Hurricane Harvey

MFE634 Quality Engineering/Syracuse University

Student Group one;/April 14, 2018.

Introduction

This presentation is about the quality analysis that we performed on the biggest and the most expensive hurricane to ever hit USA. Hurricane Harvey.

- **SIX SIGMA**:
- We will be analyzing all the aspects of hurricane Harvey under the context of Six Sigma-DMAIC process.

The Define Phase: The purpose of this step is to clearly articulate the business problem, goal, potential resources, project scope and high-level project timeline.

Define	Define the Problem
Determine	Determine the Desired State
Complete	Complete pre-project administrative work
Secure	Secure Resources
Create	Create the Team
Establish	Establish a Business Case
Draft	Draft a High Level flow chart of the process

Background

- On August 2017, Hurricane Harvey made landfall in the US, causing unprecedented flooding, which inundated hundreds of thousands of homes, displaced more than 30,000 people, and prompted more than 17,000 rescues.
- It is the most damaging and costly hurricanes in US history.
- It reached category 4 level wind speeds and caused massive flooding throughout the southern Texas.

The Differences

- WHY IT CAUSED SO MUCH DAMAGE?
- Because upper-level winds in the atmosphere usually steer big hurricanes and keep them moving after they make landfall. With Harvey, those steering winds broke down, and a high pressure system to the northwest kept Harvey locked in place. Around 14 trillion to 15 trillion gallons of water had fallen on Houston and its surrounding areas. And 5 trillion more gallons are still expected to come.
- There was no evacuation order issued before the storm hit.
- WHY IT REMAINED ON HUSTON AREA FOR SO LONG?
- In Harvey's case, a big high-pressure system over the southeastern U.S. is trying to push the storm in one direction, but a big high pressure system over the southwestern U.S. is trying to push the storm in the opposite direction.
- WHY WAS IT THE MOST DISTRUCTIVE STORM OF 2017
- Because it caused extreme rainfall and flood, and it lasted too long.

THE ACTUAL TIMELINE

On August 25, 2017, Harvey hit Port Aransas and Port O'Connor near Corpus Christi with 130 m.p.h. winds. The category 4 hurricane left 250,000 people without power.

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On August 26, Harvey moved on to Houston. It remained there for four days. Two reservoirs. The highways became overflowed waterways. Between 25 and 30 percent of Houston's Harris County was flooded. That is an area as large as New York City and Chicago combined. It was home to 4.5 million people.

On August 29, Harvey made landfall for a third time as it hit the coastal cities of Port Arthur and Beaumont Texas on the border of Louisiana. It dumped 26 inches of rain in 24 hours. It flooded Port Arthur, a city of 55,000 people. Water entered one-third of the city's building, including shelter.

On August 31, an Arkoma chemical plant in Crosby, Texas, ignited. The chemicals required refrigeration to stay inert. When the storm disabled the cooling equipment, temperatures rose and the chemicals ignited.

On September 1, Harvey dropped 10 inches of rain on Nashville, Tennessee.

Damaging Elements of the Hurricane

- FLOODING
- The floods could cause that number to balloon, and additional factors could make Harvey a $30 billion storm.
- TORNADOES
- WIND and STORM SURGE
- Usually, severe winds that tear off roofs and uproot trees are a major source of damage during hurricanes. But in Harvey's case, storm surge damage brought by the storm's winds likely won't be as extensive as inland flood damage from rivers that overflow their banks. The insured losses from just the winds and storm surge could reach more than $2.3 billion.
- HAIL

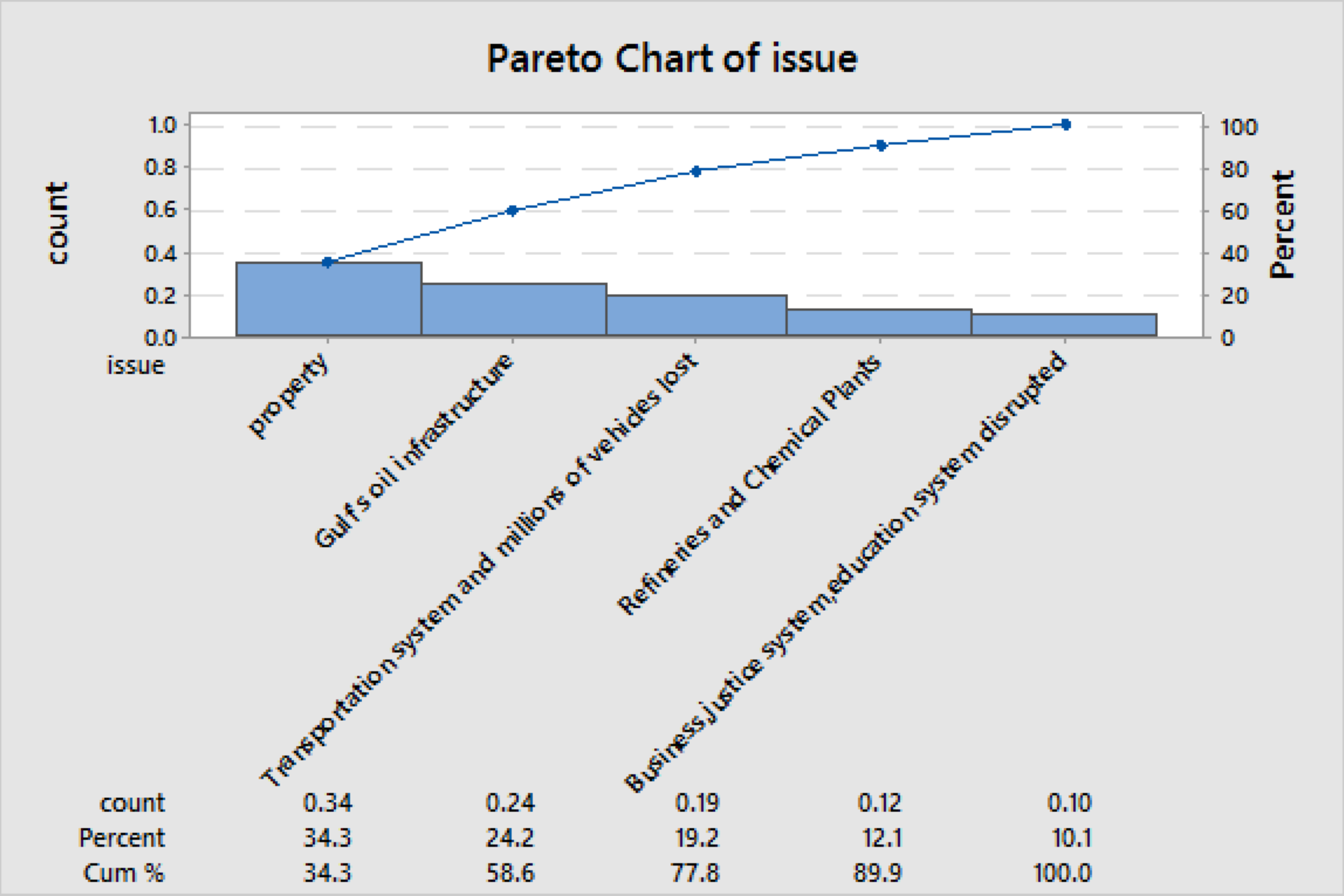
AREAS OF MAXIMUM DAMAGE

- Property (colonials, residential-43-65 billion)
- Human life
- Gulf’s oil infrastructure
- Economic impact
- Power (electricity) lost
- Transportation system and millions of vehicles lost
- Refineries and Chemical plants
- Business, justice system, education system disrupted

Pareto Analysis

the following analysis was done based upon division of funds for relief

Loss of property was greatest as seen



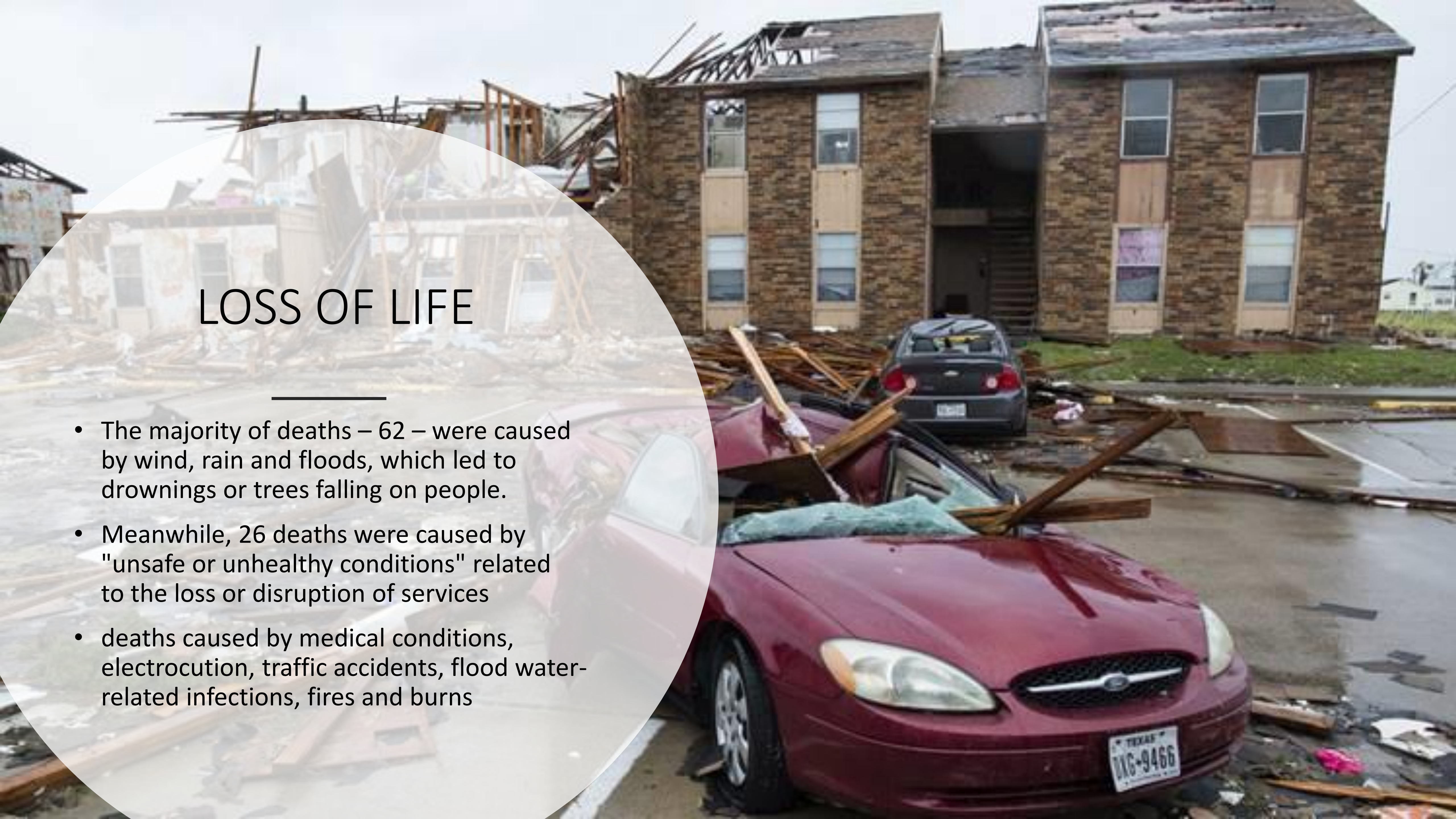
Major damage

Based on the Pareto Analysis we can categorize the major losses as :

- Economic impact
- Loss of infrastructure and Life
- Impacts along the coast

Loss of Infrastructure and Life

- **500,000 homes were affected, and of those 500,000 homes, an estimated 90,000 suffered severe damage from flooding.**
- **Almost 200,000 more homes suffered extensive flooding that impaired immediate occupancy**
- **An additional 200,000 suffered short-term impaired functionality**



LOSS OF LIFE

- The majority of deaths – 62 – were caused by wind, rain and floods, which led to drownings or trees falling on people.
- Meanwhile, 26 deaths were caused by "unsafe or unhealthy conditions" related to the loss or disruption of services
- deaths caused by medical conditions, electrocution, traffic accidents, flood water-related infections, fires and burns

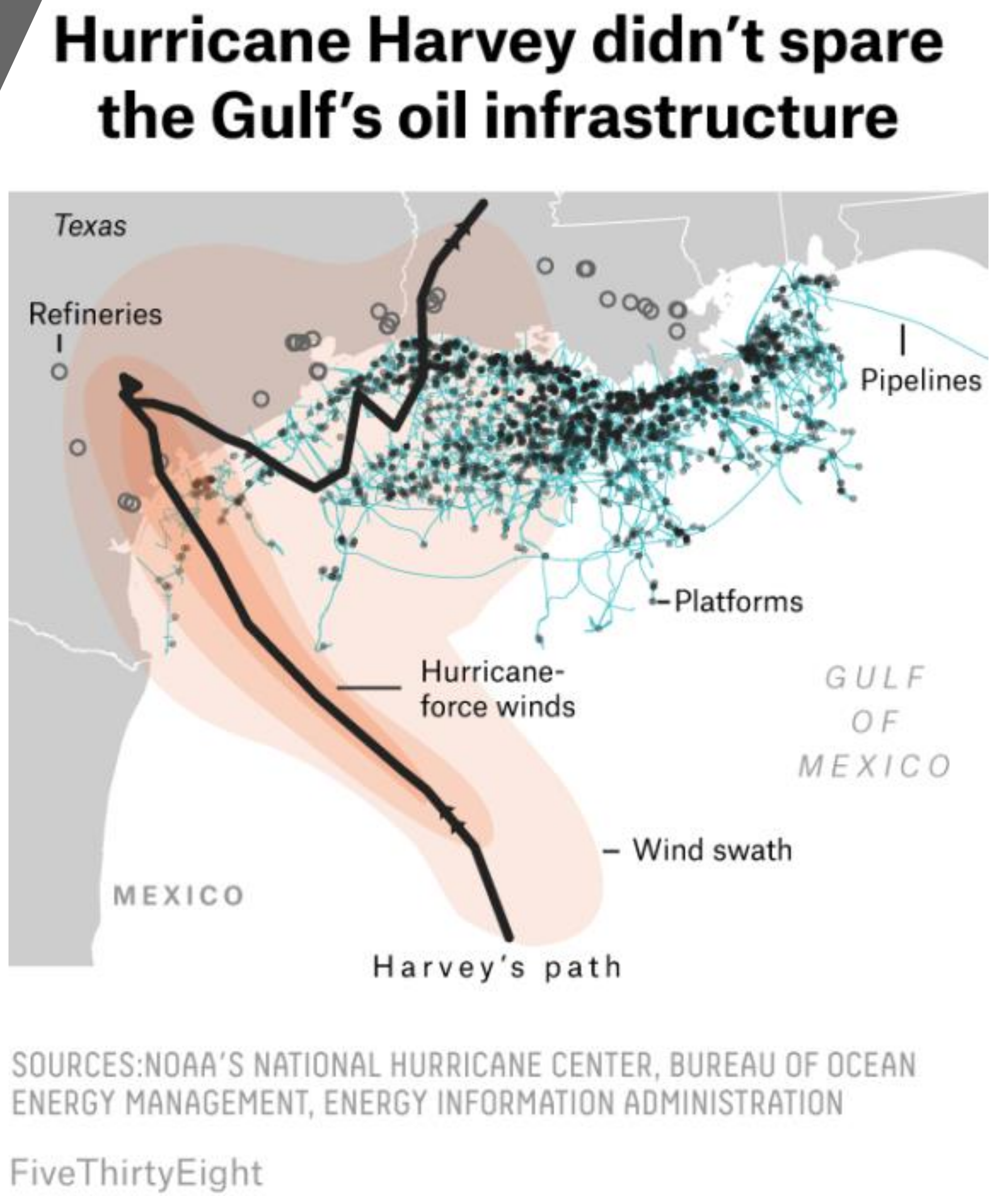
HUMAN LIFE DISTRUPTED COMPLETELY

Common Problems After a Disaster

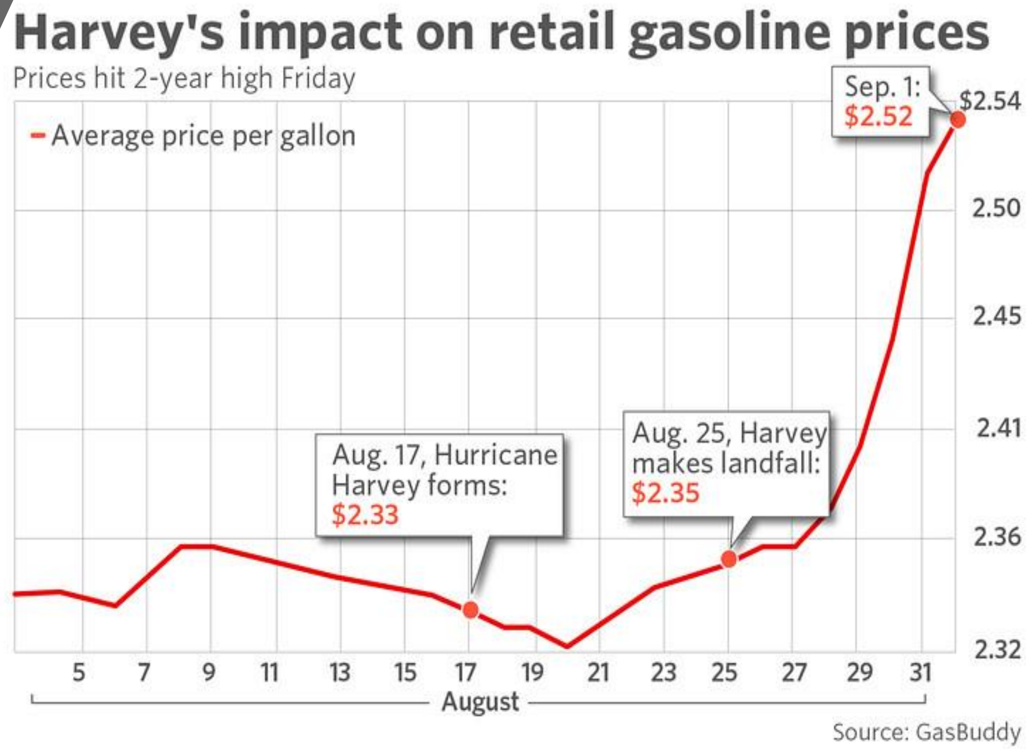
- Long-term health problems
- PTSD and Depression
- Stress from loss of possessions
- Stress from loss of job/livelihood
- Communicable disease due to lack of clean water
- Replacing Lost or Damaged Documents like Birth/Death Certificates Driver’s License

Impacts along the Coast

- Affected the Gulf Coast-responsible for large portion of the U.S. petroleum refining capacity
- Numerous large Petrochemical plants were shut down
- Released toxic pollutants that pose a threat to human health.
- An example would be Chevron Phillips Chemical plant in Sweeny, Texas. When it shut down due to Hurricane Harvey, it released into the air more than 100,000 pounds of carbon monoxide, 22,000 pounds of nitrogen oxide, 32,000 pounds of ethylene, and 11,000 pounds of propane
- In the Gulf area, 1 million vehicles were ruined beyond repair

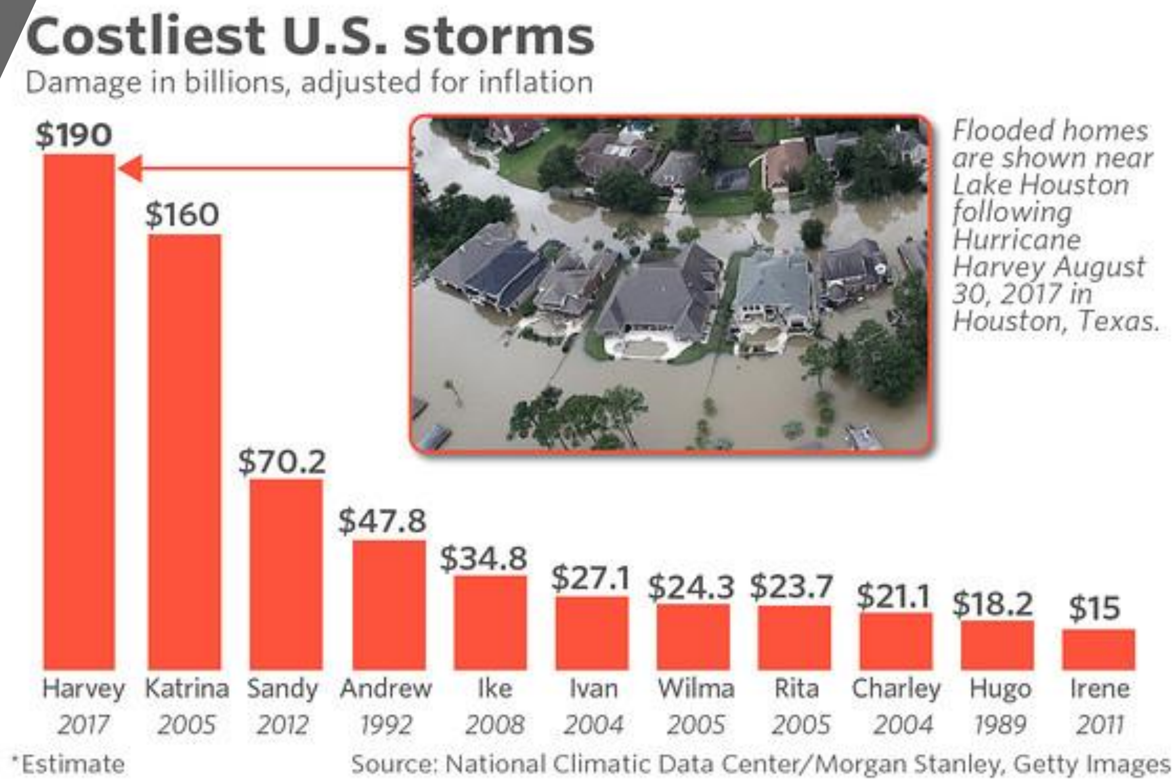


- Forced 25 percent of oil and gas production to shut down in the region
- Played a role in increasing energy prices by 2.8% in August
- Gasoline prices rising by 6.3%.
- Prices increased for input prices for a wide variety of goods and services.



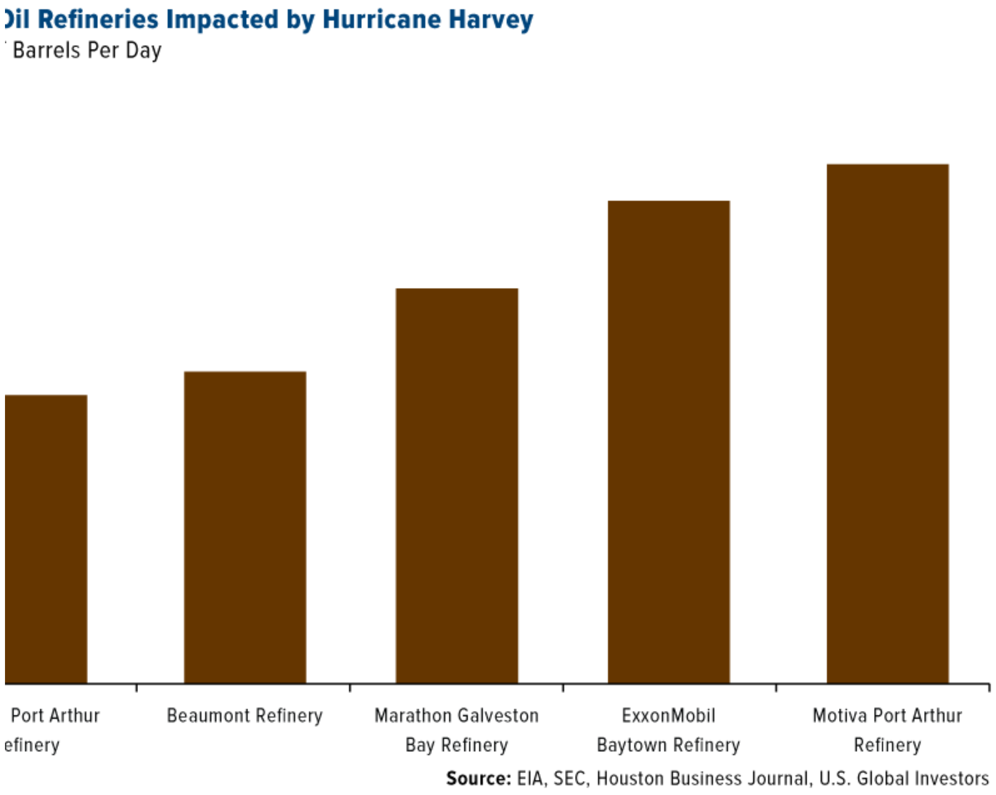
Economic Impact

1. Houston metro area - the nation's fourth-largest city
2. USA's 5th largest economy with 6.6 million residents
3. Would be world's 23rd largest economy

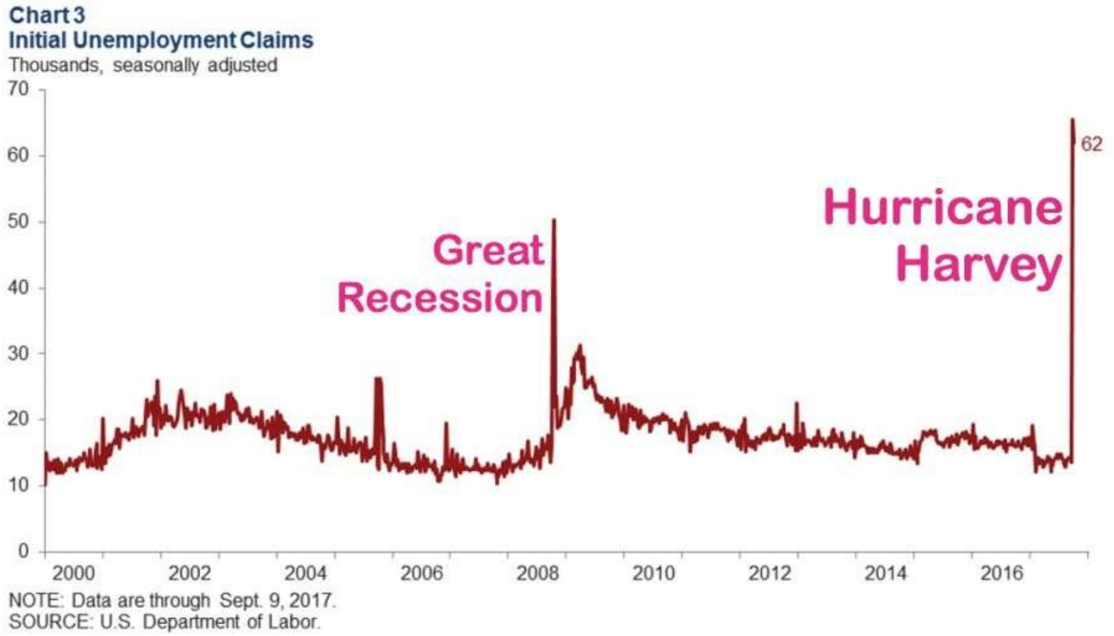


A third of Houston's economy is directly tied to the oil and gas industry

- Nation’s number one gasoline-producing state.
- Largest oil refinery in the U.S, Located in Port Arthur with a capability to produce 600,000 barrels a day was shut down.



- Also home to non-energy companies, such as KBR, Waste Management and the food service giant Sysco-All shut down
- Several hospitals, both major airports and the Port Of Houston-shut down
- Spiked Unemployment



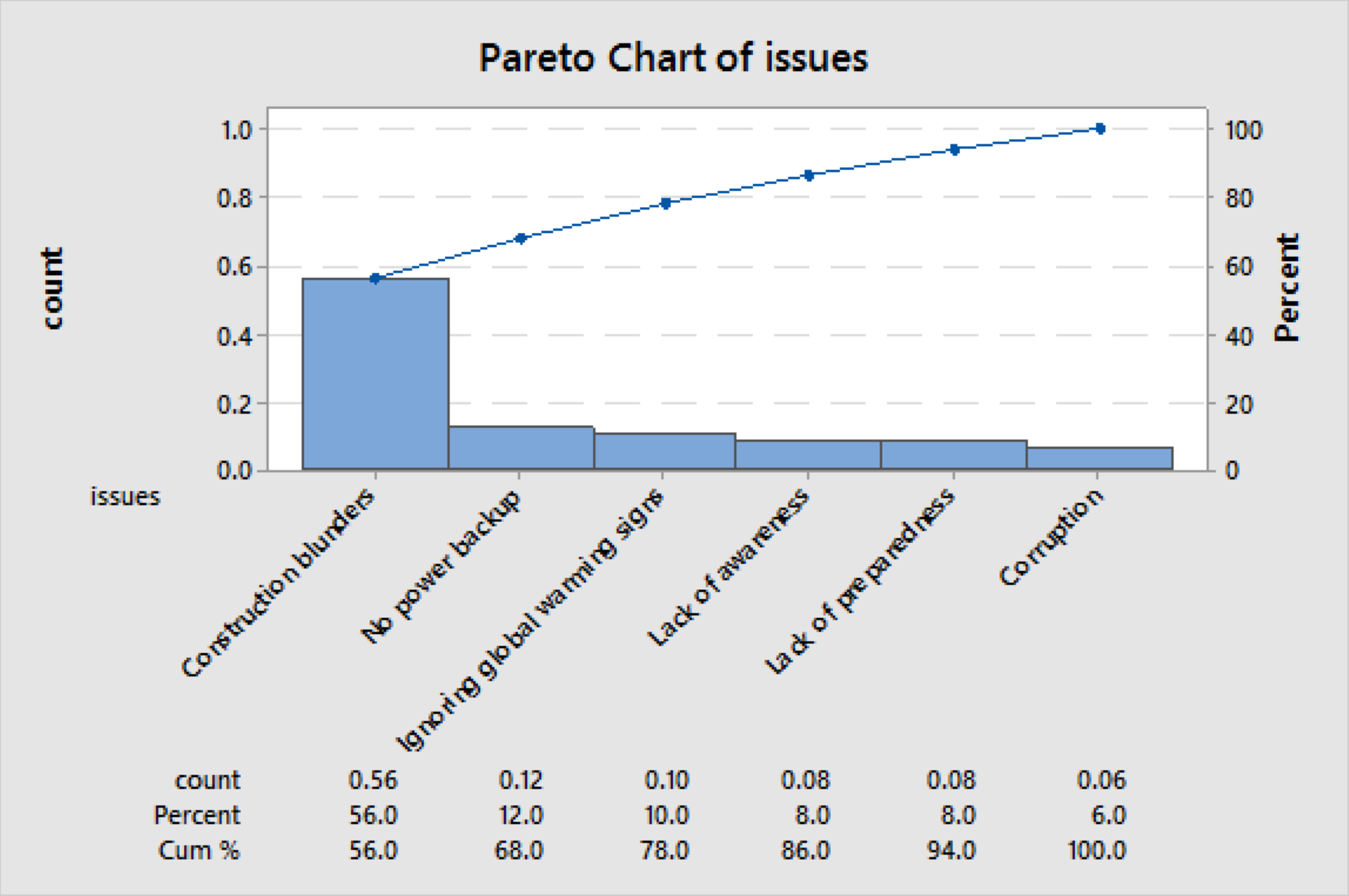
Major reasons for failure

- Construction blunders
- No Power Backup
- Ignoring global warming signs
- Lack of awareness
- Lack of preparedness
- Corruption

Pareto Analysis:

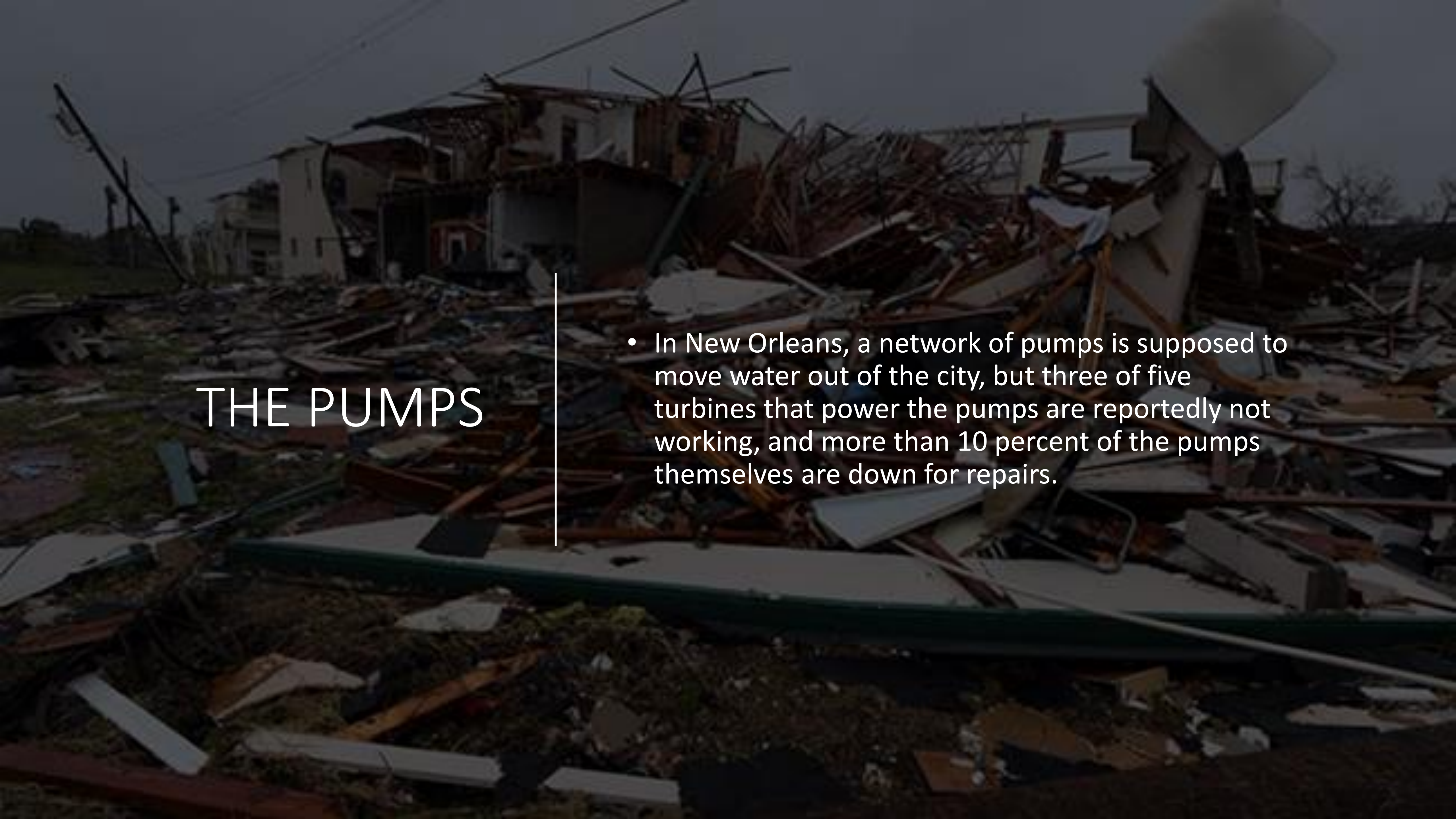
-Found that Construction blunders did most damage

-Other categories also indirectly or directly are related to Construction Blunders



Construction blunders

- The New Orleans Pumps
- The Reservoirs
- Wetland Infrastructure
- No protection along the coast



THE PUMPS

- In New Orleans, a network of pumps is supposed to move water out of the city, but three of five turbines that power the pumps are reportedly not working, and more than 10 percent of the pumps themselves are down for repairs.

THE RESERVOIRS

Huston has two major reservoirs:

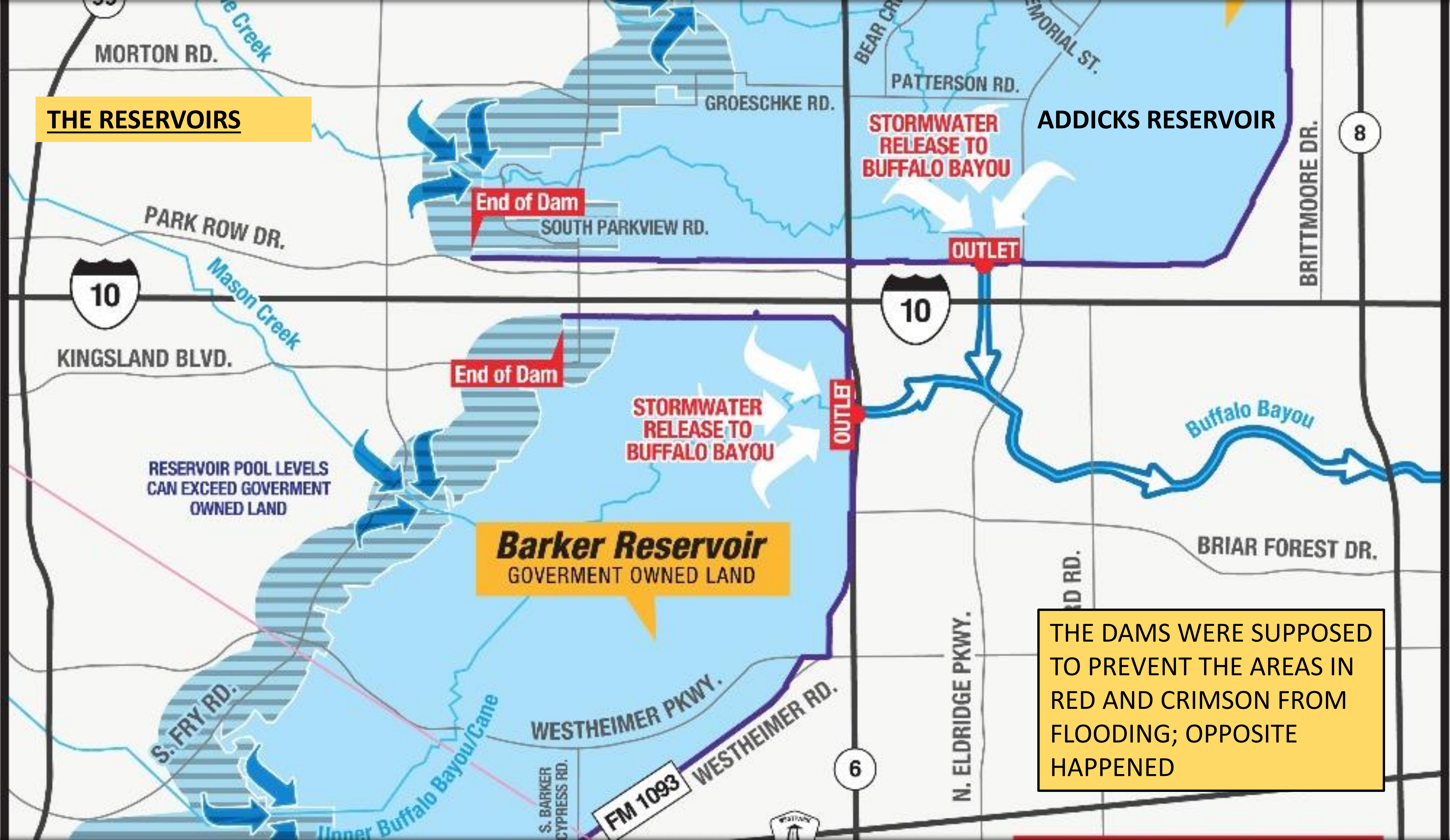
- THE ADDICKS RESERVOIRS
- THE BARKER RESERVOIRS

These two reservoirs were meant to protect the adjacent regions from flooding, however, sadly they became the major reason why the neighboring regions were flooded.

https://projects.propublica.org/graphics/harvey-reservoirs

THE RESERVOIRS

ADDICKS RESERVOIR



THE DAMS WERE SUPPOSED TO PREVENT THE AREAS IN RED AND CRIMSON FROM FLOODING; OPPOSITE HAPPENED

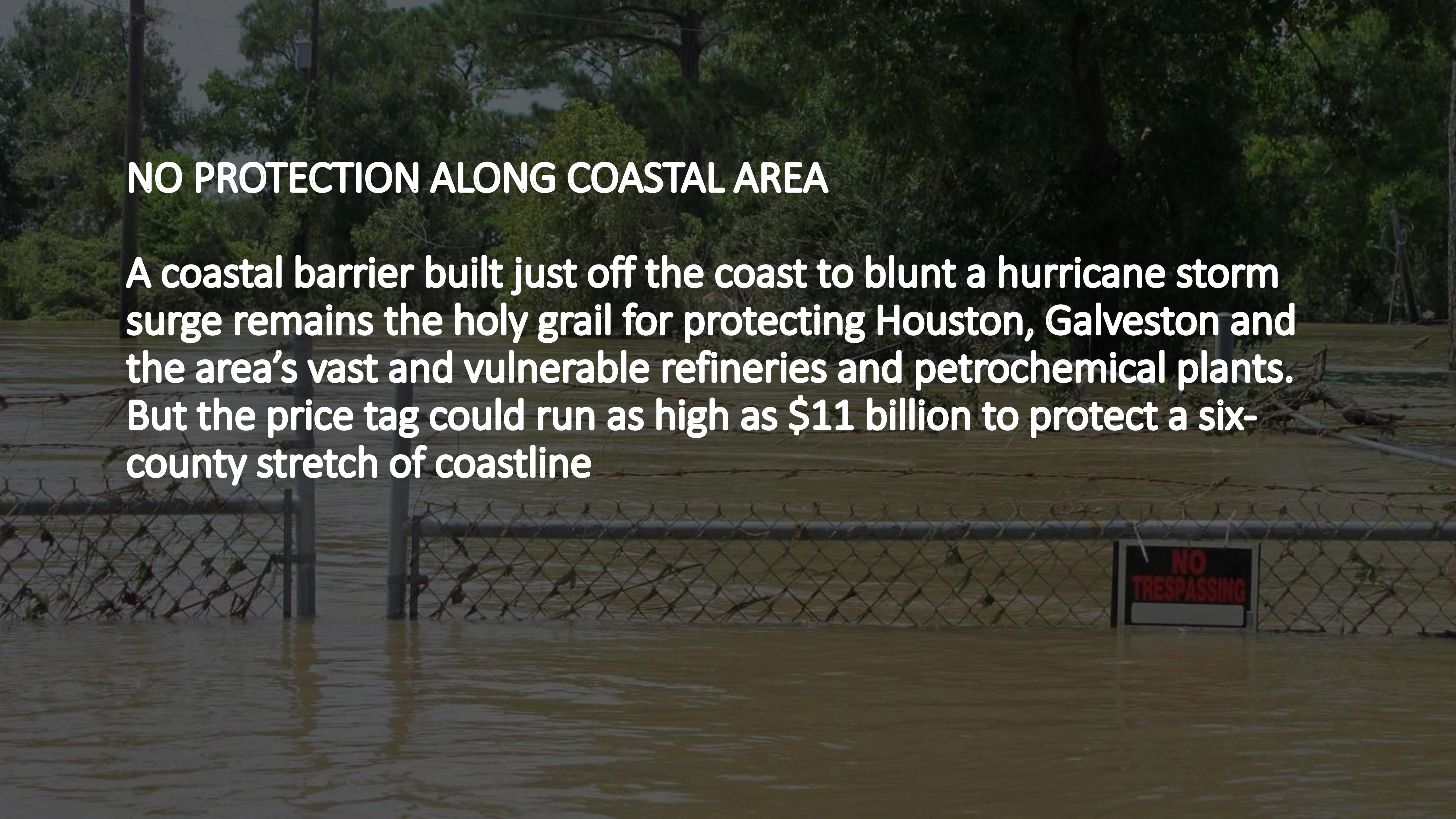
The city is flat. No hindrance – Urban Sprawl- Clearing Wetlands

Between 1992 and 2010, 25,000 acres (about 10,000 hectares) of natural wetland and Prairie infrastructure wiped out-Urban Sprawl

Region lost the ability to handle nearly four billion gallons (15 billion liters) of storm water.

That’s equivalent to $600 million worth of flood water detention capacity

Reason - No Zoning Laws



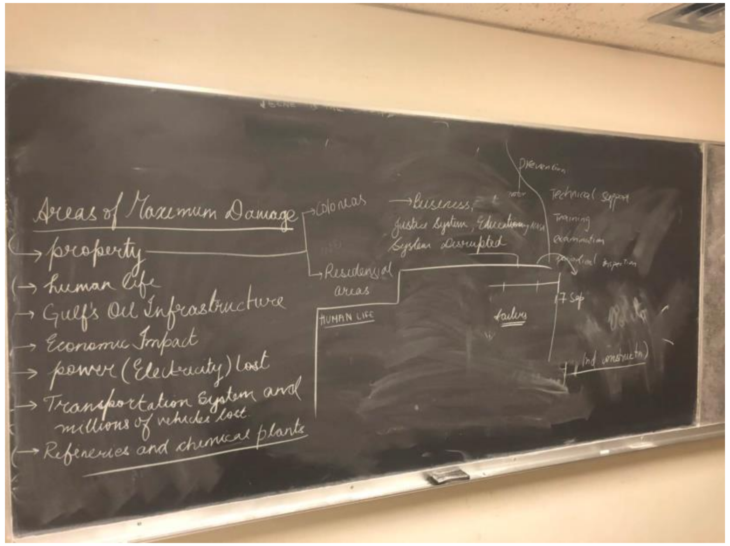
NO PROTECTION ALONG COASTAL AREA

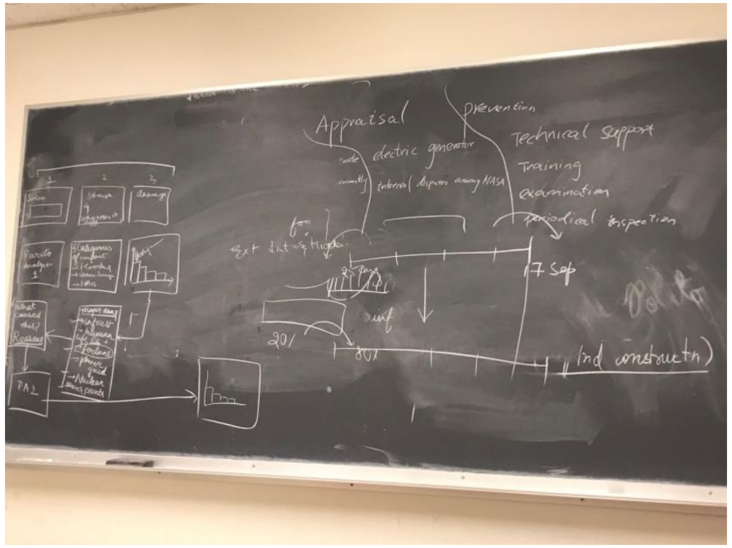
A coastal barrier built just off the coast to blunt a hurricane storm surge remains the holy grail for protecting Houston, Galveston and the area’s vast and vulnerable refineries and petrochemical plants. But the price tag could run as high as $11 billion to protect a six-county stretch of coastline

Critical to Quality Characteristics

CTQs are the key measurable **characteristics** of a product or process whose performance standards or specification limits must be met in order to make a high quality product which performs the desired functions.

- We will get to know about CTQC's by doing a doing a COPQ analysis related to the several failures that we have discussed so far.
- To build a COPQ we performed a brainstorming session and created an affinity diagram.





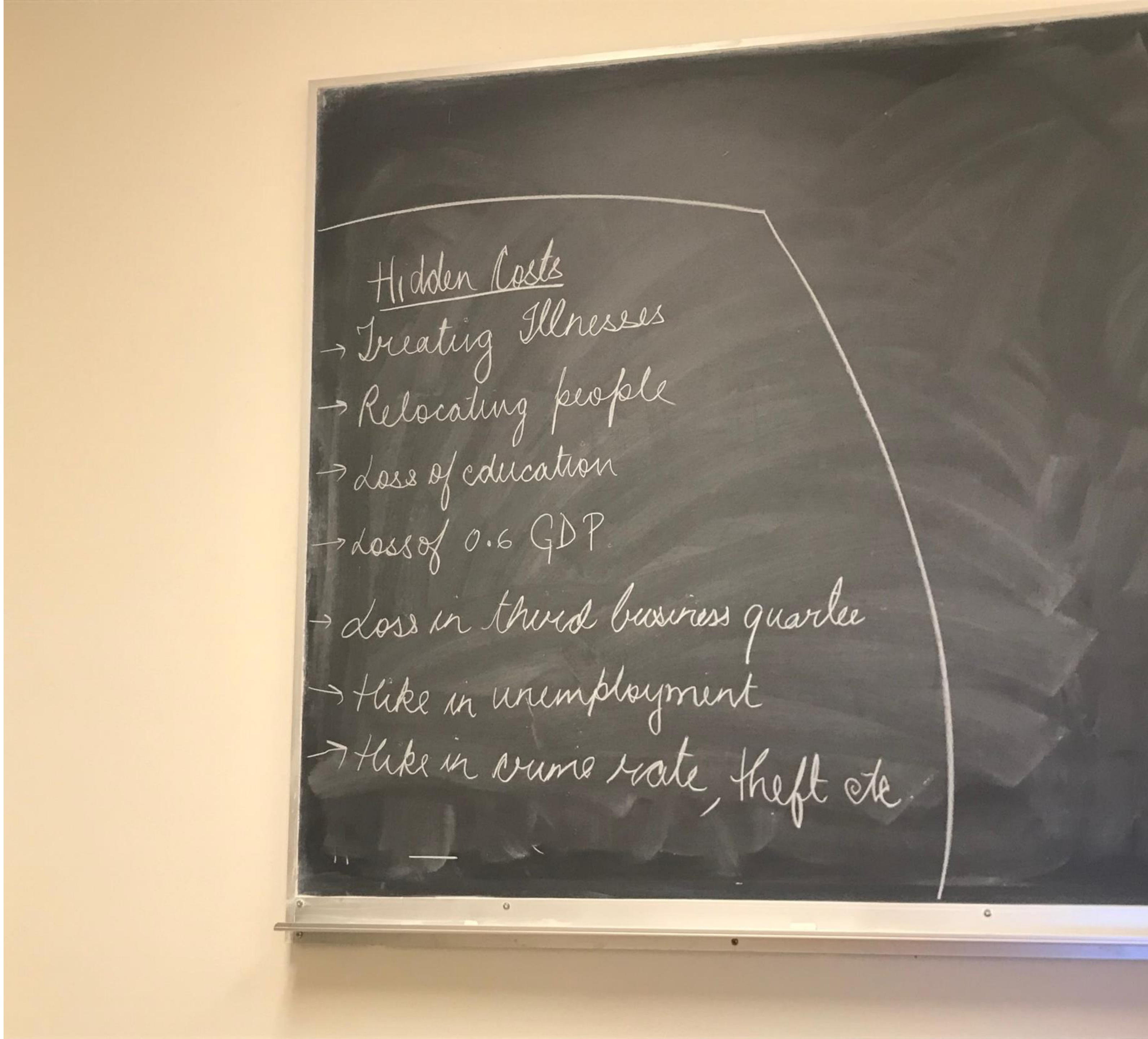
Brainstorm and the Affinity Diagram

COPQ related to failure

Cost of Poor Quality				
Process	Internal Failure	External Failure	Appraisal	Prevention
Prepare(include both long and short term):				
Monitoring Hurricane	Inspection Equipment Failure		Test all equipment	Technical Support, Periodical Inspection
Emergency Notification		False Notification		Recheck
Building Reinforce			Test Structural Strength	
Prepare to Evacuate	Evacuation team failure	False Evacuation Runs	Mock Drills for Evacuation	Have Plenty of Staff and Trained Professionals
Power Backup Guarantee	Equipment Failure	Business, Communication Failure		Make Available Alternative Power Resource
Reservoir Protection	Dam Failure, Construction Problem	Flooding	Reservoir Inspections	Build Walls Higher, Leave More Space Around Dams
Build Shelters	Shelter Collapsing	People Getting Injured/Dying	inspection of Shelters	Tents Support, Use Good Quality Material, Flood Proof Shelters
Stock Emergency Supplies	Storage Equipment Failure, Shortage	Theft, Lost		Periofical Inspection
Protect Property(temporary methods)		Damage to Property		Periofical Inspection
During:				
Send Emergency Team				
Evacuation Notices		False Notics		Recheck
Move Victims to Shelter	The Construction problem, Tents Shortage	The Residents Were Relutanted to Evacuate		Tents Support
Provide Necessity for Life	Water and Food Shortage	Complaints Were Raised by Residents	Standerization of Food and Water Supply	
Provide Power	Eletricity and Fule Shortage	Complaints Were Raised by Residents	Enmergency Eletrical Supply,Eletric Generater	Backup
Rescue	Inspection Equipment Failure		Limited 911 Services	
Diagnose wounded	Equipment Shortage	Wrong Diagnosis		Training
Treat Wounded	Equipment Shortage	Wrong Treatment		Technical Support, Medical Support, Recheck
The Wounded Transfer	Vehicle Damage and Shortage			Examination
After:				
Draw Water to Ocean	Pumps Shortage			Pumps Support
Return of Victims	Vehicle Damage and Shortage	The Residents Were Relutanted to Return		Deport Colonias
Home, Schools, Hospitals Rebuilding	Materials and Equipment Shortage			Insurance
The Disease Control	Medicine Shortage	The Residents Were Relutanted to Return		Periofical Inspection
Prepare for The Next Hurricane				Periofical Inspection, Training
Build Coastal Barrier				Longer Enough Coastal Barrier Support

Hidden Costs

- Indirect costs
- Can be long term or short term



Based upon all the analysis that we have done above, we have come up with a list of potential projects that can be performed.

- A: Rebuild the two reservoirs
- B: Improve Emergency response time
- C : Create hurricane survivor App
  - Providing the timely information of hurricane
  - Provide the amount of emergency suppliers
  - Providing rescue service
- D: Build coastal barrier

Evaluate Projects

Project	Savings ($billion)	Probability	Cost ($mil)	Time(years)	PPI
A	30	0.9	2000	1	13.5
B	1	0.8	180	0.5	8.88
C	0.4	0.5	10	1	8
D	20	0.2	1000	2	2

PROJECT SELECTION:

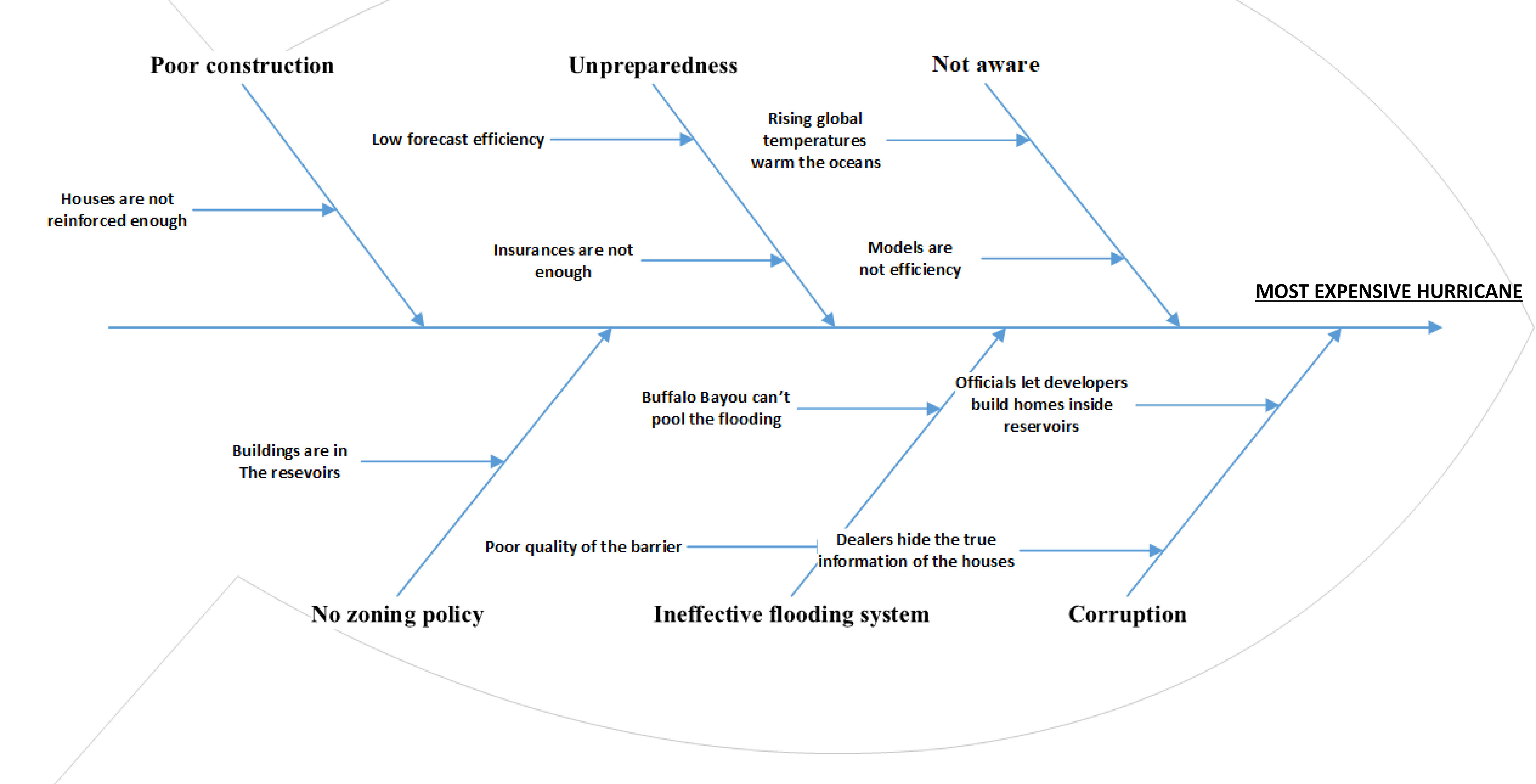
By looking at the above PPI for each project, Rebuild the two reservoirs takes highest project priority. And Improve Emergency response time and Create hurricane survivor App also have high project priority.

Measure Phase

In the Measure Phase, the team refines the measurement definitions and determines the current performance or the baseline of the process

Define the Current State

- Collect Data on the Current State
- Identify any unforeseen problems/opportunities
- Create detailed process flow charts/value stream maps


Poor construction
Unpreparedness
Not aware
Low forecast efficiency
Rising global temperatures warm the oceans
Houses are not reinforced enough
Insurances are not enough
Models are not efficiency
MOST EXPENSIVE HURRICANE
Buffalo Bayou can't pool the flooding
Officials let developers build homes inside reservoirs
Buildings are in The resevoirs
Poor quality of the barrier
Dealers hide the true information of the houses
No zoning policy
Ineffective flooding system
Corruption

KEY PERFORMANCE INDICATORS (KPIs)

<table>
<tr><th>Project Name</th><th>Division</th><th>Key Performance Indicators</th></tr>
<tr><td rowspan="4">Rebuild the reservoir</td><td>Increase the capacity of reserves</td><td>The volume of reserves</td></tr>
<tr><td rowspan="3">Improvement of the reserves construction quality</td><td>The strength of walls</td></tr>
<tr><td>Water permeability</td></tr>
<tr><td>The distance between reserves and illegal residence</td></tr>
</table>

KEY PERFORMANCE INDICATORS (KPIs)

Project Name	Division	Key Performance Indicators
Hurricane survivor App	Providing timely information of hurricane	time
		distance
		strength
	Provide the right amount of emergency suppliers	Number of emergency suppliers
	Providing rescue service	the accuracy of GPS
		the response time
		customer evaluation

KEY PERFORMANCE INDICATORS (KPIs)

Project Name	Division	Key Performance Indicators
Emergency response time	To decrease the response time of emergency team	Number of people
		Number of station
		Number of helicopter

For emergency response team

Data Collection Plan

Performance Measure*	Data Source/Location	How will Data Be Collected	When Will Data Be Collected?	Who Will Collect Data
# of people to be relocated	Gov. population department	record in system	Every Year	Disaster prevention team
# of people in every emergency team	Gov. emergency department	record in system	Every Year	Disaster prevention team
# of emergency station in the whole city	Gov. emergency department	record in system	Every Year	Disaster prevention team
# of helicopter	# of local helicopter available	Manual recording or recorded in system	Every time before it happens	Disaster prevention team
# of rescue equipment in every emergency team	Gov. emergency department	record in system	Every time before it happens	Disaster prevention team

Texas Recovery

Hurricane Harvey: Partnerships and Progress

FEMA

all totals as of Nov 20, 2017

41 Individual Assistance / **53** Public Assistance counties designated

889,425 survivors applied for assistance

41.5 THOUSAND sq. miles of land mass impacted

larger than Connecticut, Massachusetts, New Hampshire, Rhode Island and Vermont **COMBINED**

$9 BILLION IN SURVIVORS' POCKETS

Mitigation

$1.1 BIL 30 Day Estimate - Hazard Mitigation Grant Program

306 participating National Flood Insurance Program (NFIP) communities in declared areas

208 SURVIVORS IN TEMPORARY HOUSING

PUBLIC ASSISTANCE

957 REQUESTS FOR PUBLIC ASSISTANCE

10 MILLION Cubic Yards of Storm Debris Picked Up

73 Expedited Projects for **$490 MIL**

Housing and Other Disaster Related Expenses: **$1.4 BIL**

Small Business Administration (SBA) loans approved: **$2.42 BILLION**

$5.4 BIL NATIONAL FLOOD INSURANCE PROGRAM (NFIP) ADVANCE PAYMENTS AND CLAIMS PAID

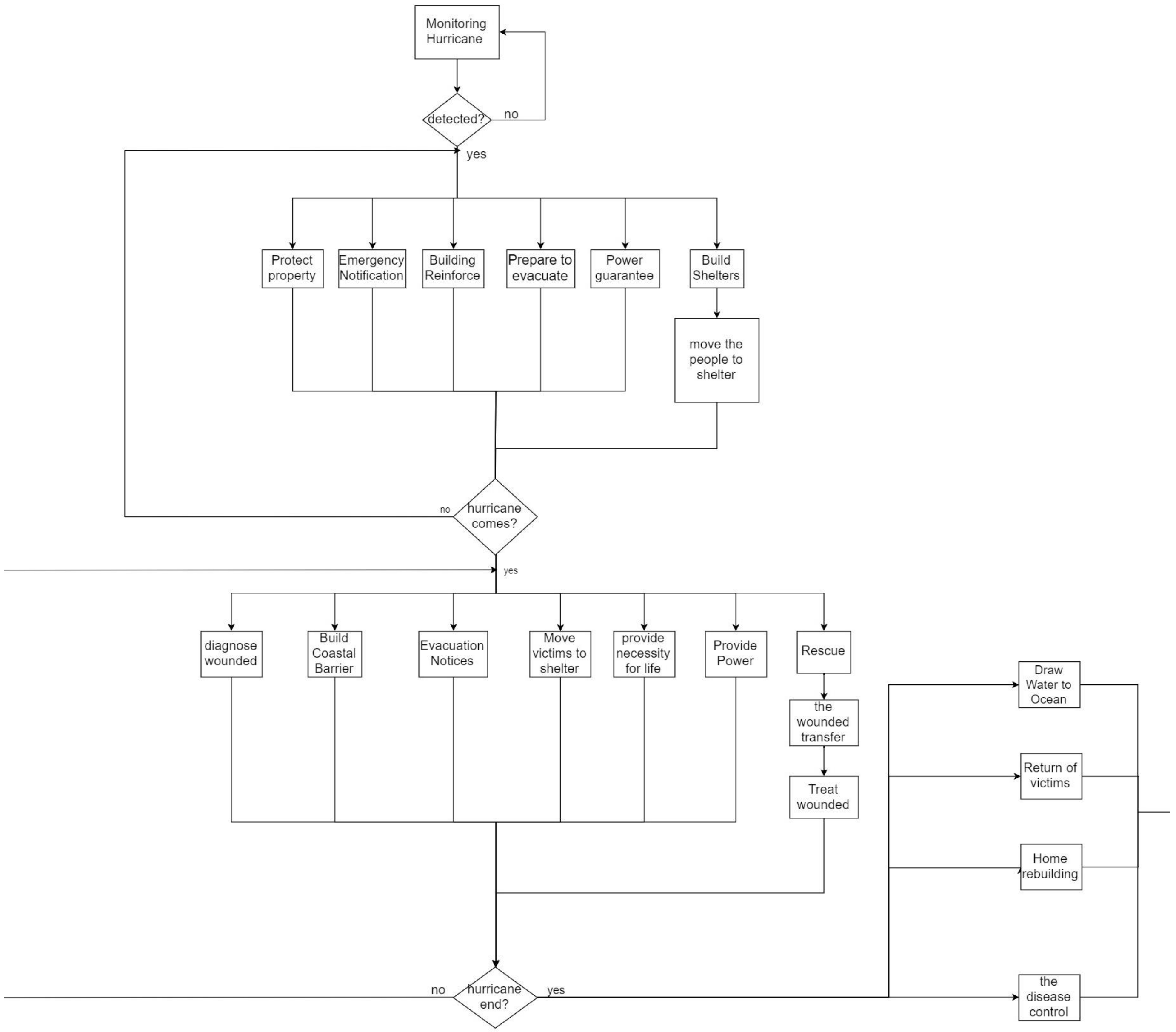
Disaster Assistance UNEMPLOYMENT **8.7 MIL**

90 THOUSAND FLOOD INSURANCE CLAIMS

Sources: U.S. Department of Agriculture, U.S. Coast Guards, Environmental Protection Agency, FEMA, U.S. Department of Health and Human Services, U.S. Small Business Administration, National Flood Insurance Program, Texas Commission on Environmental Quality

FLOW CHART

- This is the current flow chart for the emergency response services
- We will later in the presentation show how we consolidated it and improved upon the response time.



Analyze Phase

- Analyze and report on the data collected in the Measure Phase
  - Determine Process Velocity
  - Determine Process Capability
  - Calculate DPMO
  - Perform Statistical Analysis
- Identify any Bottlenecks in the process
- Determine sources of Defects / Variation

The Emergency Response Time(DOE)

After research, we found the following:

16 major stations	It took an average of 12 days to about 2300 rescue service people to save 780,000 people in need.

Based on the above results, we have made the following design of experiments the output being RESPONSE TIME and the 3 factors effecting this output are AIR AID(a), NUMBER OF PEOPLE PER STATION(b) AND THE NUMBER OF STATIONS(c).

Data:

AIR AID(A)	NUMBER OF PEOPLE(B)	NUMBER OF STATIONS			average days
0	20	10			20.0
2	20	10			6.0
0	50	10			16.0
2	50	10			5.0
0	20	25			12.0
2	20	25			3.5
0	50	25			10.0
2	50	25			3.0

Result:

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		9.438	0.187	50.33	0.013	
AIR AID(A)	-10.125	-5.063	0.187	-27.00	0.024	1.00
NUMBER OF PEOPLE(B)	-1.875	-0.937	0.187	-5.00	0.126	1.00
NUMBER OF STATIONS	-4.625	-2.313	0.187	-12.33	0.052	1.00
AIR AID(A)*NUMBER OF PEOPLE(B)	1.125	0.563	0.187	3.00	0.205	1.00
AIR AID(A)*NUMBER OF STATIONS	2.375	1.188	0.187	6.33	0.100	1.00
NUMBER OF PEOPLE(B)*NUMBER OF STATIONS	0.625	0.312	0.187	1.67	0.344	1.00

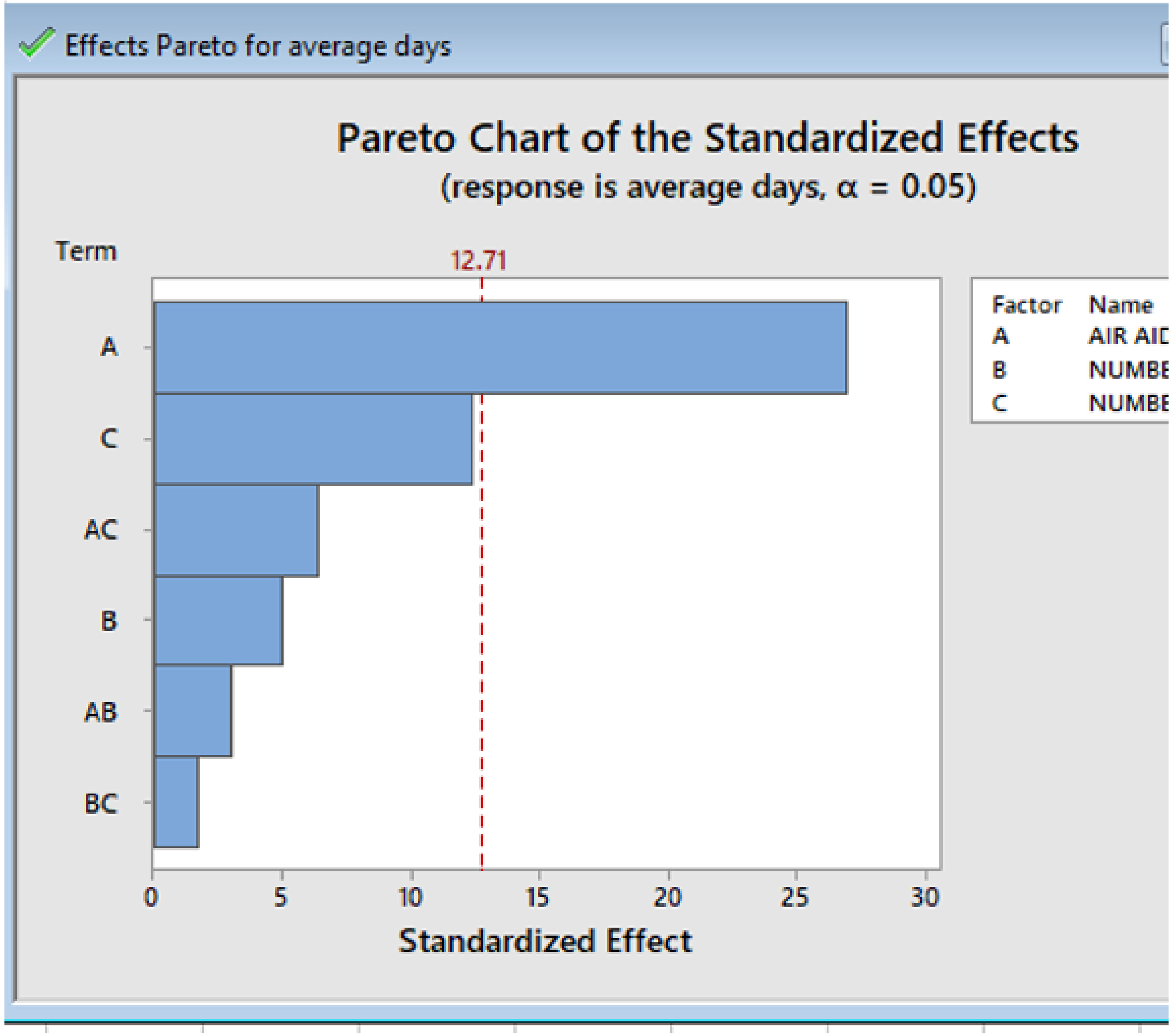
Regression Equation in Uncoded Units

```
average days = 27.87 - 9.146 AIR AID(A) - 0.1486 NUMBER OF PEOPLE(B)
               - 0.5639 NUMBER OF STATIONS + 0.0375 AIR AID(A)*NUMBER OF PEOPLE(B)
               + 0.1583 AIR AID(A)*NUMBER OF STATIONS
               + 0.00278 NUMBER OF PEOPLE(B)*NUMBER OF STATIONS
```

DOE

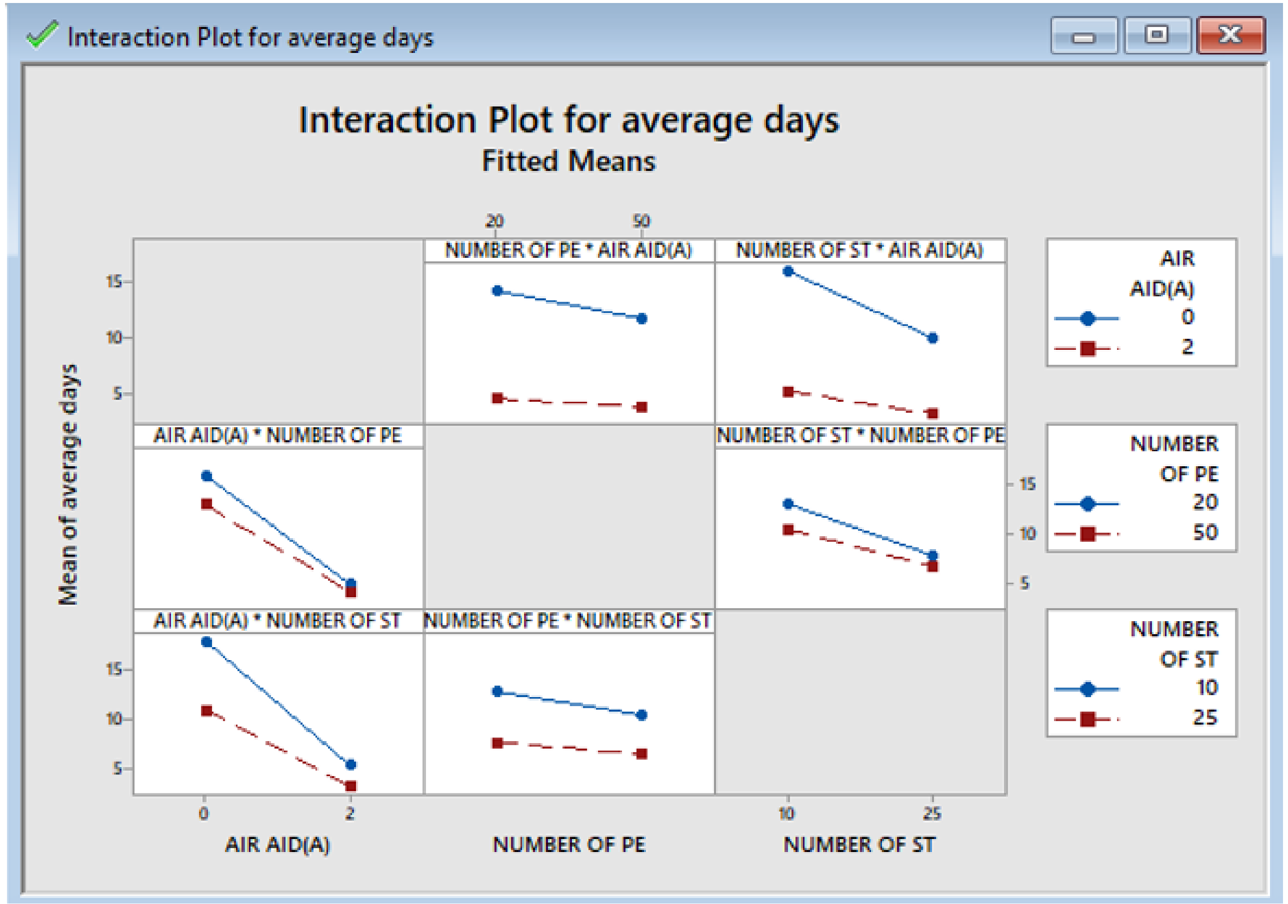
PARETO CHART

The boundary(red dotted line) is 12.71. It’s obviously that only A is above the boundary. C is close to the boundary. Other factor is far away from the boundary.



MINITAB OUTPUT

- From the result of Minitab, it is obviously that the slopes of the 2 line in all segments of the plot are nearly the same, so the conclusion could be drawn that all interaction effects are not significant. They would have been significant if the lines were intersection.



THE ANALYSIS

Description: There are 3 factors that might influence response: Air Aid, Number of People, and Number of stations. Holding experiments under 8 situations to find out which factor is most significant to response.

Conclusion: Interaction influences are all not significant to the response. For single factor, only air aid is significant to response, number of stations are close to being significant, and number of people is not significant.

STATISTICAL PROCESS ANALYSIS

Statistical process control (SPC) is a method of **quality control** which employs **statistical** methods to monitor and **control** a **process**.

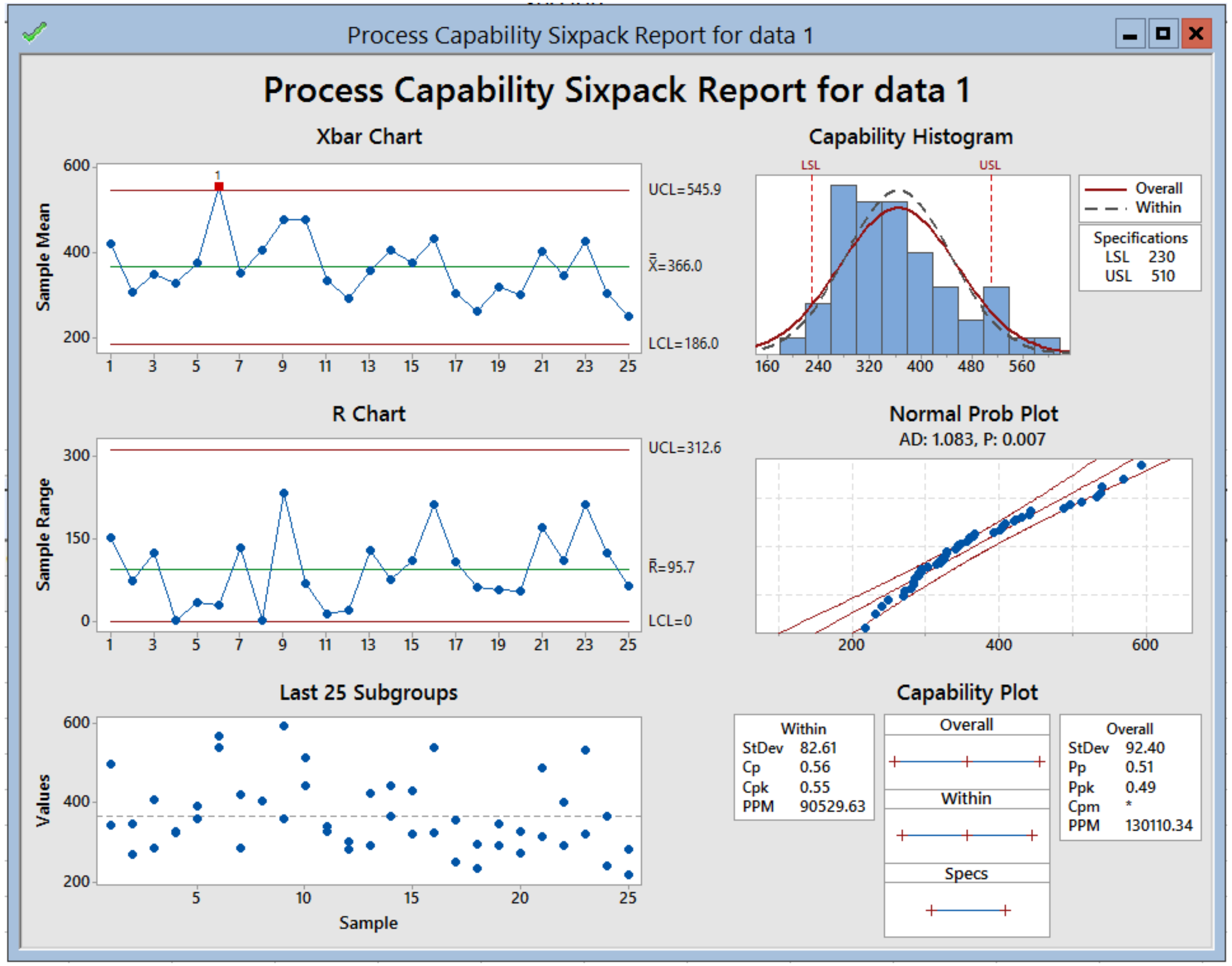
Here we are attempting to analyze the capacity of the current reservoirs in Huston which were incapable of storing the rain water and lead to massive flooding.

The current holding capacity of the two reservoirs combined is about 510 GL

We are using the capability six pack for doing this.

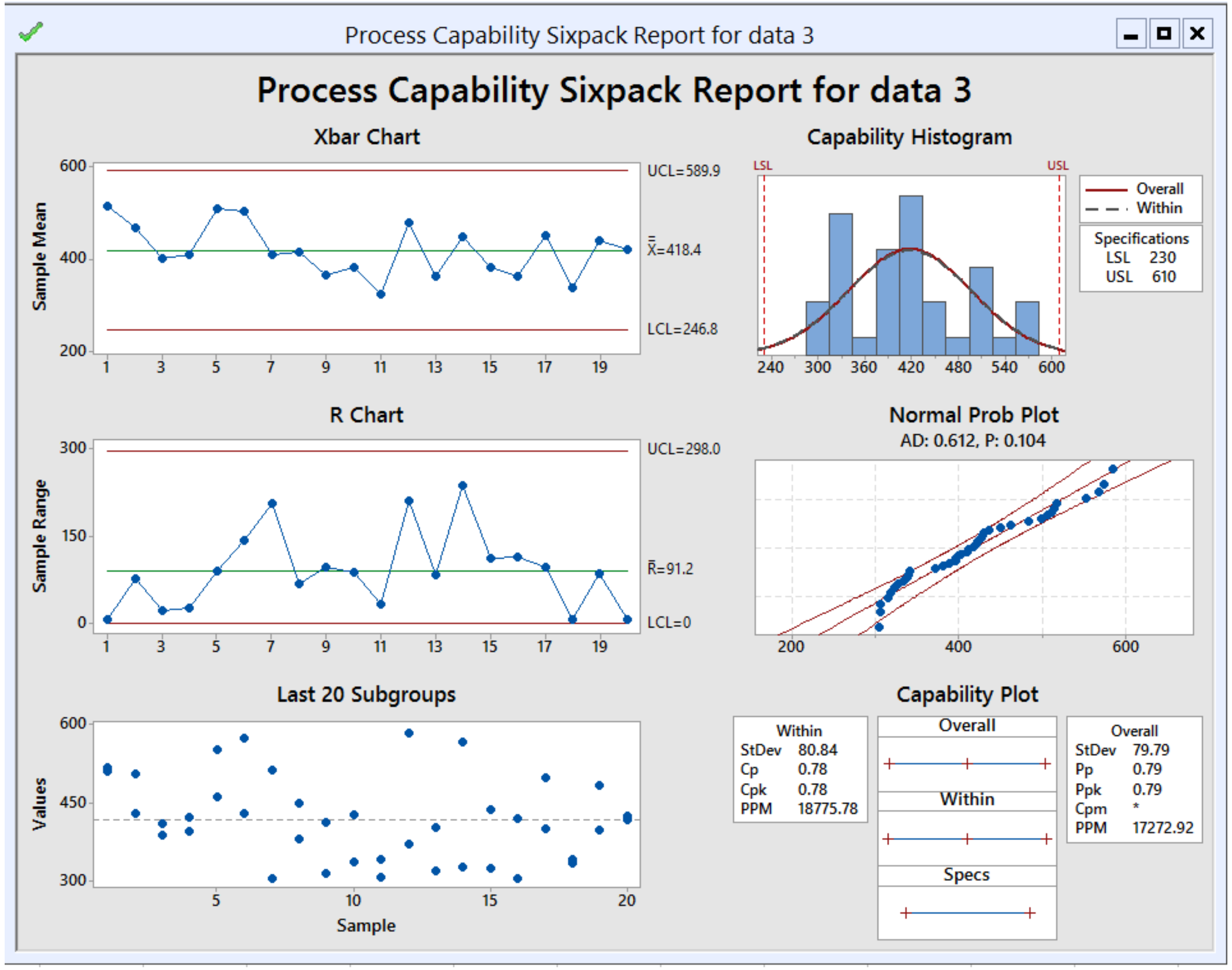
CAPABILITY ANALYSIS

- So, we can observe that the process is not very capable as both Cpk and Ppk are below 1.
- We have the X bar which has 1 outlier.
- In the R chart we can see that about 4 points are dangerously close to becoming outliers



STATISTICAL PROCESS CONTROL-after increasing the ucl to 610, its in control

- Based on the results that we saw above, we have increased the upper limit from 510 GL and kept the lower limit the same(230 GL)
- It is very evident that the capability of the process has increased, also we do not have any outliers in the X bar chart.



THE ANALYSIS

The comparison of the above two six packs tells us that increasing the upper limit, or in other words the capacity of the reservoirs would have an effect on the capability to store rain water more efficiently.

Based on this evaluation, we have performed a QFD analysis which will be discussed in the further slides.

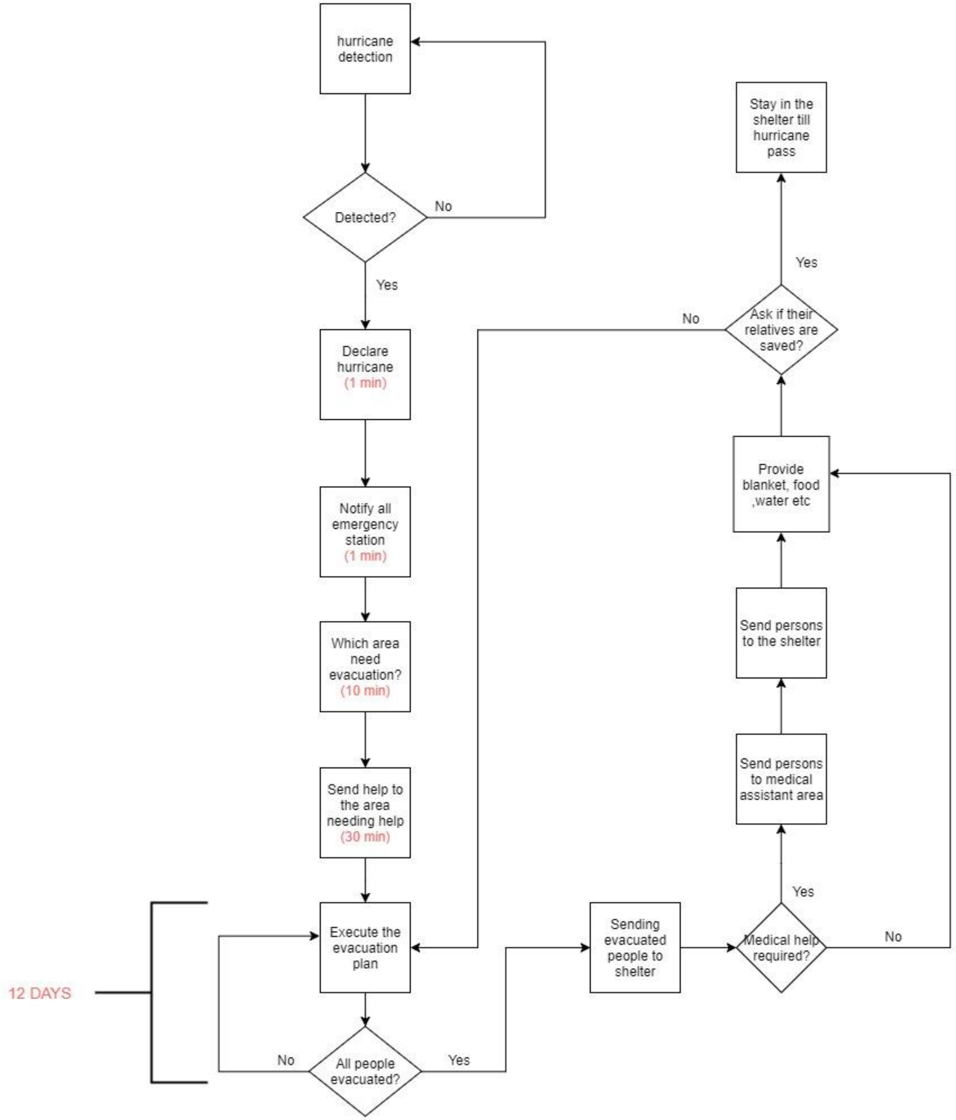
VALUE STREAM MAPPING

VSM is a technique used to document, analyze and improve the flow of information or materials required to produce a product or service.

Here we have used VSM to make the emergency response services more efficient.

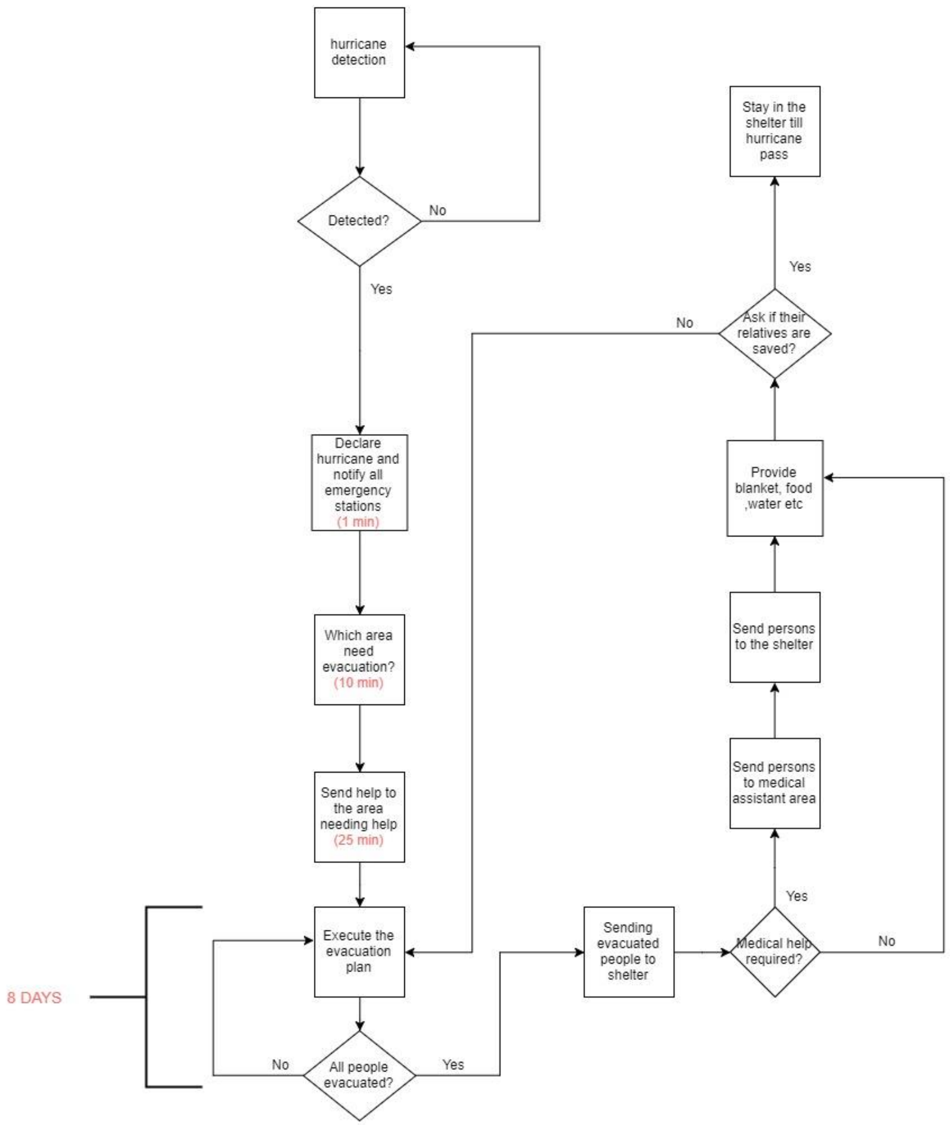
CURRENT PROCESS

- As discussed earlier, the team of 2300 rescues people took about 12 days to rescue 780,000 people from the areas in need.
- The flow chart shown here represents in consolidated form the steps and timings involved in doing the same.



THE FUTURE PROCESS

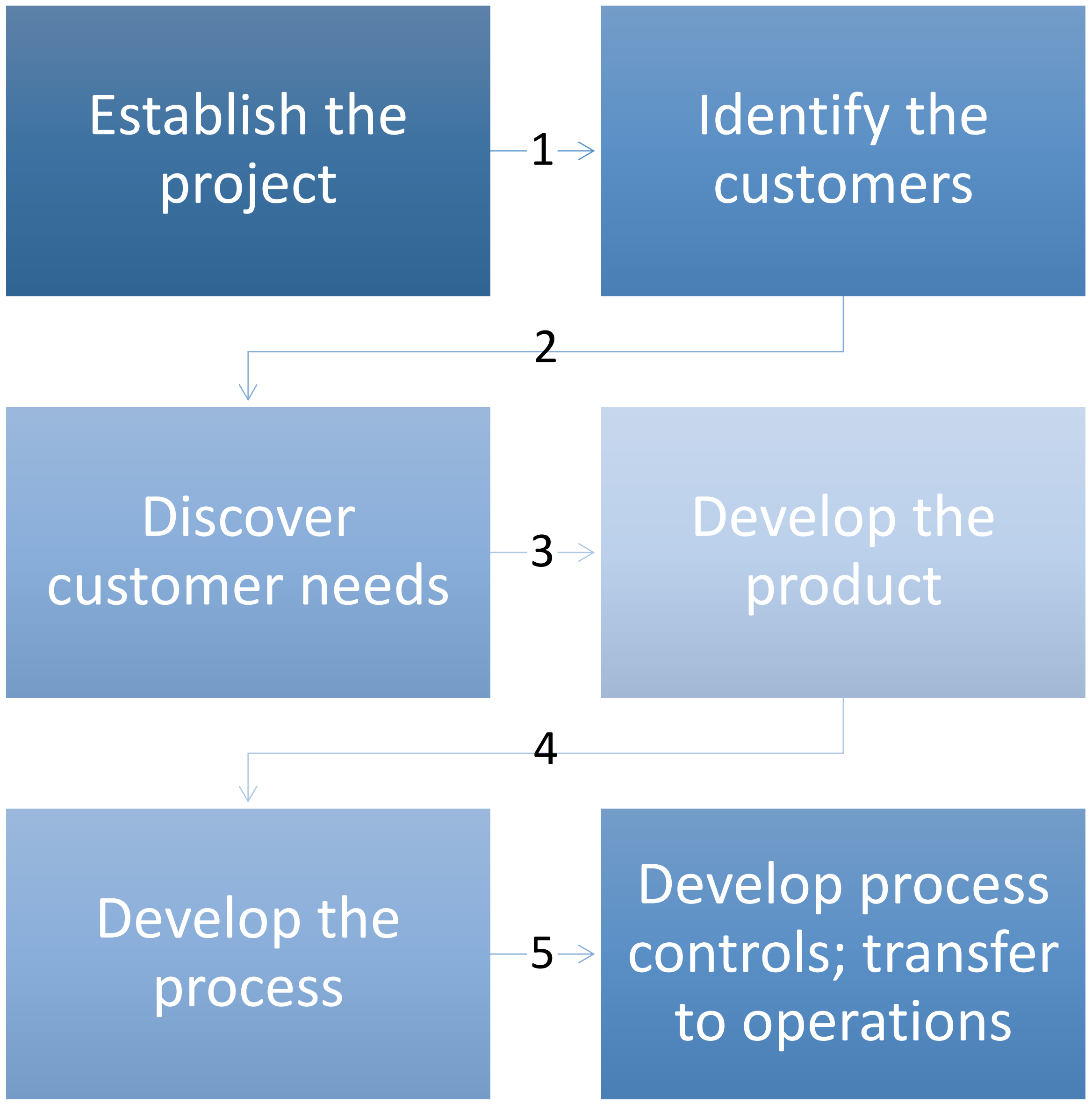
- In this VSM we can see that the execution of the evaluation plan has become more accurate by adding AIR AID, which was the most important factor in the results of the DOE analysis, and INCREASING NUMBER OF STATIONS, which was the second most important factor from the DOE analysis.
- The timing has come down from a little over 12 days to 8 days.



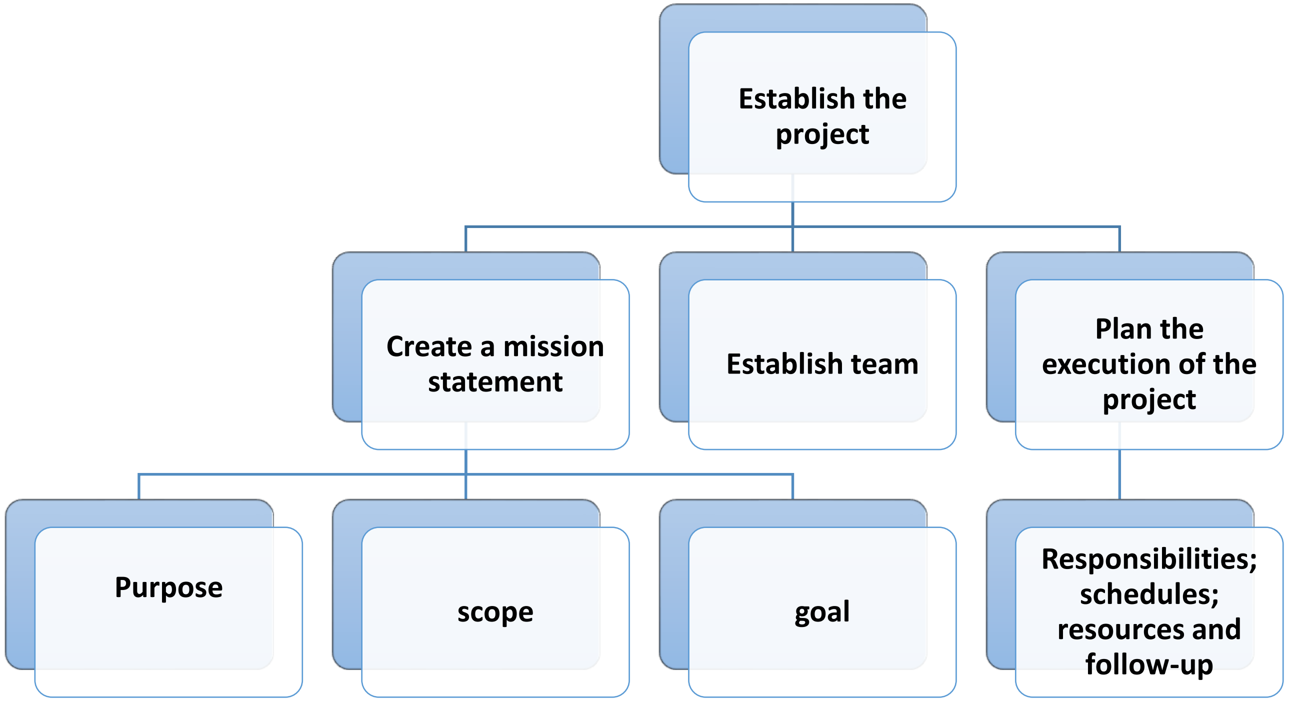
QUALITY PLANNING ROADMAP

A FRAMEWORK THAT HELPS IN PLANNING AND RE-PLANNING OF PRODUCTS AND SERVICES.

The Six Steps



Establish the Project



Mission statement

Scope: CONSTRUCTION BLUNDERS—THE RESERVOIRS

Goal and Purpose: to increase the capacity of the two reservoirs and improve their infrastructure to prevent them from overflowing in case of a flood like Harvey.

Establish a Team:

- Design Department
- Suppliers
- Government representatives
- Finance department
- Engineers
- Planning and Construction department
- Quality Department
- Experts and Specialists on reservoir construction
- Architects
- Safety department
- Project Managers
- CEO

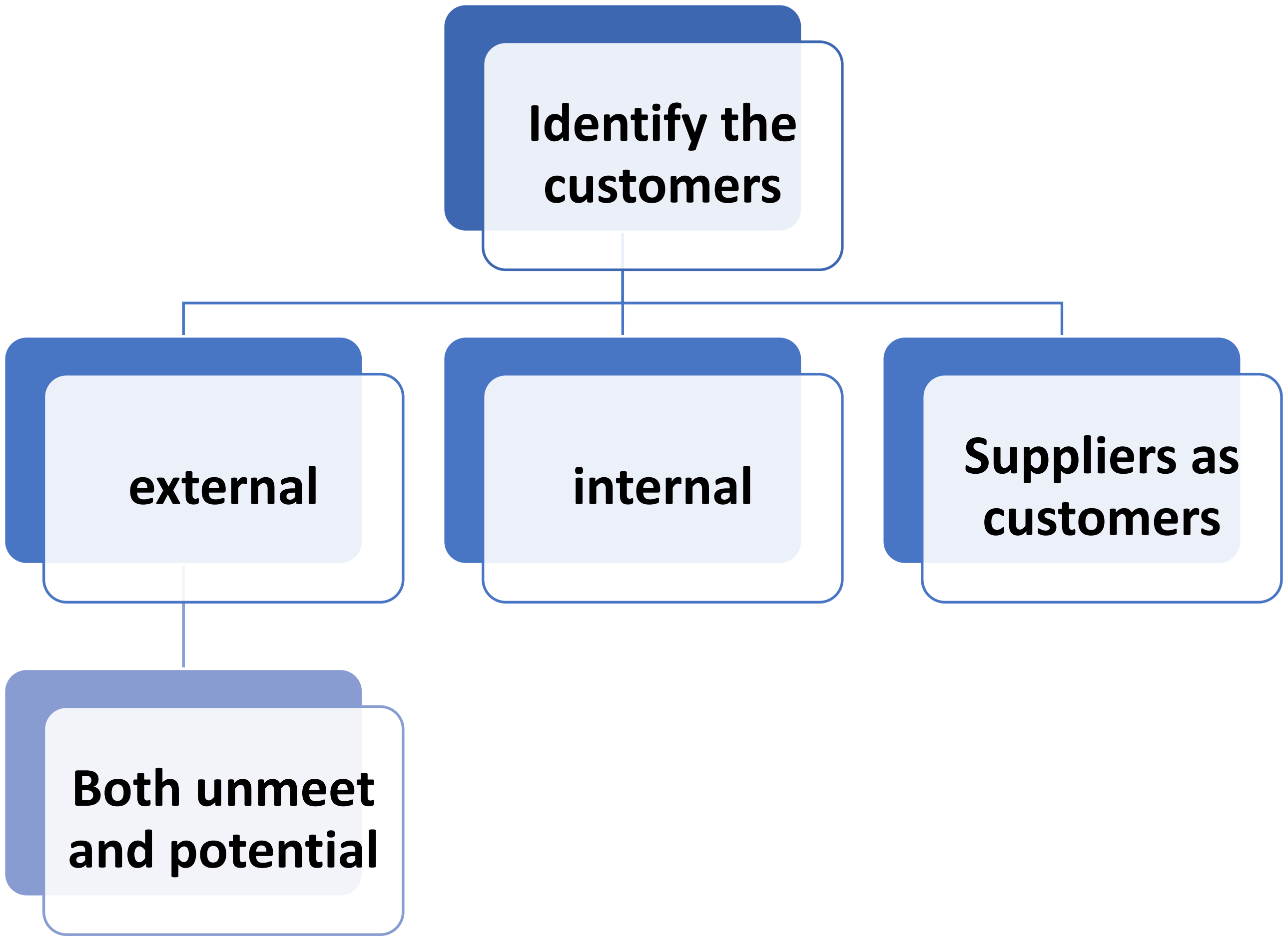
Plan execution

Different departments will have different responsibilities however, the teams will have to be cross-functional for example

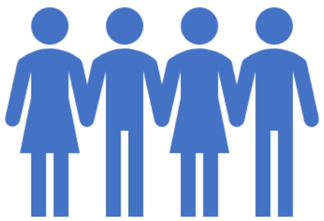
The design department, engineering department and the architects can work together to come up with the pseudo models and blueprints, engineering drawings and designs.

The resource and raw material scheduling can be done using project management tools like Microsoft project, Newfarma, Primavera etc.

Identify the Customer

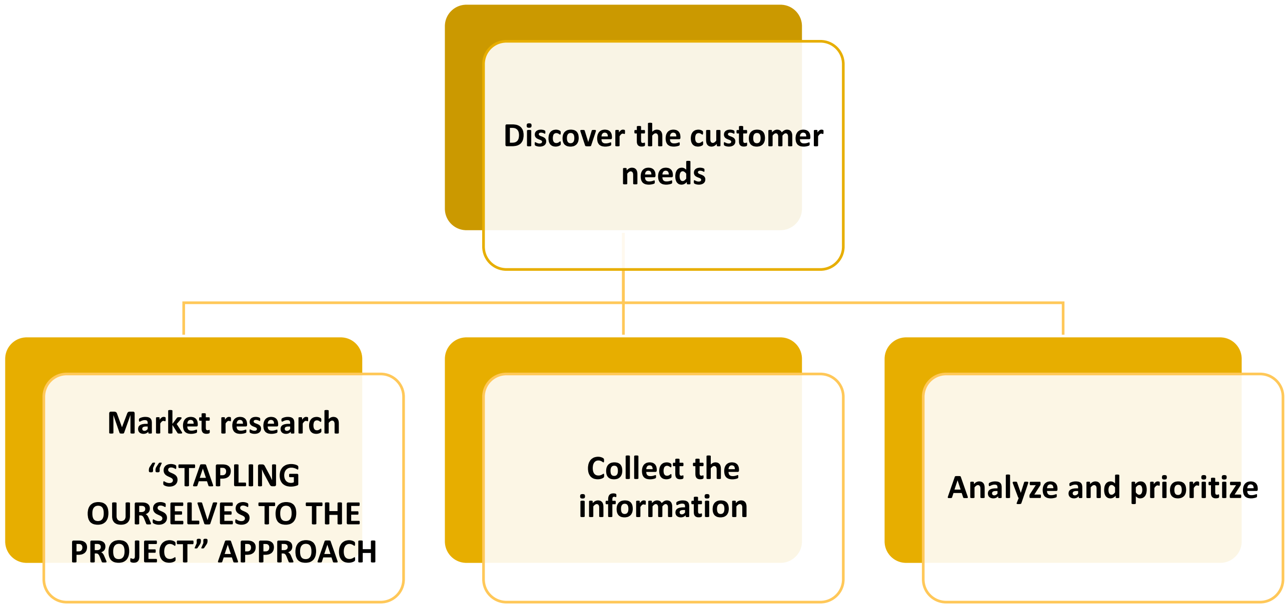


External and Internal Customers



- Our biggest and most influential external customer would be the government and the residents of the state who are directly affected by flooding. Both are powerful and influence the economy
- All the teams working on the project along with the construction workers and suppliers will be the internal customers.
- Tools like flowcharts, pareto charts and spreadsheets can be used to identify the customer.

Step 3: discover the customer needs.



Market research

"STAPLING OURSELVES TO THE PROJECT" APPROACH

1. observation
2. Capturing the data
3. Reflection and analysis
4. Brainstorming for solutions
5. Developing prototype of problem solution

CUSTOMER	NEED
GOVERNMENT	IMPROVED RESERVOIR STRUCTURE
RESIDENTS/CITIZENS	SAFE LIVING ENVIRONMENT

- The table above is based on the research done previously on the effects of hurricane Harvey. Voice of customer was captured and others tools were used for research purposes.
- Based on data collected, brainstorming sessions were conducted and the main reason for major destruction was flooding.
- Causes of flooding were uncovered, analyzed and prioritized and poor infrastructure came out to be the major issue.

Develop the Product

- Group together related customers’ needs
- Identify alternative product features
- Develop detailed product features
- Finalize product design

Develop the Process

- Identify alternative process features
- Develop detailed process features
- Establish initial process capability index
- Finalize product design

FEMA

Process Steps	Failure mode	Severity 1-10 10 = most severe	Occurrence 1-10 10 = highest prob. of occurrence	Detection 1-10 10 = lowest prob. of detection	RPN[1]	Improvement Action
Constructing the new design of the reservoirs	Design can't meet the actual requirement.	7	10	1	70	Revise the design
Get the new Design approved from stakeholders like the government	Design is not approved	5.5	10	1	55	Revise to accommodate new requirements
Disperse illegal residents	the Residents are reluctant to remove.	9	8	2	144	Provide alternative accommodation
Contacting suppliers and contractors for availability of material	Material and labor not available	9	2.5	1	22.5	Import labor and material
Resources delivered by the suppliers	Resources do not meet quality standards	7	5	5	175	Redelivery the right resources
Construction team begins to rebuild the reservoir	Construction team fails to entirely follow the blueprint.	9.5	2	7	133	Regular inspection
Pilot test	Pilot test fails	10	1	1	10	Redo all the steps above to see why pilot test failed
Pre-handover Inspection of the project	Quality department finds that reservoirs fail to meet quality standards	10	1	1	10	Revise and re-implement quality standards
Periodic inspection and maintenance	Failed to uncover problems at early stages of construction	9	4	10	360	Select monitoring Person

Develop Process Controls and Transfer to Operations

- Identify controls needed and design feedback loop
- Optimizing self control by self inspection
- Establish audit of process
- Verify process capability in operations
- Transfer plans to operations

Control Plan			
#	Process Step Risk minimization	Target	Monitoring Team
1	Adequate upfront planning. Clear scope, expectations and customer(government) requirements	Will avoid scope creep	Risk management team
2	Negotiation with people who need to be moved and providing them with rehabilitation facility	Reduce risk of reluctance to move	partner with influential people like politicians and NGOs to convince residents or hire a negotiator
3	Bidding process should be done carefully, a background quality check should be done for the legitimacy of all suppliers and contractors	Reduced risk of low quality resources and blunders in construction	Project management team
4	Set-up regular inspections; a pilot run should be conducted after completion of every stage of the project	Reduced risk of project failing in the later stages	Inspection team, quality team and maintenance team

Improve phase

The purpose of this step is to identify, test and implement a solution to the problem; in part or in whole. This depends on the situation. Identify creative solutions to eliminate the key root causes in order to fix and prevent process problems.

- Brainstorm potential Ideas / Solutions to address the defects/causes identified in the Analyze Phase
- Evaluate & Select the best solutions
- Pilot Test selected solutions
- Implement Solutions

FEMA for rebuild reservoirs

Process Steps	Failure mode	Severity 1-10 10 = most severe	Occurrence 1-10 10 = highest prob. of occurrence	Detection 1-10 10 = lowest prob. of detection	RPN[1]	Improvement Action
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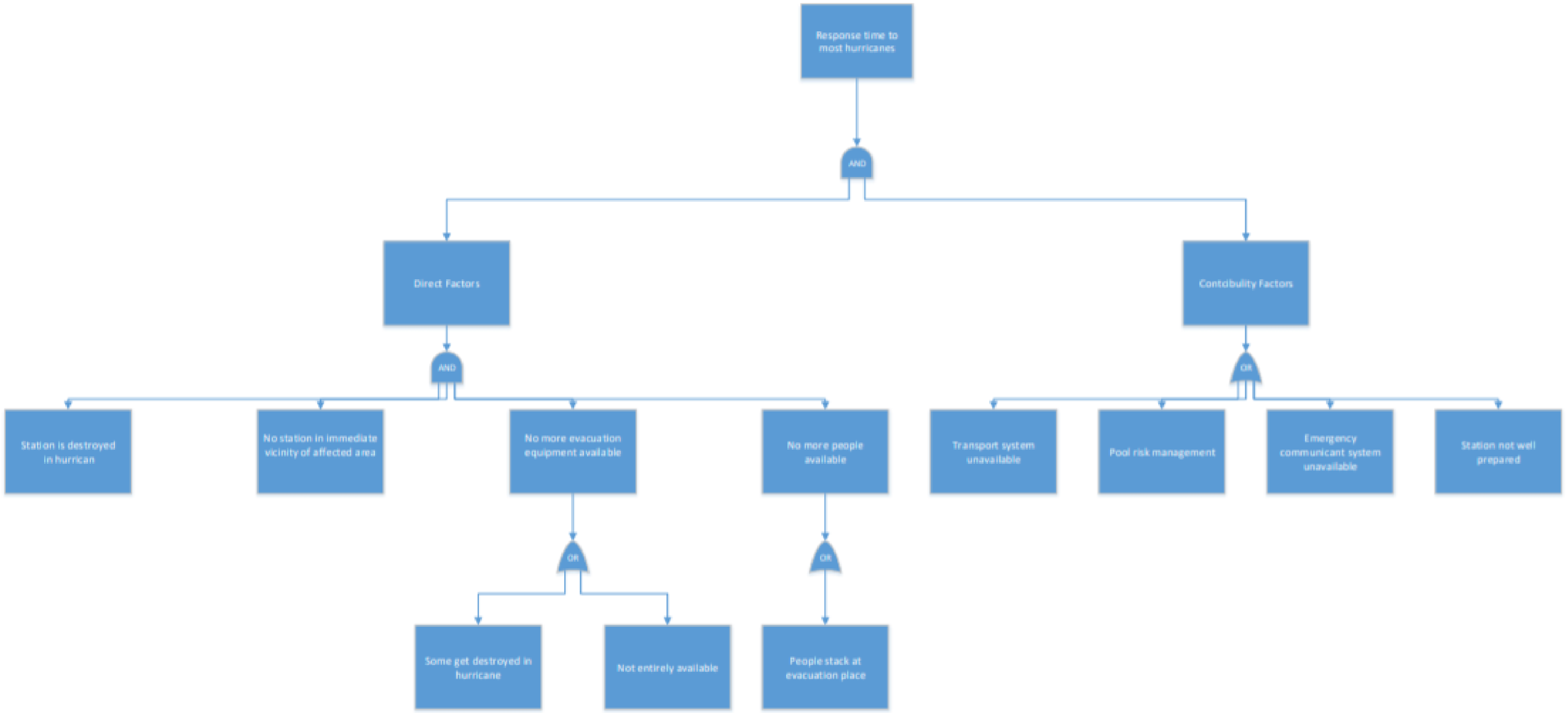
RELIABILITY ANALYSIS

The ability to measure emergency preparedness—to predict the likely performance of emergency response systems in future events—is very critical to see if the future VSM that we have made will be helpful or not

FMEA

PROCESS STEPS	FAILURE MODE	SEVERITY	OCCURRENCE	DETECTION	RPN
Declare hurricane and notify all emergency stations	Emergency communicant system unavailable	7	8	5	280
Detect which area needs help?	Detection system failed	9	5	3	135
Send help to the area needing help	transport system unavailable	10	5	7	350
Execute the evauation plan	Station not well prepared	8	4	8	256
Detect if all people are evauated?	Not enough evauation equipment	10	7	6	420

As seen above, the process steps, Send help to areas needing help and Detect if all people are evacuated have the highest RPN. Based on this we have made an FTA.



FAULT TREE ANALYSIS

Control phase

We are targeting preparedness and awareness in the Control segment of our DMAIC process, for which we have come up with the idea of an app.

- The purpose of this step is to sustain the gains. Monitor the improvements to ensure continued and sustainable success. Create a control plan. Update records as required.
  - Develop a Control Plan
  - Continually Monitor Performance
  - Take Corrective Action
  - Mistake Proof the Solution as best as possible
  - Create a Culture around the new process

CDOV for application using companion

CDOV- Concept, Design, Optimize, Verify

This is another kind of process used for Six Sigma.

We have performed a CDOV in the application called Quality Companion to develop an smart phone app that will assist people in Hurricanes like The Hrricane Harvey.

Project Today | **Team Members & Roles** ×

Team Members & Roles

Project Name:
HURRICANE HARVEY

Team Roles

Project Leader: GROUP1

Mentor/Coach: CHEN

Champion: ANDY

Sponsor: GOVERNMENT

Executive/VP: GEORGE

Financial Analyst: LIZA

Process Owner: FANG

Team Members

Name	Email	Role	Department	Job Title	Business Phone
GROUP 1					
GROUP1		Project Leader			
GOVERNMENT		Sponsor			
ANDY		Champion			
GEORGE		Executive/VP			
LIZA		Financial Analyst			
CHEN		Mentor/Coach			
FANG		Process Owner			

HURRICANE HARVEY

Management
- Project Today
- Project Charter
- Financial Data
- Team Members & Roles
- Tasks

Roadmap
- **Concept**
  - VOC Plan
  - VOC Summary
  - Pairwise Comparison Matrix
  - Pugh Matrix
- **Design**
  - House of Quality Matrix 1
  - House of Quality Matrix 2
  - Design FMEA
  - House of Quality Matrix 3
  - Process Map
  - Process FMEA
  - DOE Planning
- **Optimize**
  - DOE Analysis
  - Monte Carlo Simulation
- **Verify**
  - Control Plan (HoQ)
  - Control Chart
  - Capability Analysis

Project Today ×

Project Today

Project Name: HURRICANE HARVEY

Project Leader: GROUP1

Sponsor: GOVERNMENT

Methodology: CDOV

Project Status & Progress

Status: In Progress

Start Date: 4/1/2018

Due Date: 9/29/2018

Project Health: Green

Current Phase

Current Phase: DMAIC - Define

C D O V

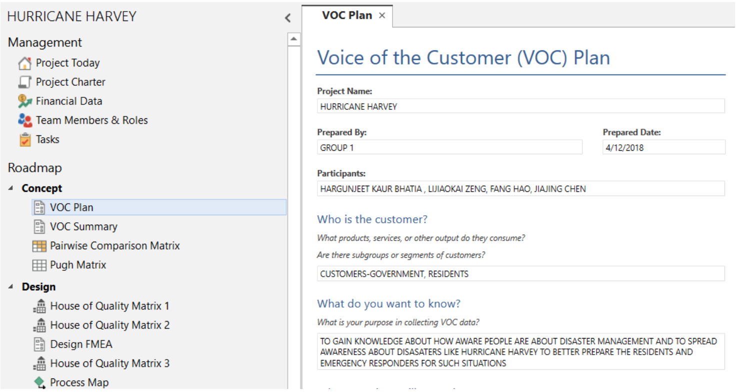
Ready for Phase Gate Review: Yes

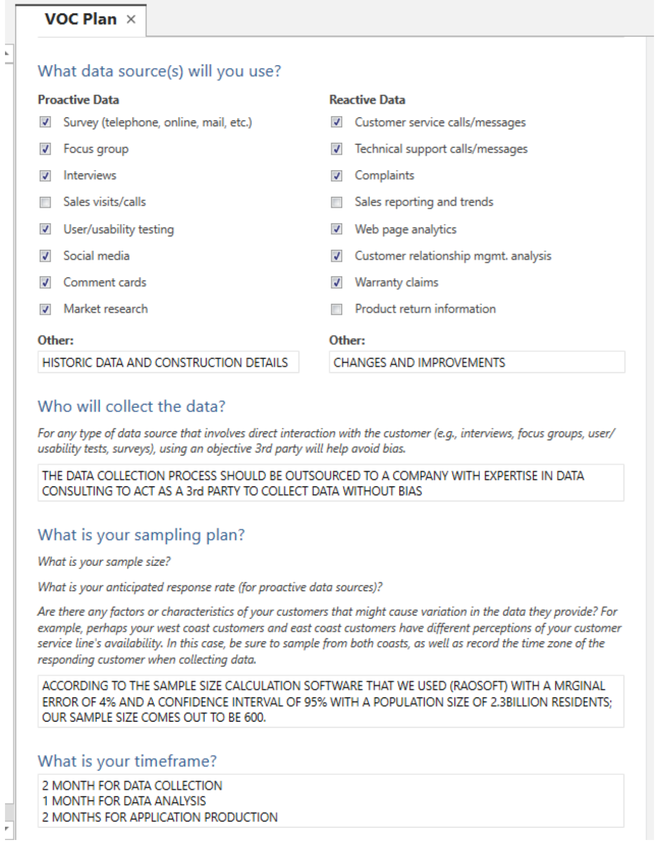
Ready

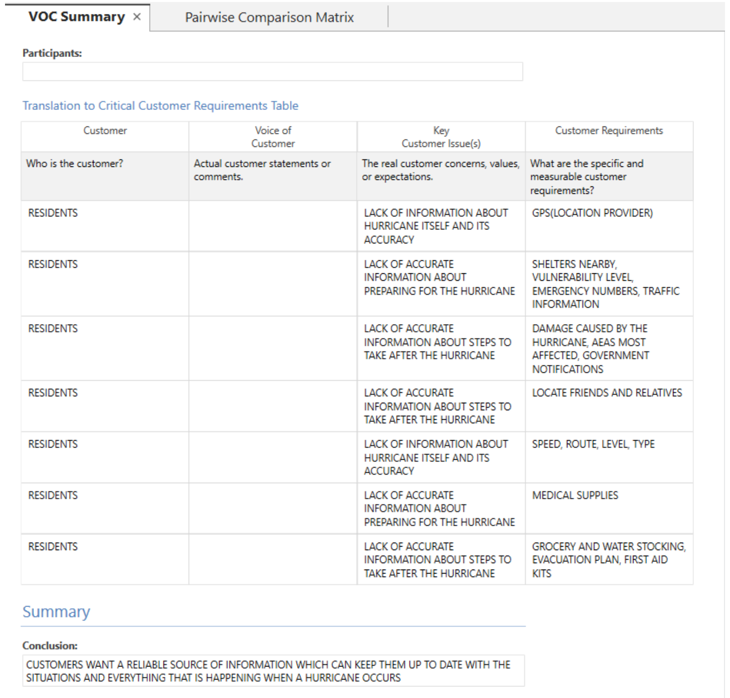
Phase Data

Order	Phase Name	Start Date	Phase Gate Review Date	Duration (days)
1	Concept	4/1/2018	4/10/2018	9
2	Design	4/11/2018	5/31/2018	50
3	Optimize	5/31/2018	6/30/2018	30
4	Verify	6/30/2018	7/6/2018	6
5	Design Scorecards	7/9/2018	8/1/2018	23

DEFINING THE PROJECT START AND END DATES AND THE TEAM MEMBERS WHO WILL BE WORKING ON IT.



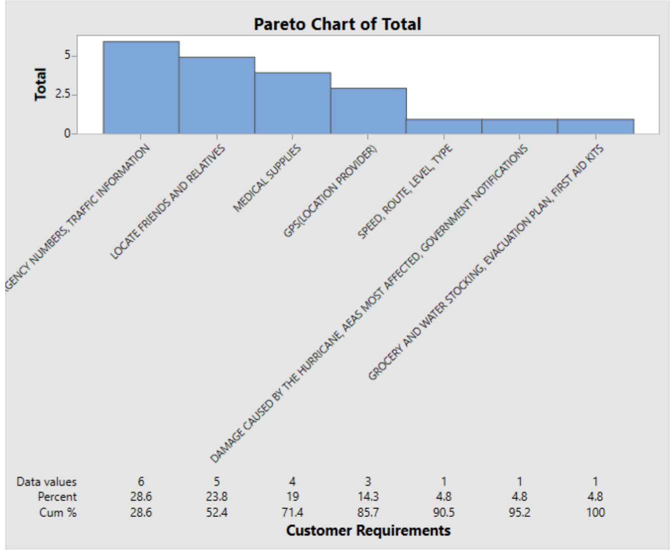




CAPTURING THE VOICE OF THE CUSTOMER

Pairwise Comparison Matrix ×

Pareto Chart of Total



Pairwise Comparison Matrix ×

Customer Requirements Table

ID	Requirement	Total	Importance Rating	Critical?
1	GPS(LOCATION PROVIDER)	3	3	Y
2	SPEED, ROUTE, LEVEL, TYPE	1	1	Y
3	DAMAGE CAUSED BY THE HURRICANE, AEAS MOST AFFECTED, GOVERNMENT NOTIFICATIONS	1	1	Y
4	MEDICAL SUPPLIES	4	3	Y
5	LOCATE FRIENDS AND RELATIVES	5	4	Y
6	SHELTERS NEARBY, VULNERABILITY LEVEL, EMERGENCY NUMBERS, TRAFFIC INFORMATION	6	5	Y
7	GROCERY AND WATER STOCKING, EVACUATION PLAN, FIRST AID KITS	1	1	Y

Pairwise Comparison Matrix ×

Pairwise Comparison Matrix

Note: table rows are created by adding rows to the Customer Requirements Table.

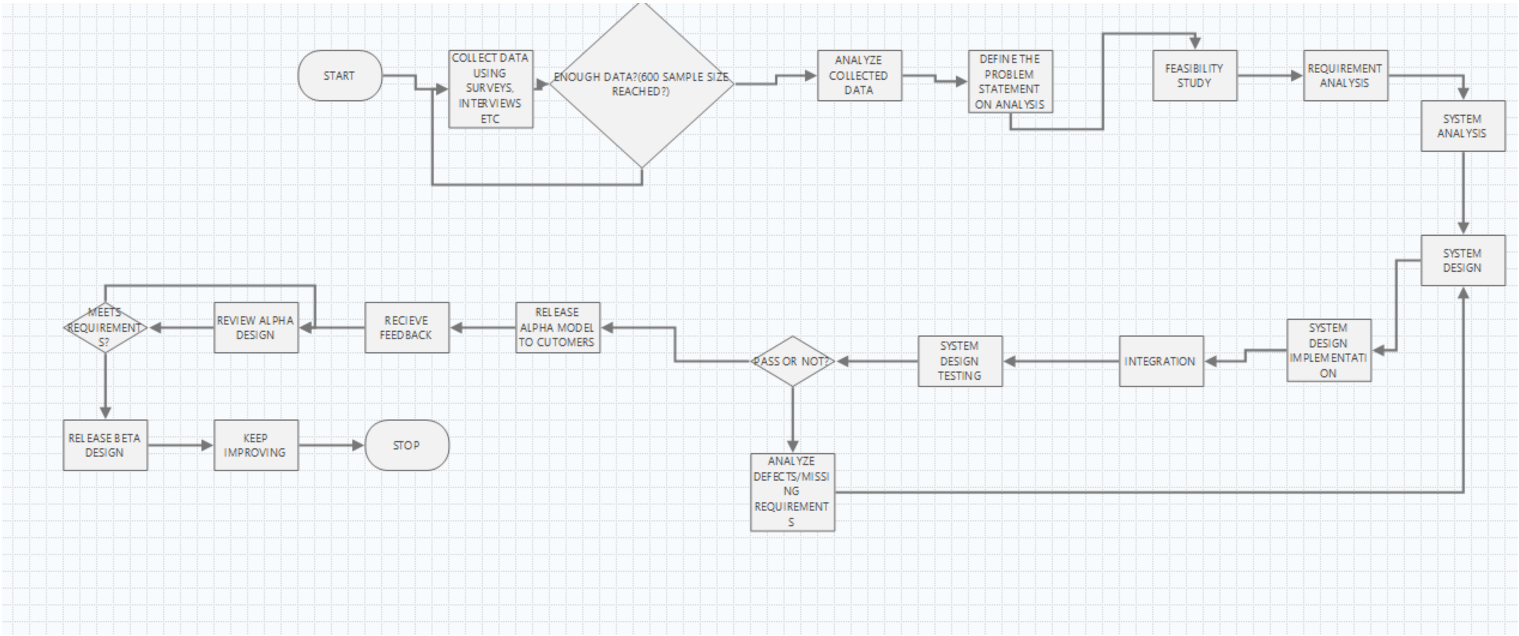
ID	Requirement	1 GPS(LOCATION PROVIDER)	3 DAMAGE CAUSED BY THE HURRICANE, AEAS MOST AFFECTED, GOVERNMENT NOTIFICATIONS	6 SHELTERS NEARBY, VULNERABILITY LEVEL, EMERGENCY NUMBERS, TRAFFIC INFORMATION	5 LOCATE FRIENDS AND RELATIVES	2 SPEED, ROUTE, LEVEL, TYPE	4 MEDICAL SUPPLIES	7 GROCERY AND WATER STOCKING, EVACUATION PLAN, FIRST AID KITS
1	GPS(LOCATION PROVIDER)							
3	DAMAGE CAUSED BY THE HURRICANE, AEAS MOST AFFECTED, GOVERNMENT NOTIFICATIONS	1						
6	SHELTERS NEARBY, VULNERABILITY LEVEL, EMERGENCY NUMBERS, TRAFFIC INFORMATION	6	6					
5	LOCATE FRIENDS AND RELATIVES	5	5	6				
2	SPEED, ROUTE, LEVEL, TYPE	1	2	6	5			
4	MEDICAL SUPPLIES	4	4	6	5	4		
7	GROCERY AND WATER STOCKING, EVACUATION PLAN, FIRST AID KITS	1	3	6	5	7	4	

THE PAIRWISE COMPARISON MATRIX

House of Quality Matrix 1 ×

Performance Criteria Matrix

				Direction of Improvement ↑				
			ID	1	Competitive Evaluation (Customer Requirements)			
Customer Requirements	Performance Criteria	Importance Rating		Reliability	Our Company	Competitor A's Product	Competitor B's Product	Competitor C's Product
1	GPS(LOCATION PROVIDER)	3		3	4	4	3	3
3	DAMAGE CAUSED BY THE HURRICANE, AEAS MOST AFFECTED, GOVERNMENT NOTIFICATIONS	1		1	5	1	4	1
6	SHELTERS NEARBY, VULNERABILITY LEVEL, EMERGENCY NUMBERS, TRAFFIC INFORMATION	5		3	4	3	3	4
5	LOCATE FRIENDS AND RELATIVES	4		9	4	2	2	3
4	MEDICAL SUPPLIES	3		9	3	2	2	4
7	GROCERY AND WATER STOCKING, EVACUATION PLAN, FIRST AID KITS	1		3	3	3	4	4
2	SPEED, ROUTE, LEVEL, TYPE	1		1	2	3	5	2
			Raw Score	92				
			Relative %	100%				



THE HOUSE OF QUALITY MATRIX AND PROCESS FLOW MAP.

PROCESS FMEA

Process Map | Process FMEA ×

Process Step / Process Parameter	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN
DATA COLLECTION	ENOUGH DATA NOT AVAILABLE	TIME FOR COMPLETION WILL INCREASE AS MORE TIME WILL BE REQUIRED TO COLLECT DATA	4	AVAILABLE DATA IS UNRELIABLE, NOT ENOUGH DATA OR DIFFICULT TO ACCESS DATA ABOUT HURRICANES	4	GOOD DATA COLLECTION TEAM	1	16
DATA ANALYSIS	UNRELIABLE ANALYSIS TECHNIQUES	INEFFECTIVE SYSTEM DESIGN	6	LOTS OF DATA TO ANALYSE, LOW NUMBR OF DATA ANALYSTS	5	ADEQUATE STAFFING BASED ON SKILLS AND AMOUNT OF DATA EXTRACTED	4	120
FEASIBLITY STUDY	ALL FACTORS NOT INCLUDED IN STUDY	DATA ANALYSIS NEEDS TO BE REDONE	6	RESULTS OF THE STUDY ARE NOT CONSISTANT WITH DATA ANALYSIS RESULT	5	GOOD ANALYST, SEVERAL MEETINGS TO SEE EVERYTHING IS CONSISTANT	4	120
REQUIREMENT ANALYSIS	MISSED IMPORTANT REQUIREMENTS	INEFFECTIVE SYSTEM DESIGN	8	PM MEETING NOT CONDUCTED, NON-CROSSFUNCTIONAL TEAMS	9	TWO DIFFERENT REQ. ANALYSIS TEAMS, SEVERAL MEETINGS WITH CLIENT	5	360
SYSTEM ANALYSIS	FAILS	NEED TO REDO EVERYTHING	7	SOME POTENTIAL ERROR OCCURED IN REQ. ANALYSIS OR FEASIBILITY STUDY	6	RE-CHECK, DISCUSSIONS, MULTIPLE RUNS BEFORE MOVING TO NEXT STEP	4	168
INTEGRATION	INCOMPATIBLE SEGMENTS	NEED TO DO SYSTEM ANALYSIS AGAIN	7	FAULTS IN THE FEASIBILITY STUDY AND INCOMPATIBLE SYSTEM PARTS	6	RE-CHECK, DISCUSSIONS, MULTIPLE RUNS BEFORE MOVING TO NEXT STEP	4	168
TESTING	FAILS	NEED TO DO SYSTEM ANALYSIS AGAIN	8	THRE COULD BE AN ERROR IN ANY OF THE ABOVE FOR TESTING TO FAIL	8	RE-CHECK, DISCUSSIONS, MULTIPLE RUNS BEFORE MOVING TO NEXT STEP	3	192

CONTROL PHASE

Control Chart ×

Data

Measurement Variable Description:

NUMBER OF TIMEWS THE PRODUCT FAILS TESTING

Total Sample Size:

40

Subgroup Size (Optional):

Data Collection Details:

NUBER OF TIMES TESTING FAILS

Justification that Samples Represent the Target Population:

Checklist

- [x] The measurement system has been validated

Analysis

UCL:	Center Line:	LCL:
10	5	1

Graphical Output (Control Chart):

THE PRODUCT FOR MOST PART WAS IN CONTROL

Results

Description and Explanation of Out-of-Control Points:

TESTING FAILED 2 TIES WHICH IS LOWER THAN THE CENTRE LINE AND THIS OCCURED DUE TO ERRORS IN REQUIREMENT ANALYSIS

Thank you

Question?