



Interdependence of Critical Energy Infrastructure Systems

Security and Assurance of the North American Energy System. Woodrow Wilson Center: Cross Border Forum on Energy Issues.

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Is Energy Infrastructure Concentration An Asset or Liability?

- **Concentration of infrastructure along the Gulf of Mexico ("GOM") is an asset not liability.**
- **While many areas of the Gulf South will take years to be rehabilitated from the 2004 AND 2005 tropical activity, the energy sector has been able to take rebound in a matter of months from the most comprehensively destructive set of storms in its history.**
- **Despite concentration of assets, the overwhelming majority of all energy infrastructure was rehabilitated in less than 45 days after the events of 2005 – there is probably no place in the world where that kind of restoration activity could have been done in that amount of time.**
- **Emphasis should be on developing policies that help insure infrastructure and quickly rehabilitate infrastructure in concentrated areas. -- "Bend don't break"**

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How Concentrated is Activity on the GOM?

The Gulf of Mexico:

- **Supports 30 percent total domestic crude oil production and 20 percent total natural gas production.**
- **Provides over $6 billion in federal royalties and fees.**
- **Supports 45 percent of total U.S. refining capacity (62 percent east of the Rockies)**
- **Home to the last greenfield refinery in U.S. (Garyville, LA, 1975)**
- **Supports 60 percent of total crude imports (LOOP supports 15 percent alone).**
- **Home to 43 percent of the SPR storage capability.**
- **A large share of the refining, pipeline and petrochemical industry in the U.S.**
- **Most of the pipeline capacity in U.S. originates in the GOM (25,000 miles in LA alone)**
- **Home to the Henry Hub.**
- **The largest natural gas users in the world (LA's industrial and power generation use as large as China)**

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Hurricanes and Energy Production, Processing, and Transportation

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Summary on Impacts of Hurricanes

- Clearly drove home what a natural disaster-created event could do to the energy sector – real world "worst case event" -- happened in the worst possible area (GOM) at the worst possible time (summer).
- Hurricanes were incredibly destructive to energy business. Catastrophic destruction experienced in all sectors (infrastructure categories) in the region. Hard to believe that a man-made event could be as broad.
- Hurricanes clearly showed the interrelationship of all types of energy infrastructure in the Gulf – the "4 Ps" – production, processing, pipes, and power.
- Hurricanes impacts were felt nationally and internationally – drives home importance of Gulf coast and critical energy infrastructure.

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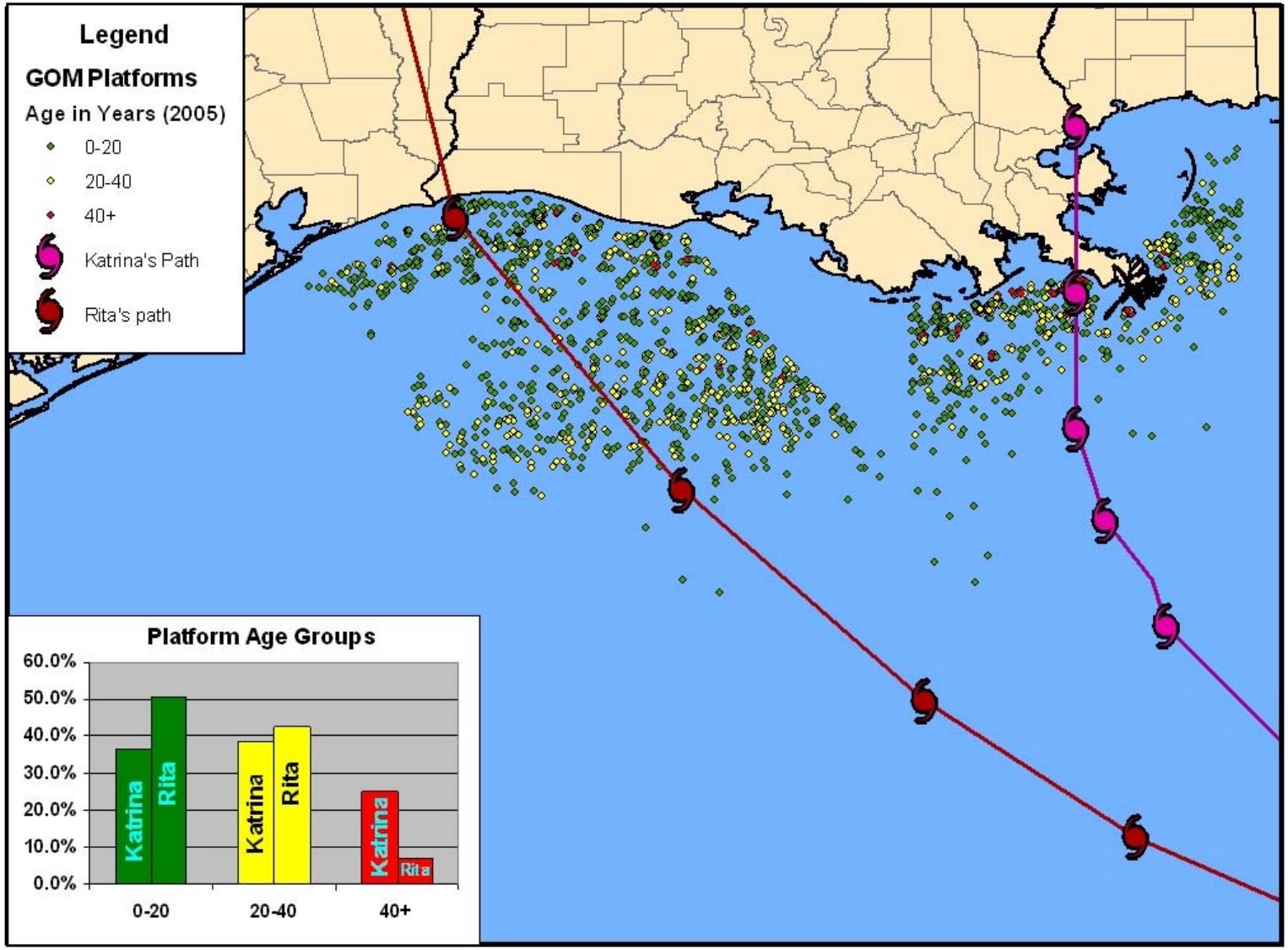
Platforms/Structures Impacted by 2005 Hurricanes



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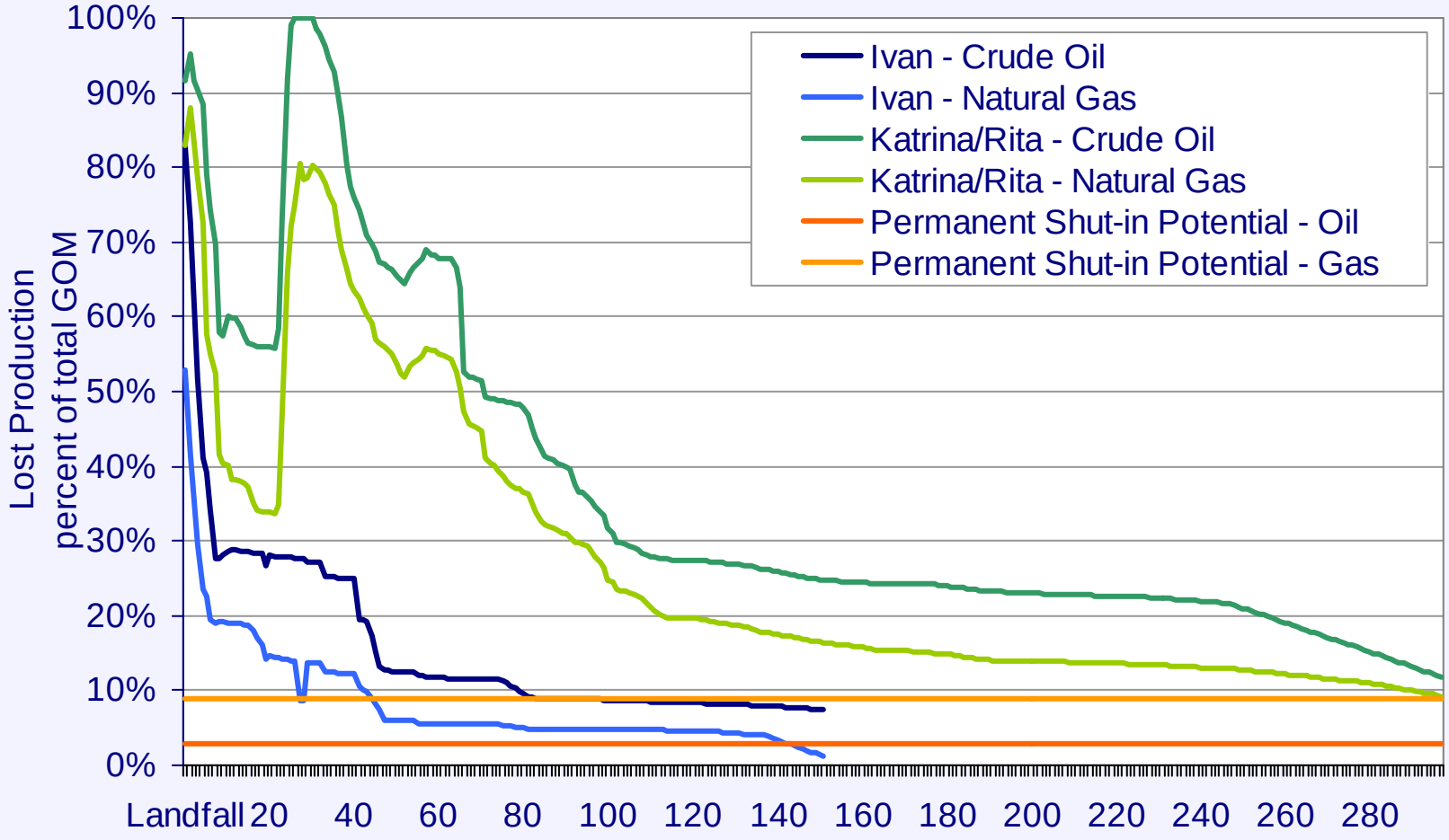
Estimated Return of Existing Crude Oil and Natural Gas Production

As of June 2006, there was some 936 MMcf/d and 179 MBBl/d of shut in gas and oil production. In total some 800 Bcf of gas shut in and 165 MMBbs of oil shut in from the hurricanes.



Note: Shut-in statistics for Ivan were no longer reported after 150 days. The last shut-in statistics for Katrina and Rita were published on June 21, 2006 (the 296th day after Katrina made landfall).

Source: Minerals Management Service

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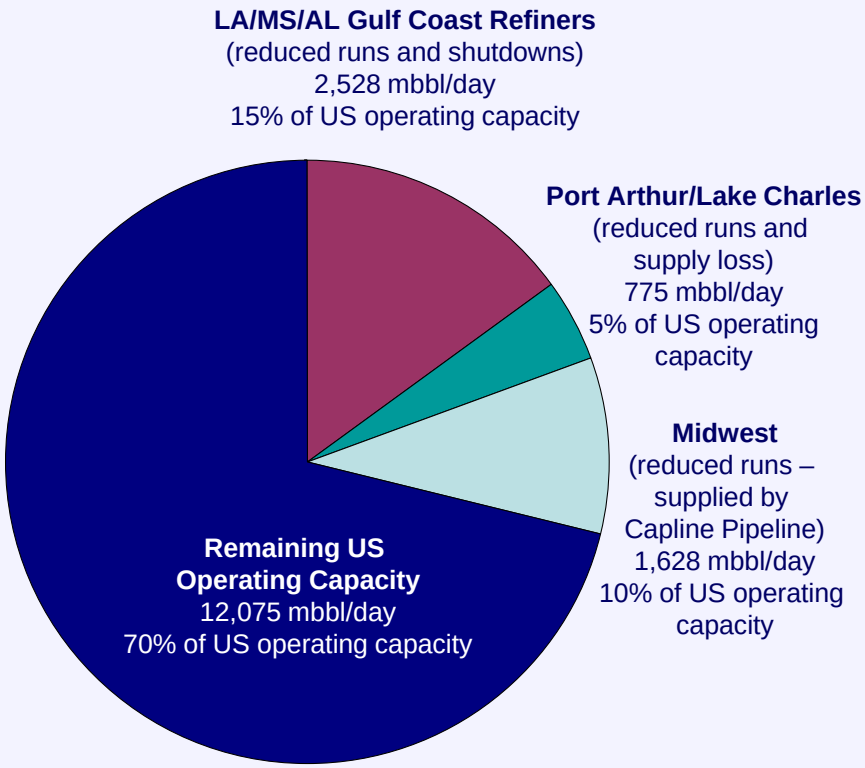
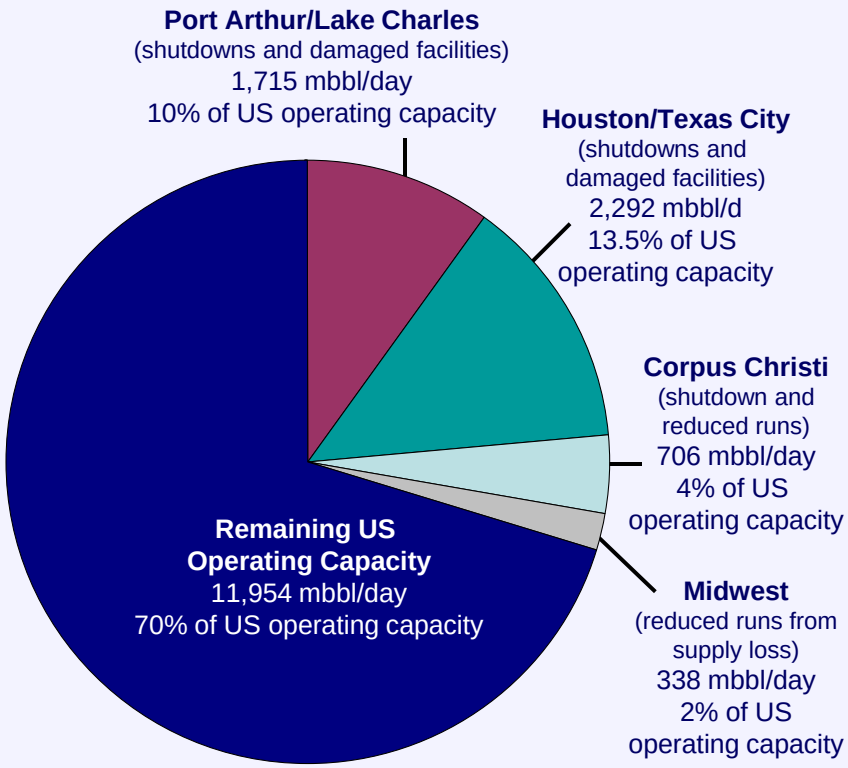
Total Immediate Refinery Impact

Hurricane Katrina



Total Refinery Impact
4,931 mbbl/day
30% of US operating capacity

Hurricane Rita



Total Refinery Impact
5,052 mbbl/day
30% of US operating capacity

Source: Energy Information Administration, Department of Energy

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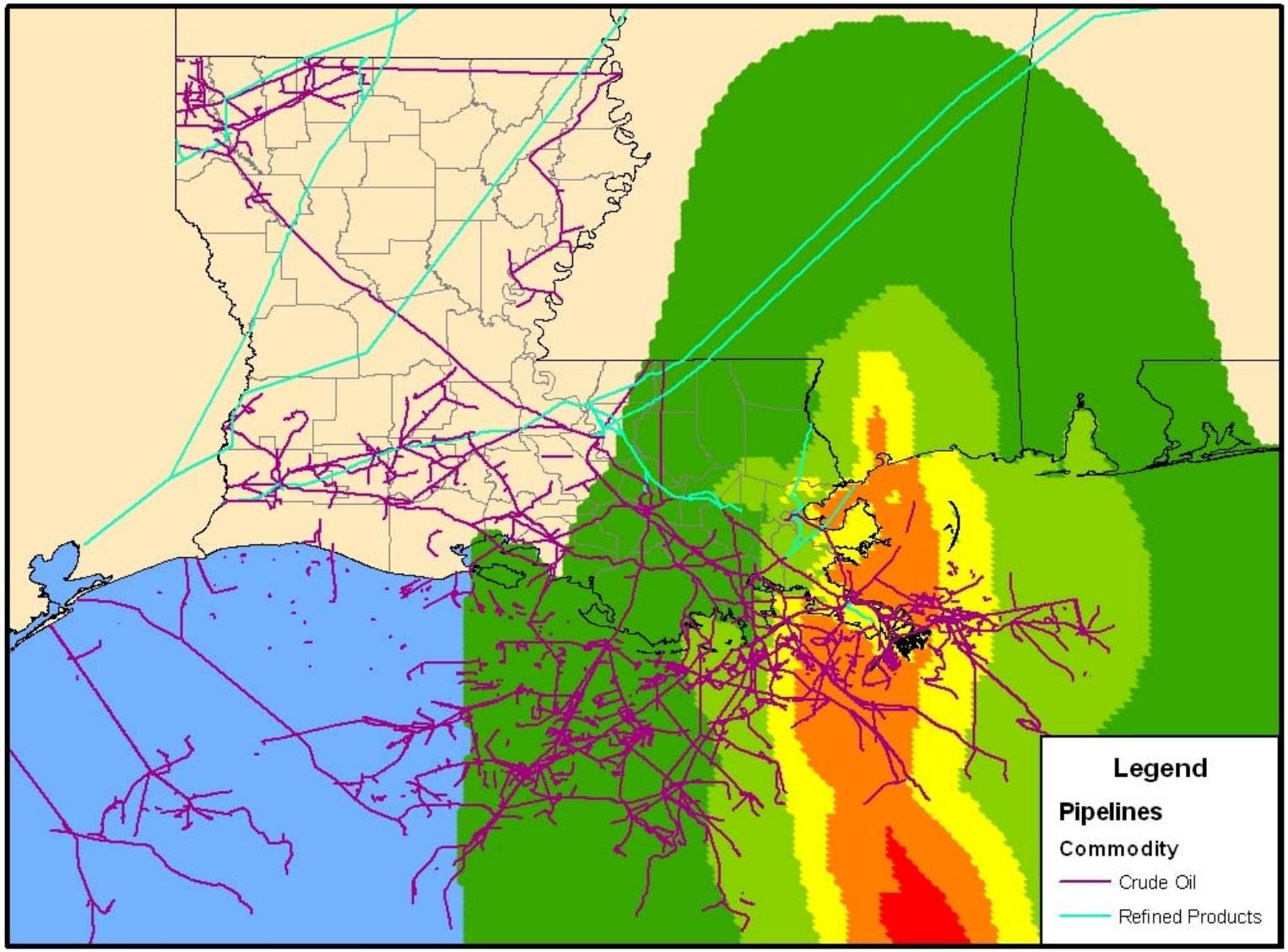
Crude and Product Pipelines Impacted by Katrina



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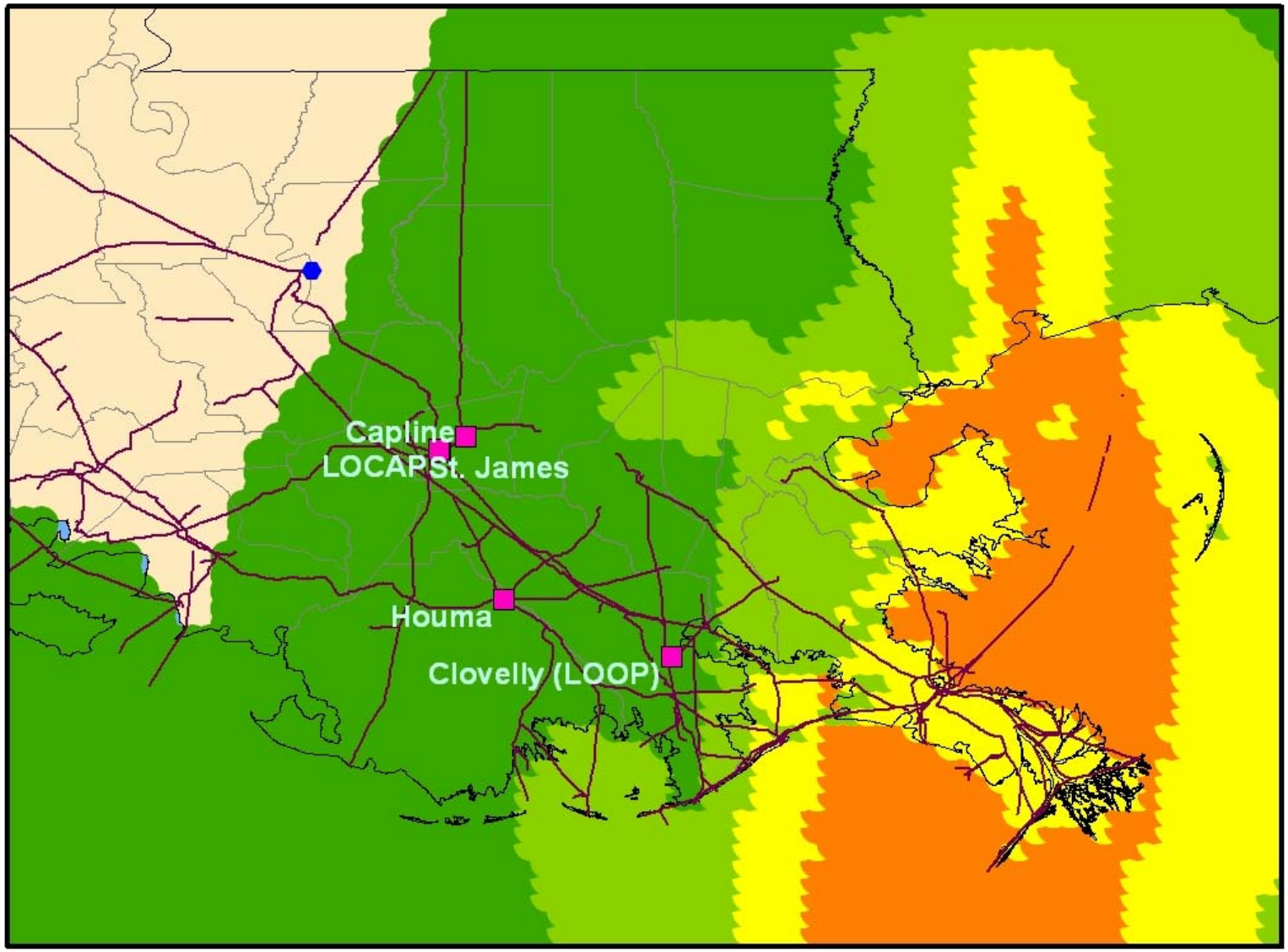
Critical Terminals Impacted by Katrina



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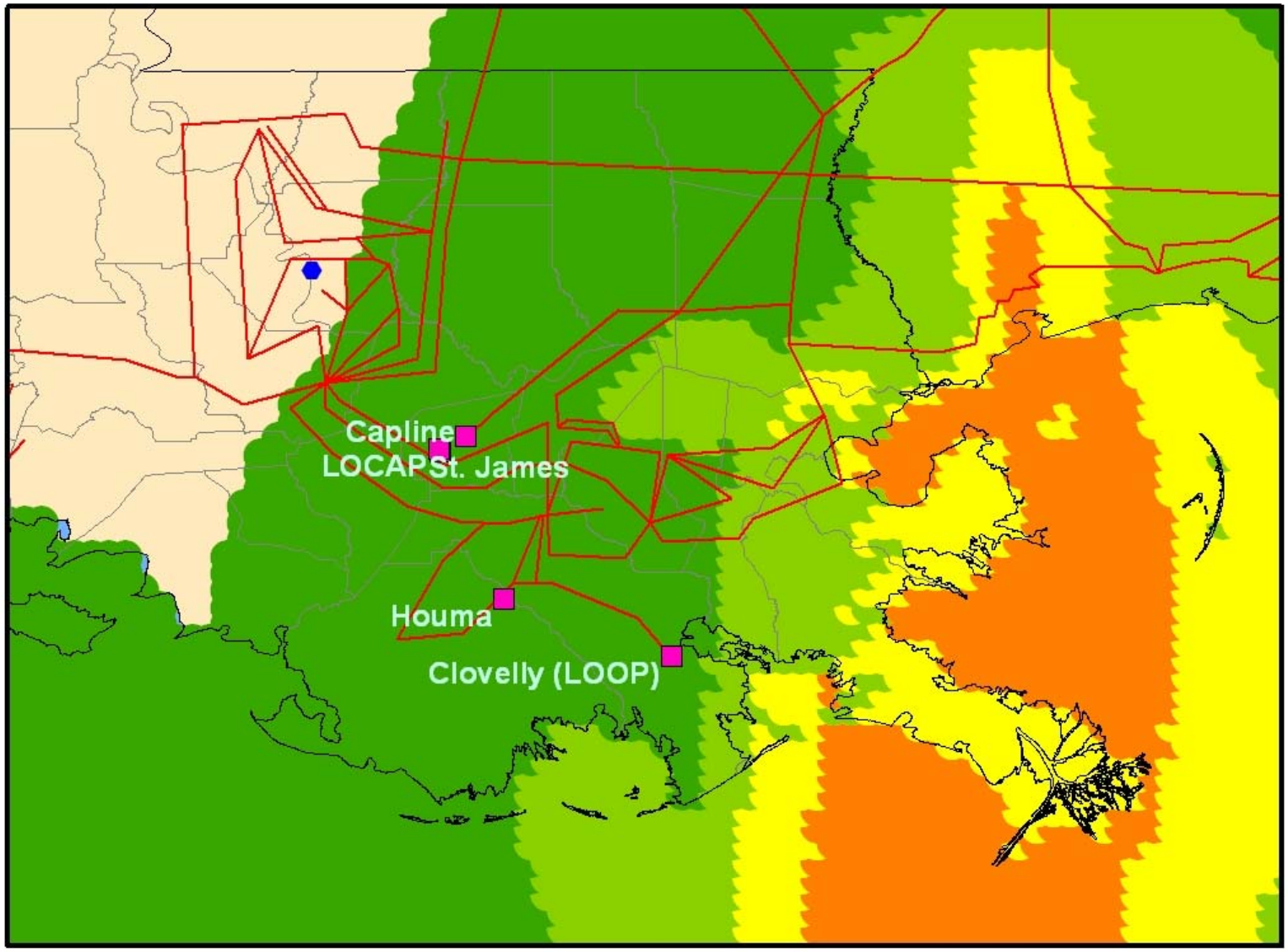
Critical Electricity Transmission Lines Impacted by Katrina



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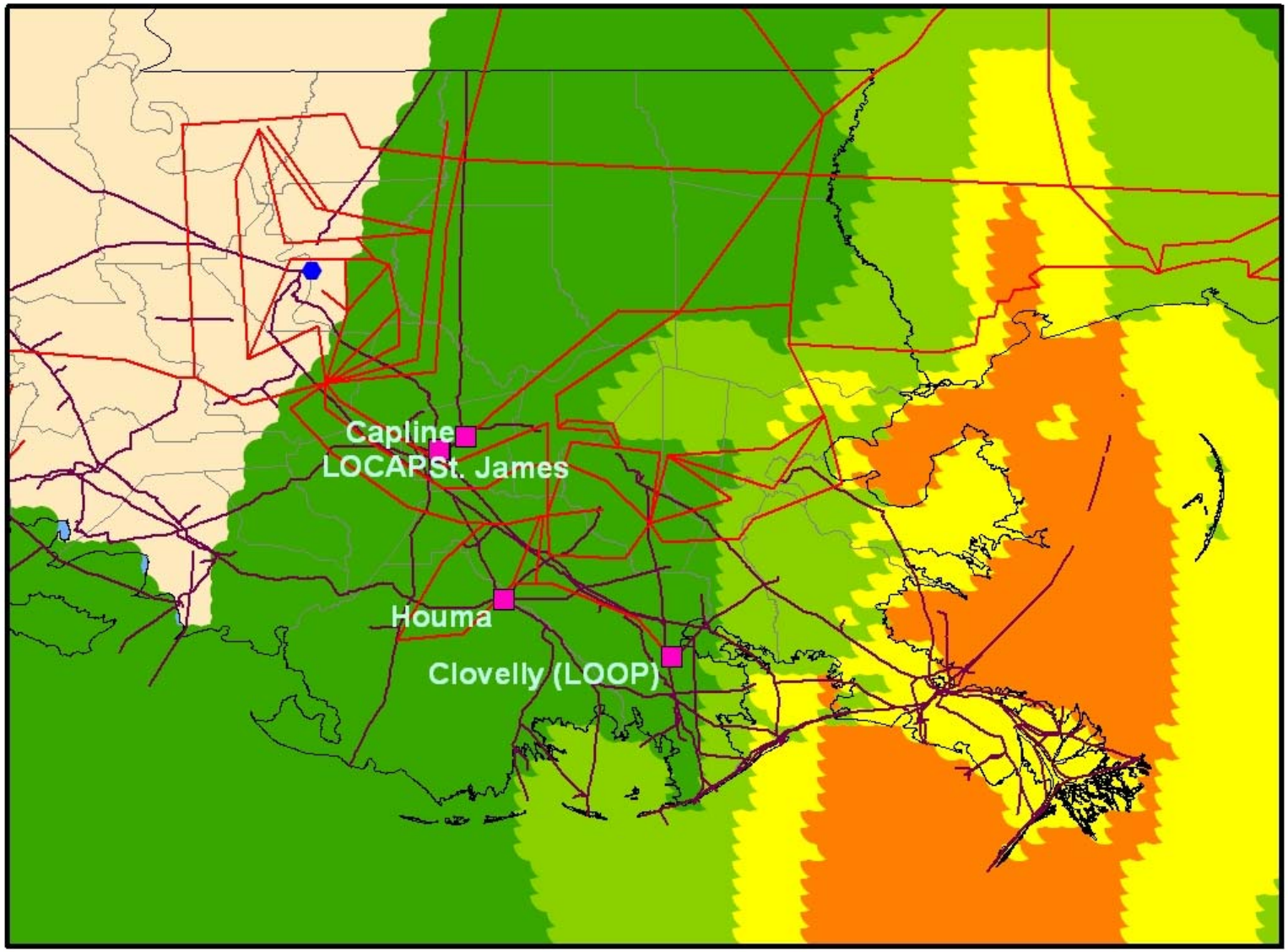
Critical Terminals and the Power-Pipeline Infrastructure



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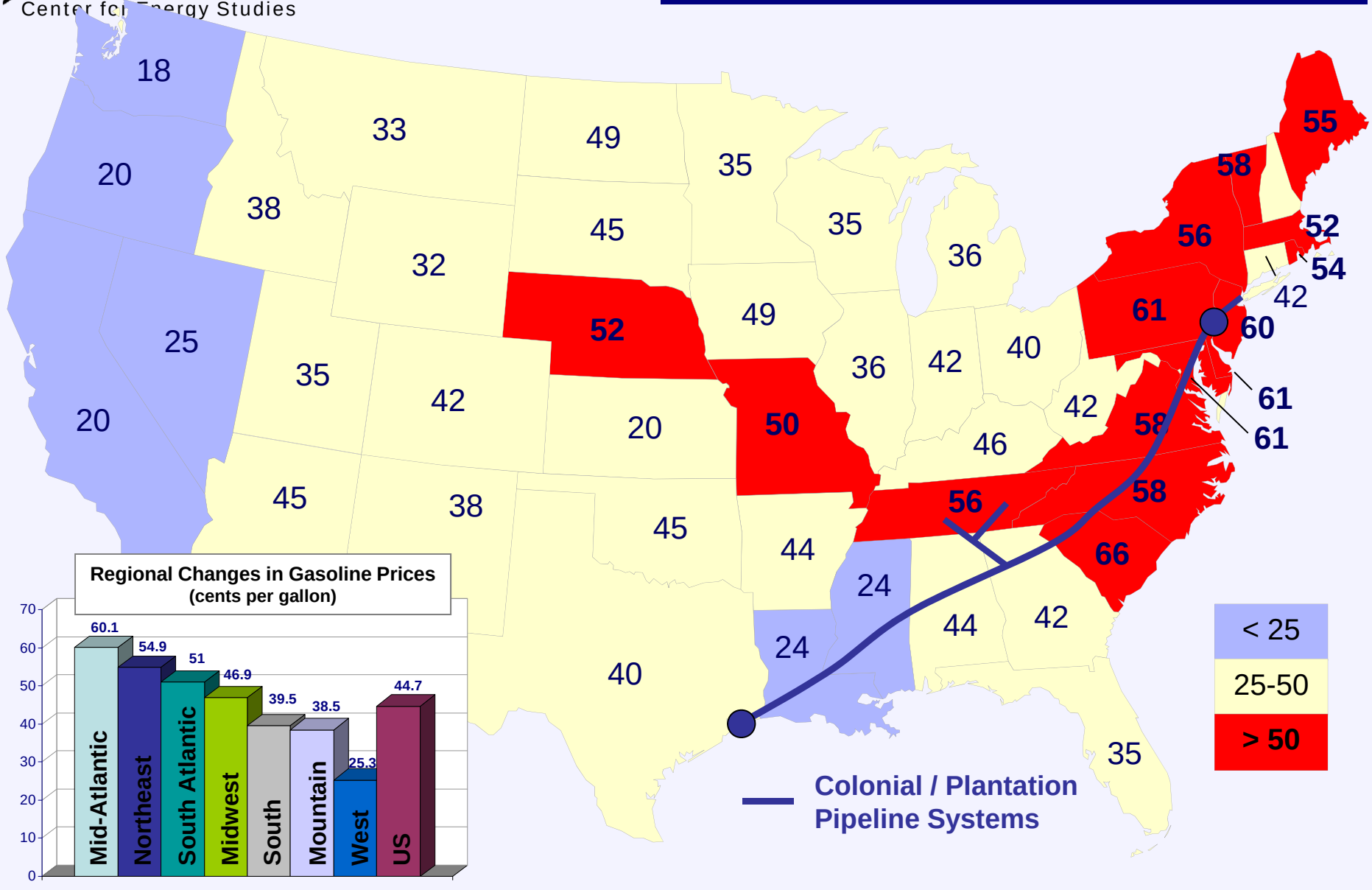
Gasoline Price Increases
August 30, 2005 to September 6, 2005



Regional Changes in Gasoline Prices
(cents per gallon)

Source: American Petroleum Institute

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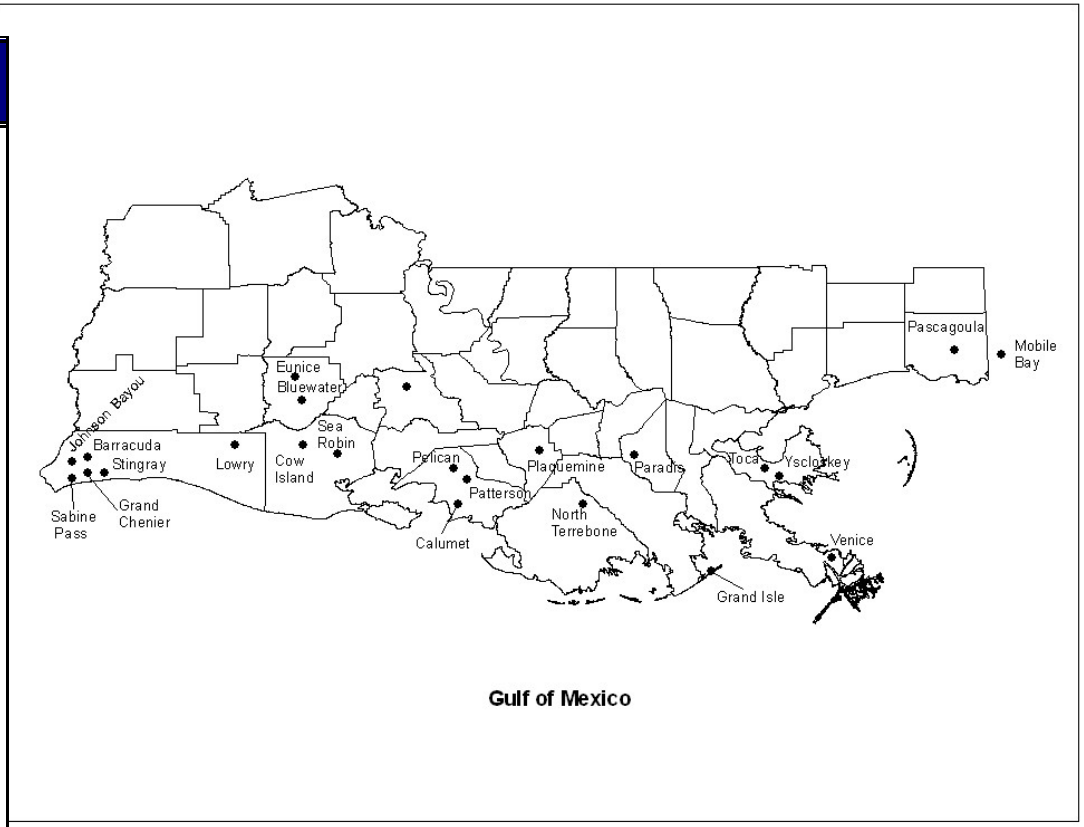
Number of Natural Gas Processing Facilities Out

Outages at gas processing facilities throughout all of south Louisiana was one of the more unique aspects of the combined hurricanes.

State/Company	Facility	Gas Capacity (MMcf/d)
Alabama		
Duke Energy Field Services	Mobile Bay	600.0
Shell Western E P Inc	Yellowhammer	200.0
Louisiana		
East Louisiana Plants		
Venice Energy Services Co LLC	Venice	1,300.0
Enterprise Products Operating LP	Toca	1,100.0
Dynegy Midstream Services LP	Ysclosky	1,850.0
West Louisiana Plants		
Dynegy Midstream Services LP	Barracuda	225.0
Dynegy Midstream Services LP	Stingray	305.0
BP PLC	Grand Chenier	600.0
Williams Cos	Johnson Bayou	425.0
Gulf Terra Energy Partners LP	Sabine Pass	300.0
Central Louisiana Plants		
Amerada Hess Corp	Sea Robin	900.0
Duke Energy Field Services	Patterson II Gas Plant	500.0
Dynegy Midstream Services LP	Lowry	300.0
Enterprise Products Operating LP	Calumet	1,600.0
Enterprise Products Operating LP	Neptune	650.0
Gulf Terra Energy Partners LP	Cow Island	500.0
Gulf Terra Energy Partners LP	Pelican	325.0
Marathon Oil Co	Burns Point	200.0
Norcen Explorer	Patterson	600.0
Mississippi		
BP PLC	Pascagoula	1,000.0
TOTAL		**13,480.0**
TOTAL GOM CAPACITY		**20,285.0**
PERCENT OF TOTAL GOM		**66.5%**



Source: Oil and Gas Journal; Energy Information Administration, Department of Energy

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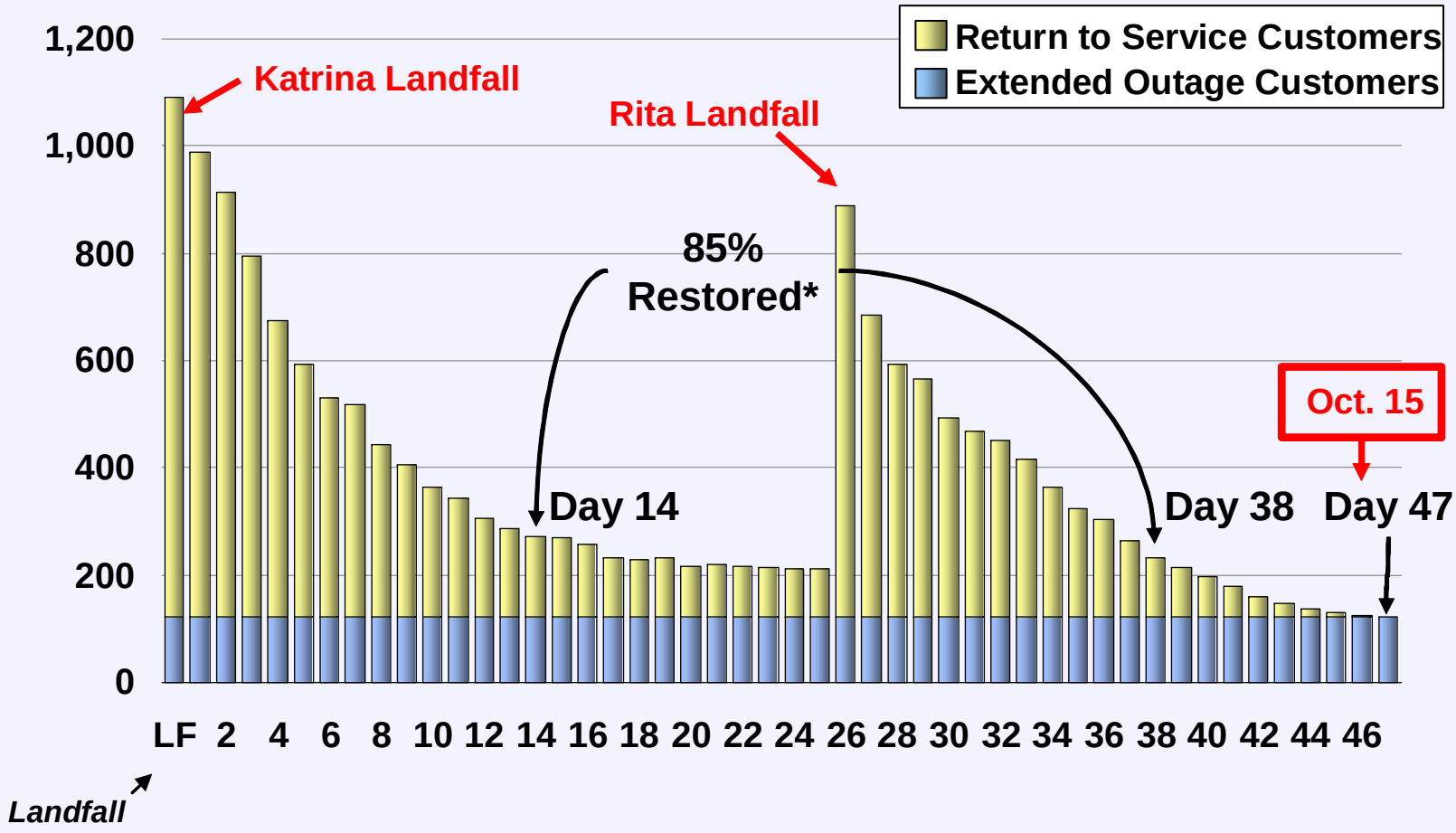
Power Outages From Hurricanes

Damage to power infrastructure (transmission) extensive. Restoration was monumental and impressive, but still created "nervous" moments for other energy infrastructure.



Source: Entergy Corp.

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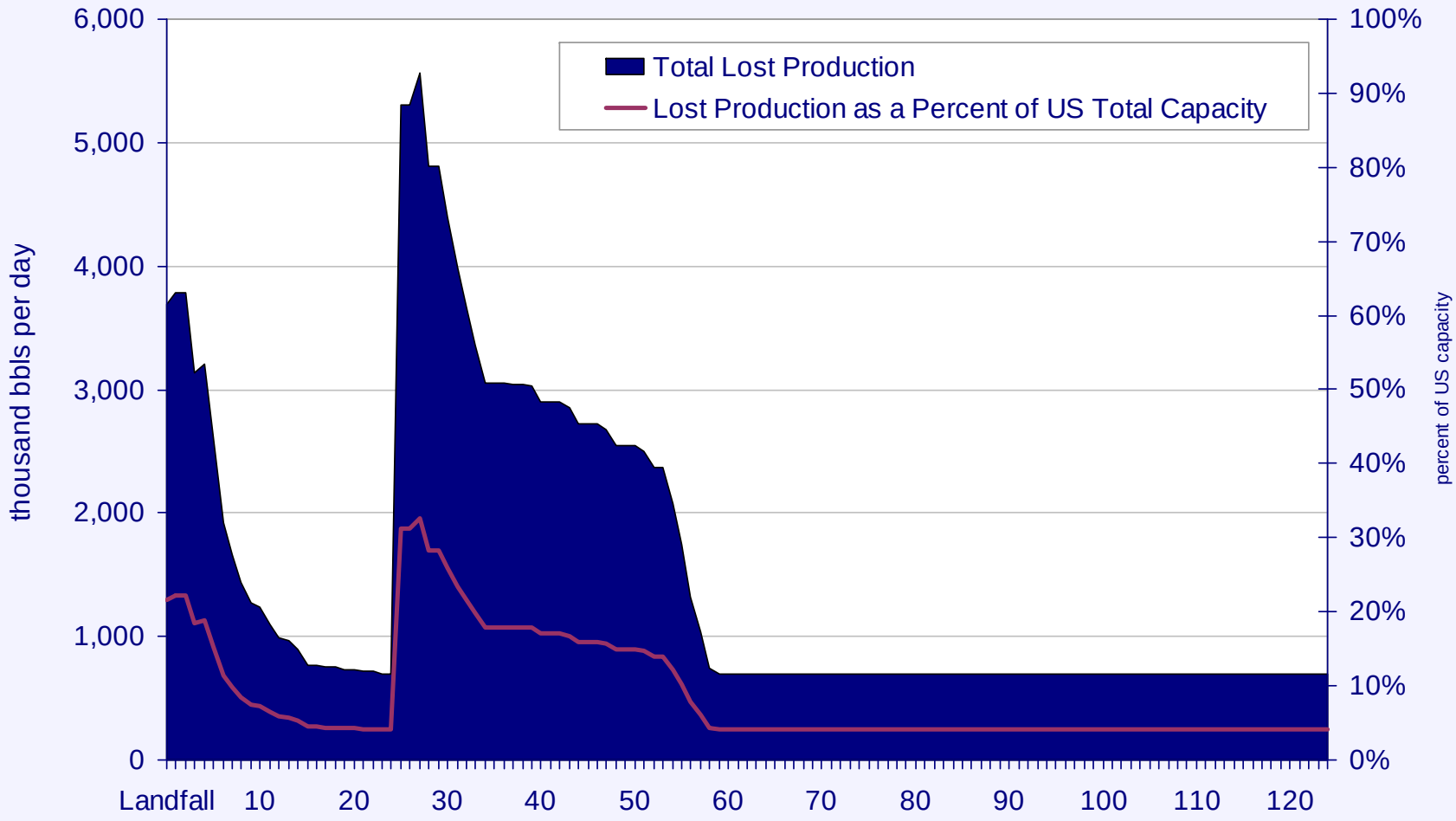
Estimated Decrease in Refining Production from both Katrina and Rita– First 120 Days

Refining capacity restoration closely follows power system restoration, which in turn have direct impacts on refined product markets.



Source: Assumes 95 percent capacity factor; assumes 4 week recovery for facilities damaged by Rita.

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Proven System Resiliency

- All refineries seriously impacted by the hurricane are operational.
- Most gas pipelines have been repaired or alternative routes/service has been secured for most shippers.
- All petrochemical facilities are operational.
- All service basis and ports are operational. Some in MS at 70-80 percent capacity.
- Electricity restored to all homes that can take service within 2 weeks (some 2.7 million without power Day 1 after Hurricane Katrina)
- To date, all but one gas processing facility is back on line.
- Most all crude oil production and natural gas production is back on line in GOM
  - -- Crude oil shut-in: 179 MBbls/d (12 percent).
  - -- Natural gas shut-in: 936 MMcf/d (9 percent).

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Potential Ongoing Threats to Critical Energy Infrastructure Development

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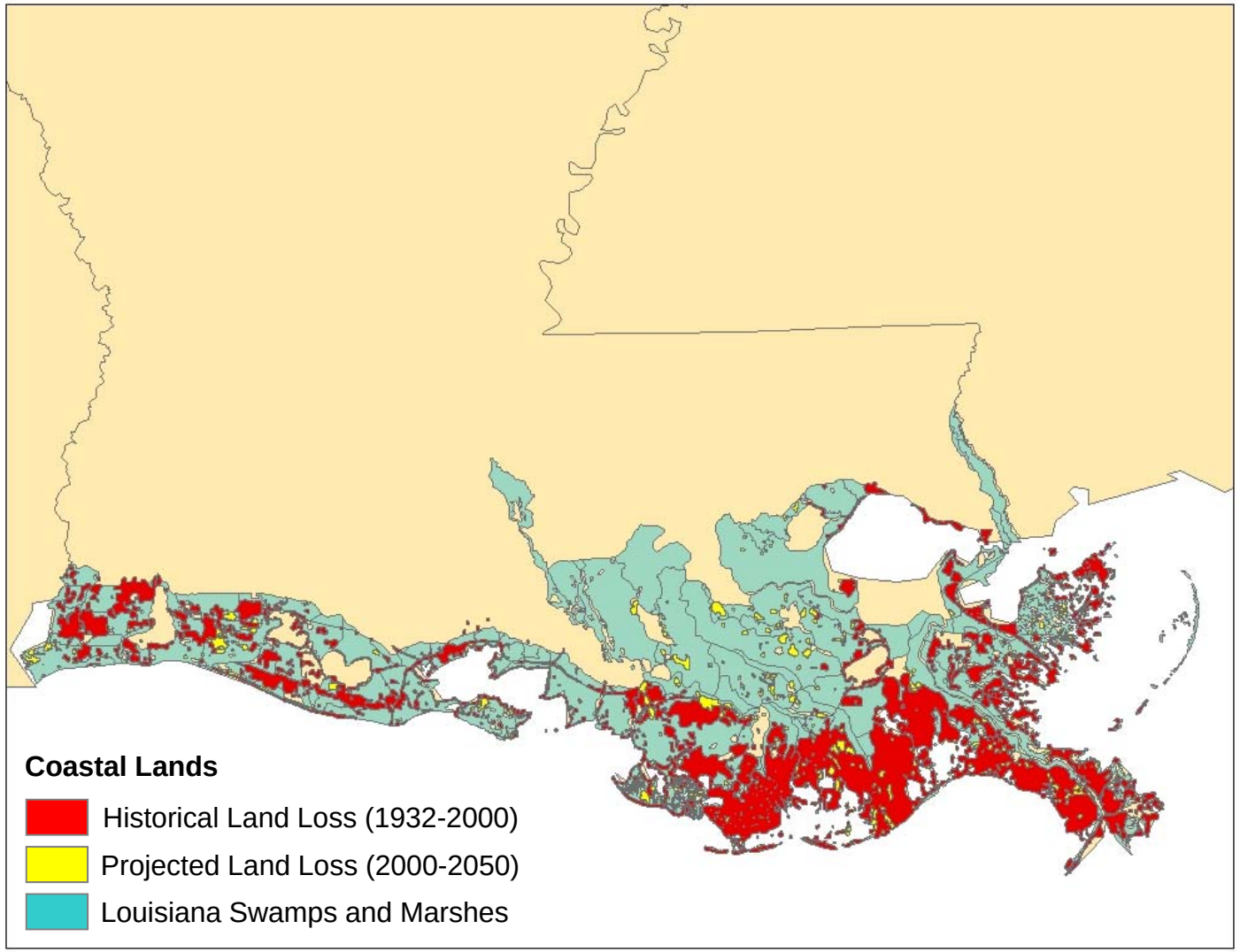
Coastal Land Loss in Louisiana



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What are the Likely Impacts of Coastal Erosion

- **Gradual coastal erosion will increase the cost of operating in coastal areas. This will require higher O&M costs, faster depreciation (corrosion/exposure), and capital costs (upgrade and new investments). A more gradual, longer term, and hidden cost to American consumers.**

- **Economic impacts of catastrophic events are larger than otherwise given the greater flooding and storm surge intrusion. A much larger and recognizable (although debatable) impact. Richardson/Scott approach well suited for this type of impact (provided the incremental impacts are determined).**

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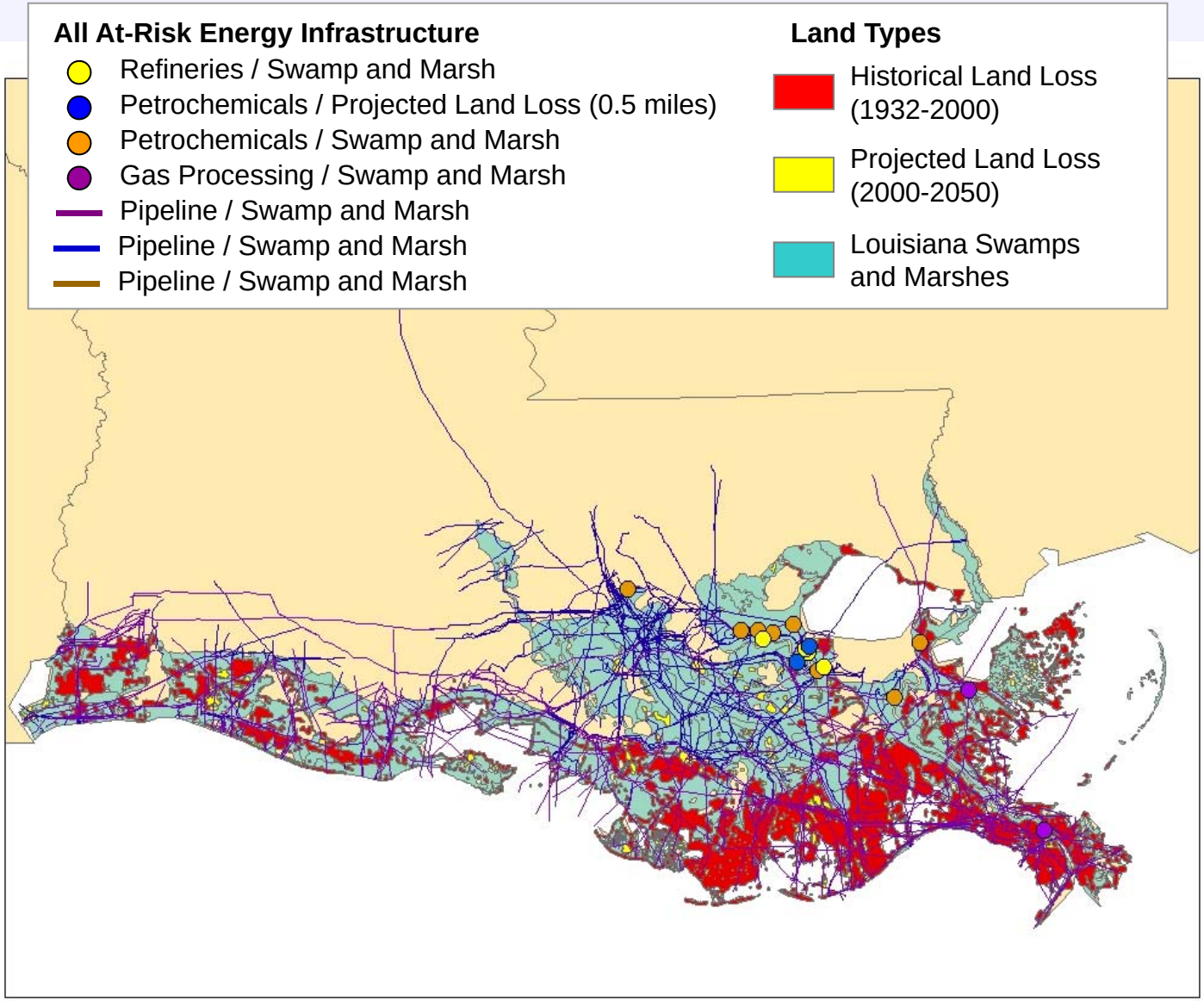
Louisiana Land Loss and Critical Energy Infrastructure



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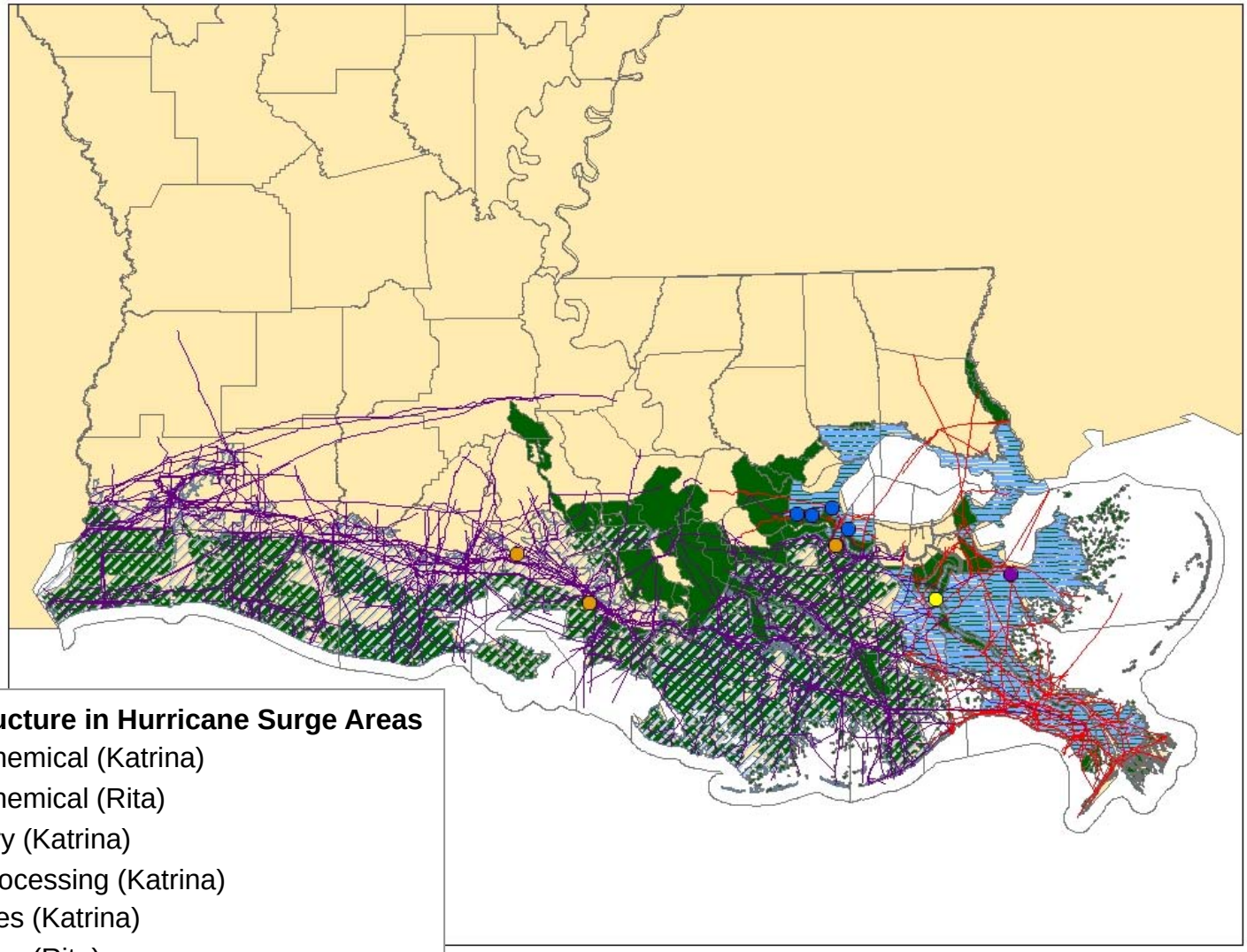
All Infrastructure in Katrina/Rita Surge Inundation Zones with Marsh Overlay



All Infrastructure in Hurricane Surge Areas

- Petrochemical (Katrina)
- Petrochemical (Rita)
- Refinery (Katrina)
- Gas Processing (Katrina)
- Pipelines (Katrina)
- Pipelines (Rita)

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Conclusions

- GOM region has played an important historic role in the development of energy infrastructure. Not likely to change despite hurricane activity.
- Hurricanes proved that the region, its workforce, and the underlying assets are resilient and can be restored quickly, even in the face of two natural disasters.
- Some concerns about "diversifying" energy infrastructure in the region. Given current economic challenges concern is that diversity in some infrastructure areas could "diversify" to other parts of the world, which actually increase US vulnerability, not decrease it.
- Man-made incidents and catastrophic incidents should not be taken lightly -- but the "stochastic" nature of these events requires a more probabilistic approach to mitigation – more than likely a resiliency as opposed to "hardening" solution.
- Should the real threat mitigation resources be directed towards the slower, less noticeable, but cumulatively more important threats to this critical infrastructure (i.e., coastal erosions) – which in turn, can aggravate the catastrophic events many are placing their attention upon.

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Questions, Comments, & Discussion

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