or not, the operator's house will be repaired and not replaced. It will have all new plumbing, including a new sewage treatment plant. It does not appear that there is structural damage to either the span or the towers. The mechanical drive equipment on top of the towers was not damaged.

New Design Changes:

Now that the damage from the hurricanes has been repaired, our biggest challenge is to determine what changes can be made to future movable bridge designs that would limit the damage suffered during one of these hurricane events.

Water Levels: Normally, the decision to build a movable bridge is made because the limitations of the location of the waterway crossing make a fixed overpass inappropriate and/or not cost effective. Often the Structural Engineers want to keep the span elevation as low as possible, and the Mechanical/Electrical Engineers have to fight to keep their equipment above the 100 or 50 year flood levels. The storm surges from Katrina and Rita far exceeded these levels, and I do not believe it is appropriate to try to design for those levels in all cases. However, for new movable bridges that are located close to the coast, and are not behind an adequate levee system, some design changes can help minimize the damage.

Swing Span Pivot Bearings: In Louisiana, we like to use swing span bridges wherever possible. They are simple to construct, inconspicuous, and significantly cheaper than either vertical lifts or bascules. However, as we saw with the hurricanes, they are more vulnerable to high water due to their low profile. Our standard pivot bearing housing design has only a dust seal. Because of this, storm surge water, sediment, and marsh grass infiltrated the bearings when they were submerged. We have already started including better seals on our new pivot bearing housing designs that we hope will prevent infiltration in the future.

In fact, we are starting to look at what we can do to make all the Mechanical/Electrical equipment more resistant to submersion. In a lot of cases, it’s not practical. However, some ideas include using submersible hydraulic cylinders and locating junction boxes up in the span.

Swing Span Hydraulic Power Units (HPU): In general, we no longer use rack and pinion gear drives on our swing span bridges in Louisiana. All our newer swing spans are hydraulic. Our current design had two HPUs, one located on the pivot pier deck to drive the span cylinders, and one up in the span to drive the wedge cylinders. Even though the difference in elevation between the two HPUs may be only 4-5 feet, in many cases that was the difference between one HPU being submerged by the storm surge and the other one remaining above it. Our new designs are combining the two HPUs into one and locating it up in the span. While this may not prevent the HPUs from being submerged in all cases, we hope that many more will stay above hurricane storm surges in the future.

Backup Generators: Our current Operator’s House design is a two story structure that has the mechanical room with the backup generator on the lower level and the operator’s control station on the upper level. It is located adjacent to the movable span for visibility purposes. In many locations, this arrangement is fine and does not need to be changed with the exception of raising the elevation of the house a few more feet based on surge levels experienced at that location during Katrina and Rita. However, we did have some coastal area bridges where the only piece of equipment submerged by the storm surge was the backup generator. This was usually on older bridges that had a separate mechanical building housing the backup generator. These separate mechanical buildings were usually located on the bridge right-of-way prior to the approach spans, and were therefore often at a lower elevation than the rest of the Mechanical/Electrical equipment on the movable spans. Frustratingly, we would have a bridge that was not damaged by the storm and could operate, but since the local utility power was out, and the backup generator had flooded, the bridge could not open. In the future, and at very select locations, we may look at placing the backup generator high up on a separate platform that will keep the generator from flooding even in a severe storm surge event.

In a related issue, some of the district maintenance units have their backup generator set to automatically start when a local power failure is detected. This is great for normal power outages of short duration in which the bridge remains manned. However, as a hurricane approaches, the bridge operator's are pulled off the bridges, and allowed to seek refuge from the storm. It may be several days after the storm passes before conditions allow the operators to report back to the bridge. If the local power has been out for that period of time, and it often has, the operator finds that the generator has already burned all its fuel. Under these conditions, it can often be difficult to get more diesel fuel out to the bridge sites. The solution to this problem is simple and complex at the same time. The operator should set the generator from automatic to manual before he/she leaves the bridge. However, since this event happens so rarely, and since operators can change frequently, it can be difficult to make sure all the operators know to do this.

Summation:

Louisiana had 33 on-system (state owned) movable bridges damaged in the one two punch that was Hurricanes Katrina and Rita. Another 10-15 off-system (parish owned) movable bridges received enough damage to qualify for FEMA repair funds.

The LA DOTD is not overseeing the repairs to the parish owned bridges, so I could not get accurate figures on the cost to repair them. However, since the cost to repair the state owned bridges was right around $10,000,000, I believe it would be safe to say that the total cost to repair all the movable bridges in Louisiana was less than $15,000,000.

Compared to the $100 billion plus number being talked about for the total recovery effort, this sounds very reasonable.