Veolia & Swiss Re

Building a more resilient New Orleans through physical and financial protection

Technical Report

Contents

Introduction

The Technical Report in connection with the risk evaluation of the Board's potable water, sewerage, drainage, and self-generated power infrastructure supplements the Executive Summary Report and describes, inter alia, the methods used to assess the Board's assets exposure.

The scope of our work, as determined by the Board, is detailed in the Disclaimer on page 4. The Disclaimer should be read in conjunction with the Executive Summary Report and this Technical Report.

You should note that our findings do not constitute recommendations to you as to whether or not you should proceed with certain capital expenditures.

The Technical Report and the Executive Summary Report are for the benefit and information only of the Board and should not be disclosed, in whole or in part, without our prior consent, except as specifically permitted in the Amendment. To the fullest extent permitted by law, we will not accept responsibility or liability to any other party in respect of our work in the Executive Summary Report and the Technical Report.

Summary of objective and scope

An analysis of the risks and impacts related to wind and storm surge events, and the reliability of energy supply to assets, was performed from June to October 2016 and covered the assets of Sewerage and Water Board of the city of New Orleans (SWB).

The analysis was identified as part of discussions with SWB Management and was performed at their request with the approval of the SWB Board on 15 February 2016.

It is associated with the strategy launched by the City of New Orleans on the 10 year anniversary of Katrina.

It is important to note that this association does not indicate full coverage or satisfaction of the strategic risk as a strategic risk is managed through a number of actions carried out by the City of New Orleans.

As identified with Management, the overall objective of the analysis was to consider the risk exposure and vulnerabilities of the assets to potential scenarios of wind and storm surge as per the modelling tool developed by Swiss Re, and to the level of reliability of the energy supply provided by Entergy, and to identify any improvement opportunities.

The analysis does not cover other operational risks or other weather events, however if during the course of the analysis, additional risks were identified then these have been shared with SWB Management for further investigation.

The analysis did not cover the effectiveness of the levees, or any other measures taken to date since hurricane Katrina. These measures were considered as effective to protect the city to the levels they were designed for by the US Army Corp of Engineers and accredited by FEMA.

The specific objectives, scope and approach of the analysis were agreed with SWB Management.

Disclaimer – Scope of Work

- The Technical Report or any information submitted in connection therewith does not serve to modify, revise, change, negate or otherwise amend any provisions of Amendment No. 1 to the Professional Services Agreement. The content of the Technical Report is necessarily limited by the information that has been available and reviewed to date, portions of which may still be subject to verification.
- Our work commenced on 23 June 2016 and our fieldwork was completed on 18 October 2016. We have not undertaken to update our Report for events or circumstances arising after such completion date.
- In preparing the Report, our primary source of information has been the management of the Sewerage and Water Board of New Orleans ("SWB"). We do not accept responsibility for such information which remains the responsibility of SWB. Details of our principal information sources are presented in the Report and we have satisfied ourselves, so far as possible, that the information presented in our Report was consistent with other information which was made available to us in the course of our work in accordance with the terms of Amendment No. 1 to the Professional Services Agreement. We have not, however, sought to establish the reliability of the sources by reference to other evidence.
- When referring to our "analysis", this indicates only that we have (where specified) undertaken certain analytical procedures on the underlying data to arrive at the information presented; we do not accept responsibility for the underlying data.
- The information used for the analysis was provided and validated during the course of the meetings with SWB management.
- Veolia Water North America-South LLC and its affiliates under no circumstances warrant the accuracy or completeness of the information given in the Report. All liability for the accuracy and completeness thereof or for any damage or loss resulting from the use of the information contained in this Report is expressly excluded. Under no circumstances shall Veolia Water North America-South LLC or its affiliates be liable for any financial or consequential loss relating to the use of the Technical Report.
- Land subsidence was not taken into account for the analysis: considering that some studies show subsidence ranging from 0 to 1 inch per year, it is important to note that subsidence should be determined for each asset before engaging in capital expenditure and monitored over time to ensure mitigation measures are still effective.
- Levees and other protection measures implemented post Katrina by the US Army Corp of Engineers were not analysed or tested and were considered appropriate for the purpose of the Swiss Re modelling of potential events. Following Katrina, the US Army Corp of Engineers undertook studies to determine the appropriate levels needed for the levees and built them in light of their analysis and modelling.
- The scope of our work did not include an analysis of the works performed by the US Army Corp of Engineers. Moreover, the Swiss Re model assumes that the structures put in place would respond effectively to the weather events up to 100 - year return period.
- The scope of our works did not include the review of any of the flood protection measures in place outside of the assets under the control of SWB at the time of the analysis (e.g. canals, levees, storm surge walls)..
- The scope of our works did not include any assessment or audit of the compliance of systems, processes, or operations in accordance with regulation or standards. In

particular, water quality and compliance with standards were not in the scope of the analysis and therefore not tested.

- The analysis performed focussed on the critical assets of SWB's portfolio determined by its management.
- Our review did not include a valuation of the assets of the SWB portfolio. These values were provided by SWB's management..
- The mitigation costs are estimates and may be subject to change.

Existing Risk Analysis of the Sewerage and Water Board

Modeling Disclaimer

General notice

Material discussed in following section of this report is provided by Swiss Re. This material is provided for information only and is not intended as a recommendation or an offer or solicitation for the purchase or sale of any insurance product or other financial instrument nor as a recommendation or an offer or solicitation to initiate or invest in changes based on suggestions made in the document.

The information contained in these materials is preliminary and subject to change and is also incomplete and does not constitute all the information necessary to adequately evaluate the consequences of acting upon recommendations made therein. The information should not be the sole justification for the deployment of engineered infrastructure designed to protect a particular location, building or asset from the impacts of flood, wind and rain. Additionally, while information herein has been obtained from sources believed to be reliable, no representation is made as to its completeness or accuracy. In no event shall Swiss Re be liable for any use by any party of, for any decision made or action taken by any party in reliance upon, or for any inaccuracies or errors in, or omissions from, the information contained herein and such information may not be relied upon by you in evaluating the merits of recommendations made in the document.

Additional notice:

The following assumptions and disclaimers relate to the risk information detailed in the document:

- All calculations, unless otherwise stated in the document, are based on Swiss Re proprietary underwriting systems ("UWS"). Such systems are optimized to quantify expected losses for an underlying portfolio of an insured interest using a probabilistic rather than a deterministic approach. This particular type of model has specific constraints such as and not limited to:
    - The UWS is not an hydraulic-engineering model designed to address <u>any</u> interconnectivities between individual assets
    - UWS <u>do not</u> provide deterministic results for individual assets with an accuracy needed to inform actual, technical improvements
    - UWS provide results referring to "averages" such as "average expected loss" using a large number of probabilistic, hypothetical events. Actual losses of individual events, due to the highly specific nature of their occurrence can be expected to deviate from expected average loss figures, in part substantially
    - UWS are not designed to allow for forecasting of events
    - UWS are optimized to accurately reflect the behavior of a portfolio of assets (>200 individual assets) not to assess individual asset losses

- Probabilities/losses are calculated using Swiss Re's UWS, consistent with Swiss Re's externally audited Group Risk Model, and are for illustrative purposes only. The project team has not evaluated the adequacy, completeness or appropriateness of Swiss Re's internal UWS, and related assumptions. Results produced by such UWS will likely show differences when compared with results possibly provided by other third party risk modelers.

- Any mention of "return period" has to be seen in the context of the geographical scope. What might be an event with a 10 year return period of the United States of America, can be a 200 year event of the city of New Orleans.

- Return period of flood maps, vs. UWS: Flood maps are typically designed to represent the level of water reached or exceeded for a given return period at any point represented on the map. One individual event, representing certain return period, can but must not reach or exceed every point marked on the underlying flood map as characteristic for such a return period (it may reach or exceed some but might fall well below such mark for other points)

- The quality of the model outcome is significantly dependent of the quality of its input. Due to the limited availability of reliable data for some parts of the analysis significant assumptions had to be made, namely for:
  - Quantification of the overall exposure of the city of New Orleans
  - Addressing the connectivity between property damage and subsequent implications for business interruption
  - Projection of future climate implications

  All calculations are based on current Swiss Re underwriting standards, and, where applicable, in line with latest external and internal research. However, reliability of the results will be greatest in comparing relative changes against established base case scenarios, not in evaluating absolute numbers.

Model Description

The risk analysis for both the current climate and future climate change scenarios is performed using Swiss Re's proprietary Tropical Cyclone model for the United States (TCUS). Released in 2012, the Swiss Re TCUS model follows the four-box catastrophe model framework[1] (figure 1) and uses the most up to date scientific and engineering research.

Figure 1: The catastrophe model four box module.

Hazard

Wind

The underlying historical data set used for the probabilistic track modeling of hurricanes is the HURDAT Best Track[2] data set from the National Hurricane Center in Miami, FL. HURDAT contains so-called track nodes with six-hourly storm positions (latitude/longitude of the storm center), maximum sustained wind speeds (one-minute average at 10 m above surface) and, where available, central pressure for all tropical and subtropical cyclones forming in the Atlantic Basin between 1851 and 2008. The sub-period utilized to develop probabilistic tracks and central pressure climatology is 1891-2008. The justification for choosing the late 19th, 20th and 21st century tracks is outlined in the points below:

- Coastal population was dense enough along the eastern seaboard for all landfalling tropical cyclones, even minimal tropical storms, to be detected
- All hurricane-prone US cities were incorporated by 1900; Miami was the last of these in 1896.
- Atlantic shipping lanes were sufficiently dense to detect most storms, especially major hurricanes, in the open ocean.

Additionally, the central pressure at landfall was inserted for each storm in case it is situated in between the standard HURDAT times of 00Z, 06Z, 12Z and 18Z. The basis for this information is the "Chronological List of All Hurricanes which affected the Continental United States" maintained by the Hurricane Research Division. The final historical data set which serves as a basis for the TC US model consists of 1,117 tropical and subtropical cyclones between 1891 and 2008 (118 years). Each track has a probability of occurrence (`event frequency') of 1/118 years.

In order to generate a sufficient amount of simulation years for statistical analysis, each historical ("mother") track is perturbed via a direct random walk process 199 times (figure 2). The track is developed considering both direction and pressure of the mother tropical cyclone, which is randomly varied. This random element, however, is "directed", meaning it is dependent on the values of the prior track node and on its deviation from the mother track. Additionally, the directed random deviations are limited by the climatology and certain physical boundaries. For storms which make landfall, storm decay is initiated as the track crosses the coast, and the filling methodology used follows Vickery[3].

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[1] Zimmerli, P. (2003): Natural catastrophes and reinsurance. *Swiss Reinsurance Company*. Downloaded at http://www.swissre.com/library/88565222.html

[2] Jarvinen, B. R., C. J. Neumann, and M. A. S. Davis, 1984: A tropical cyclone data tape for the North Atlantic Basin, 1886-1983: Contents, limitations, and uses. NOAA Technical Memorandum NWS NHC 22, Coral Gables, Florida, 21 pp. http://www.nhc.noaa.gov/pdf/NWS-NHC-1988-22.pdf

[3] Vickery, P. J. (2005). Simple empirical models for estimating the increase in the central pressure of tropical cyclones after landfall along the coastline of the United States. Journal of applied meteorology, 44(12), 1807-1826.

The 199 modified tracks and 1 historical track per mother result in a probabilistic track set containing 223,400 tropical cyclones. With an annual occurrence rate of 9.46 TC/yr, this methodology produces 23,600 probabilistic years, an adequately long time frame to capture low frequency events. Producing 199 daughter tracks ensures a high density of landfalling storms along the coast, especially in areas that are less hazard prone (such as the Northeast United States). A probabilistic ("daughter") track can be shorter, the same or longer-lived than its historic mother track. The Swiss Re methodology for tropical cyclone track development has been reviewed and agreed upon by state insurance regulators in the United States, and is patented[4].

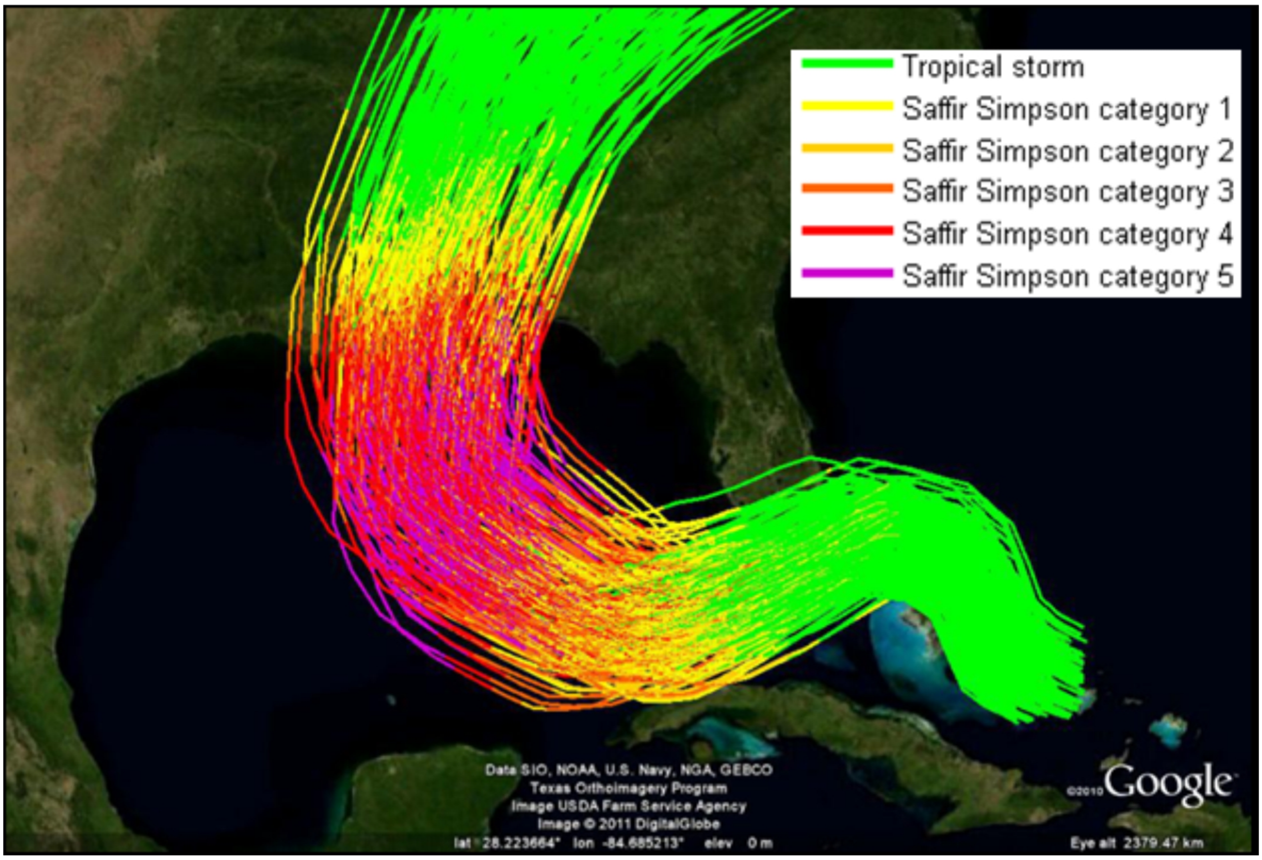

Figure 2: The 200 tracks of Hurricane Katrina (2005), 1 historical and 199 probabilistic.

Once the probabilistic tracks are generated, the wind footprint for each tropical cyclone can be developed. The wind variable around the hurricane track that is useful for our purposes is the 3-second peak wind gust at 10m above ground because it is generally regarded as being correlated with insurance damage and is hence widely used in engineering design codes and insurance risk assessment models.

The steps which yield the wind footprint are described in the following:

- Calculate 1-hour sustained wind in the free atmosphere (above the first 100s of meters above ground) using the Holland formula.[5] [6]
- Add the forward speed of the tropical cyclone, which results in an asymmetric wind field.
- Convert the 1 hour sustained wind to 3 second peak gust and scale down to the surface, using surface roughness and distance-to-coast, since the transition from the land to the ocean is not "felt" by the storm immediately.

[4] https://www.google.ch/patents/US7340346

[5] Holland, G. J. (1980). An analytic model of the wind and pressure profiles in hurricanes. Monthly weather review, 108(8), 1212-1218

[6] Holland, G. (2008). A revised hurricane pressure-wind model. Monthly Weather Review, 136(9), 3432-3445.

The final result is the "Hazard Set" which represents the entirety of one wind footprint for every track of the probabilistic event set and consists of a 3-second peak gust wind field at 10 meters above surface (figure 3). Each wind footprint, and hence also Swiss Re's entire hazard set, explicitly captures the hazard correlation - and subsequent potential economic and insurance loss correlation - across the entire North Atlantic.

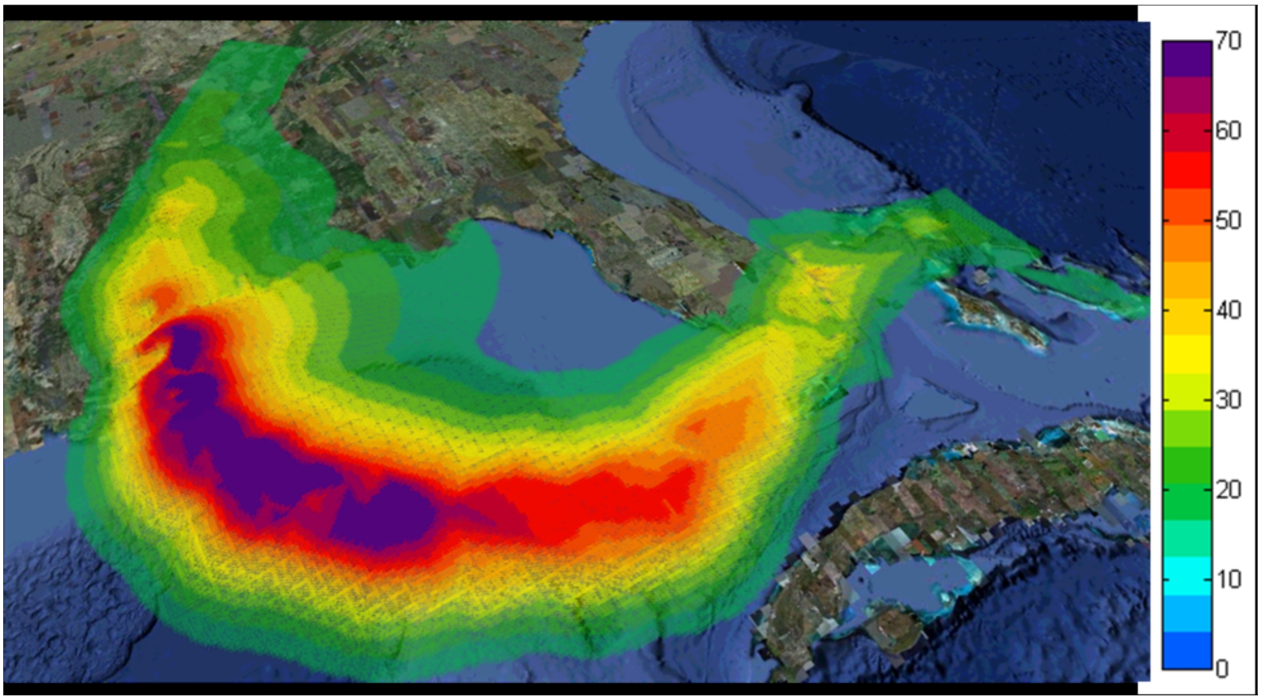

Figure 3: Wind footprint of Hurricane Katrina 2005. The colors represent the 3-second peak wind gust in m/s.

Storm Surge

On the U.S. East Coast and the Gulf of Mexico, hurricanes generate storm surges. Therefore, the TCUS storm surge model uses the same hurricane track set as the TCUS wind model. This hurricane event set contains storm tracks with detailed information about the geographical position, the pressure and the wind speed of each hurricane event. All this information is needed to link the SR event set to the Sea, Lake and Overland Surges from Hurricanes (SLOSH) model[7].

The SLOSH model is a numerical model run by the U.S. National Hurricane Center (NHC; figure 4). It is used to estimate the storm surge height induced by historical, hypothetical or predicted hurricanes. Calculations take into account the atmospheric pressure, forward speed, size, angle of landfall with respect to the coastline and track data of the corresponding hurricane as well as topography and bathymetry to give an estimate of storm surge heights. The modeling focuses on the right front quadrant of the storm, since this is the area in the Northern Hemisphere that generates the largest surge. As storm surges occur only in coastal areas, each storm track of the event set is cut off after landfall from a certain distance to the coastline on. Cut off distance was set to 60 km for areas above 32°N and at 30 km for the rest of the coastline.

[7] http://www.nhc.noaa.gov/surge/slosh.php

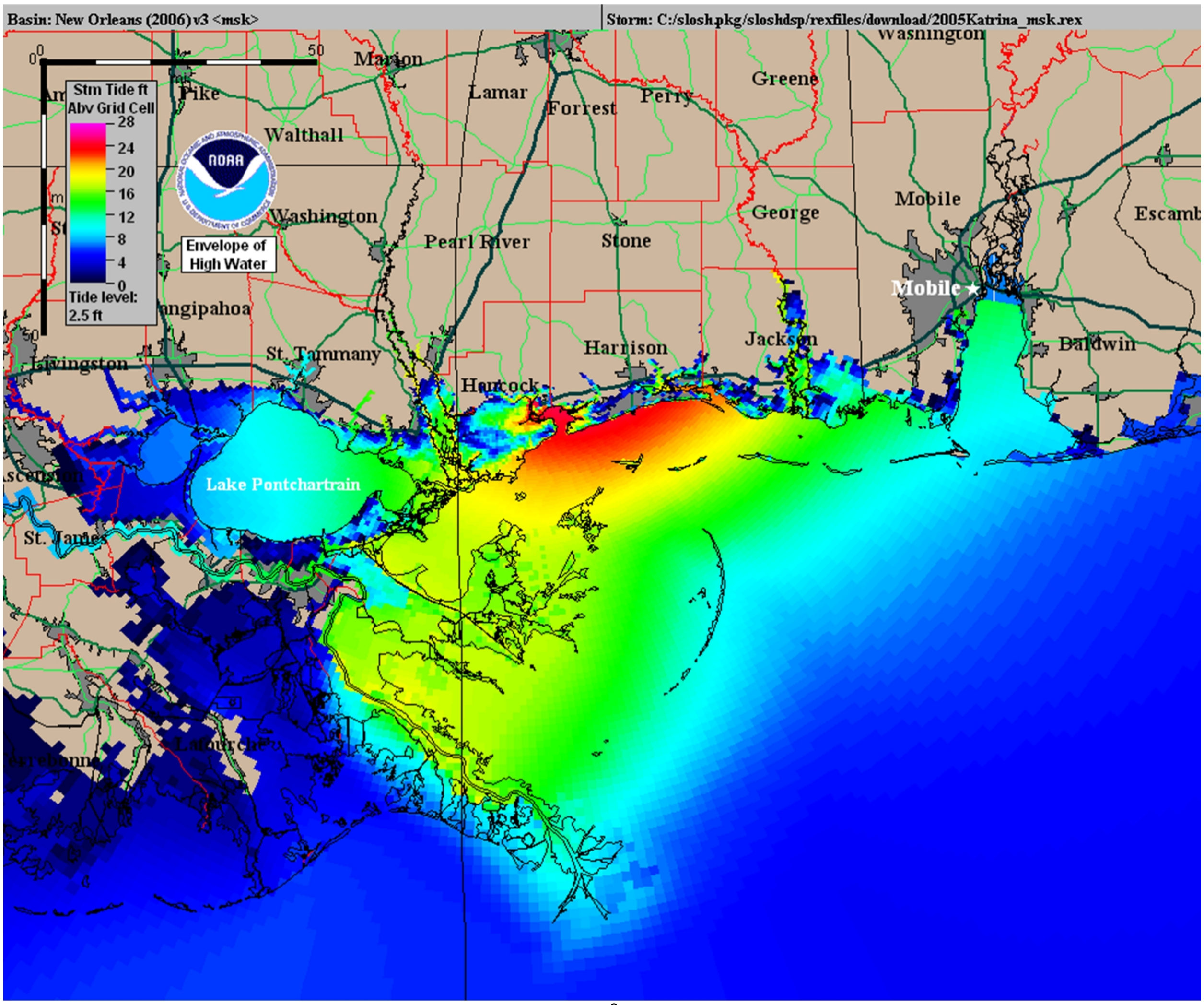

Figure 4: Historical SLOSH model run for Hurricane Katrina[8]

The SLOSH model is combined with the hurricane track set to produce Maximum Envelope of Water (MEOW), which is the worst case scenario for any storm of a given intensity, forward speed, trajectory and initial tide level, incorporating uncertainty in the forecast of the landfall location. MEOW values are calculated by running several parallel hurricane tracks with a similar intensity, forward speed, trajectory and initial tide level. The only difference between the runs is that each run is conducted in some distance to the left or right of the main track. The storm surge hazard set therefore consists of MEOW values corresponding to the 223'400 tropical cyclones from the TC event set.

Consideration of flood protection improvements made the City of New Orleans

In the wake of Hurricane Katrina, the US Army Corps of Engineers made significant improvements to the system of levees and flood walls that surround New Orleans. The impact of these improvements is implicitly accounted for within our storm surge model by assuming that no locations protected by the upgraded infrastructure are exposed to flood levels below the 100-year return period wind speed in the respective calculation unit

Vulnerability

The vulnerability component of the model links the event intensity and the varying responses of the structures it affects. Different types of physical exposure respond differently to the same level of intensity, for example, a 3-second wind gust of 80 mph. A mobile home will not respond the same to the aforementioned 80 mph 3-second wind gust as a concrete warehouse constructed of reinforced concrete. The mobile home, due to both the different

[8] http://www.nhc.noaa.gov/surge/HistoricalRuns/?large&parm=2005_katrina#contents

materials used to construct it, along with a lack of solid anchor, will sustain more damage from an 80 mph 3-second wind gust than a warehouse. To account for these variable responses that are dependent on both construction quality and occupancy type, Swiss Re has developed a multitude of vulnerability curves so that the impact of hurricane winds and storm surge can be captured for portfolios which contain all sorts of exposure.

The vulnerability curves, of which a subset are displayed in figure 5, relate the percent of structural damage from a given 3 second wind gust or water depth. They are developed for both large portfolios of exposure (mixed residential, mixed commercial and mixed industrial) and for numerous specific risk types, including those of relevance to this study, such as wastewater treatment plants, freshwater treatment plants and pumping and drainage stations. The vulnerability curves in the Swiss Re models are created and refined by engineers using the most recent literature and damage surveys from historical events.

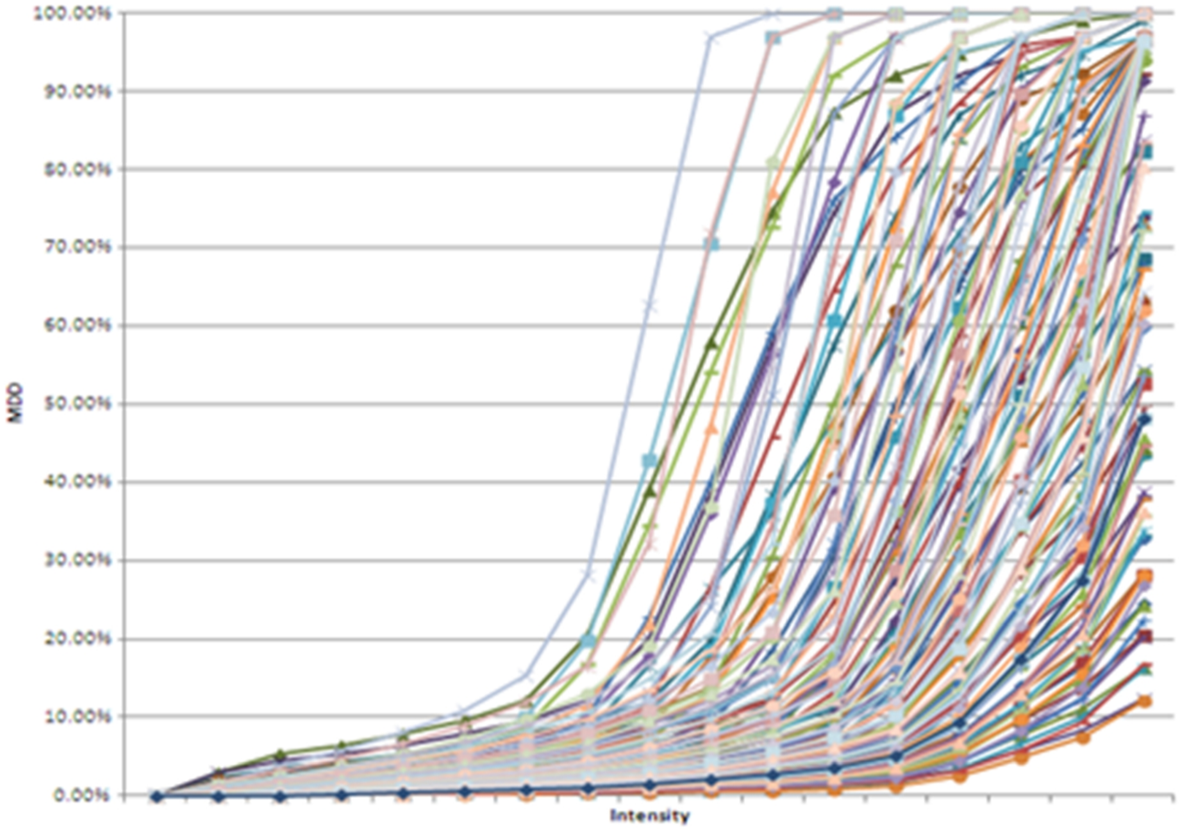

Figure 5: A subset of vulnerability curves for various occupancies within the Swiss Re TCUS model.

Model Calibration

Swiss Re puts the models through an intensive and rigorous calibration process. The hazard component is validated using historical data. An example of the validation process is shown below. All probabilistic and historic tracks within 50 miles of New Orleans are extracted from the hazard set and a frequency comparison of historic and probabilistic central pressure is plotted. The plot demonstrates that the model accurately calculates tropical cyclone frequency in New Orleans.

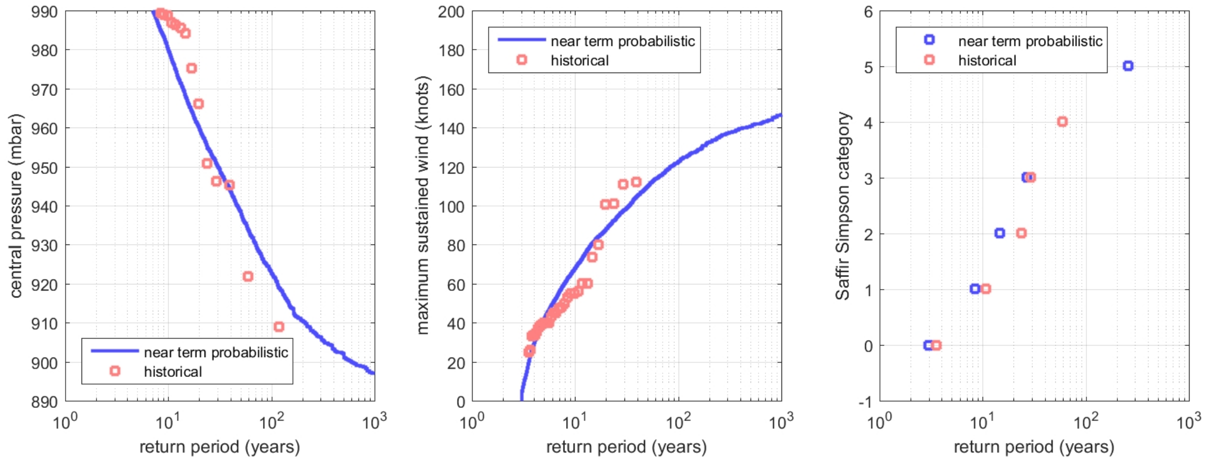

Figure 6: Return period plot for historical (red) and probabilistic (blue) tropical cyclone occurrence within 50 miles of New Orleans. From left to right, the metrics are minimum central pressure (millibars), 1-minute maximum sustained winds (knots) and Saffir Simpson Category.

The vulnerability component is combined with the hazard component to benchmark and calibrate the full model. Both insured market portfolios and individual risk portfolios (telecommunications, utilities, etc) are run through the model and the losses are compared to reported losses for historical events. Sanity checks are also performed using vendor models, such as RMS and AIR. The process is iterative and repeated as many times as necessary to bring the modeled curves in line with historical experience and expert expectation.

The Sewage and Water Board Asset Portfolio

A list of physical assets owned by the Sewage and Water Board (SWB) was provided to Veolia and Swiss Re to perform the risk analysis and resiliency measure assessment.

The asset catalog lists 203 different assets; of these 203 assets, 65 assets are identified as critical assets. Some are single risks in a single location, such as a pumping station, while others are single component of a larger compound, such as an electrical substation at a wastewater treatment plant. The current value of the buildings and contents is USD 3.4 billion; the assets identified as critical account for USD 2.9 billion.

The assets are mapped to the Swiss Re TCUS model occupancies based on the descriptions of both the facilities and the assets. Figure 7 displays the occupancies selected and the total value mapped to these occupancies.

Occupancy Type	Total Asset Value
Fresh water procurement or treatment plant	1,358,000,000
Low hazardous goods storage - warehouse	2,500,000
Maintenance and repair shop	5,300,000
Office building	12,160,000
Power distribution: substation	300,000
Waste water treatment plant	300,000,000
Water pumping station	1,736,685,000

Figure 7: The values mapped to the various occupancy classes within the Swiss Re TCUS model.

Pumping stations account for the vast majority of the values (USD 1.7 billion), followed by the two fresh water treatment plants (Carrolton and Algiers; USD 1.4 billion).

Risk Analysis

The portfolio of assets is run through Swiss Re's TCUS wind and storm surge model to calculate the both the loss potential across all return periods, referred to as the loss frequency curve, and the annual expected loss.

The loss frequency curve relates how many events one can expect in a given period to meet or exceed certain damage levels. For example, the 50 year loss level is expected to be met or exceeded once in any fifty year period. The distinction between return period and recurrence interval is an important one; one should not assume that if a 50 year event happens in a certain year, an additional 50 years will elapse before the next one occurs. Rather, return period communicates the chance of experiencing a loss of a certain amount in any given year. It is possible, and has been witnessed historically, for 20, 50, 100 year events to occur in back-to-back years.

The annual expected loss is calculated by summing the losses across all events, and dividing by the number of years in the analysis. Some years will have no loss, while others will have large loss events. The annual expected loss communicates how much one would have to budget annually to place into reserve for repairs from, in this instance, tropical cyclones.

Baseline

Both the critical asset portfolio and total asset portfolio are run through the TCUS model as-is to determine baseline risk under current climate conditions, current levels of flood protection at individual Sewage and Water Board Assets and the current level of protection of the broader flood protection infrastructure upgrades in the New Orleans area (figure 8). The large scale flood protection within the Swiss Re model considers the deployment of the Hurricane and Storm Damage Risk Reduction System (HSDRRS), which was implemented by the US Army Corps of Engineers, and is believed to protect the city up to the 100 year storm surge level.

The loss frequency curves and annual expected losses for the baseline run and all subsequent analyses reflect property damage only; no consideration of the impact on the Sewage and Water Board revenue or broader economic impact on the city of New Orleans is considered in this subsection.

Critical Assets			**Total Assets**		
Return Period	**Wind**	**Surge**	**Return Period**	**Wind**	**Surge**
AEL	3,299,082	5,677,459	AEL	3,874,897	6,582,013
50	36,799,875	-	50	43,091,250	-
100	78,234,764	223,219,151	100	91,385,836	263,381,382
250	154,582,189	569,692,612	250	182,674,456	647,529,862
500	204,164,496	699,515,012	500	239,214,817	784,965,440
1000	290,091,209	775,710,107	1000	341,345,666	891,477,295

Figure 8: The baseline loss frequency curve for the SWB critical (left) and total (right) asset catalogs under the current climate with current flood protection infrastructure among SWB assets and in the New Orleans metro area.

The annual expected loss to the total portfolio is USD 10.5 million; of this USD 10.5 million, the critical assets contribute USD 9 million, or 86%, to the total expected loss.

The enhanced flood protection implemented by the city in the wake of Hurricane Katrina results in the high frequency part of the curves being dominated by wind losses, and losses beyond 100 years being dominated by storm surge. At 100 years, the property damage from storm surge alone is approximately 7% of the total asset value.

Impact of additional individual asset hardening

Given the flood protection already afforded to the Sewage and Water Board by the large-scale flood protection infrastructure, the additional storm surge hardening proposed by Veolia on the basis of USACE 100 year and 500 year flood depths (assuming flood walls hold and pumps are running at 100%) have a negligible impact.

Critical Assets

Return Period	As-Is	Hardened	% Change
AEL	5,677,459	5,562,918	-2.02%
50	-	-	
100	223,219,151	211,306,005	-5.34%
250	569,692,612	561,469,647	-1.44%
500	699,515,012	692,920,204	-0.94%
1000	775,710,107	767,211,184	-1.10%

Figure 9: The baseline storm surge loss frequency curve for the SWB critical asset catalog under present day hardening (left) and additional hardening (right) under the current climate and current flood protection infrastructure in the New Orleans metro area.

The expected loss from storm surge is reduced by approximately USD 120,000, or 2.02%, to USD 5.6 million for critical assets (USD 6.5 million for total assets). Along the loss frequency curve, the hardening reduces the risk by approximately USD 10 million at each return period, which equates to a 1% - 5% risk reduction across all return periods.

The impact of the hardening on the expected loss at each individual location is assessed as well. For all locations, the ratio between the savings incurred from the hardening and the cost of implementing the hardening is less than 0.01.

Hardening measures proposed on the basis of Swiss Re's estimated 100 year flood depth ranges reduce the annual expected loss by 50% to USD 2.8 million for critical assets (USD 3.8 million for total assets). This reduction implies an annual saving of USD 2.8 million. The complete set of identified hardening measures on the critical assets list amounts to a total of USD 690 million.

The analyses of the reduction in risk profile (% decrease of expected loss before and after mitigation) and the investment required relative to the asset insured determines a prioritized action plan ("strategic action plan") to assist in how to allocate capex more appropriately.

As a result, the focus can be placed on the “must have” mitigation measures for critical assets, while still paying close attention to “quick wins” (highest reduction with the least investment) versus the “good to haves” (high reduction but relatively high investment).

This strategic action plan amounts to a total investment of USD 404 million (equivalent to 25% of total value of assets selected in this plan for a reduction in expected loss of 64%).

Sensitivity Analysis

Deterministic Analysis – US Army Corps of Engineer Flood Maps

New Orleans is a highly engineered city, given both its current location below sea level and the catastrophic damage it suffered in the aftermath of the levee failure upon Hurricane Katrina's landfall in August 2005. Therefore, many public documents outlining the flood risk in New Orleans are available.

The US Army Corps of Engineers (USACE) is responsible for maintaining and enhancing the massive flood protection infrastructure around the City of New Orleans. The USACE is thought to have a good understanding of the flood protection levels as well as potential flood scenarios due to dam failure or wave overtopping.

The levee systems and flood gates protecting the greater New Orleans area were massively improved after Hurricane Katrina. According to the USACE, the protection will now withstand a 500 year storm surge event and flooding within the parish of Orleans only results from overtopping and meteoric rainfall (see figure 6).

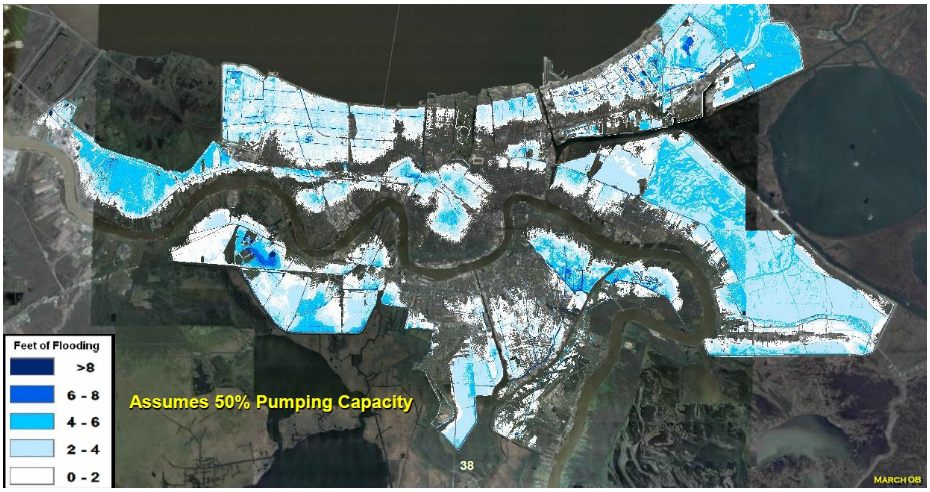

Figure 10: USACE flood scenario for a 500 year surge event showing flood depths in 2 feet steps throughout the greater metropolitan area of New Orleans. In this scenario, the flood infrastructure holds and flooding results from rainfall and overtopping wave action. Pumps are assumed to run at 50% capacity.

The USACE 500 year flood scenario was utilized to calculate losses which may occur inside the administrative boundaries of Orleans parish as a result of this particular event. For this purpose the USACE map was imported into ArcGIS, georeferenced and digitalized. Thereafter, flood depth levels, originally given in two foot intervals, were simplified to polygons assigned to mid-value ranges of 1, 3, 5, 7 and 9 feet.

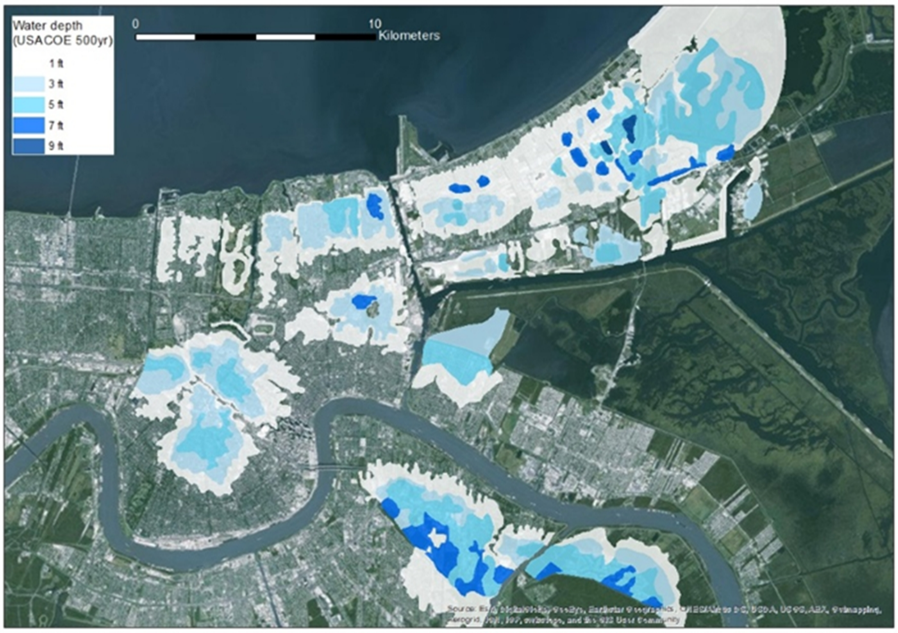

Figure 11: Digitized version of the USACE 500 year scenario with averaged flood depths per category.

The digitalized USACE 500 year flood scenario was overlain on the SWB's assets and flood depths per location were extracted. Generic property damage vulnerability values for each SWB asset class per flood depth category were assigned to each of the affected assets.

The difference between losses with and without hardening measures for the USACE 500 year flood scenario was found to be approximately 10%, in line with the probabilistic risk assessment.

Probabilistic Analysis – Changing the return period of infrastructure protection

Hurricane Katrina, only one hurricane has directly impacted the New Orleans metropolitan area: Hurricane Isaac in 2012. Despite Isaac being only a Category 1 hurricane on the Saffir

Simpson Scale, its large size, slow movement and direction of approach to the coast meant it provided the first real test of New Orleans' improved flood infrastructure (HSDRRS).

The HSDRRS proved successful in protecting the city against surge caused by Hurricane Isaac. However, the system has been partially tested only once, and an assumption of protection beyond the design return period when performing baseline modeling would be optimistic. Still, we changed the assumption about the return period to which the HSDRRS protected New Orleans to both demonstrate the importance of the HSDRRS and how further enhancing (or reducing) the level of protection might impact physical damage losses to the SWB.

Three different scenarios were considered:

- There is no flood protection.
- The flood protection protects up to the 200 year storm surge level.
- The flood protection protects up to the 400 year storm surge level.

The annual expected losses for the total assets as-is is displayed in figure 12.

Scenario	**Annual Expected Loss - Total Assets**	**Change (Relative to basecase)**
Baseline: 100 year flood infrastructure, SWB assets as-is	6'581'832	0
Worst Case: No flood protection, SWB assets as-is	18'642'624	12'060'792
200 year flood infrastructure, SWB assets as-is	3'966'980	(2'614'853)
400 year flood infrastructure, SWB assets as-is	2'225'492	(4'356'340)

Scenario	**100-year event damage - Total Assets**	**Change (Relative to basecase)**
Baseline: 100 year flood infrastructure, SWB assets as-is	267'631'019	0
Worst Case: No flood protection, SWB assets as-is	413'380'432	145'749'413
200 year flood infrastructure, SWB assets as-is	6'925'144	(260'705'875)
400 year flood infrastructure, SWB assets as-is	0	(267'631'019)

Scenario	**500 year event damage - Total Assets**	**Change (Relative to basecase)**
Baseline: 100 year flood infrastructure, SWB assets as-is	799'959'377	0
Worst Case: No flood protection, SWB assets as-is	804'621'900	4'662'523
200 year flood infrastructure, SWB assets as-is	709'835'662	(90'123'715)
400 year flood infrastructure, SWB assets as-is	560'784'782	(239'174'595)

Figure 12: Annual expected loss for the total assets, hardening as-is, under various flood protection level assumptions.

Given New Orleans' high flood hazard, removing all flood protection infrastructure causes the expected loss to approximately triple, increasing by USD 12 million. Not surprisingly, increasing the return period of the protection level has an opposite effect, with the expected loss decreasing by USD 2.6 million and USD 4.4 million for the 200 year and 400 year return period protection levels respectively.

Figure 13 shows the change in expected loss if the assets are hardened based on the measures derived from the USACE flood maps; while the magnitude of the changes are less, given the enhanced protection around some of the individual assets, the direction of change and conclusions remain the same.

Scenario	Annual Expected Loss - Total Assets	Change (Relative to basecase)
Baseline Plus: 100 year flood protection, SWB assets hardened	6'467'292	0
Worst Case: No flood protection, SWB assets hardened	17'425'002	10'957'710
200 year flood infrastructure, SWB assets hardened	3'916'061	(2'551'231)
400 year flood infrastructure, SWB assets hardened	2'203'108	(4'264'184)
Scenario	**100-year event damage - Total Assets**	**Change (Relative to basecase)**
Baseline Plus: 100 year flood protection, SWB assets hardened	260'220'776	0
Worst Case: No flood protection, SWB assets hardened	398'413'355	138'192'579
200 year flood infrastructure, SWB assets hardened	6'925'144	(253'295'632)
400 year flood infrastructure, SWB assets hardened	0	(260'220'776)
Scenario	**500 year event damage - Total Assets**	**Change (Relative to basecase)**
Baseline Plus: 100 year flood protection, SWB assets hardened	793'364'569	0
Worst Case: No flood protection, SWB assets hardened	798'027'092	4'662'523
200 year flood infrastructure, SWB assets hardened	704'722'938	(88'641'631)
400 year flood infrastructure, SWB assets hardened	558'103'773	(235'260'796)

Figure 13: Annual expected loss for the total assets, enhanced hardening, under various flood protection level assumptions.

Side Box – Tropical cyclone impact on the City of New Orleans

An economic risk assessment for city of New Orleans was conducted as well, using the same model and methodology that is used for the Sewage and Water Board analysis. The underlying asset catalog for the risk assessment is the insured market portfolio for the city of New Orleans. The portfolio contains both building and content values for all insured residences, commercial enterprises and automobiles. The total value within the portfolio is USD 59 billion. The modeled loss values are inflated by 1.57 to adjust the results to represent potential city-wide physical damage losses; this is based on the insurance penetration in New Orleans.

Key Findings of existing risk

- The expected loss from tropical cyclones is USD 570 million.
- The split between wind and storm surge expected loss is approximately 50/50, with USD 296 million from wind, and USD 274 million for surge.
- Below 100 years, wind losses drive the loss profile; the 50 year return period wind loss is USD 3.3 billion. The 50 year return period surge loss is zero.
- At 100 years and above, surge losses dominate the loss profile. At 100 years, the surge loss is USD 10.4 billion; the wind loss is USD 7 billion.
- The 500 year return period loss is nearly USD 50 billion.

Key Findings of sensitivity analysis

- Based on US Army Corp of Engineers (USACE) 500-year flood depth maps at 50% SWB pumping capacity, Swiss Re estimates that property damage in Orleans Parish could be below USD 4 billion, provided the flood walls do not fail.
- According to changing the return period of infrastructure protection in Swiss Re's tropical cyclone model, the flood protections in place today are saving Orleans Parish USD 650-750 million of property damage per year from storm surge on an annualized basis. These savings are significant, but should not distract from the fact that there is

still considerable residual flood risk. Even with the investments made, the annual expected loss from hurricane-related storm surge is an estimated USD 175–275 million of property damage.

Climate Change Scenarios

The time horizon for the climate change scenarios are the 2050s. It is worth noting that while we will use the year 2050 within the text as a reference, it should understood that the analysis does not refer to an individual year necessarily, but rather a time frame occurring in the 30 – 50 years.

Wind

The impact of climate change on Atlantic tropical cyclones is an evolving science. Recent research performed by the Geophysical Fluid Dynamics Laboratory[9,10] in Princeton, NJ, finds that it is possible for climate change to influence Atlantic tropical cyclones in the following ways[11]:

- *Anthropogenic warming by the end of the 21st century will likely cause tropical cyclones globally to be more intense on average (by 2 to 11% according to model projections for an IPCC A1B scenario).*
- *This change would imply an even larger percentage increase in the destructive potential per storm, assuming no reduction in storm size.*
- *There are better than even odds that anthropogenic warming over the next century will lead to an increase in the occurrence of very intense tropical cyclone in some basins. An increase that would be substantially larger in percentage terms than the 2-11% increase in the average storm intensity. This increase in intense storm occurrence is projected despite a likely decrease (or little change) in the global numbers of all tropical cyclones.*
- *Anthropogenic warming by the end of the 21st century will likely cause tropical cyclones to have substantially higher rainfall rates than present-day ones, with a model-projected increase of about 10-15% for rainfall rates averaged within about 100 km of the storm center.*

To consider climate change within our TCUS model, we rely on the analysis performed by Bender, et. al (2010), which looked at how the frequency of tropical cyclones will change by 2100, under the Intergovernmental Panel on Climate Change (IPCC) A1B emissions scenario, which is a middle of the road scenario. The conclusion of the study is that in the Atlantic Basin, the total number of tropical cyclones is likely to decrease, but the number of intense (hurricanes that reach Category 4 or 5 intensity on the Saffir-Simpson Scale) are likely to increase. The authors look at the results from a suite of individual climate models, along with the average, or ensemble mean, across all climate models.

To adjust the occurrence frequencies of tropical cyclones in our model to reflect the conclusions drawn by Bender, et. al (2010), we rely on the simulation from the GFDL-CM2.1 climate model, which produces one of the more aggressive solutions.

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[9] Bender, M. A., T. R. Knutson, R. E. Tuleya, J. J. Sirutis, G. A. Vecchi, S. T. Garner and I. M. Held (2010): Modeled impact of anthropogenic warming on the frequency of intense Atlantic hurricanes. *Science*, **327**, pp. 454-458.

[10] Knutson, T. R., J. J. Sirutis, G. A. Vecchi, S. Garner, M. Zhao, H.-S. Kim, M. Bender, R. E. Tuleya, I. M. Held and G. Villarini (2013): Dynamical downscaling projections of late 21st century Atlantic hurricane activity: CMIP3 and CMIP5 model-based scenarios. *J. Climate,* 26, pp. 6591-6617.

[11] https://www.gfdl.noaa.gov/global-warming-and-hurricanes/

By 2100, the GFDL-CM2.1 climate model finds that while the total number of tropical cyclones decreases by 4%, the number of major hurricanes (Category 3 and higher on the Saffir-Simpson Scale) increases by 40%. As tropical cyclone intensity increases, the percent increases are even more pronounced; by 2100, the frequency of tropical cyclones that reach Category 5 intensity is expected to increase by 160% (figure 14).

From Bender et al. (2010)	% Change
All TCs	-4.0%
Hurricanes	-7.5%
Major Hurricane	40.0%
Category 4 and 5	110.0%
Wind Speeds >65m/s	160.0%

Figure 14: The percent change in occurrence frequency of various tropical cyclone intensities by the year 2100.

We use a four-step process to develop the adjustment factors to apply to our individual event occurrence frequencies within the TCUS model.

1. Based upon the annual average number of events in the control climate and the percent change in the warm climate, calculate the average number of events in the warm climate
2. Subtract the next quantity from the quantity of interest (i.e., subtract the average number of hurricanes from the average number of all TCs) to get the change in the annual average number of relevant events (i.e. tropical storms) in both the warmed and the control climate.
3. Calculate the percent difference for ONLY the relevant events (i.e., tropical storms) and add 1 to get the adjustment factor.
4. Since the analysis was done using the current (2000 - 2020) climate simulations and the 2080 - 2100 simulations, linearly interpolate between 2010 and 2090 to get the adjustment factor for 2050 (2040 - 2060).

The approach described above gives us the following adjustment factors (figure 15).

Storm Bin	Frequency Adjustment (2100)	Frequency Adjustment (2050)
Tropical Storms	1.057	1.028
Minor Hurricanes (Category 1 & 2)	0.683	0.842
Category 3 Hurricanes	1.204	1.102
Category 4 Hurricanes	1.985	1.493
Category 5 Hurricanes	2.600	1.800

Figure 15: Frequency adjustment factors applied to the Swiss Re TCUS model to reflect the impact of climate change.

The application of these factors results in a leftward shift in the distribution of tropical cyclone intensity, showing an increase in more intense storms, when the storm's minimum central pressure throughout its lifetime is the chosen metric (figure 16).

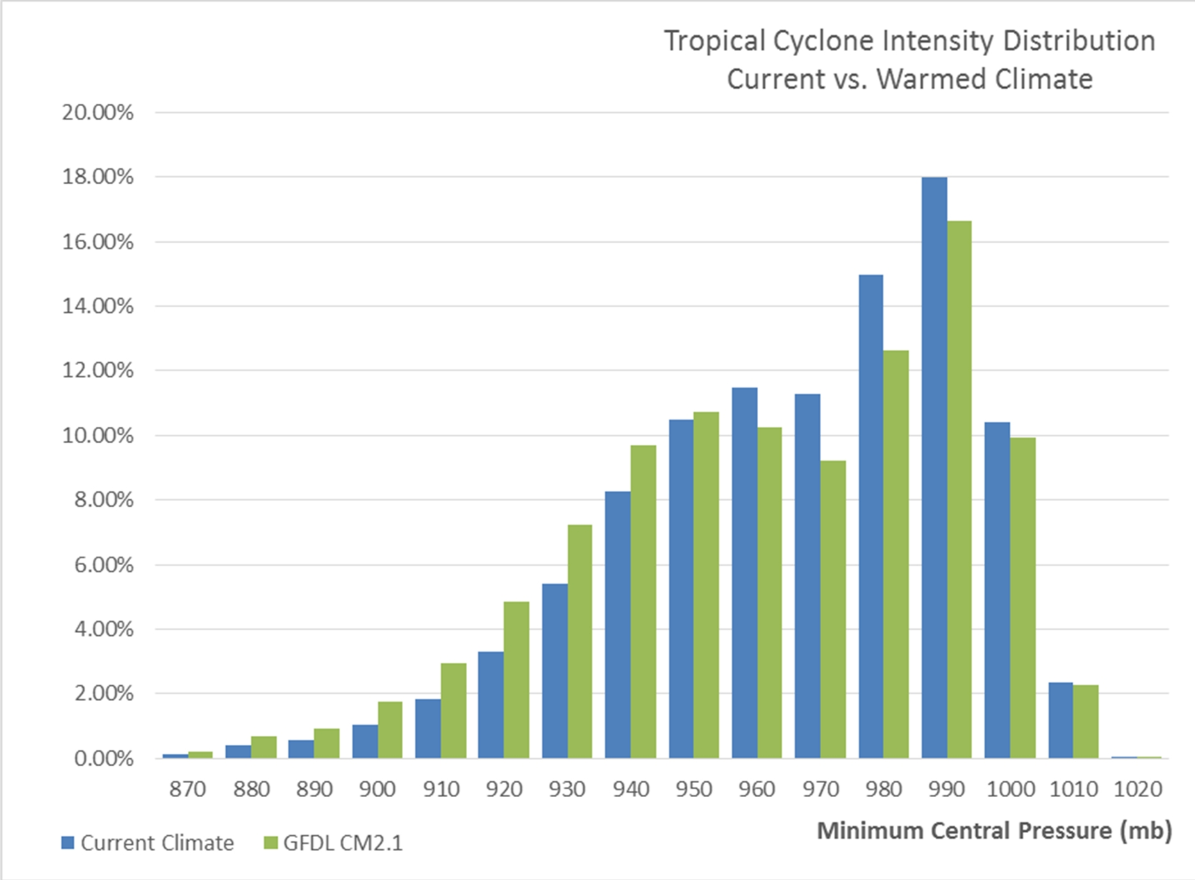

Figure 16: Atlantic tropical cyclone intensity distribution in the current (blue) and warmed (green) climate. The chosen metric to communicate intensity is lifetime minimum central pressure, expressed in millibars.

Sea Level Rise

Even in the absence of hurricane frequency shifts, the effects of storm surge in low-lying places will worsen due to increasing sea levels. The causes behind the rise in sea levels are threefold; first, due to a process known as thermal expansion. As liquids warm, they increase their volume. As ocean temperatures rise, the seas will do just that. The second is the melting of land ice into the ocean, which simply adds more liquid water. Third, and of particular relevance for New Orleans and the surrounding region, is subsidence, or sinking land. A joint study by NASA and Lousiana State University found that parts of New Orleans were sinking at a rate of up to 50 mm (2 inches) per year[12].

In August 2015, Climate Central published a sea level rise assessment[13] for the state of Lousiana, which considers both global sea level rise projections and localized geologic impacts, such as subsidence, to develop a regional sea level rise projection for the state. The analysis relies on historical water levels from Grand Isle, LA and Sabine Pass North, TX as the baseline from which to make the projections. For the mid-century, the average sea level rise projection across the two Louisiana-area sites ranges between 0.9 feet under slow climate change scenarios and 2.5 feet under rapid climate change scenarios, with the authors notng that the faster sea level rise rates are at Grand Isle. For sea level rise within our model, we choose the 2.5 feet projection, since it's impossible to parse the contribution of each location, but we know that Grand Isle, closer to New Orleans, contributes more to the rate.

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[12] Jones, C. E., K. An, R. G. Blom, J. D. Kent, E. R. Ivins and D. Bekaert (2016): Anthropogenic and geologic influences on subsidence in the vicinity of New Orleans, Louisiana. *J. Geophys. Res.*, **121**, pp. 3867-3887.
[13] Strauss, B., C. Tebaldi and S. Kulp (2015): Louisiana and the surging sea: A vulnerability assessment with projections for sea level rise and global flood risk. **Climate Central.** Retrieved from: http://sealevel.climatecentral.org/uploads/ssrf/LA-Report.pdf

Loss Assessment

Storm Surge

The risk to the Sewage and Water Board from storm surge induced flooding will increase significantly by the 2050s due to shifts in both sea level rise and hurricane occurrence. Figure 17 shows the physical damage curve for storm surge losses only under a high climate change scenario

Surge 2050

Return Period	As-Is	Hardened	Total (Critical Assets As-Is)
AEL	10,917,278	10,759,852	12,564,856
50	112,851,711	106,487,023	135,807,597
100	520,966,459	514,260,613	595,719,395
250	776,381,168	767,529,815	878,832,576
500	882,690,519	874,988,741	995,650,469
1000	970,073,320	958,965,759	1,101,869,247

Figure 17: Storm surge physical damage risk profile for the Sewage and Water Board under a high climate change scenario for the 2050s.

Regardless of hardening a handful of assets, the future evident future impacts are:

- A doubling of expected loss by the 2050s.
- More frequent storm surge induced flood losses.
- A 0.2% annual chance in any given year of losses nearing USD 1 billion, equating to approximately 1/3 of the total asset value.

The change in the risk profile for all three portfolios is shown in figure 18; the starkest increase is at lower return periods.

Critical Assets
Surge

Return Period	Current Climate	2050 Climate	% Change
AEL	5'677'459	10'917'278	92%
50	-	112'851'711	
100	223'219'151	520'966'459	133%
250	569'692'612	776'381'168	36%
500	699'515'012	882'690'519	26%
1000	775'710'107	970'073'320	25%

Critical Assets Hardened
Surge

Return Period	Current Climate	2050 Climate	% Change
AEL	5'562'918	10'759'852	93%
50	-	106'487'023	
100	211'306'005	514'260'613	143%
250	561'469'647	767'529'815	37%
500	692'920'204	874'988'741	26%
1000	767'211'184	958'965'759	25%

Total Assets
Surge

Return Period	Current Climate	2050 Climate	% Change
AEL	6'582'013	12'564'856	91%
50	-	135'807'597	
100	263'381'382	595'719'395	126%
250	647'529'862	878'832'576	36%
500	784'965'440	995'650'469	27%
1000	891'477'295	1'101'869'247	24%

Figure 18: Storm surge physical damage risk profile today (left) and the 2050s (right) for the critical asset (top), hardened critical asset (middle) and total asset (bottom) catalogs.

Wind

Given the composition of the SWB asset catalog, and New Orleans's location below sea level, surge is understandably of paramount concern, particularly in the aftermath of Hurricane Katrina. However, wind impacts cannot be ignored.

Figure 19 shows change in the physical damage risk profile from wind for the critical and total asset catalogs. While the differences aren't as stark as the storm surge changes, wind risk is expected to increase across all return periods as the frequency of intense hurricanes increases in a warmed climate.

Critical Assets
Wind

Return Period	Current Climate	2050 Climate	% Change
AEL	3,299,082	5,106,942	55%
50	36,799,875	66,994,409	82%
100	78,234,764	131,170,827	68%
250	154,582,189	202,901,550	31%
500	204,164,496	275,456,440	35%
1000	290,091,209	318,273,126	10%

Total Assets
Wind

Return Period	Current Climate	2050 Climate	% Change
AEL	3,874,897	5,997,538	55%
50	43,091,250	78,551,666	82%
100	91,385,836	153,224,492	68%
250	182,674,456	234,575,181	28%
500	239,214,817	320,861,741	34%
1000	341,345,666	369,504,452	8%

Figure 19: Wind physical damage risk profile today (left) and the 2050s (right) for the critical asset (top) and total asset (bottom) catalogs.

Financial and Economic Risk Impact Analysis

Like any living organism, a city thrives on the collaborative and efficient functioning of interconnected systems. Each system and the service it provides is critical and the interconnected function of these systems make them indispensable to the liveability of a city. Shocks, such as natural disasters, can damage critical physical assets, as well as interrupt the deliverance of these services to residents and businesses, creating often deep and profound long-term economic impacts.

Every corner of an economy can face a variety of impacts from disruptive events, such as hurricanes – some more than others. Economies heavily dependent on tourism, hospitality or the movement of goods can suffer more deeply as revenues from these sectors are often diverted elsewhere and are rarely recovered. While the physical assets of various sectors of an economy may be unscathed from a disaster, their ability to operate diminishes if critical infrastructure is impaired. These services include energy, water, telecommunications, and wastewater treatment. The disruption of these services can have far-reaching impacts. For example, in the Great Flood of 1993, 64% of businesses that closed their doors following the event cited the cause was a lack of water.[14]

The speed of recovery from a natural disaster often dictates the quality of that recovery. In fact, nearly 40% of all small businesses in the US never reopen after a disaster and another 25% close their doors within the first year.[15] This is most often the result of inadequate financial resources to absorb a loss of cash flow. Even if these businesses have no direct physical impact, a failure of a critical resource, such as water, can have devastating consequences. Reducing the downtime of various critical services would enhance the resilience of city and all of its components, changing the economic trajectory positively in the longer term.

This chapter examines various approaches to quantifying the economic impact of natural disasters, with particular focus on the indirect losses of a city post-disaster. More specifically, we analyze the tax revenue losses of the City of New Orleans, the revenue losses of the New Orleans Sewerage and Water Board, the disruption to the operations of small businesses, as well as GDP impact on the city. To conclude, we take a look at insured losses and city covers as well as beyond city borders and into the effects of the metropolitan statistical area.

Direct vs Indirect Losses

Direct losses refer to the repair or replacement costs associated with the destruction or impairment of physical assets and all forms of infrastructure, whether publicly or privately owned. Direct economic losses can be inferred from insurance claims or from estimates on the replacement costs of the building stock and infrastructure.

Indirect losses refer to losses resulting from the consequences of physical destruction, i.e. as a result of direct losses. Indirect losses include lost production output, retail sales, wages and work time, additional time commuting to work, demand surge for reconstruction materials, additional costs to businesses from rerouting goods and services around the affected area, utility disruptions, impaired social and medical services, foregone tax revenue, lost tourism or increased financial market volatility and others.

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[14] Tierney, Kathleen J. "Impacts of recent US disasters on businesses: the 1993 Midwest floods and the 1994 Northridge Earthquake." (1995).

[15] FEMA https://www.fema.gov/protecting-your-businesses

"The ultimate economic impact of a disaster depends upon the disposition of the damaged assets. Some of these assets are not replaced and so their loss causes a reduction in consumption".[16] In other words, direct losses are the precursor to indirect losses, as illustrated in Figure 20 below.

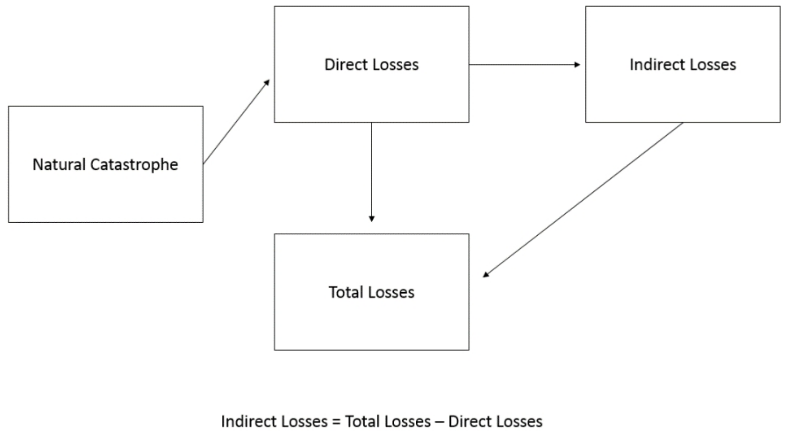

Figure 20: Direct vs Indirect Losses

Quantifying Losses

The impact a natural catastrophe has on a city or system depends primarily on two factors:

(1) The extent to which critical infrastructure and services are impaired or fully interrupted,
(2) The length of time that these services are not available.

Calculating direct losses is a well-developed practice of the insurance industry. Over several decades, the ability to model, assess and quantify the financial impact of direct physical loss has evolved with substantial collection and analysis of valuable data. However, the calculation of indirect losses can be challenging. Attributing specific indirect economic impacts to a single event is a more complicated process as uncorrelated variables can rarely be excluded from data sources. Taking the hotel industry as an example: The daily loss of revenue for hotels being closed due to lack of fresh water can be quantified. However, additional loss of income can be expected as tourists cancel visits due to real or perceived problems with transportation in the aftermath of a disaster. Other causes may include cancellation of conferences, stores and restaurants closing, and the displacement of citizens, unable to work or conduct normal activities. To attribute the total loss of hotels to individual sectors is highly complex and oftentimes requires broad assumptions.

Adding to the complexity, positive impacts may offset negative ones: while cost of living might increase for many individuals due to shortage of certain goods and materials, the city as a whole may benefit from the surge of economic activity of reconstruction efforts mid-term after a disaster, including a response from the national government.

Against this background, our study aims to provide a robust picture of the city's overall financial sensitivity to indirect post disaster economic losses. Our focus is on the following questions:

- How fast is the city able to restore critical services?
- How fast do businesses return to normal after services are back?

[16] Lindell, Michael K., and Carla S. Prater. "Assessing community impacts of natural disasters." *Natural hazards review* 4.4 (2003): 176-185.

- What's the overall economic impact?

Historical analysis

Katrina's impact on New Orleans

The experience of New Orleans following Hurricane Katrina, one of the costliest natural disasters ever, which flooded approximately 80% of the city in August 2005[17], serves to illustrate the combined effect of direct and indirect losses.

The physical damage left by the storm and the ensuing impacts, interrupted citizens' lives, as well as tourism, commerce, import and export, education, the entertainment and gambling sector and the hospitality industry. In the months following the storm, New Orleans experienced a sufficient spike in short-term unemployment and a longer term drop in population. This drop of population equalled nearly half of pre-Katrina populations; and even eleven years later, New Orleans is at 85% of its pre-storm population. All of these issues compound in a meaningful impact to city tax revenues.

While nearly all business activity came to a complete standstill when Katrina made landfall, the ability of businesses to reopen, and the city's sales tax revenues to rebound, were strongly correlated to the availability of critical services. Drainage pumping stations began working after one week, taking eleven days to de-water the city. Drinking water returned fully after fourteen weeks and the primary waste water treatment facility was to full capacity after eleven weeks. For the purposes of this study, it is reasonable to assume businesses were closed on average eighty days.[18]

Tax revenue

A drop in spending, advertising, and ultimately visitors translates into a drop in government revenue. In fact, it is estimated that tourism in New Orleans, a top tourist destination in the United States, generates on average around USD 250 million in direct tax revenue for the city annually; the single largest industry revenue producer.[19]

Anecdotal evidence suggests that Katrina profoundly disrupted this key industry:

- During 2005 after Hurricane Katrina, the Convention and Visitors Bureau was forced to cancel 40% of business (USD 2 billion of revenue), as meetings and events were forced to relocate. From an average of 1300 annual meetings pre-Katrina, 2006 saw only about 360 meetings all year, with less than 30% of previous year's attendees. Along with the loss of business came a brand impairment, which has only slowly been re-emerged.[20]

  Hotels, airlines, and restaurants also saw a sizeable drop in customers and revenue, as leisure travel to the city declined significantly. The number of visitors dropped by 50% during 2006 compared to the previous years.[21]

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[17] Lindell, Michael K., and Carla S. Prater. "Assessing community impacts of natural disasters." *Natural hazards review* 4.4 (2003): 176-185.

[18] Eisler, Peter, Tom Kenworthy, and Traci Watson. "Huge Pumps Start Draining Toxic Floodwater from City." *USATODAY* (2005): n. pag. Web.

[19] New Orleans Metropolitan Convention and Visitors Bureau Inc. *Tourism, Hospitality and Culture Economy Fact Sheet*. Print.

[20] New Orleans Metropolitan Convention and Visitors Bureau Inc. *Tourism, Hospitality and Culture Economy Fact Sheet*. Print.

[21] New Orleans Metropolitan Convention and Visitors Bureau Inc. *Tourism, Hospitality and Culture Economy Fact Sheet*. Print.

- Prior to the storm, the city had over 37,000 hotel rooms. Only eleven years later have the number of hotel rooms returned to their previous values. The same patterns can be observed with airline routes and passengers, as well as restaurants, casinos, and entertainment hubs.[22]

Catastrophes Decrease Tax Revenue

As a basis for the analysis the revenues from New Orleans's financial statements between 2002 and 2016 were normalized to 2016 US dollars using Consumer Price Index (CPI). This comprises mainly taxes, but also other sources such as e.g. fees.

Year	Total Taxes	Service Charges	Licenses/Permits	Total Fines/Forfeits	Sum
2002	302,116,000.00	63,322,000.00	76,271,000.00	19,246,000.00	460,955,000.00
2003	313,919,000.00	65,796,000.00	79,251,000.00	19,998,000.00	478,964,000.00
2004	324,995,000.00	68,117,000.00	82,948,000.00	20,704,000.00	496,764,000.00
2005	266,852,000.00	44,867,000.00	69,340,000.00	12,236,000.00	393,295,000.00
2006	236,246,000.00	27,674,000.00	62,176,000.00	7,907,000.00	334,003,000.00
2007	238,038,000.00	45,629,000.00	47,491,000.00	11,407,000.00	342,565,000.00
2008	252,821,000.00	49,920,000.00	54,197,000.00	19,452,000.00	376,390,000.00
2009	267,603,000.00	54,212,000.00	60,904,000.00	27,497,000.00	410,216,000.00
2010	278,822,000.00	55,858,000.00	64,335,000.00	34,465,000.00	433,480,000.00
2011	301,507,000.00	77,408,000.00	61,399,000.00	36,987,000.00	477,301,000.00
2012	301,546,000.00	78,408,000.00	59,556,000.00	35,870,000.00	475,380,000.00
2013	318,864,000.00	81,310,000.00	65,242,000.00	32,577,000.00	497,993,000.00
2014	336,340,000.00	82,173,000.00	63,416,000.00	28,755,000.00	510,684,000.00
2015	353,983,000.00	85,523,000.00	59,915,000.00	35,018,000.00	534,439,000.00
2016	371,152,000.00	85,711,000.00	62,319,000.00	38,649,000.00	557,831,000.00

Figure 21: New Orleans Tax Revenue and other sources of income from Official City of NOLA Website. Projected and inflated to 2016 values.

By looking at the relative change in revenues year-on-year, we can identify several key drops that coincide with hurricanes Katrina (2005), Gustav (2008) and Isaac (2012).

Property taxes are calculated biannually, based on property devaluation, market spikes or interest, people moving away or coming to a city, as well as other factors. Due to this property tax variations are seen after some time. Usually the second year after a disaster you see the real fall of this government revenue. On the other hand, sales and other taxes such as utility and lodging are calculated very frequently, so spikes in these taxes are seen almost immediately. For this reason calculating tax revenue decreases after a hurricane must be done by calculating the variations for the two years following the disaster, compared to the previous year.

[22] New Orleans Metropolitan Convention and Visitors Bureau Inc. *Tourism, Hospitality and Culture Economy Fact Sheet*. Print.

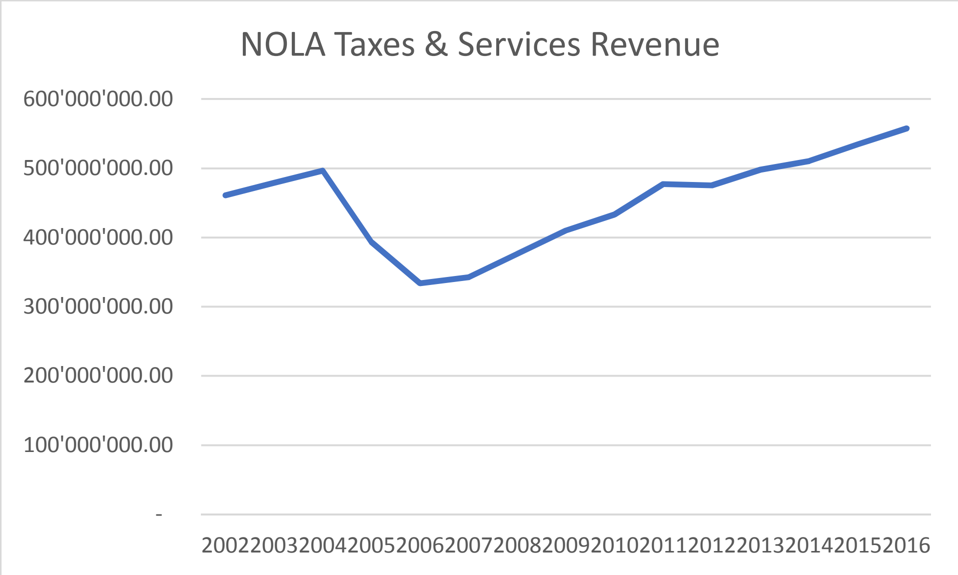


Figure 22: New Orleans tax and services collection 2002 – 2016, inflated to 2016 values.

Catastrophes Cause Major Damage

Swiss Re defines total economic losses as the sum of total damages directly attributable to a major event, including losses due to business interruption as a direct consequence of property damage. These totals are shown below for hurricanes Katrina in 2005, Gustav in 2008 and Isaac in 2012.

Hurricane	Date	Total economic Loss
Katrina	August 23, 2005	$ 173'079'799'200
Gustav	August 25, 2008	$ 11'170'404'679
Isaac	August 21, 2012	$ 3'422'707'048

Figure 23: Total economic losses from historic events

Source: Swiss Re Economic Research & Consulting, US Federal Reserve, BEA, PCS/ISO. Inflated to 2016 values.

The proportion of total economic losses which were actually sustained by the city of New Orleans are isolated in two steps:

1. The total losses suffered by the State of Louisiana as a proportion of total losses attributable to each event is assumed to reflect the proportion of insured losses in Louisiana as a proportion of total insured losses, which are known. For each hurricane the attributed Louisiana contribution varied: Katrina: 61.35%, Gustav 95.12% and Isaac 80.65%. With this, the Louisiana damages costs are obtained.

2. The total losses sustained by New Orleans as a proportion of insured losses to the state, as well as research and expert judgement on the size of damage in the city itself.

The below figure shows the total damages from hurricanes Katrina, Gustav and Isaac for Louisiana and Orleans parish, respectively.

Hurricane	Total economic Loss in the US	LA % Contribution	Louisiana economic damage	Orleans Parish Attribution %*	NOLA economic damage
Katrina	$ 173'079'799'200	61.35%	$92,025,000,000	50%	$46,012,500,000
Gustav	$ 11'170'404'679	95.12%	$4,090,160,000	30%	$1,227,048,000
Isaac	$ 3'422'707'048	80.65%	$645,200,000	33%	$212,916,000

Figure 24: New Orleans hurricane damage. * Louisiana Department of Insurance claims analysis (2006) and Swiss Re expertise.

Hurricane Damage Compared to Tax and other Revenues

Calculating drops in tax and other revenues over a specified period of time for a specific event requires certain assumptions. First, since a constant growth in revenues were observed in the years leading up to 2005, it was assumed that any major drop in tax and other revenues could be attributed to an increasing baseline – trended with 1% growth – for the year of the disaster. During the period considered in this research, several global events and crisis, such as the housing bubble in 2008, affected prices, spending, and taxes. Other factors such as economic, technological, and financial impacts may have also influenced taxes in a negative way. For this analysis all of those external factors were not taken into account, instead only hurricanes were taken into consideration though an expert judgement based analysis.

Year	Total tax and other revenues trended with 1% increase (new baseline) assuming Katrina did not happen
2002	$ 460,955,140
2003	$ 478,963,888
2004	$ 495,864,000
2005	$ 515,698,560
2006	$ 536,326,502

Figure 25: Total tax and fee revenues baseline, assuming Katrina did not happen, trended for a 1% annual growth. Inflated to 2016 values.

Through the sum of the tax losses of the years of the three hurricanes (Katrina 2005, Gustav 2008, and Isaac 2012), a significant change in tax revenues is observable. Here, the year of Katrina as well as the following year 2006, still highly influenced by Katrina, certainly show up with the most drastic negative signal. Contrary to expectations it comes to a surprise that taxes and other revenues even increased in the year of Gustav.

Year	Total Tax and other Revenues Lost
2005	$ 122,403,360
2006	$ 202,324,102
2008	$ (20,122,795)
2012	$ 21,224,393

Figure 26: Overall Tax and other Losses for New Orleans in years of major hurricanes

By averaging the direct economic damage caused by Katrina divided by the taxes lost during 2005 and 2006, it can be concluded that the City of New Orleans lost approximately USD1 of tax revenue for every USD164 of property damage, a total of USD 325 million in tax and other revenues. In other words, for every USD100 in physical hurricane damage, the city lost approximately USD 0.61. As opposed to the physical losses, which end up with individuals/businesses and their insurances liabilities, tax and other revenues losses described here exclusively end up on the Government's budget.

Hurricane	Physical damage for every $ in tax and other revenues lost
Katrina 2005/2006	$ 164.50
Gustav 2008	$ (158.41)
Issac 2012	$ 42.92

Figure 27: Hurricane damage/tax revenue loss – direct physical loss for every $1 lost in tax and other revenues

The Sewerage and Water Board

A key service provider for the city of New Orleans is the SWB. The SWB delivers fresh water, treats the city's sewerage and is responsible for the operation of drainage water pumps. As New Orleans is partially situated below sea level, the continuous operation of the drainage system prevents persistent flooding throughout the city. All those water services can be seen as critical for the city's daily business.

The SWB contributes to the city's budget with contingent revenue income from the provision of their services. These services are also vital to the functioning of most businesses and commercial sectors of the city. A disruption of these services can lead to tax income losses as many industries are forced to shut down during the period when services are unavailable or require boil water advisories, which can impact normal activities. Determining the SWB's direct revenue loss due to a hurricane and the relevance of the SWB's services for other sectors is crucial. This is the indirect loss of income of other sectors due to the absence of critical services usually provided by the SWB, and hence the decrease in tax revenue passed on to the government.

Revenue Impact to SWB

By indexing the SWB's financial statements over the last several years to the 2016 Consumer Price Index (CPI), the significant losses that may have resulted from Katrina[23] can be observed in present value. To calculate losses due to the hurricane the SWB's revenues are projected according to an averaged linear increase for the two years before the event. According to the trending, the SWB's could have expected revenues of USD175.5m in 2005, a 6% increase from the 2004 value of USD166.2m. Similar increases could have been expected for the years of hurricane Gustav in 2008 and Isaac in 2012. Assuming all negative deviations from a relatively steady revenue stream were exclusively influenced by the three hurricanes and no other events during the year, the total revenue losses for Katrina, Gustav and Issac are USD 52.6m, 12.7m, and 11.5m, respectively (see figure 16).

Event	Absolute lost revenues
Katrina	$ 52,613,124
Gustav	$ 12,737,734
Isaac	$ 11,473,316

Figure 28: Annual absolute and daily loss of revenues for the SWB in the hurricane years.

[23] Sewerage and Water Board of New Orleans, 2016

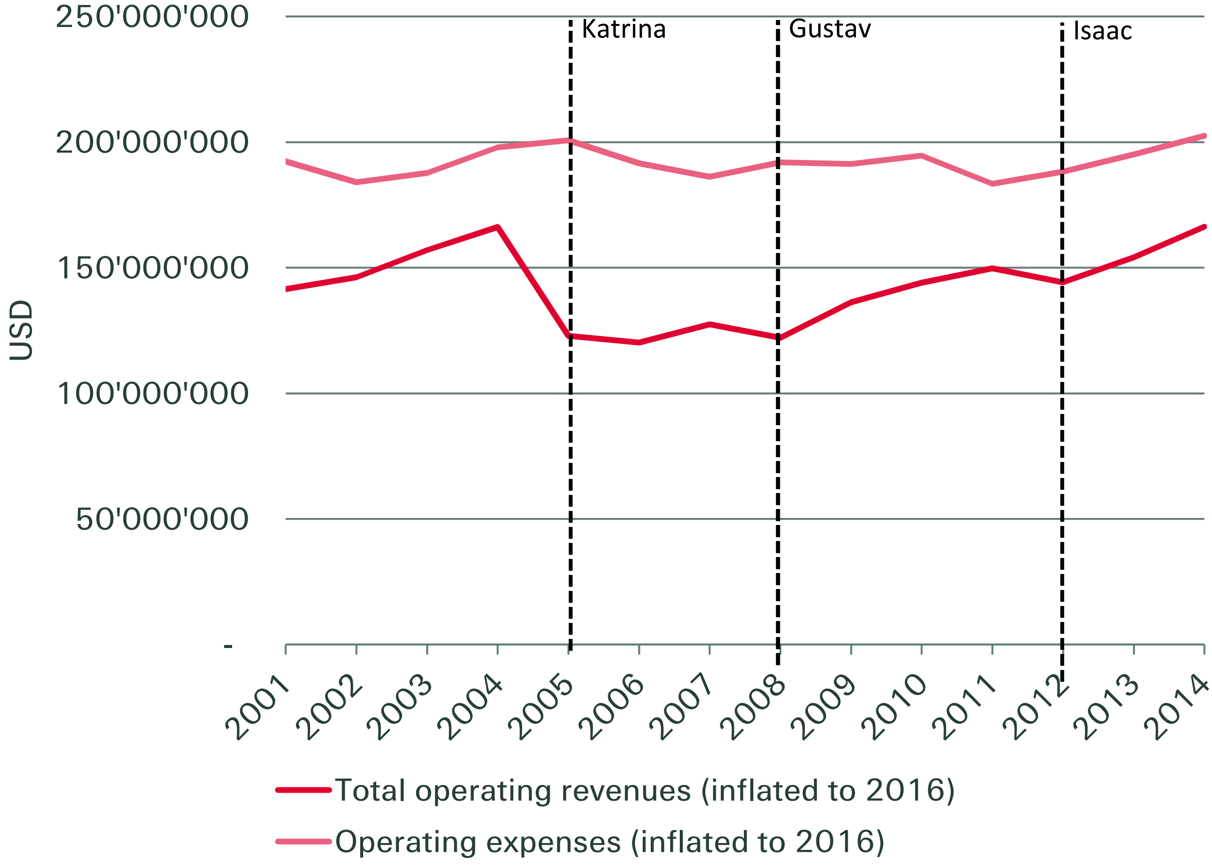


Figure 29: The Sewerage & Water Board's declared operating revenues versus operating expenses as of 2001. We see a sharp decline in revenue income in the year of Katrina and less strong signals in 2008 and 2012. Overall the SWB practices a negative business as revenues apparently never level out expenses. All numbers trended to 2016 values.

GDP and the Importance of Small Businesses

Given the importance of small businesses to the economy of Orleans parish, the impact they endured can provide insight into the impact of a hurricane on the local Gross Domestic Product (GDP).

First we have to remind ourselves small businesses are not the only contributors to GDP. GDP consists of the sum of four main categories: Consumer spending, government spending, country investments and the total net exports (exports − imports)[24]

During the first two months after Katrina struck, about 80% of the city was flooded.[25] This very likely also came with a complete standstill for 80% of all GDP contributing businesses until November 2005. The lucky ones, about 20% of all business in the NOLA area, were more or less unaffected and kept going with their daily operations. After drainage of the parish in November 2005 an increasing percentage of businesses previously flooded restarted their operations each month. According to some studies approximately 65% of all businesses successfully reopened in October 2007, 26 months after Katrina[26]. For simplicity reasons it can be assumed that also small businesses reopened in a linearly increasing fashion between November 2005 and October 2007.

24 http://www.investopedia.com/terms/g/gdp.asp#ixzz4QLoJ4Dx6 (November, 2016)

[25] Lindell, Michael K., and Carla S. Prater. "Assessing community impacts of natural disasters." *Natural hazards review* 4.4 (2003): 176-185.

[26] Arenas, Helbert. "AN AGENT-BASED SIMULATION MODEL FOR BUSINESS REOPENINGS IN." *Louisiana State University and Medical College Dissertation* (2011): n. pag. Web Lam et al, 2009.

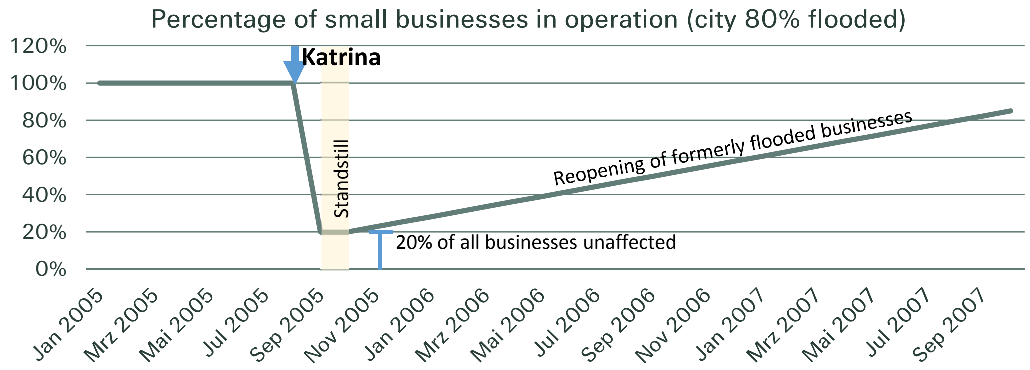


Figure 30: After two months standstill about 80% of previously flooded businesses reopened in a linear fashion. Many of them are small businesses who contribute 50% of the total GDP.

Without Katrina the GDP of New Orleans would have otherwise maintained a steady increase as it did in preceding years. Our baseline GDP projection for Orleans parish in 2005 is USD 25.35bn, which is a linear ~0.1% increase calculated from the years 2003 and 2004. In 2006 and 2007 another slight increase could have been expected to USD 25.38bn and USD 25.41bn, respectively. The GDP projections serve as baseline for our analysis (figure 31).

Year	Projected GDP of New Orleans assuming Katrina did not happen (~0.1% annual increase)
2005	$ 25,351,150,679
2006	$ 25,380,648,106
2007	$ 25,410,145,533

Figure 31: Projected GDP for Orleans parish during and after Katrina

The contribution of small businesses

A study from 2005 found about 50% of the USA's GDP originates from small businesses[27]. In the case of New Orleans a similar assumption can be made. The other half of the GDP is contributed from sources such as personal consumption and expenditure, large-scale industries, investments, net exports and government expenditure[28]. In addition to that it can be speculated a failure of the SWB's services can, at most, influence up to 50% of the city's production in GDP in case of a complete shut-down.

The above assumptions and a linear reopening rate enable a simple calculation of the GDP loss caused by small business disruption. For each month GDP loss can be subtracted from the projected GDP baseline for 2005. The total annual GDP loss from small businesses, which were forced to shut down after Katrina, therefore was USD 3.29bn in 2005 and USD 7.23bn in 2006. This translates into a percentage loss compared to a projected undisturbed situation of 26% in 2005 and 57% in 2006, respectively (figure 32).

Year	Projected GDP contribution from small businesses (without Katrina)	Actual GDP contribution from small businesses	Loss of GDP contribution from small businesses compared to GDP projections	NOLA's actual loss in GDP contribution from small business not in operation compared to projected situation without Katrina
2005	12,675,575,340	9,381,246,124	3,294,329,216	26%
2006	12,690,324,053	5,459,483,160	7,230,840,893	57%
2007 (until October 31st)	10,587,560,639	7,709,067,590	2,878,493,049	27%
Total	**35,953,460,031**	**22,549,796,874**	**13,403,663,157**	**37%**

Figure 32: Missing GDP contribution from small business for the years during and after Katrina.

Daily GDP loss

As Katrina struck the city 130 days before year end, the total GDP loss can be divided by 130 to arrive at the daily average GDP loss from small businesses. In the last 130 days after Katrina the city lost an aggregated average of USD 25.3m per day (USD 760 million per month). In fact, many small business were not in operation at the end of 2005. At the end of the year 2006 about 29% of small businesses were able to reopen. Assuming a consistent linear reopening rate as described above, the average daily loss for the entire year 2005 was USD 19.8m.

Existing Insurance Programs

While physical risk mitigation is always a primary priority to reducing future losses, not all risk can be averted. As such, it is important for public entities to transfer residual risk away from the balance sheet of their organizations and ultimately the citizens they serve.

The SWB actively manages a property insurance program for its portfolio of assets across the Parish. This engagement includes both the global private insurance market as well as the government-backed National Flood Insurance Program.

The SWB has a portfolio of assets that is valued at more than USD 3 billion with 203 individual buildings. For the purposes of insurance, however, the total insured value is slightly over USD 1 billion. In the private insurance markets, the SWB purchases both "named storm" (wind) insurance as well as "all other perils" coverage, which largely entails fire risk. These policies

[27] Leung, Danny and Rispoli, Luke. "The Contribution of Small and Medium-sized Businesses to Gross Domestic Product: A Canada-United States Comparison." *Economic Analysis (EA) Research Paper Series* (2005): n. pag. Web.
[28] http://marketrealist.com/2014/05/must-know-update-beginner-investors-calculating-gdp/ (last accessed 14.10.2016)

do not cover any damages related to flooding or storm surge. For purposes of named wind exposure, the total insured limit is USD10 million. This USD10 million insured limit is subject to a 5% deductible with a minimum of USD 500,000 on the value of each covered building.

Flood Insurance

For the purposes of flood risk, the SWB purchases flood insurance for many of its most critical assets. This insurance coverage is provided by the National Flood Insurance Program. While these policies are effective at assisting with high frequency loss scenarios, there are limitations. These insurance policies cover assets individually with policy limits of up to USD 500,000 for buildings and USD 500,000 for contents regardless of the value of the building itself or of its contents. The total insured limits for buildings across the USD 3 billion portfolio are USD 31 million or 1% of the total value of the properties.

Flood insurance can be purchased in the private global insurance markets in excess of the NFIP policies, however this is not pursued by the SWB currently.

The power facility at the Carrollton water treatment facility is valued at USD 500 million when including both the building and contents. As with all NFIP commercial policies, the total insurable limit for this facility exhausts at USD 500,000 for the building and USD 500,000 for its contents above a USD 5,000 deductible.

A note of caution, for assets that are not currently insured with an NFIP that suffer damage from a flood, FEMA will effectively look at the absence of insurance as a deductible. That is to say, the SWB would be compelled to pay USD 500,000 for a building before being considered for any federal reimbursement, particularly if there is a previous loss as in Katrina.

SWB influence the city's economic activity

A Sewerage and Water Board's ability to properly function dictates the normal economic activity of cities. As the SWB naturally provides critical services, every day of downtime directly results in an interruption of economic activity. Economic activity can best be described in terms of the GDP. In order to better quantify losses resulting from a standstill of the parish, it is crucial to think about how the SWB's assets interrelate to each other and how potential downtime scenarios may play out.

Assets, such as water treatment plants, when flooded or unable to function for more than one day can create a chain reaction. Cooling of drainage water pumps requires a continuous flow of fresh water. If the water treatment plants are down, drainage water pumps are also forced to shut down and flood levels immediately start to rise within the city limits. Disruption of the Carrollton water treatment plant alone would affect fresh water within the East Bank of the river, dampening approximately half of the GDP output in this area. An estimate of 80% of Orleans parish's GDP is produced here.

This interrelation suggests hardening of those critical assets is a smart action for the city and the only way to efficiently mitigate high frequency losses. In addition to that, having an insurance backed plan for safety after very remote high severity events is one of the best ways for a city to move towards resiliency. Planning ahead lowers costs as well as results in a quicker recovery time. Hence, less business closures, days off work, and drastic negative spikes in population and GDP.

Specific loss scenarios

Local engineering knowledge helps to understand that three SWB assets could dictate the functioning of the normal city life. Veolia identified 3 system critical failure scenarios, including damage to the Recycle Basin MCC of the Carrollton water treatment plant, the West Bank Control Room and East Bank Sewerage Pump Station A.

The first of these is the Recycle Basin MCC, part of the Carrollton plant complex. Wind damage to the roof of the Recycle Basin MCC building triggers this scenario. The Recycle Basin MCC is located in a concrete building raised approximately one foot off the ground. The roof of the MCC building is metal. During major hurricane events wind speeds can reach between 120 to 156 mph causing severe damage to buildings, more specifically their metal roofs, pealing them away exposing the MCC to the elements. The rain causes the electrical equipment to short and either trip the circuit breakers or cause fires. The Recycle Basin MCC could be fully destroyed. Consequently the recycle basin pumps will be unable to backwash the sand filters. Eventually the East Bank Water Treatment Plant would be forced to shut down after one day. This leaves about 80% of the residents and businesses without fresh water. Half of this area's GDP output will be affected. Downtime to rebuild the MCC is calculated to be approximately 30 days.

The second scenario affects a raised power cable tray in the West Bank Control Room (Station C Building). During major hurricane events, strong winds can cause flying debris to damage Station C's building roof and the raised power cable tray. The two feeders from Entergy supplying power to the Control room switchgear would be lost. Carrollton's remaining 25 Hz feeder number 26 would also be down. Control would start the generator to supply 60 Hz power to the plant. The power cables to the pumps for the water intakes, which supply water to the Water Treatment Plant from the Mississippi, would also be lost, shutting down the plant entirely. Residents and businesses would lose water supply after one day. Downtime to enable replacement of the power cables is estimated to be15 days. Since the West Bank services approximately 20% of Orleans Parish, the city may lose approximately USD 100m in GDP. Revenue loss to the SWB will be in the USD millions. Hardening costs of the Station C roof amount to an estimated USD 500,000 and are likely to be a good resilience investment for both SWB and the city.

A third irreplaceable asset is the East Bank Sewerage Pump Station A. If Station A fails for whatever reason, no sewerage would be pumped from the Central Business District and from SPS 1, 3, 5, 6, 8, 9, 14, and 15. As a result, sewerage would back up. Downtime to repair is estimated at 2 weeks, but it is difficult to quantify affected GDP. Revenue loss to the SWB will be in the USD millions. Hardening costs amount to an estimated USD 7m.

Some of SWB's assets are more important than others and play a key role for the functioning of the entire parish. The above described scenarios are only a few out of many possible. Any failure of this complex interconnected system goes along with serious consequences, such as flooding and the inability to treat wastewater. This ultimately cascades down to an interruption of economic activity as measured by a decrease in GDP, not to mention secondary intangible consequences in the fields of sanitation, health implications, and over costs.

Beyond City Boundaries: Indirect losses from other private business sectors

After a disaster both tourism and inner-city spending both slow down. This is seen in the decreases of the city government revenue. Yet looking at the broader picture we also see great impacts that disasters to the city make on a state level. Industries such as the casinos/entertainment, the port authority, and others see large consequences in their bottom lines.

In combination with the Port of South Louisiana, the Port of New Orleans handles the most bulk tonnage in the world. After Katrina, employment was severely affected. Jobs had been added previously to the sector due to high and fast paced growth. In August 2005 the port saw a massive decline, and due to the higher wages paid in the sector, the overall financial impact of the jobs that were lost was extremely high. During the 10-month period, port operations saw about 3,500 jobs disappear and lost wages amounted to approximately USD 136 million.[29]

Conclusions & Recommendations

During Katrina most of the SWB's assets were severely affected, compromising the proper functioning of Orleans Parish. A standstill for days, or even months, can be attributed to flooding, sanitation, health, amongst other reasons.

In addition to physical loss, the Orleans parish lost USD 0.61 of tax revenue for every USD 100 of hurricane damage. This loss fully ended up on the Governments budget, a significant impact. Improved resiliency measure could aid in the prevention of sudden drops in the city's revenue sources. At times of a disaster, the government needs to be stronger and able to support a city in recovery mode. Budget shortages can be avoided with the help of pre-disaster financing.

The small and large businesses that close during catastrophic events also cause a dent in the city- and even the state's economic balances. There is a great amount of businesses that are forced to close down for an unhealthy period of time. The city obtains tax revenues from businesses, a considerable part of its overall GDP. This additional indirect loss has never really been mentioned in loss statements. Yet, it has to be considered just as physical losses are. After a disaster the city is shut down, small businesses close, most sectors of the economy slow down, and the effects to the city are both substantial and traceable.

Even with an insurance policy currently active, the SWB is not able to quickly rehabilitate its services. Several assets cause others to fail, shutting the city off sometimes for months. Through the purchase and set up of index, or parametric, insurance covers that could pay out in less than a week and with the aid of infrastructure companies such as Veolia, the SWB could see a cut in the recovery time of the disaster. Cutting recovery time not only aids in the process, but bring businesses and people back to the regular schedules and work flow. With this, the city would see a less volatile bottom line, not having to take such large tax cuts and having a pre-set plan to aid in the recovery of such disasters. New Orleans' GDP can also be normalized and prevent spikes and large declines during times of disaster through such methods of resiliency.

[29] http://www.bls.gov/opub/mlr/2007/06/art1full.pdf

Resilience Analysis of SWB critical assets

Approach

For the purpose of the analysis, the SWB provided an asset list considered as complete as at July 2016.

For each asset, SWB management provided:

- GIS data (longitude and latitude only), elevation coordinates were not available and were estimated by SWB Management,
- their best estimate of asset values (replacement cost),
- estimated time of recovery,

The asset list accounts for 203 individual assets for a total estimated value (replacement cost) of USD3.4 billion.

Sixty-five of these assets were defined as critical by SWB. The assets identified as critical account for USD 2.9 billion of the total. The largest critical assets include pumping stations, followed by the Carrollton and Algiers water treatment plants.The resilience analysis was focussed on these 65 assets for which an individual asset resilience report is provided using the analysis tool developed by Veolia. The methodology supporting the analysis is detailed in appendix A "Methodology for the resilience analysis tool".

Based on extensive site visits, we have defined and quantified the costs of hardening measures for all assets that SWB classified as critical. Hardening measures include raising sites/assets as well as flood and wind proofing. In order to test sensitivity, we used two benchmarks for raising sites/assets:

(a) Expected water depths at 100- and 500-year surge events from the University of Louisiana's map that uses the Flood Insurance Rate Map data from FEMA (http://maps.lsuagcenter.com/floodmaps/) and from USACE. These scenarios assume that the physical flood protection system of the city holds and 100% pumping capacity.

(b) Swiss Re expected water depth ranges at a 100-year surge event after a failure of flood protection measures, rendering the impact of pumping irrelevant.

The analyses of the reduction in risk profile (% decrease of expected loss before and after mitigation) and the investment required relative to the asset insured determines a prioritized action plan (investment required to assist in to the appropriate allocation of for hardening measures for all assets that SWB classified as critical.

In addition, as part the analysis, interviews were carried out at site level to gain a better understanding of context and overall processes in relation to Procurement, Chemicals, Client, Network and Asset management (the topics discussed with are detailed in Appendix B).

Key results and recommendations of the strategic action plan:

Based on our analysis the strategic plan includes operational improvements and hardening measures summarized below, for which the details can be found in the individual resilience asset reports.

As a general observation, based on the interviews conducted on site with SWB Management and members of the field teams present during the different site visit, a number of key strengths should also be highlighted.

- **Strengths**

Hurricane Katrina

- Prior to the levee failures due to storm surge erosion of the landward sides of the levee there was no significant flooding at any of the SWBNO facilities. General consensus by SWBNO employees interviewed is had the levees not failed Katrina would have had minimal impact on the SWBNO assets and New Orleans residents. Once the levees failed (approximately Day 3 of

Hurricane Katrina impacts) the drainage pump stations were shut down to keep from simply recycling the same water to Lake Pontchartrain and back. Once the levees failed the power plant at the Carrollton Water Treatment Plant was shut down due to water flooding the basement approaching the existing electrical equipment (which has since been moved upward to the first and second floors). Once the levees were repaired the SWBNO Storm drainage pump stations were able to de-water New Orleans between 8 to 14 days after levee repairs.

Strong management culture throughout the business

- Through the course of the interviews, it is apparent that the SWB has a strong management culture throughout the business reflected through the dedication and commitment of members of staff to the operations. The intangible value of SWB culture contributes to the quality of operations including in moments of stress and shocks that could be experienced.
- However it also evident that this aspect needs to be nurtured in light of the pressure on the recruitment process (refer to HR finding and recommendation).

Level of control of business processes and operations

- Based on the interviews and site visits conducted, it appears that there is a good level of control of business processes and operations with dedicated staff responsible for each process and documented procedures.
- However some improvement opportunities have been identified to strengthen the level of formalization through the use of IT tools, maximize the use of available operational data, reduce the level of dependency on key staff, and improve process and operational efficiencies.

Emergency management

- A hurricane preparedness manual exists that designates 350 employees as key employees. The SWBNO expects these employees to be at their assigned location 24-hours before the hurricane is scheduled to make landfall and remain until the hurricane has passed. The SWBNO has prepared emergency backpacks (flashlights, batteries, etc.) for the key employees; water, MRE's, and cots available at critical locations; and a fleet of "John" boats deployed at the start of hurricane season and removed from critical locations after hurricane season. The "John" boat motors are turned over every two weeks to make sure they will run when needed.

Flexibility in power supply and energy mix

- SWB Management identified the reliability of availability of power provided by local supplier Entergy as a risk to operations and continuity of operations. SWB has therefore undertaken to adapt its energy mix between self-produced energy and energy provided by Entergy to reduce its vulnerability or exposure to power supply. The current energy mix is 75% self-produced and 25% provided by Entergy.
- Although, this has improved SWB's exposure on energy reliability, the cost of self-produced energy is higher and therefore there is need to further analyse the opportunity to optimize the cost effectiveness of the energy mix strategy of SWB.

Spare part management and inventory

- Where spare parts are able to be sourced, SWBNO maintains a large warehouse and dedicated staff to manage inventory. Their facility and processes were impressive including stock organization, storage conditions, strict controls and security for staff access, an inventory barcoding system, detailed and periodically reviewed / verified inventory catalogue, recording of stock number changes associated with work orders, automatic reordering thresholds, etc.

- Summary of recommendations - Operational improvements and hardening measures

Reflecting property damage only, the annual expected loss to the total portfolio is USD 10.5 million (thereof USD 6.6 million surge). Of this USD 10.5 million, the critical assets contribute USD 9.0 million (thereof USD 5.7 million surge), or 86%, to the total expected loss.

Given SWB's large-scale flood protection infrastructure, the additional storm surge hardening proposed by us on the basis of USACE 100-year and 500-year flood depths do not have a significant impact in terms of avoided losses. The annual expected physical damage from storm surge to all assets is reduced by approximately USD 120 000 or less than 2%, to USD 6.5 million.

Hardening measures proposed on the basis of Swiss Re's estimated 100-year flood depth ranges reduce the annual expected loss by slightly less than 50% to USD 3.8 million (i.e. an annual saving of USD 2.8 million). The complete set of identified hardening measures on the critical assets list amounts to a total of USD 690 million.

- **Operational improvements:**

1. ***Improve energy reliability measures (example: Boston)***

To improve power supply reliability, cost effectiveness and eliminate exposure to wind events, we recommend building a new substation at the Carrollton site, which would be connected to the Entergy transmission substations via two underground transmission cables.
The cost of implementation is estimated at USD 60-70 million with a 4 to 5 year payback based on estimated annual savings.

2. ***Improve operational intelligence***

We recommend that all historic data be computed into an IT system and analyzed and develop an IT Dashboard of the SWB network to improve visibility of operations, operational efficiency and maintenance planning.
This action is estimated at USD 1.5 million. This would result in a significant reduction of dependency on manual processes and significant gain in remote control of operations.

3. ***Define a recruitment strategy to include alternatives and succession planning to reduce impact of a shortage of skilled human resources.***

Given the type of operations and the nature and age of the assets, the SWB requires a highly skilled workforce. Furthermore, there is strong dependency on specific members of staff who are critical to maintaining operations (e.g. Power Dispatcher Operations Central Control).
However, the SWB organization is under significant stress in terms of staff shortages and recruitment, we therefore recommend identifying key staff and formalizing succession planning for them.
In addition, an in-house staff-hiring process needs to be developed in order to on-board staff faster. Moreover, we recommend subcontracting or outsourcing certain positions to compensate for vacancies on critical positions. The HR strategy should also aim to further develop relationships with local universities and colleges and extend this approach to other states.

Other operational improvements are detailed in the Full report in relation to protection of assets against fire/explosion hazards, additional storage of critical parts and mitigation of supply chain risks.

- **Hardening measures**

Based on extensive site visits, we have defined and quantified the costs of hardening measures for all assets that SWB classified as critical. Hardening measures include raising sites/assets as well as flood and wind proofing.
In order to prioritize the allocation of investments, **"Must Have"** mitigation measures represent a total investment of USD 160 million (46% of asset value) for a reduction of 60% in expected losses and **"Quick Wins"** (with the highest reduction for the least investment) correspond to a total investment of USD 6.5 million, 1% of asset value for a reduction of 72% in expected losses.
"Other" (high reduction but relatively high investment)
"Good to haves" correspond to a total investment of USD 277 million, 51% of asset value for a reduction of 56% in expected losses.

Asset Resilience Report

The following reports are extractions of the resilience analysis tool developed by Veolia. The content of this reports have been shared with SWB for confirmation of accuracy.

Unit Resilience Report: New Orleans Sewerage & Water Board

Primary Function	The Sewerage and Water Board of New Orleans (SWBNO) provides water and sewer services to the City of New Orleans and its public institutions as mandated by state law in accordance with R.S.33:4096 and R.S.33:4121, respectively.
Context Information	The Operations Department of the SWBNO comprises four units: (1) Water Purification, (2) Sewage Treatment, (3) Water Pumping and Power, and (4) Sewerage and Drainage Pumping. The SWBNO operates the Carrollton and Algiers Water Purification Plants (WPPs), which purify raw water from the Mississippi River and supply potable water to New Orleans residents. The Carrollton plant currently purifies approximately 135 million gallons per day (mgd) of water for the East Bank of Orleans Parish. The Algiers plant, which serves the predominantly residential West Bank portion of the parish, purifies roughly 11 mgd of water. The treated water from the two plants is pumped through approximately 1,800 miles of mains to the service connections within the City, as well as to several customers in adjacent parishes. The sewerage collection system includes several miles of lateral sewers, trunk sewers, and 83 electrically operated pump stations. Raw sewage is conveyed through a force main system. Sewage Pumping Stations (SPSs) A and D on the East Bank and SPS C on the West Bank are attended stations. SPS A houses a supervisory control and data acquisition (SCADA) system which monitors operation of all other sewage stations 24 hours a day. The SWBNO operates two sewage treatment plants, one on the East Bank and one on the West Bank. The East Bank Sewage Treatment Plant has a treatment capacity of 122 mgd (dry weather) and treats sewage from the East Bank community. The West Bank Sewage Treatment Plant has a treatment capacity of 20 mgd (dry weather) and serves the West Bank community of New Orleans, as well as a few customers in Plaquemine Parish. Both plants were built or expanded in the 1970s and have been upgraded or expanded to increase reliability and capacity. The contract operator, Veolia Water, currently operates and maintains the plants for SWBNO. In addition, the SWBNO is responsible for operating and maintaining the 24 major drainage pumping stations in New Orleans and 11 smaller but automatic underpass stations. The majority of those stations are manned 24 hours per day, 7 days per week. Each station is equipped with multiple pumps which are activated in response to increasing water levels. Personnel monitor these pumps and the numerous miles of drainage canals on a routine basis to ensure proper drainage in the area. The 25 cycle power plant operated by the SWBNO provides power for portions of the WPPs and approximately 60 percent of the drainage pumps. Two large vertical sewage pumping units at Station A are also run on 25 cycle power.

Operational Resilience Indicator

Parameter	Comments	Score* (1-5)
Emergency Response Plan	ERP plan tested annually and performance assessed by external auditors	5
NIMS Compliance	NIMS certification achieved 2013	5
Mutual aid and assistance	Twinning program established with Tampa and Los Angeles	4
Emergency power for critical ops	Independent power generation facility supports key assets	4
Ability to meet daily demand	Regarding wind threat the SWB would be able to meet daily demand even if the main distribution lines would be damaged. The SWB could be unable to meet daily demand in case of flooding. But it could occur for a 100 year return period or more event.	3
Critical parts and equipment	Assets undergoing rolling review of part criticality to drive supply chain reviews	4
Critical staff resilience	The SWBNO has an aging work force. The senior staff are all generally approaching retirement in the next few years. The inability to find and retain younger staff is attempting to be addressed through a specialized training program at the Delgado Community College with the benefits not expected to be seen for many more years.	3

Financial Resilience Indicator

Parameter	Comments	Score* (1-5)
Business continuity plan	BCP target completion November 2016	5
Utility bond rating	A- since Nov 2015	3
GASB Assessment		4
Unemployment	Orleans parish 0.8% above US national average (April 2016) See http://www.bls.gov/regions/southwest/summary/blssummary_neworleans.pdf	3
Median household income	The 2015 median household income for New Orleans is $48,343 (US: $55,775 - Louisiana :$45,727). Real median household income peaked in 2007 at $54,995 and is now $6,652 (12.10%) lower. From a post peak low of $45,350 in 2013, real median household income for New Orleans has now grown by $2,993 (6.60%).	3

*1: Poor →5: Very good

Energy supply: Short Resilience Report

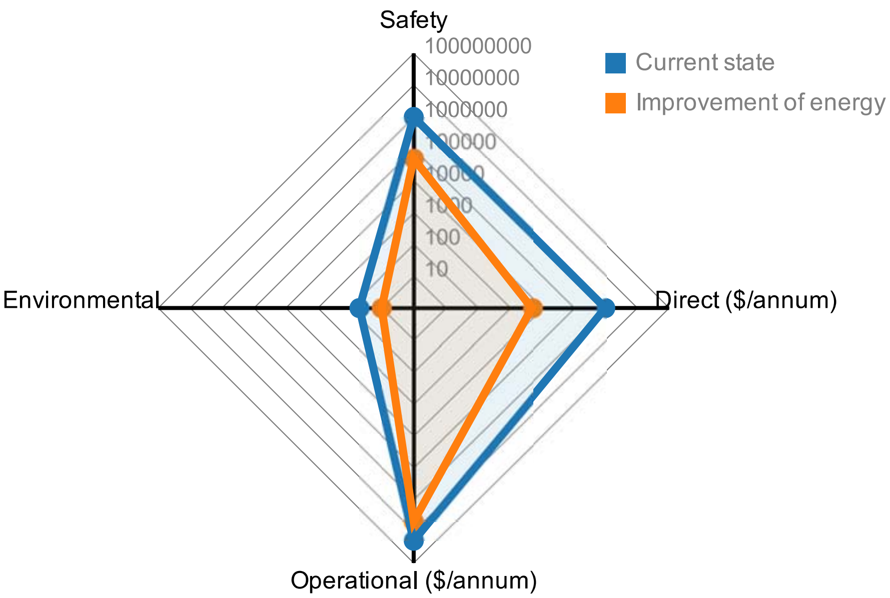
Location Description	8800 S Claiborne Av
Primary Function	Supply 60Hz and 25Hz electricity for the different equipment, installations and plants. The 3 systems (water, waste water and drainage) are using energy.
Context Information	The S&WB derives its power from multiple sources to meet its demand. Approximately 60% of the S&WB power is purchased from the local utility (Entergy) at 60 HZ. Entergy's power is delivered above ground from its substation to the S&WB Carrollton Plant as well as directly to numerous drainage pump stations. The S&WB can generate 60 HZ power (6 MW Gas Turbine) as well as 25 HZ power from its steam generation plant. The steam generation plant is utilizing refurbished 1920's equipment which is inefficient and well beyond its functional life span. Entergy supplies power from overhead distribution lines which are susceptible to power interruptions during severe weather, high winds or just utility switching. The S&WB generating station is old, inefficient and beyond its useful life. Emergency generators are available a critical locations. Transmission systems are rated at 69,000 volts or higher (e.g. 115,000 volts, 230,000 volts, 345,000 volts, etc). Assumptions: Self Generation; 45,000,000 kwh/ year at a cost of (including O&M) $0.40/ kwh = $18,000,000 Purchase Power: 75,000,000 kwh/ year at a cost of $0.14/ kwh = $10,500,000
Full Replacement Cost	$ 500000000

Energy supply: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	There are at least 3 different ways to supply energy: direct from Entergy, SWB power building and emergency generators	H
Supply chain strength	Installations producing 25Hz are old. Pump and motor parts machined by machine shop, little spare parts.	L
Skills availability	The SWBNO has an aging work force. The senior staff are all generally approaching retirement in the next few years. The inability to find and retain younger staff is attempting to be addressed through a specialized training program at the Delgado Community College with the benefits not expected to be seen for many more years. People working on energy supply have to memorize a blueprint with main electrical connexions	L
Ease of access	Depending on equipment	M
Documentation and procedures	The SWB uses only a paper blueprint.	L
Flood protection	Vary from facility to facility	M
HAZMAT and Fire protection	No fire protection. Very low risk linked to hazardous materials	L
Building code compliance	Vary from facility to facility	M
ARI		**0.582**

Threat: Hurricane < 100 years - Wind

Comments	After 80 years without any major power outages the S&WB has experienced at least four (4) major failures and several other 'near failures' since Hurricane Katrina. The numerous brief disruptions of power from the utility, which have been well documented by the S&WB, have severe impacts on the drainage and purified water systems. Brief power disruptions elongate the time to drain storm water as well as cause sudden drops in water pressure, which can ultimately result in mandatory 'boil water' order.
Earliest Recovery of Function	0.04 days
Repair and recommissioning cost	$ 20000000



Current Risk Type	Comments
Safety	In case of wind Entergy could stop energy supply. In case of energy disruption drainage systems and water distribution could be impacted. In case of drop in water pressure in water distribution it could require to implement a boil water order. To avoid any disruption the SWB has implemented different backups. Some of them are old. Depending on people (vulnerable or deficient) health issues can occur.
Environmental	Low risk for environment. In case of energy disruption the sanitation systems could be impacted. The 2 WWTP have an emergency generator that could supply energy for a week. But in case of waste water treatment disruption plants would be by-passed and the effluents would not be treated. So there is a risk of environmental pollution. This risk is limited
Operational ($/annum)	There are two different impacts. One is linked to business interruption and the second is based on overcosts linked to operate SWB installations
Direct ($/annum)	Wind can have an impact on distribution lines (falling vegetation...).

Measure Improvement of energy supply **SELECTED**

Total One-Time Cost	$ 65000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 20000000
Earliest Recovery of Function	0.04 days
Repair and recommissioning cost	$ 100000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Put underground distribution lines	One-time	50000000			50000000
Create a new substation	One-time	10000000			10000000
Install new transformers	One-time	5000000			5000000

Warehouse: Short Resilience Report

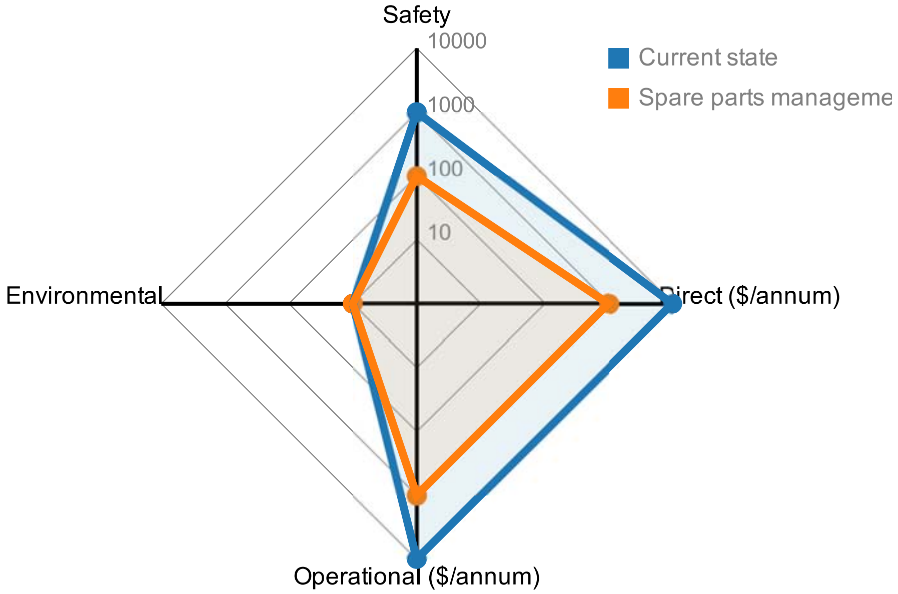
Location Description	2800 Peoples Avenue
Primary Function	To supply spare parts, mobile pump, pipe, chemicals, food ration ... storage
Context Information	Warehouse's frame: - Elevated floor: 6' above surrounding gravel parking/drive areas - Concrete block until 14' and metallic panel from 14' to the roof and for the roof - 5 sectional doors - Inside the building different parts are separated by concrete block walls The facility was built early 2000's pre-Katrina and was designed with the roof rated for 125mph, the building is positive displacement with air flows, and the doors are hurricane proof (PG: some doors are damaged) with cross bars that can be put in place to keep the sectional doors from failing. According to Swiss Re's models the level of water would be higher than the top of bottom floor. According to FEMA's and USACE the risk of flooding is very limited. But whatever the model the area around the site would be flooded and the site would not be accessible.
Full Replacement Cost	$ 2500000

Warehouse: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	The SWB has only one main warehouse. But this warehouse is mainly involved before an event since parts, mobile pumps, sand bags, food ration... are deployed within the hours before the event. So in case of natural event this building does not seem to be critical. But it would not be accessible. So a backup site could be a "good to have" improvment	H
Supply chain strength	Due to the number of different parts this is difficult to evaluate precisely if there are some critical parts regarding the supply chain. But according to the visit, the management process of parts seems to be robust to face a natural disaster.	H
Skills availability	Some people have to stay at this location in case of alert. There is no specific skill management process	M
Ease of access	Quite easy to access. Close to the Florida canal and a railroad. Any street flooding eliminates access to the Central Yard and warehouse. According to FEMA's data, the area around the site could be flooded in case of an 100 year event	L
Documentation and procedures	There is a defined Hurricane Preparedness Plan in place that identifies what needs to be obtained form the warehouse at several milestones pre-hurricane landfall.	H
Flood protection	The building is elevated (6'). During Katrina after the breach of the levee the building did not have any flooding.building would not be flooded but the area around could be.	M
HAZMAT and Fire protection	The building is well protected with sprinklers. Risks due to hazardous material release are low because amounts of chemicals are low and chemicals are stored on retention containers	H
Building code compliance	The warehouse frame is partially concrete block and metallic panels. The expected wind speed according to Swiss Re's models is 105 mph. The facility was built early 2000's pre-Katrina and was designed with the roof rated for 125mph, the building is positive displacement with air flows, and the doors are hurricane proof (some doors were damaged in June) with cross bars that can be put in place to keep the sectional doors from failing.	H
ARI		**0.851**

Threat: Events: 100 year return period

Comments	This building is around 6 ft elevated. So impact in case of flooding would be limited based on FEMA/USACE scenarios. Access could be limited since whatever the models all the area around the site would be flooded as of a 100 year event. And even if this building is not so critical some spare parts stored inside could be critical.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 1000000



Current Risk Type	Comments
Safety	There is no specific risk linked to a 100 year event except exposure to flying parts. If we consider Swiss Re's models as reference risk would be higher.
Environmental	No risk for environmental as the chemicals stored on containements
Operational ($/annum)	The operational risk is to the various facilities dependent on parts/equipment from the warehouse. In case of hurricane there would be no access to the warehouse to obtain parts/equipment.
Direct ($/annum)	There is no direct threat to the physical building beyond water damage. The building is storm proof. Some devices (doors) was damaged in June during the visit. If we consider Swiss Re's models as reference risk would be higher.

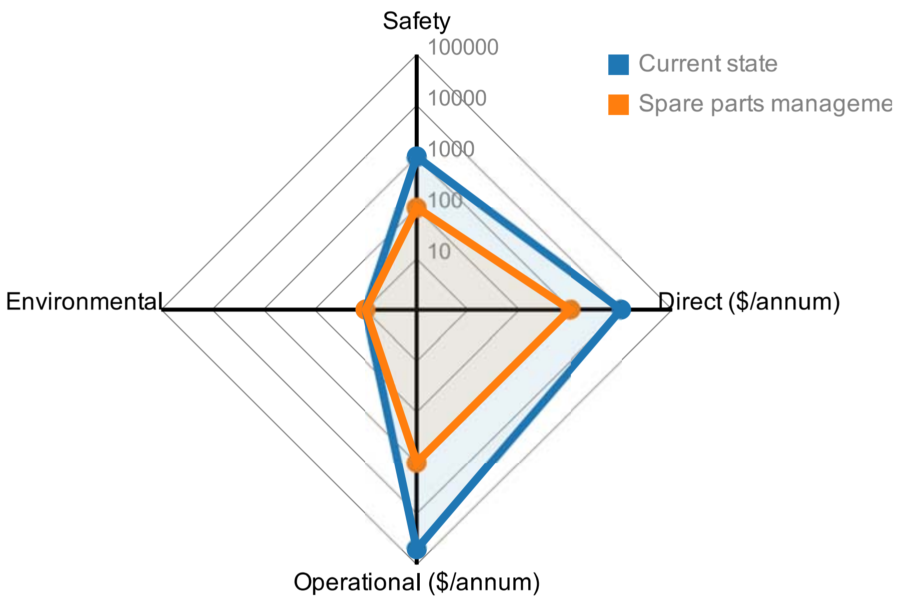
Measure Spare parts management **SELECTED**

Total One-Time Cost	$ 500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 10000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Spare parts storage management	One-time	0			0
Set another warehouse in Algiers	One-time	500000			500000

Threat: Events: 500 year return period

Comments	This building is 6 ft elevated. So impact in case of flooding would be limited. But access could be limited since according to FEMA's data all the area around the site would be flooded as of a 100 year event. Even if this building is not really critical some spare parts store inside could be critical
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 3000000



Current Risk Type	Comments
Safety	See 100 year return period events
Environmental	See 100 year return period events
Operational ($/annum)	Recovery time of the access to this building should be higher than for a 100 y event. But it is difficult to estimate the level of water and the recovery time. Based on Katrina, we should expect that access to the central yard would be difficult around a week.
Direct ($/annum)	As the level of water would be higher (than for 100 y event) damages should be higher. But due to the building elevation consequences would be limited

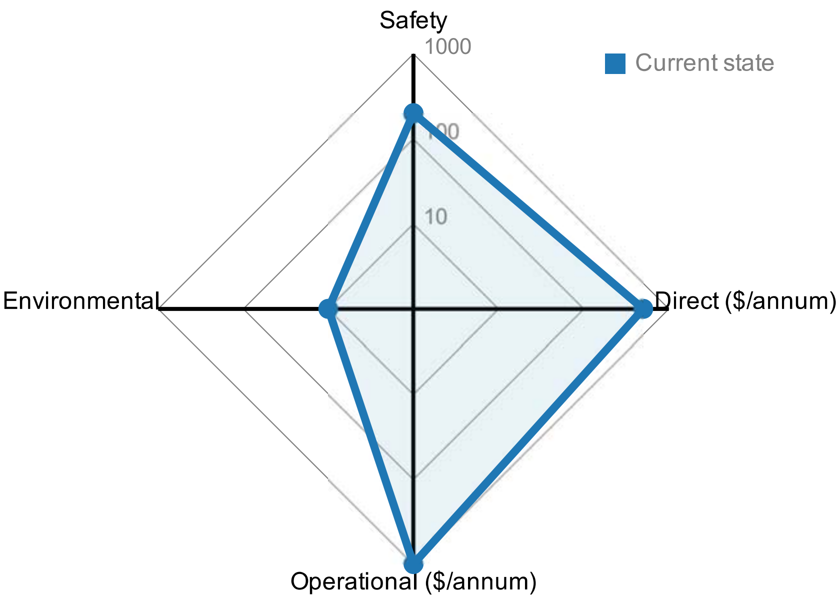
Measure Spare parts management **SELECTED**

Total One-Time Cost	$ 500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	
Earliest Recovery of Function	0
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Spare parts storage management	One-time	0			0
Set another warehouse in Algiers	One-time	500000			500000

Threat: Hurricane < 100 years - Wind

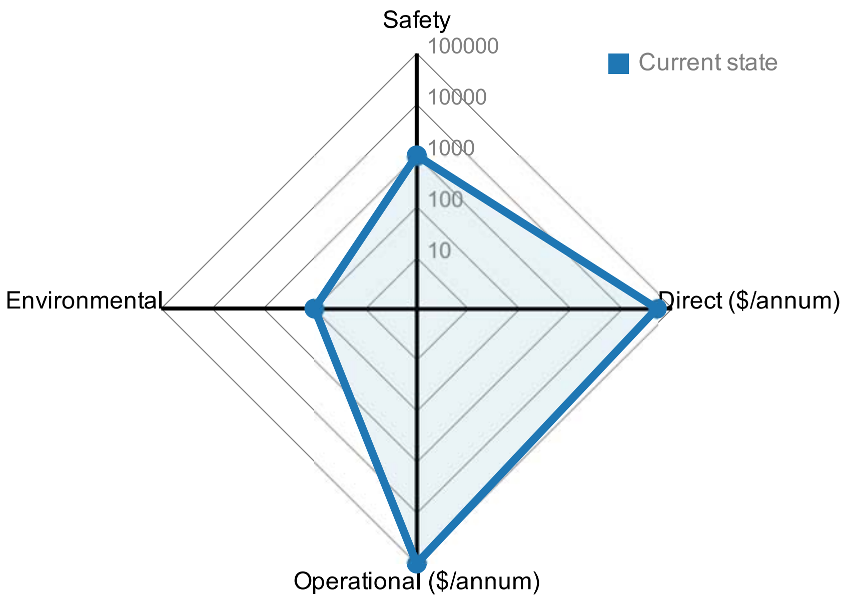
Comments	This building is built to be hurricane proof. But some hurricane proof doors should be repaired
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 20000



Current Risk Type	**Comments**
Safety	There are interior rooms built with block walls designed for hurricanes.
Environmental	Chemical storage room is built with block walls designed for hurricanes.
Operational ($/annum)	The Hurricane Preparedness plan is detailed to maintain operations.
Direct ($/annum)	The facility was built early 2000's prior to Katrina and designed to be resilient against hurricanes. No direct risk.

Threat: Scenario: SR 100 years

Comments	According to Swiss RE scenario (100 year event), the level of water could achieve 10 to 12.5 ft. So the building would be under water since it is only 6 ft elevated. Due to the size of the building it is not cost efficient to raise the whole building. So we suggest improving spare part storage and creating a second warehouse on the West Bank to reduce the probability of not having access to critical spare parts. See other scenarios
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 2000000



Current Risk Type	**Comments**
Safety	As the building could be under water, we can expect that staff would not stay in the warehouse thought this building is hurricane proof. Nevertheless water could convey pieces or damage racks that could injury staff
Environmental	As the building would be under water, we could expect a pollution due to chemicals stored in the warehouse (oil...)
Operational ($/annum)	Based on Swiss Re's scenario, the building could be under water. In that case, critical spare parts would not be supply to locations where there are some needs until water will have receded.
Direct ($/annum)	Asset value is $2.5m. So based on Swiss Re's scenario, at least half of the building could be under water.

East Bank WWTP: Short Resilience Report

Location Description	6501 Florida Ave, New Orleans 70117
Primary Function	To treat up 120 MGD (average 105 MGD)of raw sewerage from the entire east bank of the Orleans parish (approx. 440,000 people) pumping the effluent downstream into the Mississippi river.
Context Information	The East Bank WWTP was originally constructed in 1973 and upgraded in 1980 expanding treatment capacity from 23 MGD to 122 MGD. The plant is located on the east bank of the Mississippi river, near the St Bernard Parish line and serves the entire East Bank of the Orleans Parish. The facility sits near an abandon landfill to the east, undeveloped wetlands to the north and west, and a residential neighborhood to the south. Two 54" and one 60" sewer mains deliver wastewater to the plant for initial treatment, where screens remove trash and debris. Oxygen is added and a biological reaction takes place, causing solid material to bind together. Water is transferred to transferred to large basins called clarifiers where further treatment takes place. Thickened biosolids are removed during this process, then pressed to remove excess water, and finally incinerated on-site or taken off-site for disposal at a landfill.(Biosolids from the West WWTP are also treated here.) As a final step of the process, chlorine is added to disinfect the treated water before it is discharged into the Mississippi River. Other figures/data: Population served: 440,000 Staff: 32 people Shift pattern: Day, Evening & Night (2 people) Capital replacement value: $244,000,000.00 Redundancy: No Replacement Time: Tbd Special users: Hospitals, business district, hotels, malls, Superdome, universities Location: remote area Vicinity: No exposure Our contract will end in 2025
Full Replacement Cost	$ 200000000

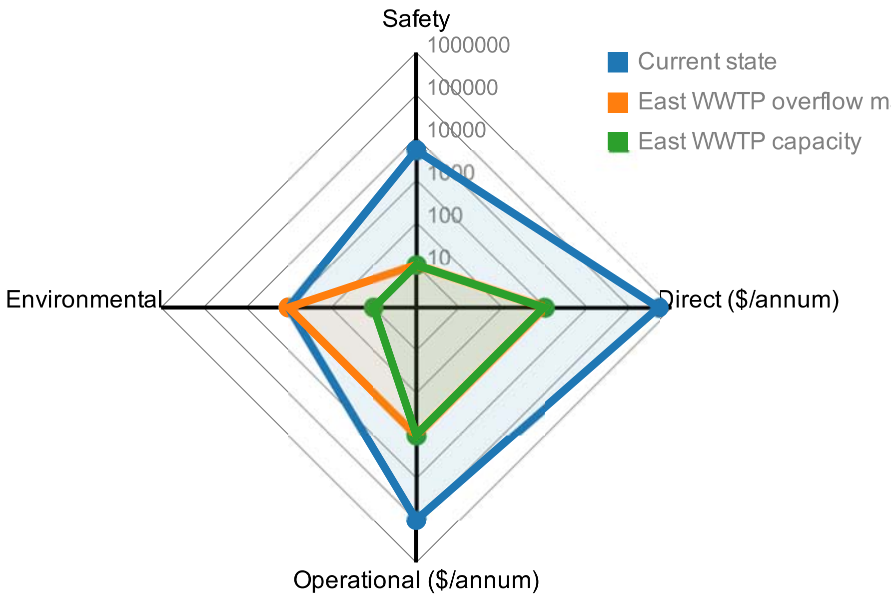
East Bank WWTP: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	At the highest level - considering the entire plant as an asset - there is no redundancy. If the plant is completely out of service, there is no backup treatment option, diversion, storage, etc. The plant has a designed treatment capacity of 122MGD average and 210MGD peak. Average influent flows range from 90 - 105MGD, but the collection system suffers from significant I&I issues, so flows during and shortly after heavy rain events can peak to over 200MGD and sustain levels far exceeding 122MGD for days. As an example, during the plant assessment (09/06/2016) there had been moderate rain over the weekend before where flows exceeded 190MGD and were still well over 140MGD days later. These capacity issues were expressed by plant staff as one of the plant's primary weaknesses in terms of resiliency / excess capacity. For redundancy features within the plant, see individual sub-assets for discussions.	L
Supply chain strength	Overall, the plant is relatively new compared to many of the S&WB's other assets, so aspects of supply chain strength such as spare parts availability, lead time, etc. are relatively good. Originally commissioned in 1973, and extensively expanded in 1980, the majority of the East Bank plant's assets are less than 40 years old, and a significant portion are less than 15 years old as many upgrades were also carried out following Hurricane Katrina. The majority of the VSA system assets were also reportedly replaced around 2010. The supply chain strength for chemicals is also relatively good (discussed in further detail in related sub-assets), as well as utilities (city water, natural gas, electricity, etc.). Unfortunately there is no inter-connectivity between the plant's maintenance department and the expertise and capabilities of the S&WB's facilities maintenance department concerning major maintenance - thus the majority of activities such as major rebuilds, refurbishments, overhauls, etc. are outsourced.	H
Skills availability	All people working on the plant have appropriate certifications for their roles. Veolia manages skillsets in a very formalized manner with regular training, renewing of operator and maintenance certificates, etc.	H
Ease of access	Road & rail access, though the road access to the plant can be difficult to find for newcomers and would be completely flooded in case of storm surge. Rail access is for chlorine gas deliveries only.	M
Documentation and procedures	Main procedures are documented - a hurricane preparedness plan is maintained for the plant with key staff and preparatory actions identified. Rations, water, etc. kept in the generator building as a hurricane measure (area also has a kitchen, showers, etc.). Standard Veolia practice of maintaining and regularly updating SOPs, PCMPs, etc.	H

Parameter	Comments	Score (L/M/H)
Flood protection	Flood wall of 18 feet around entire site, many raised buildings, etc. Expected level of water according to FEMA and US ACoE is around 4 ft for a 100 year return event. Therefore the wall is considered to provide adequate storm surge / flooding protection. Additionally, the plant only receives influent from force mains, so if pumping is stopped at the main SPSs, the plant would not receive any significant amounts of flood water via the influent lines. All site drainage is directed to a drainage pond on site where it can be circulated back into the process and eventually discharged via the effluent pumps. The effluent discharge lines have siphon breaks to prevent backflowing, and there are also valves which can be closed to isolate these mains if needed. Overall the risk of surge / flooding damage is believed to be relatively low due to this broad coverage of mitigation, though there are many items of critical equipment located at ground or basement level which could be addressed to further improve the plant's resilience. Risks of flooding due to an excess of influent flows is the only major risk perceived (discussed more in mitigation options).	M
HAZMAT and Fire protection	Containers on retention. No fire protection except hand held extinguishers. No scrubber to limit chlorine gas cloud expansion in case of leak. Due to regulatory change, rail car of chlorine is planned to be replaced by sodium hypochlorite (discussed further in associated sub-asset).	M
Building code compliance	Some buildings are believed to be compliant with last building codes, but this topic was generally not assessed in detail. Expected wind speed according to SwissRe's results: 115 mph. No obvious signs of condition issues with plant buildings that would suggest them being particularly vulnerable.	M
ARI		**0.766**

Threat: Events: 100 year return period

Comments	Flood wall of 18 feet around entire site, many raised buildings, etc. Expected level of water according to FEMA & US ACoE: around 4 ft without taking into account the wall. Therefore the wall is considered to provide adequate storm surge / flooding protection from the surrounding area. However, it is currently unclear / not formalized how operations are to prevent flooding from possible excess influent flow. The pumping capacity of the SPSs that feed the plant exceeds the plant's peak hydraulic capacity. For political reasons, it may be necessary for these SPSs to pump at full capacity to assist in reducing widespread flooding / damage around New Orleans. The plant has a drainage pump station of its own that can discharge over the surge / flood wall, but both the pumping capacity of this station and permission to operate it under such a scenario need to be addressed.
Earliest Recovery of Function	1 months
Repair and recommissioning cost	$ 12000000



Current Risk Type	Comments
Safety	The wall should protect people against flooding. Main buildings are elevated. Excess influent flows leading to flooding within the site could result in significant safety risks though.
Environmental	Even if there is a wall around the plant, due to chemicals storage at ground level, there is a risk of pollution due to oils but due to the stored capacities on site impact should be limited.
Operational ($/annum)	Main process would be protected thanks to the wall. Some pumps could be flooded. Internal risk of flooding due to SPS system exceeding plant capacity is a major concern though with catastrophic operational consequences.
Direct ($/annum)	Thanks to the wall around the plant consequences linked to storm surge should be limited. SR's models have showed that the wall reduce the risk profile of 82%. Excess influent flows leading to flooding within the site could result in catastrophic direct equipment damage related risks though.

Measure East WWTP capacity

Total One-Time Cost	$ 100000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 100000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Upgrade plant capacity	One-time	100000000			100000000

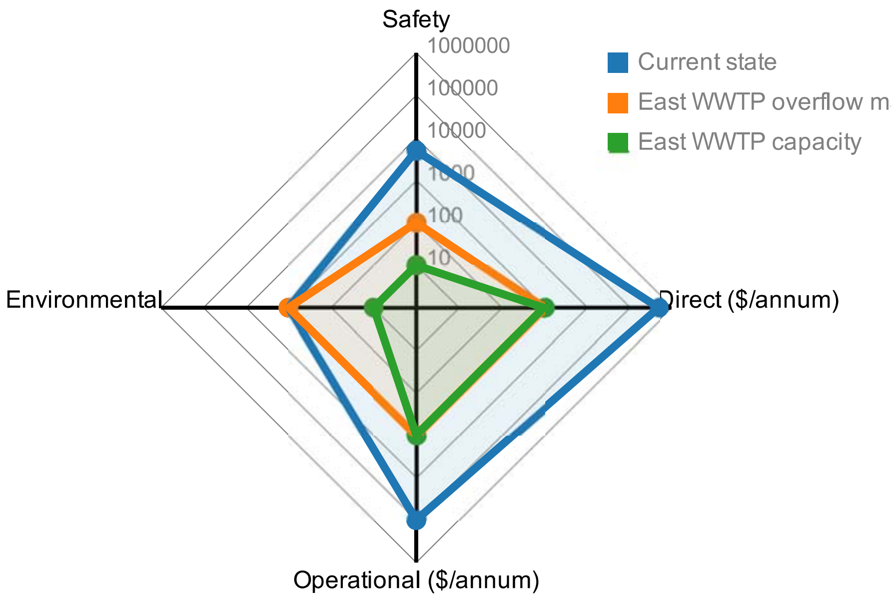
Measure East WWTP overflow management **SELECTED**

Total One-Time Cost	$ 6000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	1 weeks
Repair and recommissioning cost	$ 100000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Overflow structure / drainage pump station upgrade	One-time	6000000			6000000

Threat: Events: 500 year return period

Comments	There should not be other risk than those which could occur for a 100 y event period. The wall around the plant should protect against outside flooding and storm surge. Due to the capacity of the SPSs and the treatment capacity of the plant the risk of iinternal flooding could be higher than for a 100 year event
Earliest Recovery of Function	1 months
Repair and recommissioning cost	$ 15000000



Current Risk Type	Comments
Safety	Same as 100 year events
Environmental	Same as 100 year events
Operational ($/annum)	The activity disruption should be a little bit higher than for a 100 year event. But the activity disruption should not be significantly higher since critical assets are elevated as well
Direct ($/annum)	As the level of water would be higher the costs of damages should be higher

Measure East WWTP capacity

Total One-Time Cost	$ 100000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 100000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Upgrade plant capacity	One-time	100000000			100000000

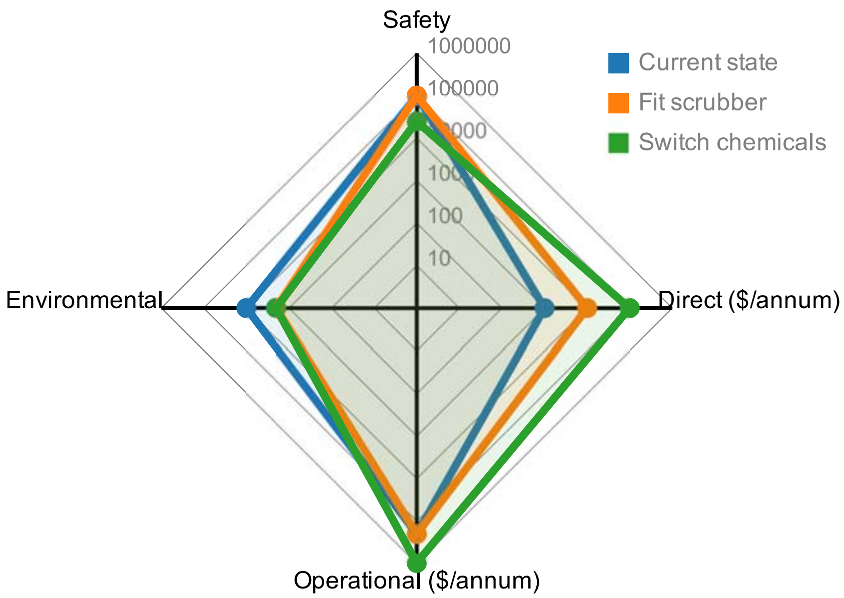
Measure East WWTP overflow management **SELECTED**

Total One-Time Cost	$ 6000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	1 weeks
Repair and recommissioning cost	$ 100000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Overflow structure / drainage pump station upgrade	One-time	6000000			6000000

Threat: Hurricane < 100 years - Wind

Comments	The 18 ft wall around the plant would be useful in case of high speed wind. Nevertheless the windows of the control room within the solid building could blow up, metallic panel could fall and fly. Wind could also convey pieces.
Earliest Recovery of Function	3 days
Repair and recommissioning cost	$ 100000



Current Risk Type	**Comments**
Safety	Coupling devices (pipes) of the chlorine installation could be broken. They are some risks of leak of chlorine. There is 90 ton of Chlorine (2 tanks) In case of wind, metallic panels could fall, fly and windows could blow to pieces. Those 2 risks could injure people
Environmental	Diesel tanks are on retention containers but not all other liquid chemicals No specific risk for environment linked to the wind
Operational ($/annum)	The wall built to protect against the flooding would also protect against the wind for low buildings/process. The solids building could be the main building that could be damaged but this building is not critical because sludges could be stored or evacuated in cas of furnace disruption.
Direct ($/annum)	Solids building frame is mainly metallic panels. Due to the wind speed we can expect damages. Other buildings have a concrete framework

Measure Fit scrubber

Total One-Time Cost	$ 50000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 500000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Safety improvement / chlorine leakage	One-time	50000			50000

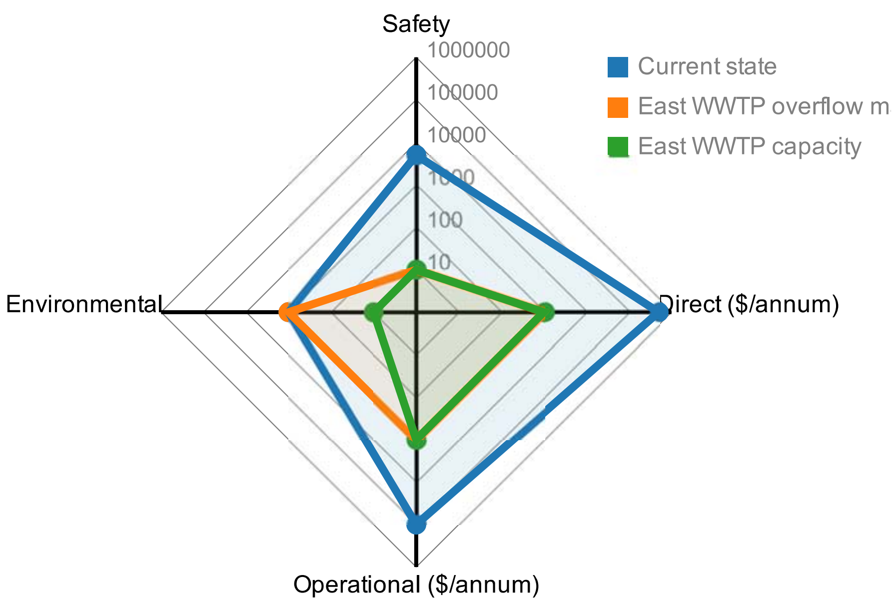
Measure Switch chemicals **SELECTED**

Total One-Time Cost	$ 500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 100000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Switch from Chlorine to Sodium hypochlorite	One-time	500000			500000

Threat: Scenario: SR 100 years

Comments	Flood wall of 18 feet around entire site, many raised buildings, etc. Expected level of water according to Swiss Re's models from 10 to 12.5 without taking into account the wall. Therefore the wall is considered to provide adequate storm surge / flooding protection from the surrounding area. However, it is currently unclear / not formalized how operations are to prevent flooding from possible excess influent flow. The pumping capacity of the SPSs that feed the plant exceeds the plant's peak hydraulic capacity. For political reasons, it may be necessary for these SPSs to pump at full capacity to assist in reducing widespread flooding / damage around New Orleans. The plant has a drainage pump station of its own that can discharge over the surge / flood wall, but both the pumping capacity of this station and permission to operate it under such a scenario need to be addressed. No more action is proposed than those suggest for 100 year return period events and 500 year return period events
Earliest Recovery of Function	1 months
Repair and recommissioning cost	$ 15000000



Current Risk Type	Comments
Safety	The wall should protect people against flooding. Main buildings are elevated. Excess influent flows leading to flooding within the site could result in significant safety risks though.
Environmental	Even if there is a wall around the plant, due to chemicals storage at ground level, there is a risk of pollution due to oils but due to the stored capacities on site impact should be limited.
Operational ($/annum)	Main process would be protected thanks to the wall. Some pumps could be flooded. Internal risk of flooding due to SPS system exceeding plant capacity is a major concern though with catastrophic operational consequences.
Direct ($/annum)	Thanks to the wall around the plant consequences linked to storm surge should be limited. SR's models have showed that the wall reduce the risk profile of 82%. Excess influent flows leading to flooding within the site could result in catastrophic direct equipment damage related risks though.

Measure East WWTP capacity

Total One-Time Cost	$ 100000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 100000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Upgrade plant capacity	One-time	100000000			100000000

Measure East WWTP overflow management **SELECTED**

Total One-Time Cost	$ 6000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	1 weeks
Repair and recommissioning cost	$ 100000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Overflow structure / drainage pump station upgrade	One-time	6000000			6000000

West Bank WWTP: Short Resilience Report

Location Description	3501 E. Canal Street, New Orleans
Primary Function	To treat up 40 MGD of raw sewerage from the entire West bank of the Orleans parish (approx. 54,000 people) pumping the effluent downstream into the Mississippi river.
Context Information	West bank WWTP was not flooded during Katrina Average LBs/Day 2015: Influent BOD 7,079.2 TSS 8,296.7 - Effluent BOD 701.2 TSS 885.9 Staff: 7 people Shift pattern: Day, Evening & Night (1 person) Capital replacement value: $100 m Redundancy: No Special users: Hotels, malls Location: remote area Vicinity: No exposure Our contract will end in 2025 List of assets likely needed for rapid recovery - Grit pump, grit blower, grit screw collector drive - Headworks electrical / MCC / control panel components - Primary clarifier sludge pumps - Primary clarifier electrical / MCC / control panel components - Intermediate pump motors / components - Intermediate pump station electrical / MCC / control panel components - Secondary clarifier drive components - Secondary clarifier sludge pumps - Secondary clarifier electrical / MCC / control panel components - Chlorination equipment (dose pumps, control panel components, etc.) - Effluent pump motors / components - Electrical distribution / switchgear / transformer components - Generator components
Full Replacement Cost	$ 100000000

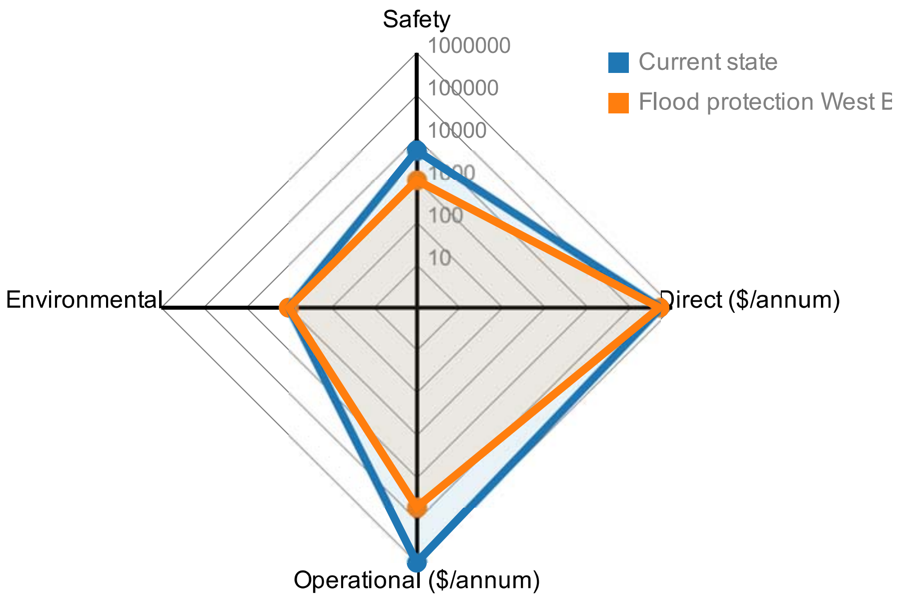
West Bank WWTP: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	At the highest level - considering the entire plant as an asset - there is no redundancy. If the plant is completely out of service, there is no backup treatment option, diversion, storage, etc. The plant has a designed treatment capacity of 40MGD. Average influent flows range from 9 - 10MGD. The collection system suffers from some I&I issues, but these are reportedly not nearly as severe as with the East Bank plant's collection system. Flows during and shortly after heavy rain events can peak to over 20MGD. As an example, during the plant assessment (09/07/2016) there had been moderate rain the evening before where flows exceeded 20MGD and were still over 20MGD the next day. Extreme weather events have resulted in influent flows above 30MGD, but there has never been an event above the design 40MGD. Capacity issues are not seen as a significant weakness in terms of resiliency. For redundancy features within the plant, see individual sub-assets for discussions.	H
Supply chain strength	Overall, the plant is relatively new compared to many of the S&WB's other assets, so aspects of supply chain strength such as spare parts availability, lead time, etc. are relatively good. Originally commissioned in 1972-1973, and extensively expanded in 1991-1992, the majority of the West Bank plant's assets are less than 40 years old, and a significant portion are less than 25 years old. The supply chain strength for chemicals is also relatively good - sodium hypochlorite, sodium hydroxide (odor control) and odor control catalyst are all sourced locally. City water is supplied via a single connection, but plant water can be used for critical processes if city water is lost. No longer a natural gas supply to the plant (old multiple hearth incinerator was decommissioned many years ago). Unfortunately there is no inter-connectivity between the plant's maintenance department and the expertise and capabilities of the S&WB's facilities maintenance department concerning major maintenance - thus the majority of activities such as major rebuilds, refurbishments, overhauls, etc. are outsourced.	H
Skills availability	All people working on the plant have appropriate certifications for their roles. Veolia manages skillsets in a very formalized manner with regular training, renewing of operator and maintenance certificates, etc.	H
Ease of access	There is only one road to access to the plant. According to SwissRe's models, this location could be flooded (12.5 - 15 ft.). In case of flooding, the plant would not be accessible.	M
Documentation and procedures	Main procedures are documented - a hurricane preparedness plan is maintained for the plant with key staff and preparatory actions identified. Rations, water, etc. kept on-site as a hurricane measure. Standard Veolia practice of maintaining and regularly updating SOPs, PCMPs, etc.	H

Parameter	Comments	Score (L/M/H)
Flood protection	There is no specific protection like at the East Bank plant. Many key assets are located at ground level or only slightly higher. According to SwissRe's results of 12.5 - 15ft storm surge / flooding being possible, the affected systems include: the headworks (grit pumps, blowers, screw drives, MCC, etc.), the primary sludge pumps and primary MCCs, the intermediate pumping station pumps and MCC / control panels, the secondary clarifiers, sludge pumps and MCC, the chlorination equipment, the effluent pumping station, the plant electrical and emergency generator systems and the sludge storage system.	L
HAZMAT and Fire protection	Chemicals / fuels used at this location include sodium hydroxide, odor control catalyst, sodium hypochlorite (being implemented at the time of this assessment) and diesel. Sodium hydroxide and odor control catalyst bulk storage tanks are not located within secondary containment, but the larger hydroxide tank is double walled. Hypochlorite bulk storage tanks are in a containment, but this is not designed to hold the entire storage volume of the tanks. The tanks themselves are double wall design. Diesel tank is located within secondary containment. No fire protection / alarming - limited to hand held fire extinguishers only.	M
Building code compliance	Some buildings are believed to be compliant with last building codes, but this topic was generally not assessed. No obvious signs of condition issues with plant buildings that would suggest them being particularly vulnerable.	M
ARI		**0.814**

Threat: Events: 100 year return period

Comments	No specific protection against surge / flood. According to Swiss Re's models, possible affected systems / assets include: headworks (grit pumps, blowers, screw drives, MCC, etc.), the primary sludge pumps and primary MCCs, the intermediate pumping station pumps and MCC / control panels, the secondary clarifiers, sludge pumps and MCC, the chlorination equipment, the effluent pumping station, the plant electrical and emergency generator systems and the sludge storage system. But according to FEMA we could expect up to 2 ft of water for a 100 year event. So the consequences would be limited
Earliest Recovery of Function	1 months
Repair and recommissioning cost	$ 10000000



Current Risk Type	Comments
Safety	The control room could be flooded since it is not elevated. Some parts of the process are elevated but there is no appropriate room to protect the staff. Overall perception is that this scenario poses significant safety risks.
Environmental	Chemicals are stored at ground level but amounts are relatively low - In case of flooding, impact would be low to moderate if any of the storage tanks leaked.
Operational ($/annum)	Some critical equipment of the plant could be flooded and extensive repairs / asset replacements would be needed to return operation to normal.
Direct ($/annum)	According to Swiss Re's models, plant could be under 15ft. of flood (based on FEMA's data we could expect only 2 ft of water - Between 20% and 90% of the assets would be under water. Overall perception is that this scenario poses catastrophic direct damage related risk.

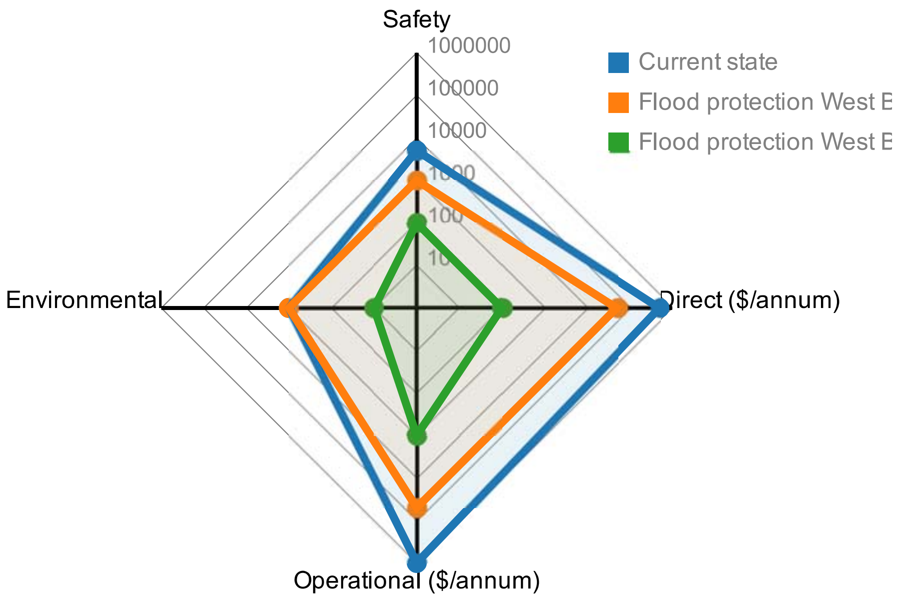
Measure Flood protection West Bank WWTP - Low cost mitigation measures

Total One-Time Cost	$ 3300000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	1 days
Repair and recommissioning cost	$ 10000000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Build a simple spare parts storage building at the site	One-time	2000000			2000000
Maintain critical spares needed for rapid recovery	One-time	1000000			1000000
Buy Tiger dams to protect some buildings (control room, sodium hypochlorite)	One-time	300000			300000

Threat: Events: 500 year return period

Comments	No specific protection against surge / flood. According to the FEMA and US Army Corps of Engineers, we could expect a level of water from 2 to 8 ft. Possibly affected systems / assets include: the headworks (grit pumps, blowers, screw drives, MCC, etc.), the primary sludge pumps and primary MCCs, the intermediate pumping station pumps and MCC / control panels, the secondary clarifiers, sludge pumps and MCC, the chlorination equipment, the effluent pumping station, the plant electrical and emergency generator systems and the sludge storage system.
Earliest Recovery of Function	2 months
Repair and recommissioning cost	$ 50000000



Current Risk Type	Comments
Safety	The control room could be flooded since it is not elevated. Some parts of the process are elevated but there is no appropriate room to protect the staff. Overall perception is that this scenario poses significant safety risks.
Environmental	Chemicals are stored at ground level but amounts are relatively low - In case of flooding, impact would be low to moderate if any of the storage tanks leaked.
Operational ($/annum)	Main equipment of the plant would be flooded and extensive repairs / asset replacements would be needed to return operation to normal.
Direct ($/annum)	According to FEMA and US Army Corps of Engineers, plant could be under 8ft of flood (compared with the 15 ft from Swiss Re's model) - Between 50% and 60% of the assets would be under water. Overall perception is that this scenario poses catastrophic direct damage related risk.

Measure Flood protection West Bank WWTP - High cost mitigation measures

Total One-Time Cost	$ 10500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	3 days
Repair and recommissioning cost	$ 1000000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Construct a surge / flood protection perimeter wall around the entire site	One-time	10500000			10500000

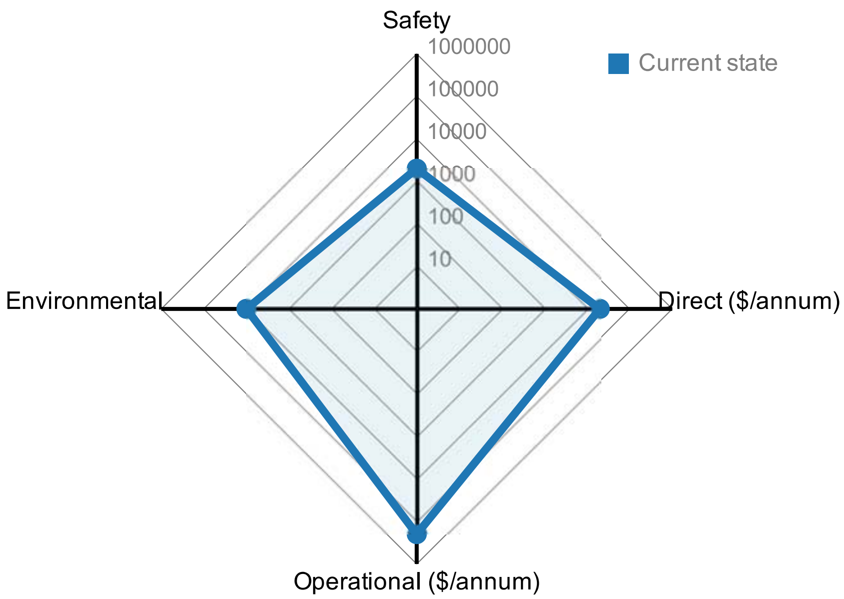
Measure Flood protection West Bank WWTP - Medium cost mitigation measures

Total One-Time Cost	$ 9800000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 10000
Earliest Recovery of Function	1 weeks
Repair and recommissioning cost	$ 5000000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Protect specific installations via raising / elevating assets	One-time	2000000			2000000
Replace certain assets with units resilient against surge / flood	One-time	1300000			1300000
Construct a surge / flood protection wall around the plant electrical and effluent pump station assets	One-time	6000000			6000000
Contingency	One-time	500000			500000

Threat: Hurricane < 100 years - Wind

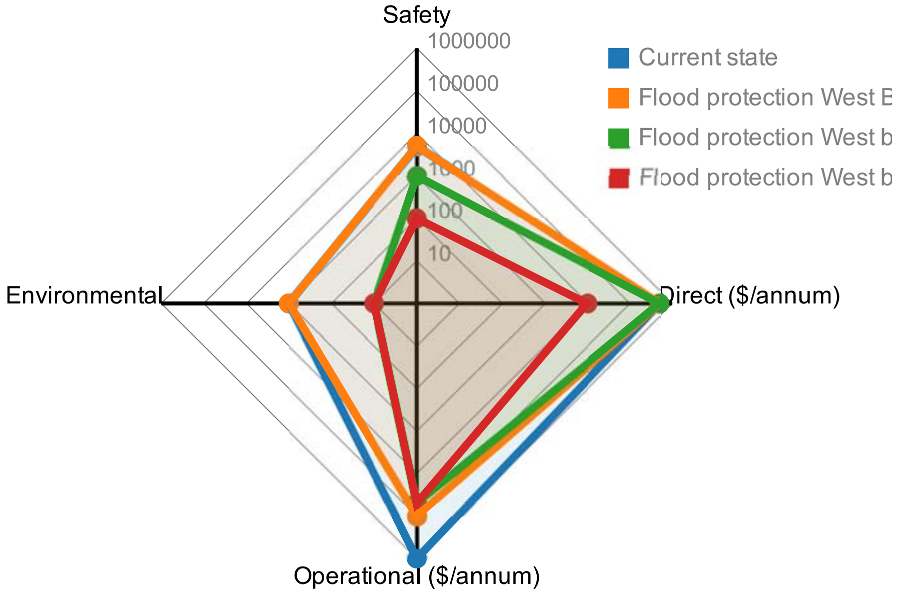
Comments	Expected wind speed according to FEMA's results: 110-119 mph. The wind would not have a big impact on the installations but we can expect some flying pieces.
Earliest Recovery of Function	1 weeks
Repair and recommissioning cost	$ 150000



Current Risk Type	**Comments**
Safety	In case of wind metallic panels or other pieces could fly and windows could blow up and injure people
Environmental	Wind and flying pieces could damage chemical storage but there are few chemicals on the site. Impact would be limited
Operational ($/annum)	Activity disruption risk due to wind is low but the control room could be damaged. 54000 people could be impacted in case of disruption
Direct ($/annum)	Damage costs would be limited

Threat: Scenario: SR 100 years

Comments	The West Bank WWTP has been modeled by Swiss Re (100 year event) to anticipate 12.5 – 15ft of surge / flood waters. No extensive flood control measures were implemented following Hurricane Katrina since this plant was not affected. Therefore a significant number of the plant's assets would be affected by such water levels
Earliest Recovery of Function	60 days
Repair and recommissioning cost	$ 80000000



Current Risk Type	Comments
Safety	The control room could be flooded since it is not elevated. Some parts of the process are elevated but there is no appropriate room to protect the staff. Overall perception is that this scenario poses significant safety risks.
Environmental	Chemicals are stored at ground level but amounts are relatively low - In case of flooding, impact would be low to moderate if any of the storage tanks leaked.
Operational ($/annum)	Main equipment of the plant would be flooded and extensive repairs / asset replacements would be needed to return operation to normal.
Direct ($/annum)	Between 70% and 90% of the assets would be under water. Overall perception is that this scenario poses catastrophic direct damage related risk.

Measure Flood protection West bank WWTP - High cost scenario based on SR **SELECTED**

Total One-Time Cost	$ 20000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	1 weeks
Repair and recommissioning cost	$ 150000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Construct a surge / flood protection perimeter wall around the entire site	One-time	20000000			20000000

Measure Flood protection West Bank WWTP - Low cost scenario based on SR

Total One-Time Cost	$ 4000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	45 days
Repair and recommissioning cost	$ 80000000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build a simple storage building at site based on SR's scenario	One-time	3000000			3000000
Maintain critical spare parts for rapid recovery	One-time	1000000			1000000

Measure Flood protection West bank WWTP - Medium cost scenario based on SR

Total One-Time Cost	$ 12800000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	1 months
Repair and recommissioning cost	$ 20000000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Protect specific installations via raising / elevating assets	One-time	4000000			4000000
Replace certain assets with units resilient against surge / flood	One-time	1300000			1300000
Construct a surge / flood protection wall around the plant electrical and effluent pump station assets	One-time	7000000			7000000
Contingency	One-time	500000			500000

Algiers Water Purification Plant: Short Resilience Report

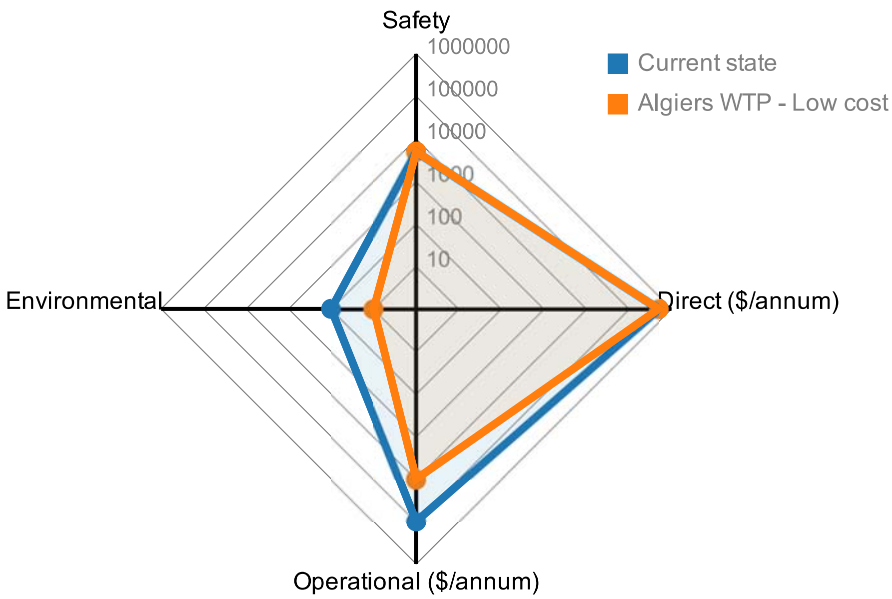
Location Description	900 Lamarque Street, New Orleans
Primary Function	To supply a minimum of 10 MGD of drinking water that meets or exceeds Federal drinking water standards to the West parishes at 70 psi Capacity 24 million gallons/day Purifies 10 MGD of water Capital Value $100m Population served 57,000
Context Information	The Sewerage and Water Board operates and maintains the water treatment plant on the west bank of the Mississippi River in Algiers. The Algiers plant, which serves the predominantly residential West Bank portion of the parish, purifies roughly 10 mgd of water.The purification process is similar to that of the Carrollton Water Plant, utilizing the same water treatment chemicals with a slightly modified process. Water enters via 36" main from one of two river water intakes (Old and new, old intake not large enough to supply enough water). River water is directed to 1 of 4 Clarifiers currently directed to number 2 Clarifier. Free chlorine (1 part per million) is added to the 36" main when the water temperature is less 20C. Lack of chlorine disinfection can only be tolerated for no longer than 10 to 15 minutes. There is 100% redundancy with regards to the chlorine pumps. Chlorine storage is available for 30 days. Total chlorine, ammonia, ferric sulphate, flouresic acid, is added to the intake of the clarifiers. Mixing zone add soduim hexametphosphate, lime, polelrolyte. Operators manually set the sludge blow back timer. Blow back purpose to keep lines clear. Clarifiers need to maintain blanket thickness. Very little documentation describing the process. Upflow clarifiers. Clarifiers effulent is gravity flow to the rapid sand filters. Anthracite capped rapid sand filters 12" thick. There are two storage tanks each with a capacity of 5 million gallons, equating to 1 days supply of water to Algiers.. The Water Purification Unit has 16 current employees with 9 vacancies. Given the current levels of staffing, overtime is required to cover all the necessary areas within the water purification.
Full Replacement Cost	$ 170000000

Algiers Water Purification Plant: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	No redundancy. In case of flooding, there is no connexion between Algiers and Carrollton plants	L
Supply chain strength	Many of the water treatment plant facilities are aged and either in poor condition (or out of service). Maintenance is mainly corrective and depends on SWB's capacity to manufacture spare parts. SWBNO maintains a large warehouse and dedicated staff to manage inventory	M
Skills availability	The SWBNO has an aging work force. The senior staff are all generally approaching retirement in the next few years. The inability to find and retain younger staff is attempting to be addressed through a specialized training program at the Delgado Community College with the benefits not expected to be seen for many more years.	L
Ease of access	Plant has easy access by road however it is assumed that the road would be prone to flooding during hurricanes.	M
Documentation and procedures	No documented SOPs, procedures. Apparently have O&M manuals. Cassworks	L
Flood protection	Plant is partially protected. Some facilities are elevated. According to Swiss Re models, these measures are not sufficient to avoid activity disruption	L
HAZMAT and Fire protection	No automatic fire protection. Fire protection consists of hand held fire extinguishers. Low HAZMAT issues provided procedures are followed.	M
Building code compliance	It is presumed all water treatment plant buildings are built to code	M
ARI		**0.547**

Threat: Events: 100 year return period

Comments	According to FEMA the plant could be partially flooded. Level of water should be low (around 2 ft). Area around the plant could be flooded.
Earliest Recovery of Function	1 weeks
Repair and recommissioning cost	$ 30000000



Current Risk Type	Comments
Safety	Assuming levels of water based on FEMA scenario flood should not add more risks.
Environmental	Chemicals have containment but some of them could be flooded.
Operational ($/annum)	Activity disruption could occur. Even if the plant is only partially some critical asset could be flooded and more important access to the plant could be impossible. And some chemicals have a limited storage capacity
Direct ($/annum)	Less than 30% of the asset value would be flooded

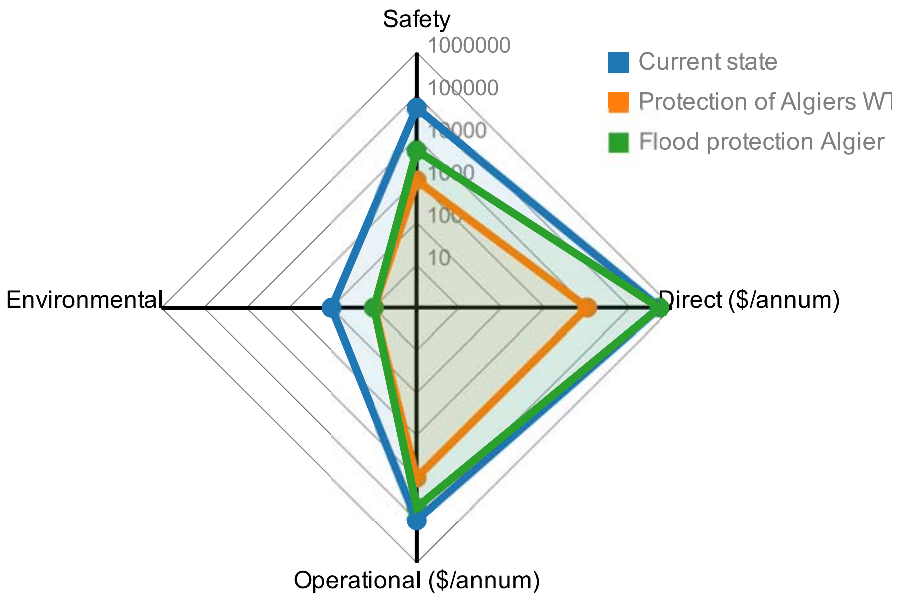
Measure Algiers WTP - Low cost scenario

Total One-Time Cost	$ 380000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 20000000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Buy Tiger dams to protect some buildings (chemicals and clarifier 4)	One-time	380000			380000

Threat: Events: 500 year return period

Comments	According to FEMA's scenario there is a risk of flooding but for the USACE this risk is very low.
Earliest Recovery of Function	2 weeks
Repair and recommissioning cost	$ 50000000



Current Risk Type	Comments
Safety	Assuming levels of water based on FEMA scenario flood should not add more risks. Critical client could be affected (hospital)
Environmental	Chemicals have containment but some of them could be flooded.
Operational ($/annum)	Activity disruption could occur. Many critical asset should be flooded and more important access to the plant would be impossible. Some chemicals have a limited storage capacity
Direct ($/annum)	The whole plant should be flooded according to FEMA --> Approximately 50% of the asset value could be affected

Measure Flood protection Algier plant - Medium cost scenario

Total One-Time Cost	$ 2000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 40000000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build heavy protections around critical buildings	One-time	2000000			2000000

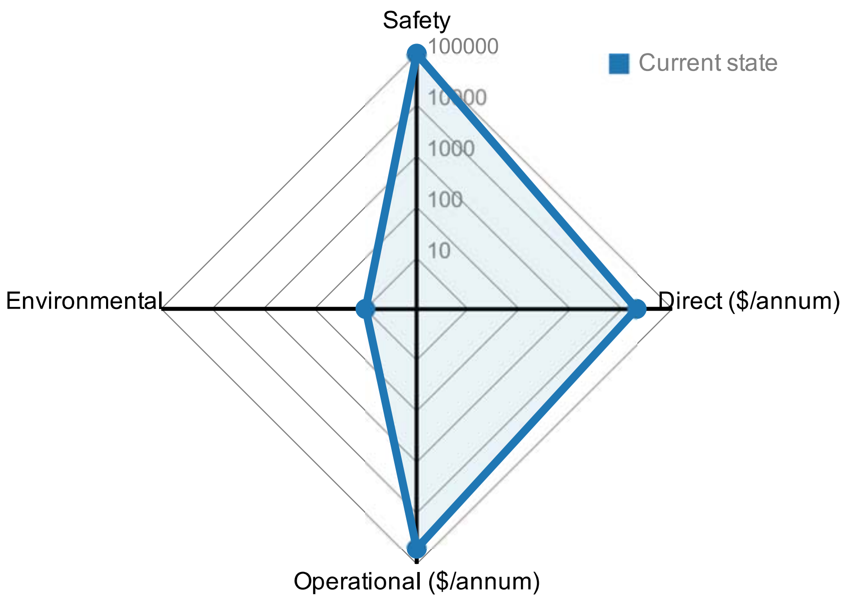
Measure Protection of Algiers WTP

Total One-Time Cost	$ 21000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 500000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build a wall around the plant	One-time	21000000			21000000

Threat: Hurricane < 100 years - Wind

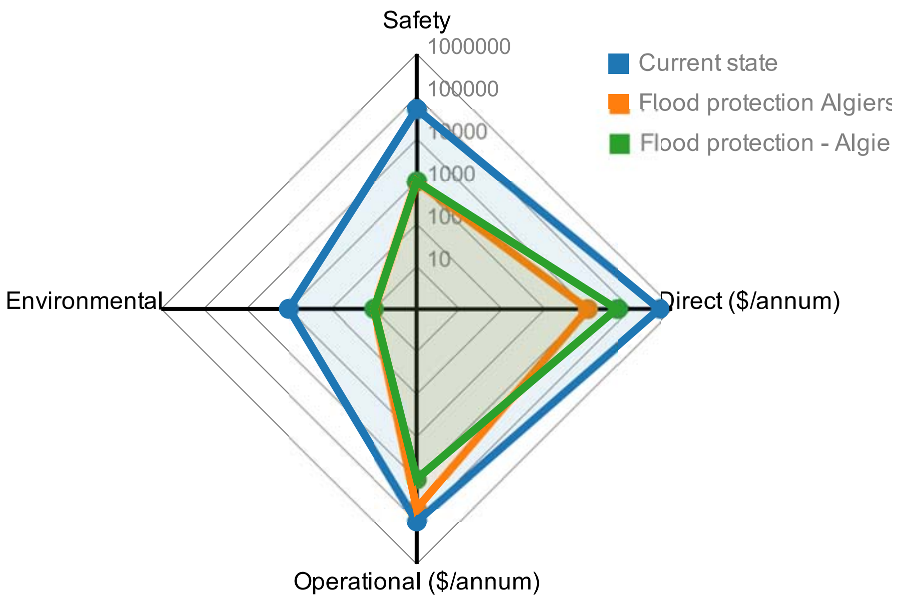
Comments	Historical wind damage limited to one metal roof that rolled up and blew off.
Earliest Recovery of Function	14 days
Repair and recommissioning cost	$ 50000



Current Risk Type	**Comments**
Safety	a myriad of safety risks were noted during site visits, including many that would generally be classed as extreme in the Veolia world. In addition to apparently little care taken to reduce slip, trip, fall, etc. type hazards, there were generally no guards placed around rotating assets (shafts, couplings, motors, etc.), numerous handrails missing around basins, stairways, catwalks, etc., numerous grates in poor condition as well as many missing completely, guards not in place around low and high voltage electrical equipment
Environmental	Low risk due to containments
Operational ($/annum)	Minimal at the scale of the plant. But some critical assets (ferric building, cable tray...) could be damaged due to the wind. If those assets would shutdown the whole plant could shutdown as well
Direct ($/annum)	Possible roof / window damage.

Threat: Scenario: SR 100 years

Comments	According to Swiss Re's models for an 100 year event flood levels could reach 10 ft to 12.5 ft. In that case entire plant would be flooded.
Earliest Recovery of Function	15 days
Repair and recommissioning cost	$ 80000000



Current Risk Type	Comments
Safety	Overall perception is that this scenario poses significant safety risks for staff and for Algiers resident. Fire risk
Environmental	The whole plant would be flooded. Chemicals containment would be full of water
Operational ($/annum)	A process disruption would not be avoided. Critical assets would be under water
Direct ($/annum)	80% of the plant would be under water

Measure Flood protection - Algiers plant - Individual building protection

Total One-Time Cost	$ 6500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	12 hours
Repair and recommissioning cost	$ 10000000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Protect specific installations via raising / elevating assets	One-time	1500000			1500000
Protect specific equipment via a wall	One-time	5000000			5000000

Measure Flood protection Algiers WTP - Wall around plant scenario **SELECTED**

Total One-Time Cost	$ 21000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	12 hours
Repair and recommissioning cost	$ 500000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Construct a surge / flood protection perimeter wall around the entire site	One-time	21000000			21000000

Algiers River Intake 1 (NEW): Short Resilience Report

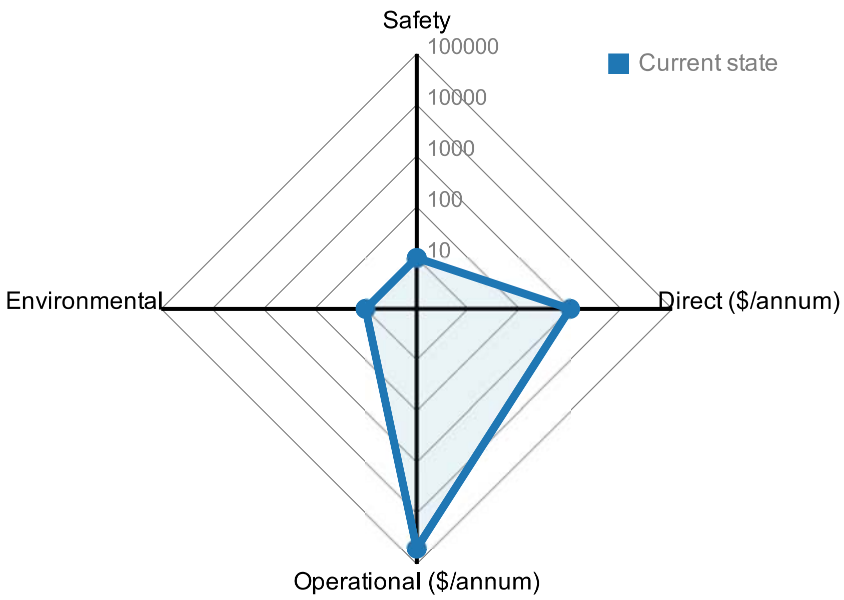
Location Description	200 Dearmas Street, New Orleans, LA 70114
Primary Function	To supply river water to the Algiers water purification plant
Context Information	Intake from Mississippi River protected by barges and bar screens on the river side. Inlet valves to pumping station with a single inlet pipe. Pumping station is manned (guard) during the daytime hours. Station is manned 24/7 during weather events. Three 15 mgd vertical turbine pumps with VFDs (8 mgd minimum output based on speed and pressure needs.) VFDs can be operated either at the pumping station or from West Bank Power Control Station at the Algiers plant.
Full Replacement Cost	$ 12000000

Algiers River Intake 1 (NEW): Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	One pipeline and pumping station only. Have excess pumping capacity	M
Supply chain strength	Aging equipment give cause for concern due to long lead times in either procuring parts or manufacturing parts internally. Delays corrective repairs.	L
Skills availability	The West Bank Power Control and pumping has 15 current employees with 2 vacancies. Power for continued operations of the water treatment systems requires staffing 24 hours per day, 7 days a week. Given the current levels of staffing, overtime is required to cover all the necessary areas within the West Power Control unit.	L
Ease of access	Easy access during dry weather, however during storm events streets could to be flooded	M
Documentation and procedures	No documented SOPs and maintenance procedures. Need to revised maintenance strategies to include predictive technologies.	L
Flood protection	Protected by the river levee at approximately 15 feet high. Ground elevation is approximately 5 feet. No other flood protection.	M
HAZMAT and Fire protection	Hand held fire extinguishers only	L
Building code compliance	Buildings are of concrete block construction presume to meet building codes	M
ARI		**0.553**

Threat: Events: 100 year return period

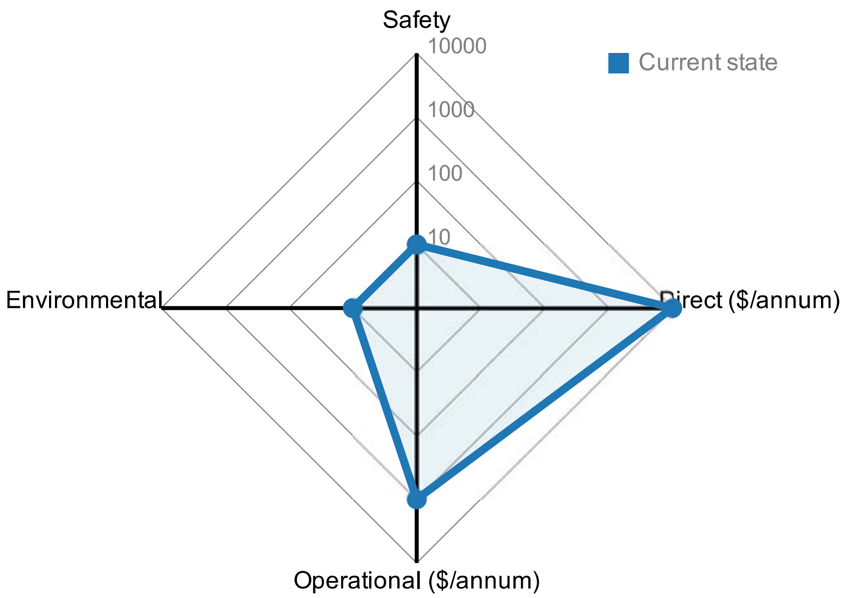
Comments	Pump intake building is protected by the river levee which is at approximately 15 feet high. Limited street flooding. Very unlikely pump intake building would be flooded.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	Minimumal risk to personnel
Environmental	No environmental consequences
Operational ($/annum)	Intake pumps would supply raw water to the WTP. Spare pump capacity should duty pumps fail.
Direct ($/annum)	Minor water damage repair costs

Threat: Events: 500 year return period

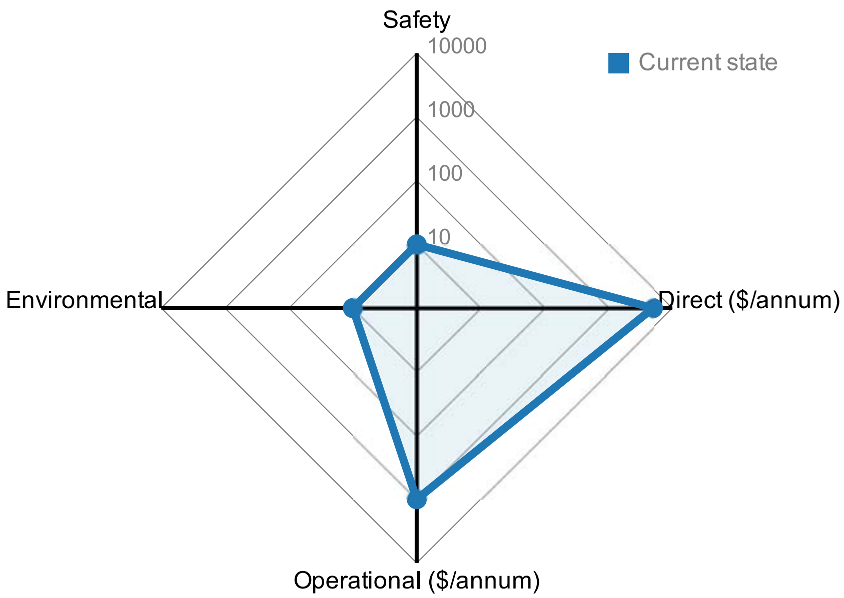
Comments	Potential flooding from overtopping and rainfall however USACE 500 year flood map displays minimum flooding in this area. Wind speeds could reach 130 mph causing possible damage to the buildings specifically roofs.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	Minimumal risk to personnel
Environmental	No environmental consequences
Operational ($/annum)	Intake pumps would supply raw water to the WTP. Spare pump capacity should duty pumps fail.
Direct ($/annum)	Wind and water damage repair costs

Threat: Hurricane < 100 years - Wind

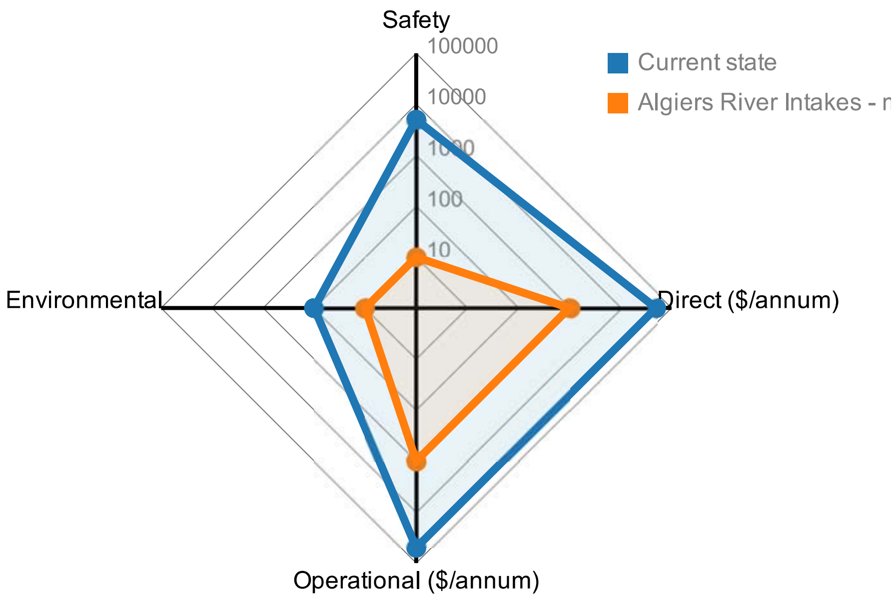
Comments	Wind speeds could reach 105 causing damage to the buildings specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	Comments
Safety	Minimumal risk to personnel
Environmental	No environmental consequences
Operational ($/annum)	Intake pumps would supply raw water to the WTP. Spare pump capacity should duty pump fail.
Direct ($/annum)	Wind damage repair costs

Threat: Scenario: SR 100 years

Comments	Swiss Re are predicting storm surge depths of 11 to 12.5 feet and wind speeds that could reach 105 mph. This could only occur with a levee break or severe overtopping and/or heavy rainfall. Wind damage to the building specifically roofs could occur. River Intake pumps and associated equipment would be flooded and shutdown causing the water treatment plant to stop producing water. Agiers residents would be without drinking water within a day Fire hydrants would also have no water.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 1000000



Current Risk Type	Comments
Safety	Algiers residents would be without drinking water within one day. Fire hydrants would not have any water. SWBNO personnel could at risk with high flood waters
Environmental	Minor lubricating oils spills
Operational ($/annum)	Algiers water treatment plant would be shutdown. No water supplied to residents within one day. Water would have to be trucked in.
Direct ($/annum)	Repairs to 5 lift pumps motors, switchgear etc

Measure Algiers River Intakes - medium cost mitigation **SELECTED**

Total One-Time Cost	$ 1000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 0

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build a wall around infrastructure to exceed surge flood depths	One-time	1000000			1000000

Sodium Hypochlorite Storage/Feed System: Short Resilience Report

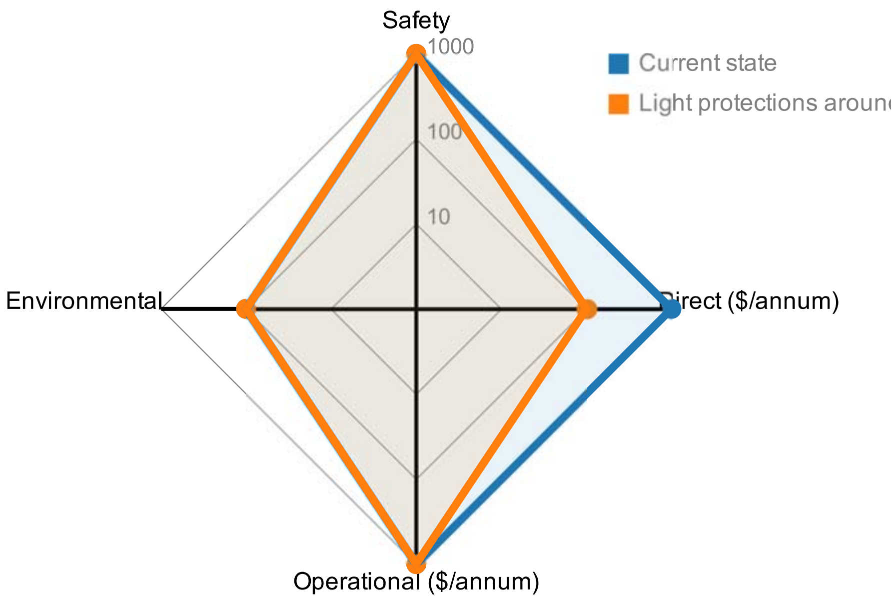
Location Description	900 Lamarque Street New Orleans
Primary Function	Storage and feed of liquid sodium hypochlorite for primary disinfection.
Context Information	Three 5,200 gallon storage tanks with fill station, level sensors, and overhead roof structure supplying liquid hypochlorite to the feed pumps adjacent to the storage tanks. Rotate tanks to minimize degradation of hypochlorite in solution. Hypochlorite feed to the sedimentation basin effluent for primary disinfection. Apparent maximum storage capacity 120 days assuming 130 gallons per day consumption. Eight feed pumps with two backup feed pumps. Pump hypochlorite to inlet of solids contact clarifiers. Ten States Standards recommends 30 days storage for all critical chemicals. Hypochlorite feed is critical and needed for compliance with disinfection requirements and coliform rules.
Full Replacement Cost	$ 3000000

Sodium Hypochlorite Storage/Feed System: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Redundant storage tanks and feed pumps with backup feed capabilities.	H
Supply chain strength	Many of the chemicals used are supplied from Florida, Texas and Mississippi and there are concerns about driver operating time. However existing procedures ensure supplies are filled to capacity prior to any weather event.	M
Skills availability	Current skillsets are good, however there are concerns about an aging workforce and transfer of skills.	L
Ease of access	Building is accessible however it is assumed that the road would be prone to flooding during hurricanes.	M
Documentation and procedures	No documented SOPs, procedures. Apparently have O&M manuals.	L
Flood protection	Pumps and tanks are elevated. Depending on the scenario taken into account it could be enough to protect the equipment from flooding	M
HAZMAT and Fire protection	Pumps and tanks are on a containment - There is no fire risk	H
Building code compliance		L
ARI		**0.661**

Threat: Events: 100 year return period

Comments	According to FEMA this part of the plant would not be flooded but water could be closed. Equipment is 2 ft elevated
Earliest Recovery of Function	12 hours
Repair and recommissioning cost	$ 10000



Current Risk Type	Comments
Safety	Very hazardous in case of skin or eye contact and in case of ingestion
Environmental	The product is biodegradable. Environmental risk is limited due to the containment
Operational ($/annum)	According to FEMA the risk of process shutdown is low. Storage capacity is high. Pumps and tanks are elevated
Direct ($/annum)	Low damages due to flooding but equipment could be damaged by flying pieces

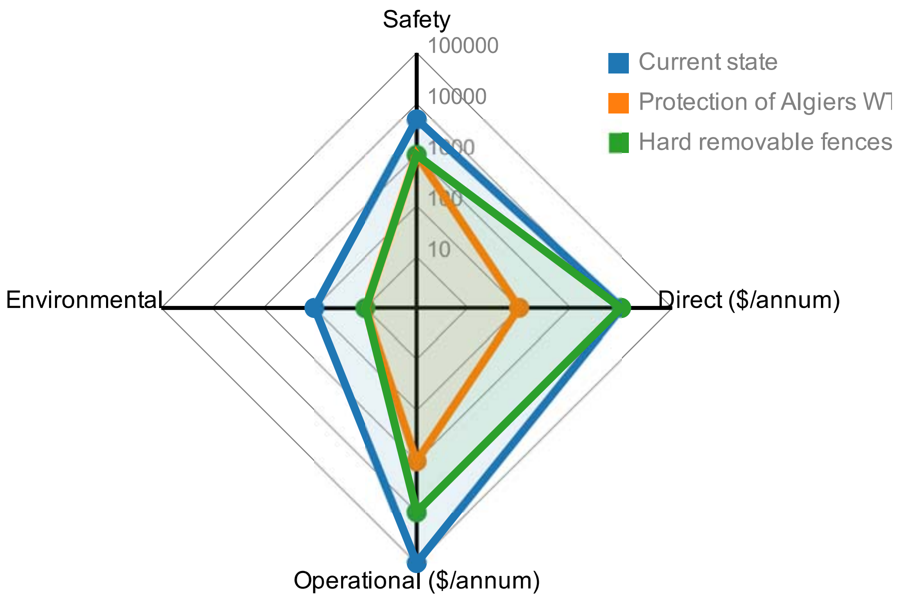
Measure Light protections around the most critical parts of the building

Total One-Time Cost	$ 300000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	
Repair and recommissioning cost	$ 5000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Buy Tiger dams to protect the most critical installations	One-time	300000			300000

Threat: Events: 500 year return period

Comments	Based on FEMA the building would be flooded but the impact would be limited. Based on USACE there is no risk of flooding
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 300000



Current Risk Type	Comments
Safety	Very hazardous in case of skin or eye contact and in case of ingestion. Possible flying pieces due to the wind
Environmental	Environmental risk are limited. This chemical is biodegradable and in case of flooding volumes of water will limit the impact on environment
Operational ($/annum)	Pumps could be flooded. In that case process would be shut down.
Direct ($/annum)	Potential loss is limited due to value of this asset

Measure Hard removable fences

Total One-Time Cost	$ 1000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	5 hours
Repair and recommissioning cost	$ 10000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build infrastructure in the ground to install hard removable fences	One-time	700000			700000
Buy removable fences	One-time	300000			300000

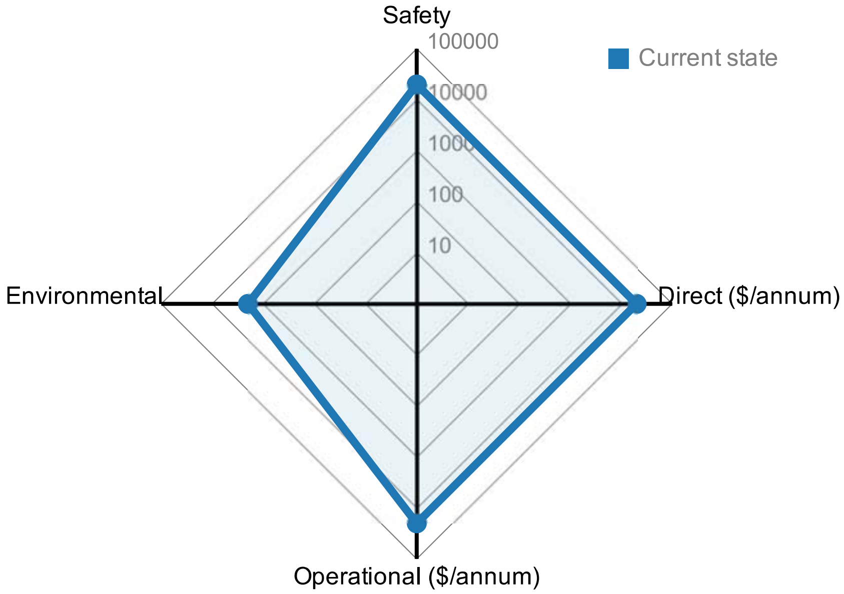
Measure Protection of Algiers WTP

Total One-Time Cost	$ 21000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	
Repair and recommissioning cost	$ 5000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build a wall around the plant	One-time	21000000			21000000

Threat: Hurricane < 100 years - Wind

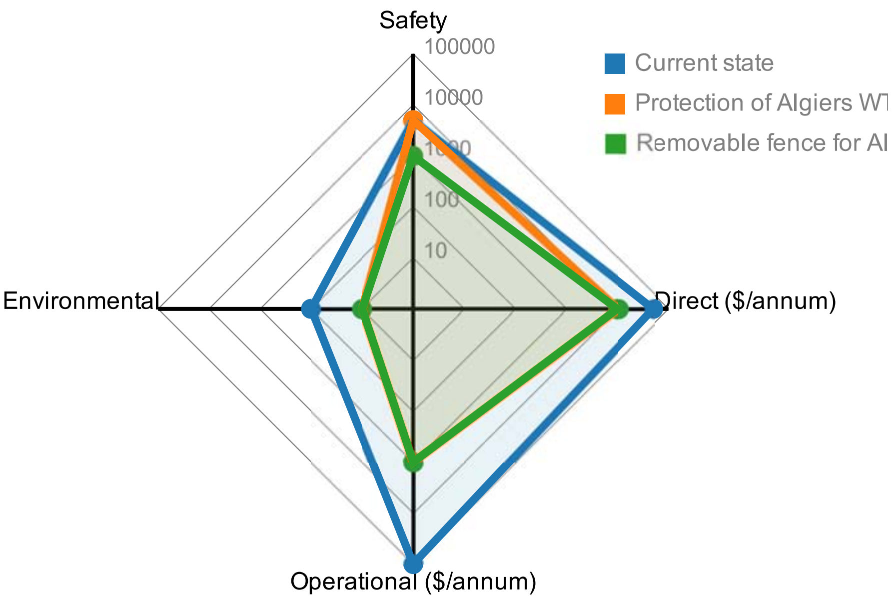
Comments	Historical wind damage limited to one metal roof that rolled up and blew off.
Earliest Recovery of Function	1 days
Repair and recommissioning cost	$ 15000



Current Risk Type	**Comments**
Safety	Very hazardous in case of skin or eye contact and in case of ingestion
Environmental	The product is biodegradable. Environmental risk is limited due to the containment
Operational ($/annum)	Under normal condition or windy conditions risk of disruption are low but disruption could need to stop the process
Direct ($/annum)	Wind could cause damage to the roof. Building only protected by the roof and the chemical house on one side So potentially flying pieces could damage a pipe or pumps. Costs should be low

Threat: Scenario: SR 100 years

Comments	Based on Swiss Re's 100 year scenario, expected range of level of water is from 10 to 12.5 ft
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 1000000



Current Risk Type	**Comments**
Safety	High safety risk. In addition to the chemical risk there is a risk of drowning
Environmental	With these levels of water we can expect a pollution but due to dilution impact should be limited
Operational ($/annum)	Process shutdown. Pumps would be flooded. 10% of the city would not have fresh water even if storage capacity are important
Direct ($/annum)	More than 50% of the equipment would be impacted

Measure Protection of Algiers WTP **SELECTED**

Total One-Time Cost	$ 21000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	5 hours
Repair and recommissioning cost	$ 10000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build a wall around the plant	One-time	21000000			21000000

Measure Removable fence for Algiers chemical house

Total One-Time Cost	$ 5000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	5 hours
Repair and recommissioning cost	$ 10000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build a infrastructure in the ground to fix the removable barriers	One-time	3000000			3000000
Buy hard removable fences	One-time	2000000			2000000

Ammonia Storage/Feed System: Short Resilience Report

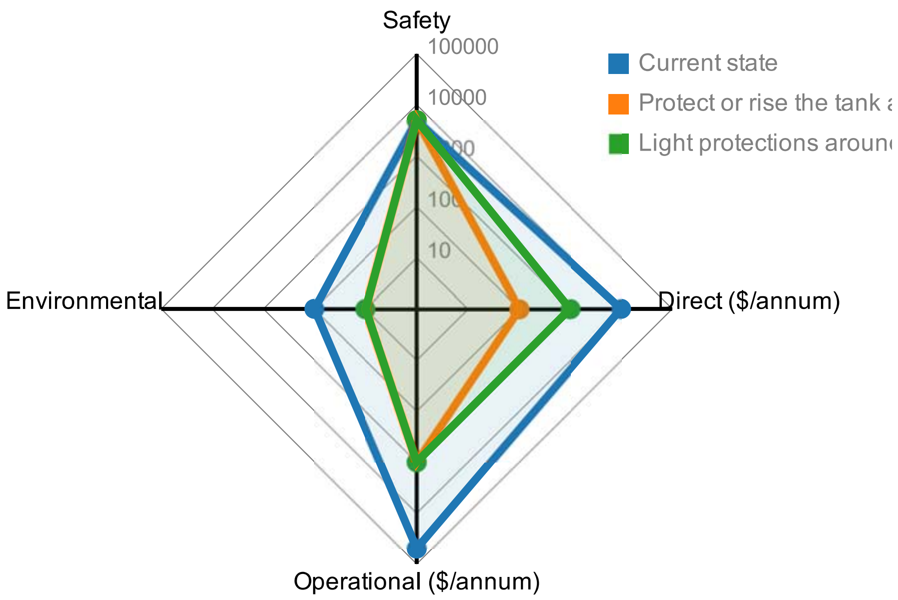
Location Description	900 Lamarque Street, New Orleans
Primary Function	Storage and application of ammonia for chloramination of the drinking water.
Context Information	1,000 pounds storage of anhydrous ammonia feeds the ammonia building. Ammonia gas is then fed through the ammonia feeders to the application point in the solids contact basin effluent. Apparent 90 pounds per day feed rate provides about 11 days storage. Ten States Standards recommends 30 days storage for all critical chemicals. Ammonia feed is critical and needed for CT compliance, residual maintenance in system, and THM minimization.
Full Replacement Cost	$ 600000

Ammonia Storage/Feed System: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Only 11 days storage capacity.	L
Supply chain strength	Many of the chemicals used are supplied from Florida, Texas and Mississippi and there are concerns about driver operating time. However existing procedures ensure supplies are filled to capacity prior to any weather event.	M
Skills availability	Current skillsets are good, however there are concerns about an aging workforce and transfer of skills.	L
Ease of access	Plant has easy access by road however it is assumed that the road would be prone to flooding during hurricanes.	M
Documentation and procedures	No documented SOPs, procedures.	L
Flood protection	Low flood protection	L
HAZMAT and Fire protection	Ammonia is considered as a flammable gas. It is heavier than air. There is no fire protection but the tank is well ventilated. Chemicals are on containments	M
Building code compliance		L
ARI		**0.516**

Threat: Events: 100 year return period

Comments	Based on FEMA the expected level of water is 2 ft. The tank and associated devices are 3 ft elevated and this is the same for the pumps.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 400000



Current Risk Type	**Comments**
Safety	Ammonia is a toxic gas. Risk is high even in case of flooding
Environmental	Ammonia is very toxic to aquatic life. But this substance is biodegradable. Unlikely to persist. In case of flooding, a pollution could occur but impact would very be limited
Operational ($/annum)	Water recede period estimation is 5 days according to the SWB. This equipment should not be flooded but the area around could be. So due to the limited capacity we could have a process disruption.
Direct ($/annum)	Only the building would be impacted by a flood according to FEMA

Measure Light protections around the most critical parts of the building

Total One-Time Cost	$ 300000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0.5 days
Repair and recommissioning cost	$ 150000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Buy Tiger dams to protect the most critical installations	One-time	300000			300000

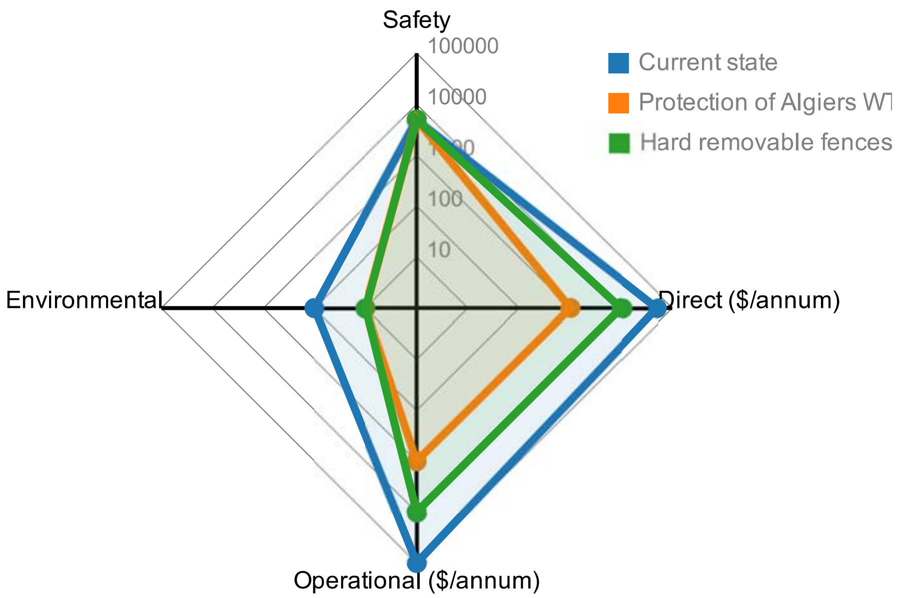
Measure Protect or rise the tank and the building

Total One-Time Cost	$ 700000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	12 hours
Repair and recommissioning cost	$ 10000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Rise/protect the tank and the building	One-time	700000			700000

Threat: Events: 500 year return period

Comments	A 500 year event could have a significant impact on the building and possibly on the devices associated to the tank. But it should be noted that for the USACE Algiers plant would not be flooded
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 1000000



Current Risk Type	**Comments**
Safety	Safety risks are high due to the toxicity of ammonia. There is no significant change for this risk due to a 500 year event
Environmental	Ammonia is very toxic to aquatic life. The substance is biodegradable. Unlikely to persist. In case of flooding, a pollution could occur but impact would be limited
Operational ($/annum)	Water recede period estimation is 5 days according to the SWB. In case of flooding an ammonia disruption would cause a process disruption. And even if the building and the tank would not be flooded but the area around the plant would be flooded, there is a risk of disruption because of the limited capacity of the storage
Direct ($/annum)	Tank and building could be flooded according to FEMA

Measure Hard removable fences

Total One-Time Cost	$ 1000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	1 days
Repair and recommissioning cost	$ 100000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build infrastructure in the ground to install hard removable fences	One-time	700000			700000
Buy removable fences	One-time	300000			300000

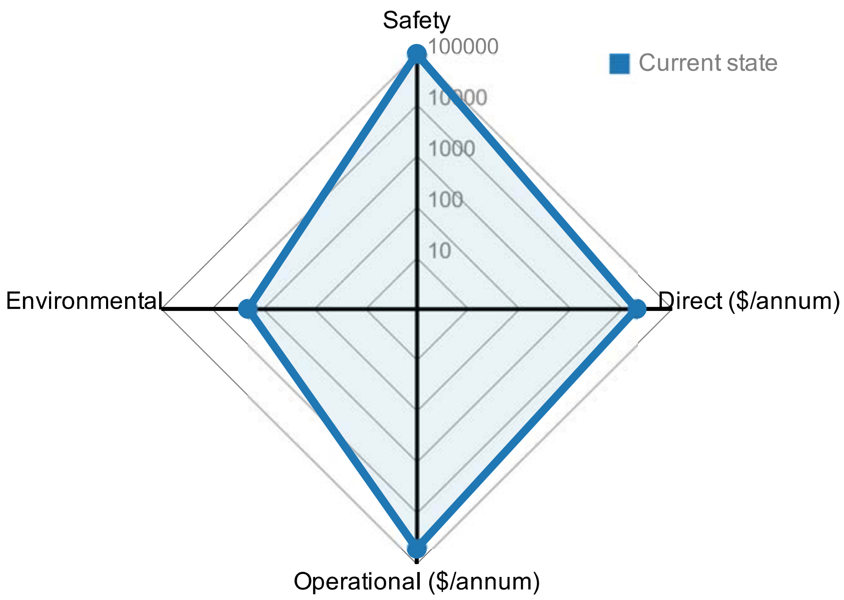
Measure Protection of Algiers WTP

Total One-Time Cost	$ 21000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	12 hours
Repair and recommissioning cost	$ 10000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build a wall around the plant	One-time	21000000			21000000

Threat: Hurricane < 100 years - Wind

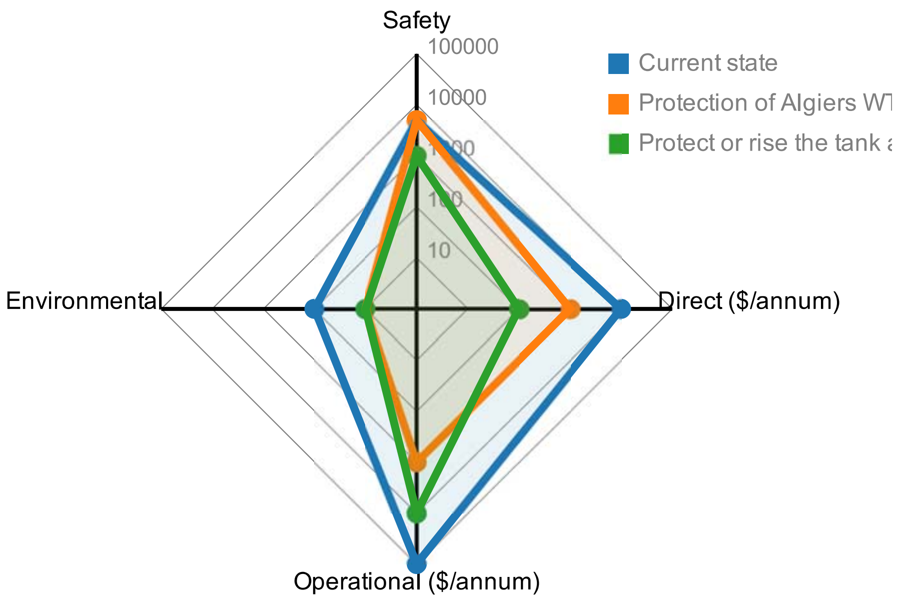
Comments	Historical wind damage limited to loss of one building metal roof that rolled up and blew off.
Earliest Recovery of Function	12 hours
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	Ammonia is a very toxic gas
Environmental	The substance is biodegradable. Unlikely to persist. Toxic to aquatic life. Risk long term impact of a pollution is low
Operational ($/annum)	Under normal condition or windy conditions risk of disruption are low but disruption could need to stop the process
Direct ($/annum)	Low impact on the tank and associated buiding

Threat: Scenario: SR 100 years

Comments	Based on a 100 year event built with Swiss Re's models a range of 10 to 12.5 ft could be expected
Earliest Recovery of Function	2 weeks
Repair and recommissioning cost	$ 900000



Current Risk Type	Comments
Safety	In addition to the toxicity, there is a risk a drowning. But in case of a hurricane, staff should stay inside except to maintain or control some parts of the process
Environmental	Tank and building would be under water so an environmental risk should not be avoided but due to biodegradability of ammonia consequences would be limited
Operational ($/annum)	A process disruption cannot be avoided. An estimation of 2 weeks of disruption (recede time + pumps replacement). Algiers plant provides water for 10% of the city.
Direct ($/annum)	90% of the asset value would be affected

Measure Protect or rise the tank and the building

Total One-Time Cost	$ 700000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 10000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Rise/protect the tank and the building	One-time	700000			700000

Measure Protection of Algiers WTP **SELECTED**

Total One-Time Cost	$ 21000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	12 hours
Repair and recommissioning cost	$ 10000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build a wall around the plant	One-time	21000000			21000000

Solids Contact Clarifiers: Short Resilience Report

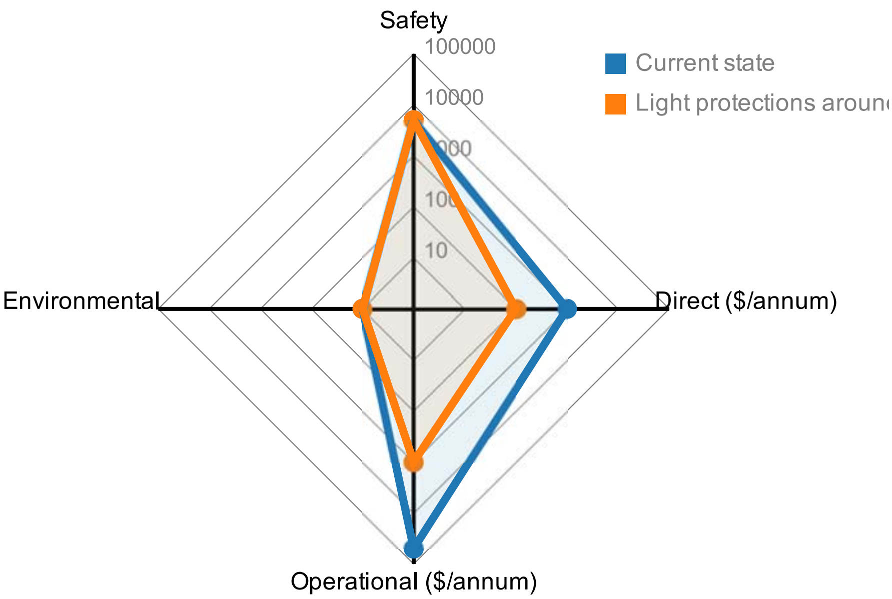
Location Description	900 Lamarque Street New Orleans
Primary Function	Primary coagulation, flocculation, and sedimentation of source water for treatment.
Context Information	Four Eimco solids contact clarifiers. Units 1 and 2 each have rated capacity of 8 mgd. Units 3 and 4 each have rated capacity of 12 mgd. Normally one basin in service for treatment. Internal solids re circulation for solids contact. Sludge collection within each clarifier with automated blow-off. Sludge directed to sludge holding basin for disposal. Total treatment capacity 40 mgd with plant rated capacity of 24 mgd. Clarifiers are elevated about 8 feet above ground level. EIMCO 4 is critical. Clarifiers are elevated but some pumps are 3 ft elevated
Full Replacement Cost	$ 2100000

Solids Contact Clarifiers: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	40 mgd treatment capacity greater than treatment plant capacity of 24mgd. Multiple units with sufficient redundancy.	H
Supply chain strength	Strong in-house skills to maintain old equipment but an equipment failure puts the component (pumps, motors, etc.) out of service until facility maintenance can repair or manufacture the needed components. We can not consider supply chain	L
Skills availability	Current skillsets are good, however there are concerns about an aging workforce and transfer of skills	M
Ease of access	Easy to access but in case of flooding could be flooded	M
Documentation and procedures	No documented SOPs, procedures. Apparently have O&M manuals.	M
Flood protection	Based on elevation	M
HAZMAT and Fire protection	Low risk	M
Building code compliance		M
ARI		**0.701**

Threat: Events: 100 year return period

Comments	Based on FEMA's scenario some parts of this equipment are very closed to the level of water.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 50000



Current Risk Type	**Comments**
Safety	Personnel could be injured or seriously hurt by flying objects. Staff should stay inside building
Environmental	Very low risk
Operational ($/annum)	Probability of a shutdown based on FEMA's scenario is low due to redundancy but not unlikely. There are 3 clarifiers that could be used. Only the 3 & 4 have the capacity to ensure the full production of the plant
Direct ($/annum)	Limited damages

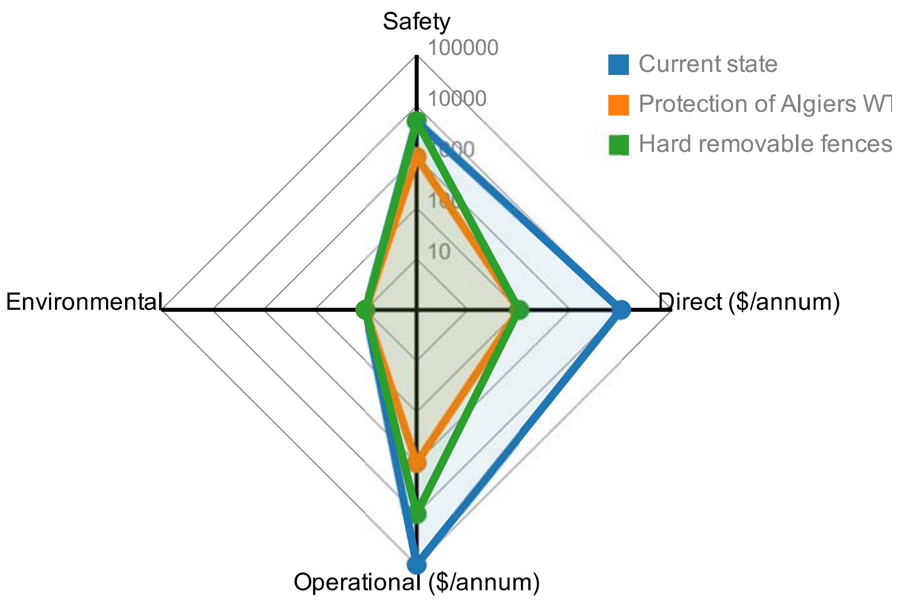
Measure Light protections around the most critical parts of the building

Total One-Time Cost	$ 300000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 5000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Buy Tiger dams to protect the most critical installations	One-time	300000			300000

Threat: Events: 500 year return period

Comments	Pumps could be flooded according to FEMA's scenario. For USACE there is no risk of flooding
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 200000



Current Risk Type	Comments
Safety	Personnel could be injured or seriously hurt by flying objects. But people should stay inside in case of hurricanes
Environmental	No risk
Operational ($/annum)	The 2 main clarifier pump equipment could be flooded. Process would be shut down
Direct ($/annum)	Damages would be limited

Measure Hard removable fences

Total One-Time Cost	$ 1000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 5000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build infrastructure in the ground to install hard removable fences	One-time	700000			700000
Buy removable fences	One-time	300000			300000

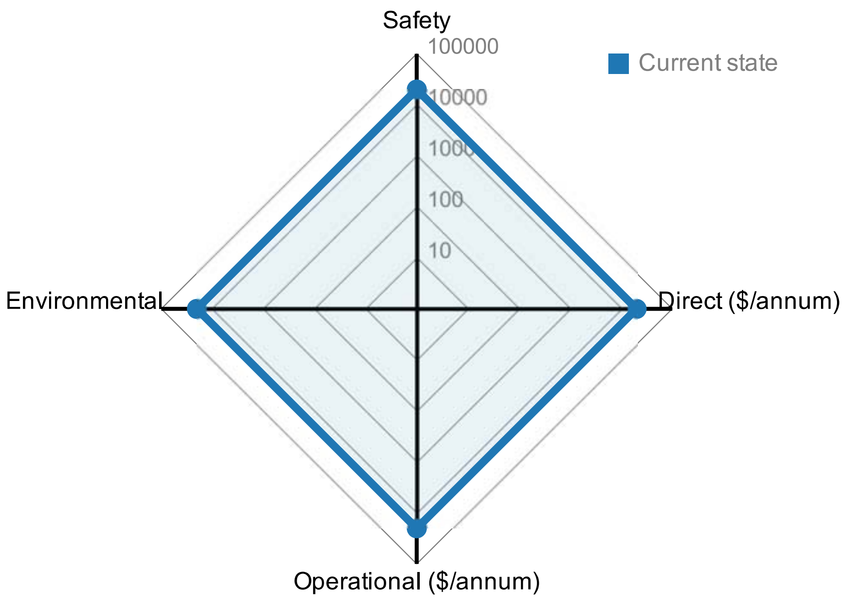
Measure Protection of Algiers WTP

Total One-Time Cost	$ 21000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 5000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build a wall around the plant	One-time	21000000			21000000

Threat: Hurricane < 100 years - Wind

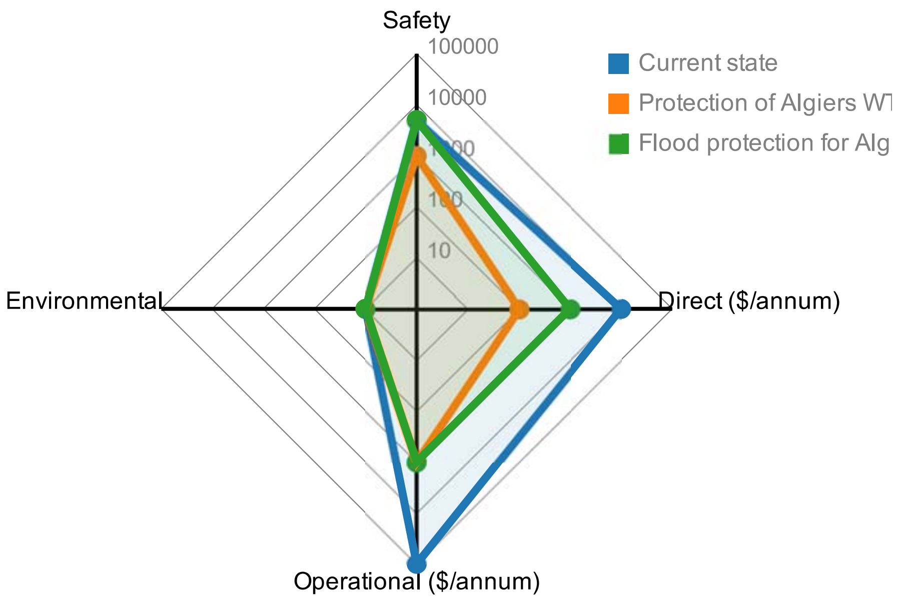
Comments	Historical wind damage limited to one metal roof that rolled up and blew off.
Earliest Recovery of Function	2 hours
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	Personnel could be injured or seriously hurt by flying objects.
Environmental	No risk
Operational ($/annum)	Pumps are protected
Direct ($/annum)	Low damages

Threat: Scenario: SR 100 years

Comments	Swiss Re model predicts 10 ft to 12.5 ft flood water levels and winds of 105 mph.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 1600000



Current Risk Type	Comments
Safety	Personnel could be injured or seriously hurt by flying objects. Due to level of water linked to this scenario there are risks of drowning. People should stay inside in case of hurricanes but there are few building at this plant with a floor above 10ft
Environmental	Very low risk
Operational ($/annum)	Many parts would be under water. Plant would be shut down. 10% of the city would not have fresh water
Direct ($/annum)	80% of the asset value could be affected

Measure Flood protection for Algiers clarifiers

Total One-Time Cost	$ 3500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	5 hours
Repair and recommissioning cost	$ 10000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise pump building	One-time	500000			500000
Raise clarifier	One-time	3000000			3000000

Measure Protection of Algiers WTP SELECTED

Total One-Time Cost	$ 21000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 5000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build a wall around the plant	One-time	21000000			21000000

Ferric Sulfate Storage/Feed System: Short Resilience Report

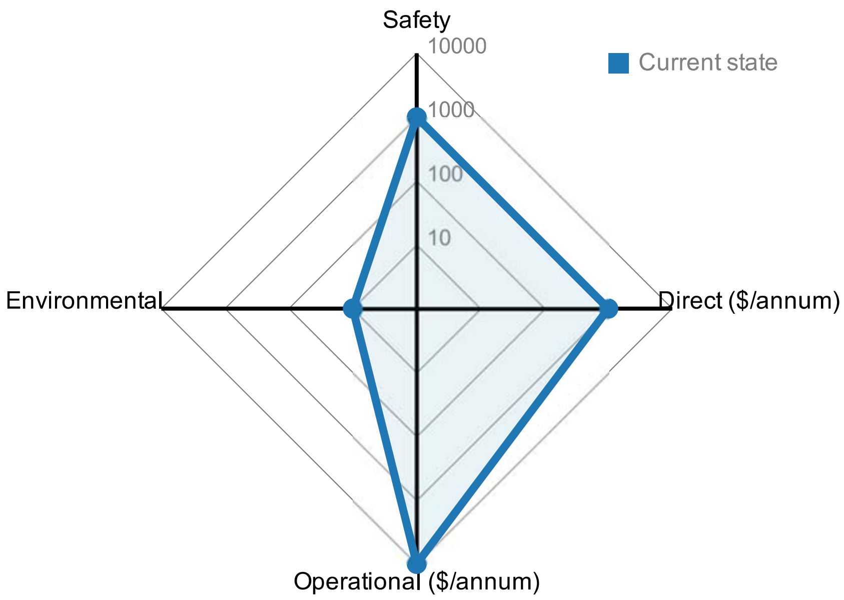
Location Description	900 Lamarque Street New Orleans
Primary Function	Store and feed of ferric sulfate for primary coagulation.
Context Information	Two 8,000 gallon storage tanks with spill containment provided (16,000 gallons total storage). Apparent storage capacity is about 29 days with 550 gpd consumption. Ferric sulfate supplied to the ferric feed building adjacent to storage. Building sets inside spill containment wall. Four ferric feed pumps provided to apply ferric sulfate to the inlet chamber for each solids contact clarifier for primary coagulation. Ten States Standards recommends 30 days storage for all critical chemicals. Coagulant feed is critical and needed for compliance with surface water treatment rules and THM minimization.
Full Replacement Cost	$ 600000

Ferric Sulfate Storage/Feed System: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Two storage tank and about 29 days storage capacity.	H
Supply chain strength	Many of the chemicals used are supplied from Florida, Texas and Mississippi and there are concerns about driver operating time. However existing procedures ensure supplies are filled to capacity prior to any weather event.	M
Skills availability	Current skillsets are good, however there are concerns about an aging workforce and transfer of skills	L
Ease of access	Plant has easy access by road however it is assumed that the road would be prone to flooding during hurricanes.	M
Documentation and procedures	No documented SOPs, procedures. Apparently have O&M manuals.	L
Flood protection	Tanks and building are in a containment. Pumps are elevated. These mitigation measures are not sufficient with regards to Swiss Re's results	M
HAZMAT and Fire protection	No risk of fire. Tanks and building set inside spill containment wall	H
Building code compliance	Metallic panels and wood structure	L
ARI		**0.663**

Threat: Events: 100 year return period

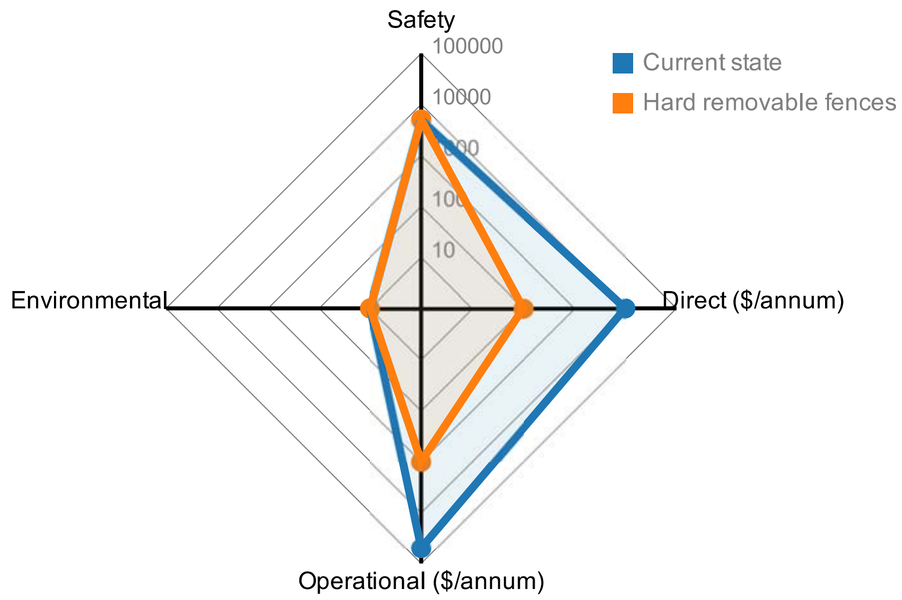
Comments	According to FEMA there is no risk for 100 year return period events. So as there is a 5ft wall around the ferric sulfate feeder building we won't suggest any improvement except this one for wind proofing
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 100000



Current Risk Type	Comments
Safety	Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Personnel could be injured or seriously hurt by flying objects.
Environmental	Environmental impact would be low since there is a containment around the building/tank
Operational ($/annum)	Low risk due to wall around the tank and the building except for wind (ref wind scenario)
Direct ($/annum)	Replacement costs of the building are quite limited - Declared asset value is $600k

Threat: Events: 500 year return period

Comments	According to FEMA there is a risk of flooding in case of a 500 year event. Level of water is not estimated. There is a 5ft wall around the building and the tank but we can not determine if a 5 ft wall would be enough to protect against flooding. Based on USACE there is no risk of flooding. Due to the uncertainty we suggest avoiding any inefficient investment on the basis of these 2 scenarios
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 400000



Current Risk Type	**Comments**
Safety	Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Personnel could be injured or seriously hurt by flying objects.
Environmental	In case of flooding ferric sulfate could leak in the water. Environmental impact would be low due to the containment around the building
Operational ($/annum)	Algiers WTP supply water for 57000 people - There is a risk of activity disruption but low
Direct ($/annum)	Building replacement cost is quite low

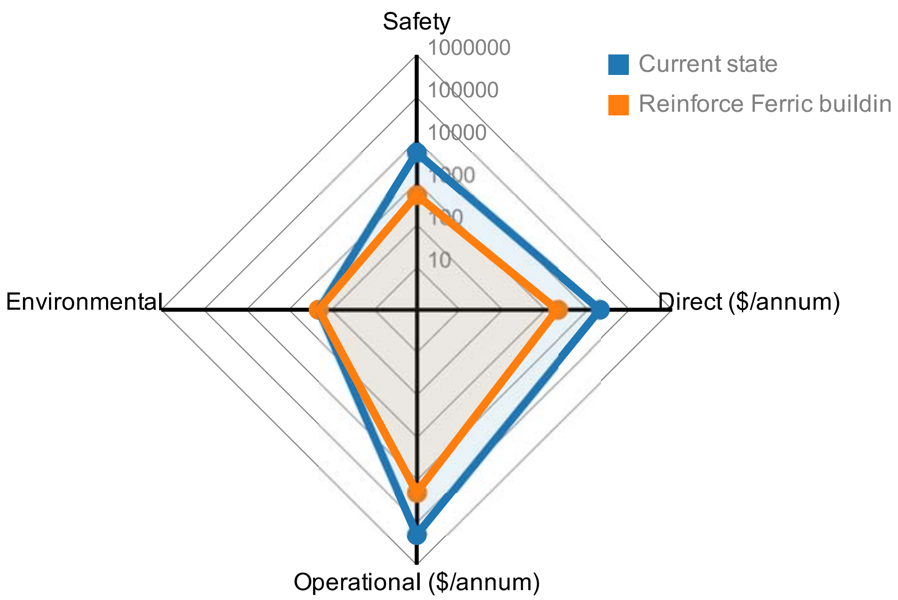
Measure Hard removable fences

Total One-Time Cost	$ 1000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	12 hours
Repair and recommissioning cost	$ 50000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build infrastructure in the ground to install hard removable fences	One-time	700000			700000
Buy removable fences	One-time	300000			300000

Threat: Hurricane < 100 years - Wind

Comments	Historical wind damage limited to one metal roof that rolled up and blew off.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 100000



Current Risk Type	Comments
Safety	Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Personnel could be injured or seriously hurt by flying objects.
Environmental	Risk are low due to the spill containment wall
Operational ($/annum)	Building structure is light (metallic panels). Pump protection is low.
Direct ($/annum)	Due to the building structure damage costs would be quite low

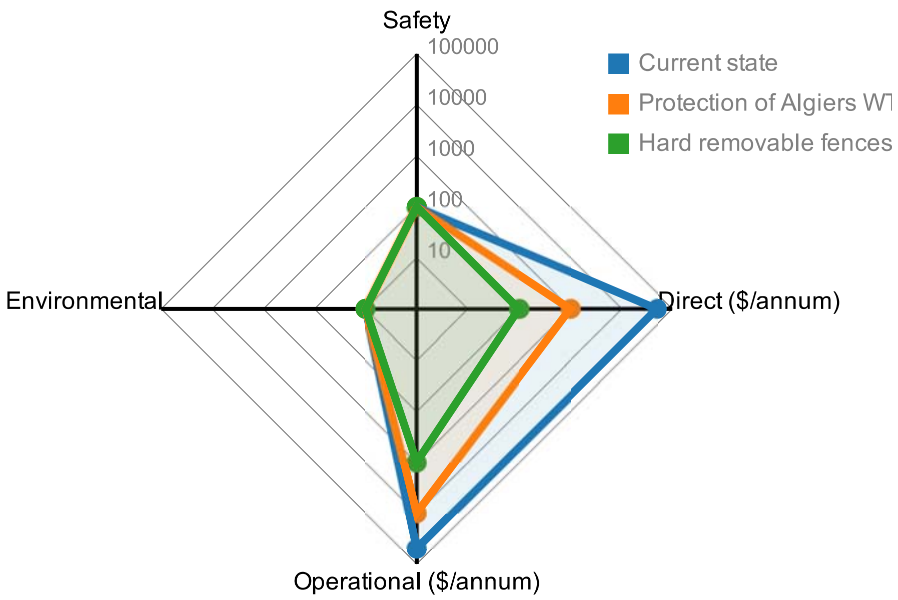
Measure Reinforce Ferric building framework - Algiers WTP **SELECTED**

Total One-Time Cost	$ 50000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	1 days
Repair and recommissioning cost	$ 5000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Reinforce the framework with metallic pieces	One-time	50000			50000

Threat: Scenario: SR 100 years

Comments	Based on a 100 year event built with Swiss Re's models a range of 10 to 12.5 ft could be expected
Earliest Recovery of Function	2 weeks
Repair and recommissioning cost	$ 800000



Current Risk Type	Comments
Safety	Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. A risk of drowning exist. But it is unlikely that staff stays outside in case of hurricane.
Environmental	Very low risk
Operational ($/annum)	Building would be under water - A process disruption would not be avoided - Algiers plant provides fresh water for 10% of the city. Due to the expected levels of water based on this scenario, most of Algiers would be flooded.
Direct ($/annum)	80% of the asset would be affected

Measure Hard removable fences

Total One-Time Cost	$ 1000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	5 hours
Repair and recommissioning cost	$ 5000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Build infrastructure in the ground to install hard removable fences	One-time	700000			700000
Buy removable fences	One-time	300000			300000

Measure Protection of Algiers WTP **SELECTED**

Total One-Time Cost	$ 21000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 100000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Build a wall around the plant	One-time	21000000			21000000

Fluoride Storage/Feed System: Short Resilience Report

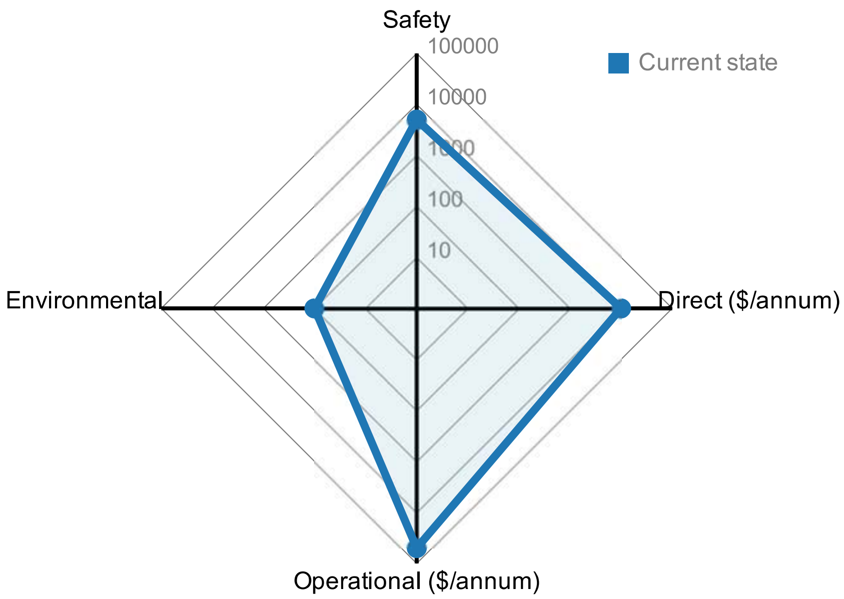
Location Description	900 Lamarque Street New Orleans
Primary Function	Store and feed hydrofluorosilicic acid (liquid fluoride) for water production and tooth decay.
Context Information	One 2,400 gallon storage tank without spill containment feeds liquid to the fluoride feed pumps near the coagulant storage tanks. Apparent 9.6 days capacity at 250 gpd consumption. Four fluoride feed pumps apply fluoride to the chlorine contact tanks effluent. One supply line to each contact tank. Ten States Standards recommends 30 days storage for all critical chemicals. Fluoride feed is critical and needed for compliance with Louisiana drinking water rules. Swiss Re model predicts 10 ft to 12.5 ft flood water levels and winds of 105 mph. The current fluoride storage tank and feed system are being replaced in the near future and moved to the main chemical building.
Full Replacement Cost	$ 600000

Fluoride Storage/Feed System: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Less than 10 days capacity currently, although plans are being prepared to relocate fluoride storage and feed into the chemical facilities in the treatment plant with additional storage.	L
Supply chain strength	Many of the chemicals used are supplied from Florida, Texas and Mississippi and there are concerns about driver operating time. However existing procedures ensure supplies are filled to capacity prior to any weather event.	M
Skills availability	Current skillsets are good, however there are concerns about an aging workforce and transfer of skills.	L
Ease of access	Plant has easy access by road however it is assumed that the road would be prone to flooding during hurricanes.	M
Documentation and procedures	No documentation of SOPs, procedures. apparently O&M manuals exist.	L
Flood protection	Tank is 4 ft elevated. the building is at ground level but pumps are 3 ft elevated	M
HAZMAT and Fire protection	No fire risk. Limited containment capacity	L
Building code compliance		L
ARI		**0.516**

Threat: Events: 100 year return period

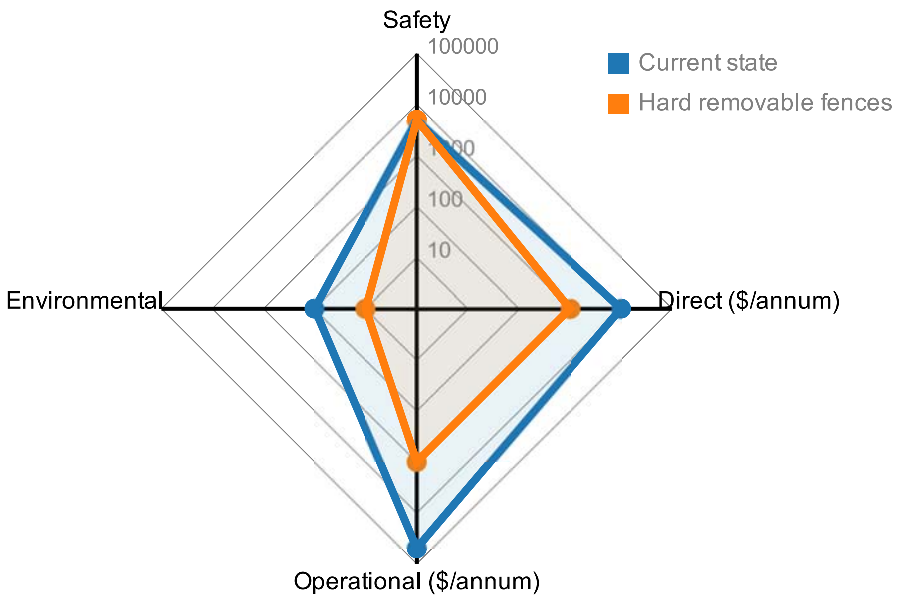
Comments	Pump building would be flooded according to FEMA's scenario. pumps and tank will be moved to the chemical room. So the new location should take into account at least FEMA's 500 year event but also Swiss Re's level of water. With regards to this moving, no specific improvement suggested. If the proposal to build a wall around the plant is accepted this equipment would be protected.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 400000



Current Risk Type	Comments
Safety	Risk is high even in case of flooding
Environmental	In case of leak pH could be modified but due to the volume of water the impact could be limited
Operational ($/annum)	In case of flooding, pumps would be flooded. This product is critical to respect Louisiana law for drinking water. Water treatment could be stopped
Direct ($/annum)	In case of flooding according to Swiss Re's results the tank would be partially under water and the pumps would be totally under water

Threat: Events: 500 year return period

Comments	As this equipment will be moved no more comment than for 100 year return period event. Based on USACE, there is no risk of flooding.
Earliest Recovery of Function	10 days
Repair and recommissioning cost	$ 600000



Current Risk Type	**Comments**
Safety	
Environmental	
Operational ($/annum)	Limited capacity of storage could be an issue currently
Direct ($/annum)	

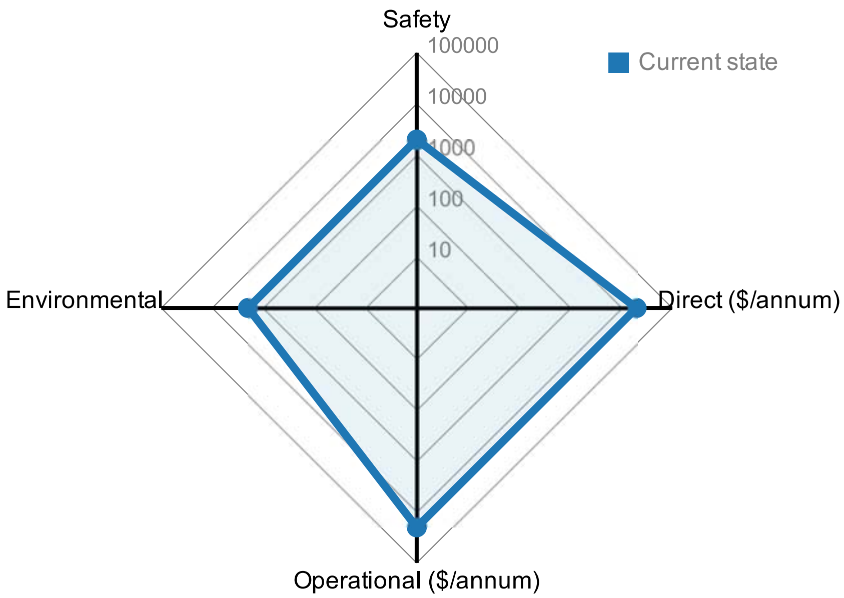
Measure Hard removable fences

Total One-Time Cost	$ 1000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	5 hours
Repair and recommissioning cost	$ 50000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build infrastructure in the ground to install hard removable fences	One-time	700000			700000
Buy removable fences	One-time	300000			300000

Threat: Hurricane < 100 years - Wind

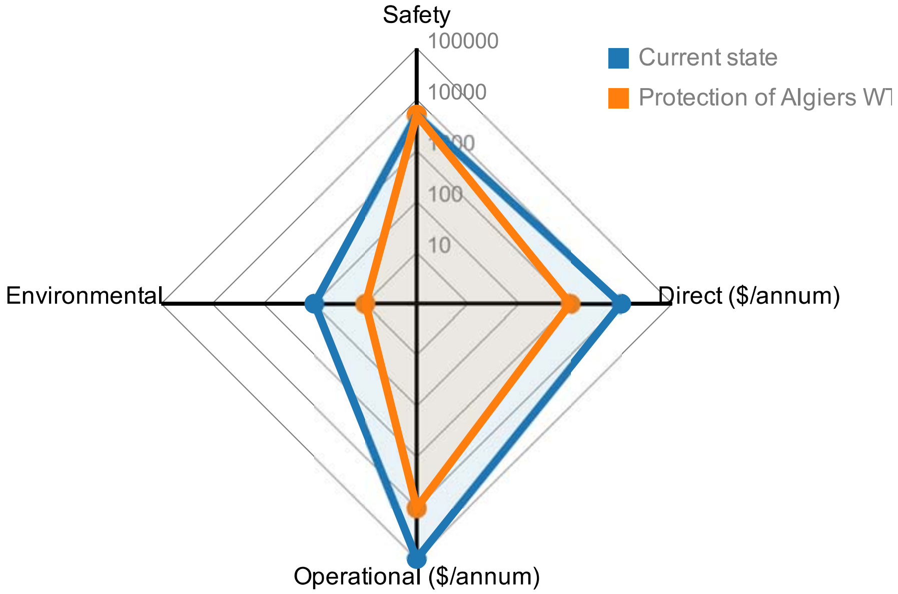
Comments	Historical wind damage limited to one metal roof that rolled up and blew off.
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 10000



Current Risk Type	Comments
Safety	Corrosive. Contact may cause severe irritation, watering, redness and swelling
Environmental	Limited containment. Accidental spillage would suddenly reduce pH level due to the product’s acidic properties. Local disastrous effects are possible.
Operational ($/annum)	Wind and day to day operations should not cause any significant business interruption
Direct ($/annum)	Pumps are inside a concrete building. Damage should be limited. Some leaks can occur due to a maintenance approach based on corrective program

Threat: Scenario: SR 100 years

Comments	Based on the 100 year Swiss Re scenario this equipment would be flooded. pumps and tank will be moved to the chemical room. So the new location should at least take into account this scenario. With regards to this moving, no specific improvement suggested.
Earliest Recovery of Function	10 days
Repair and recommissioning cost	$ 800000



Current Risk Type	**Comments**
Safety	
Environmental	
Operational ($/annum)	Limited capacity of storage currently
Direct ($/annum)	80% of the equipment would be damaged

Measure Protection of Algiers WTP **SELECTED**

Total One-Time Cost	$ 21000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 15000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build a wall around the plant	One-time	21000000			21000000

Lime Storage/Feed System: Short Resilience Report

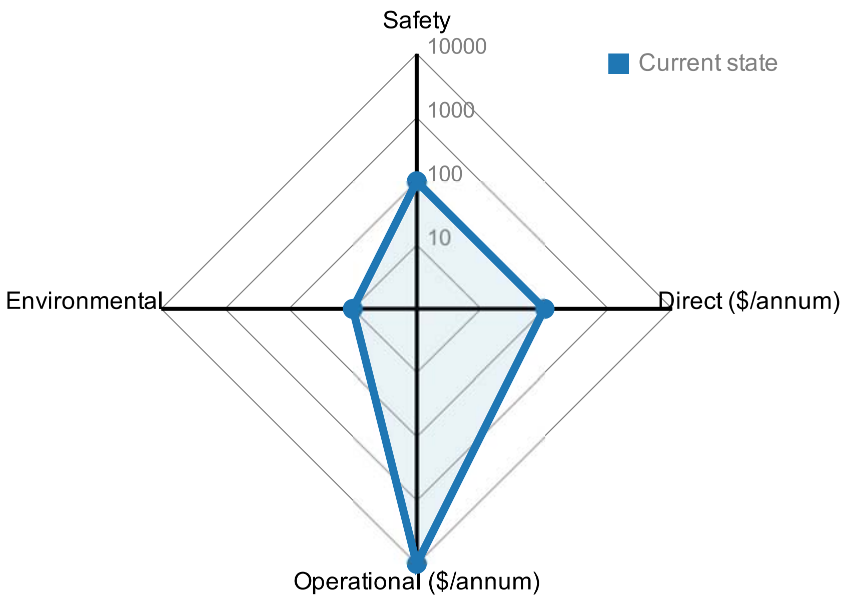
Location Description	900 Lamarque Street New Orleans
Primary Function	Store, slake, and prepare lime solution for pH adjustment and corrosion control.
Context Information	Three concrete lime silos in chemical building adjacent to main treatment building. Total storage capacity of 150 tons of pebble lime. Apparent lie usage 5,400 pounds per day providing 55 days of storage. Lime delivered in semis and unloaded pneumatically to silos. Lime silo sets above each lime slaker used to make lime slurry. Slurry made into solution at each slaker and routed to a set of solutions boxes. Solution boxes discharge into seven solution pumps (only 3 in service) pump through solution lines to the solids contact clarifier effluent for pH adjustment. Some pumps and solution lines are abandoned in place. Ten States Standards recommends 30 days storage for all critical chemicals. Lime feed is critical and needed for compliance with corrosion control treatment and lead and copper rules.
Full Replacement Cost	$ 1000000

Lime Storage/Feed System: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	More than 30 days storage and redundant feed capacity.	H
Supply chain strength	Many of the chemicals used are supplied from Florida, Texas and Mississippi and there are concerns about driver operating time. However existing procedures ensure supplies are filled to capacity prior to any weather event.	M
Skills availability	Current skillsets are good, however there are concerns about an aging workforce and transfer of skills.	L
Ease of access	Plant has easy access by road however it is assumed that the road would be prone to flooding during hurricanes.	M
Documentation and procedures	No documented SOPs, procedures. Apparently have O&M manuals.	L
Flood protection	Pumps inside the building are elevated approximately 4 feet.	M
HAZMAT and Fire protection	No automatic fire protection. Fire protection consists of hand held fire extinguishers. Low HAZMAT issues provided procedures are followed..	M
Building code compliance	Has the infrastructure been hurricane proofed?	L
ARI		**0.624**

Threat: Events: 100 year return period

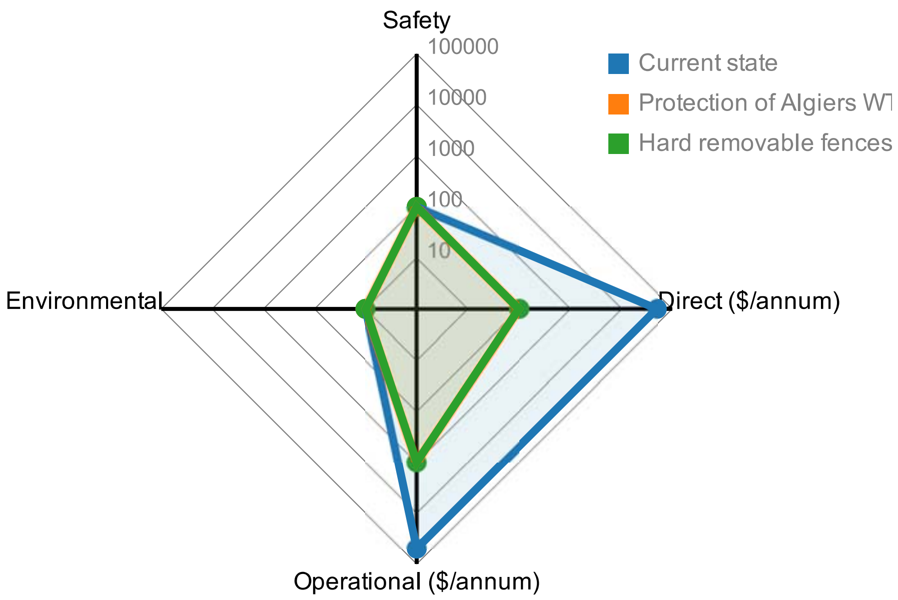
Comments	Based on FEMA's scenario there is no risk of flooding
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	If personnel come into contact with lime it could cause severe skin or eye irritation,
Environmental	Very limited risk
Operational ($/annum)	Risk of process shutdown linked to lime is very low since storage capacity is high
Direct ($/annum)	Risks linked to wind

Threat: Events: 500 year return period

Comments	Based on USACE there is no risk. Based on FEMA's scenario the building could be flooded but the equipment is 3-4 ft elevated.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 3000000



Current Risk Type	**Comments**
Safety	If personnel come into contact with lime it could cause severe skin or eye irritation
Environmental	This material is alkaline and if released into water or moist soil will cause an increase in pH however would be diluted in hurricane.
Operational ($/annum)	Based on FEMA this is not clear if the building would be flooded. Lime storage capacity is high. Disruption would be limited
Direct ($/annum)	30% of the building could be flooded

Measure Hard removable fences

Total One-Time Cost	$ 1000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 10000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build infrastructure in the ground to install hard removable fences	One-time	700000			700000
Buy removable fences	One-time	300000			300000

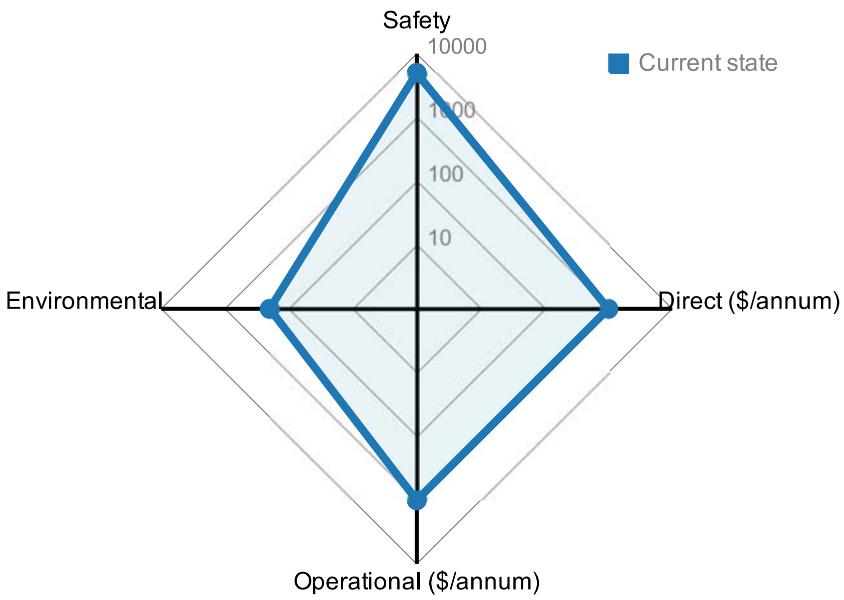
Measure Protection of Algiers WTP

Total One-Time Cost	$ 21000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 5000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build a wall around the plant	One-time	21000000			21000000

Threat: Hurricane < 100 years - Wind

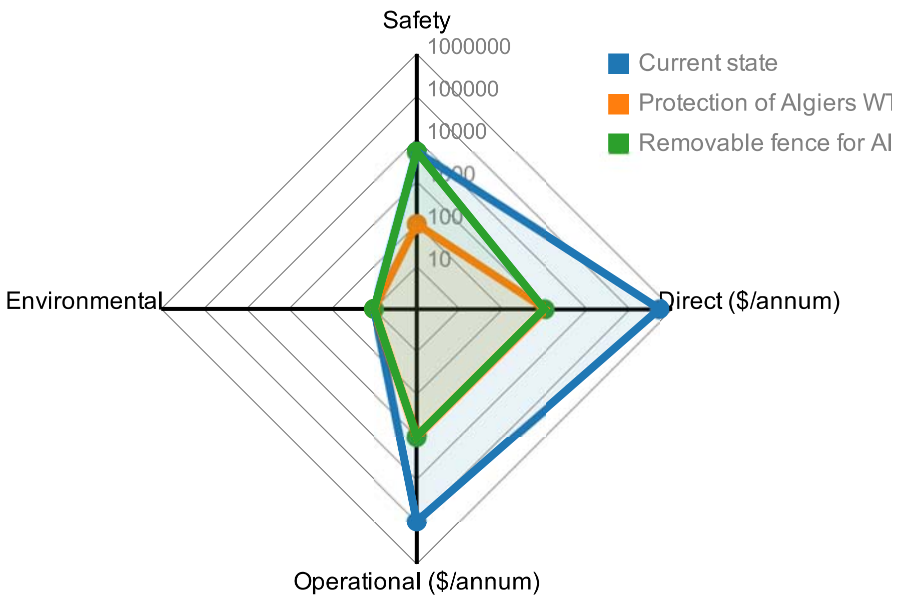
Comments	Historical wind damage limited to one metal roof that rolled up and blew off.
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 50000



Current Risk Type	**Comments**
Safety	Personnel could be injured or seriously hurt by flying objects.
Environmental	This material is alkaline and if released into water or moist soil will cause an increase in pH
Operational ($/annum)	Minimal
Direct ($/annum)	Possible roof / window damage.

Threat: Scenario: SR 100 years

Comments	Based on Swiss'Re scenario (100 year event), levels od water could reach 10 ft to 12.5 ft. Entire plant would be flooded.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 6000000



Current Risk Type	**Comments**
Safety	Even if Lime is not toxic there is a risk of drowning and there are few elevated room at the plant
Environmental	Low risk
Operational ($/annum)	Unable to soften the water. Process would be shutdown
Direct ($/annum)	More than 50% of the building would be flooded

Measure Protection of Algiers WTP **SELECTED**

Total One-Time Cost	$ 21000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 10000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build a wall around the plant	One-time	21000000			21000000

Measure Removable fence for Algiers chemical house

Total One-Time Cost	$ 5000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 20000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Build a infrastructure in the ground to fix the removable barriers	One-time	3000000			3000000
Buy hard removable fences	One-time	2000000			2000000

Emergency Generator: Short Resilience Report

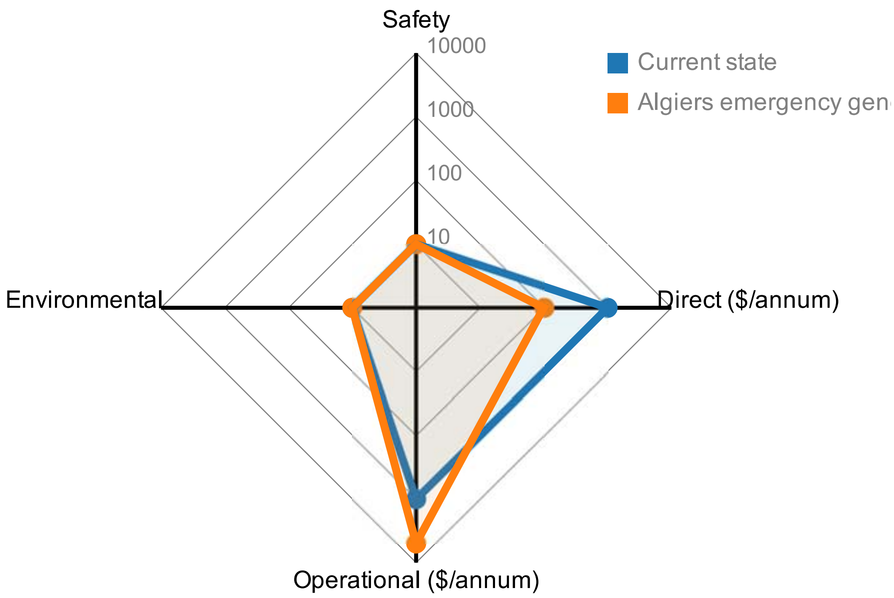
Location Description	900 Lamarque Street, New Orleans
Primary Function	To be capable of supplying 16,000 KW backup power to the entire Algiers WTP in the event Entergy and Carrollton power supplies fail or are lost during storm events
Context Information	The emergency generator is located in the Station C building Generator operated under full load 2 hours per month and then operated not loaded 30 minutes each week. Diesel consumption stated as 2,000 gallons per day fully loaded.
Full Replacement Cost	$ 6000000

Emergency Generator: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Provided full power for treatment plant operations in event of utility power outage. Also have power backup from Central control at Carrollton WTP.	H
Supply chain strength	During Katrina had to call out of state for diesel. Some diesel supplies were dirty plugging up filters. started to run out of diesel after 4 days. tank capacity 10,000. Have adequate supply of electrical spares, spare oil, oil filters, fuel filters. Spares are readily available.	M
Skills availability	Current skillsets are good, however there are concerns about an aging workforce and transfer of skills.	M
Ease of access	Plant has easy access by road however it is assumed that the road would be prone to flooding during hurricanes.	M
Documentation and procedures	No documented SOPs, procedures. Have O&M manuals available.	M
Flood protection	Some of the emergency generator equipment is raised approx. 4 feet however this is well below	L
HAZMAT and Fire protection	No automatic fire protection. Fire protection consists of hand held fire extinguishers. Emergency generator secondary containment for liquid leaks.	L
Building code compliance	Building meets existing building codes.	M
ARI		**0.664**

Threat: Events: 100 year return period

Comments	Wind speeds could reach 130 mph. causing minor damage to the building specifically roofs. Station C's roof has sustained hurricane damage before causing the roof to leak. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Carrollton is the secondary power supply
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	During a hurricane events Westbank Power control operations and maintenance personnel remain inside buildings that have been boarded up.
Environmental	Flood waters are unlikely to flood building and be contaminated with oils or fuel
Operational ($/annum)	Generator would be available should Entergy or Carrollton power supplies fail
Direct ($/annum)	Minor water or wind damage

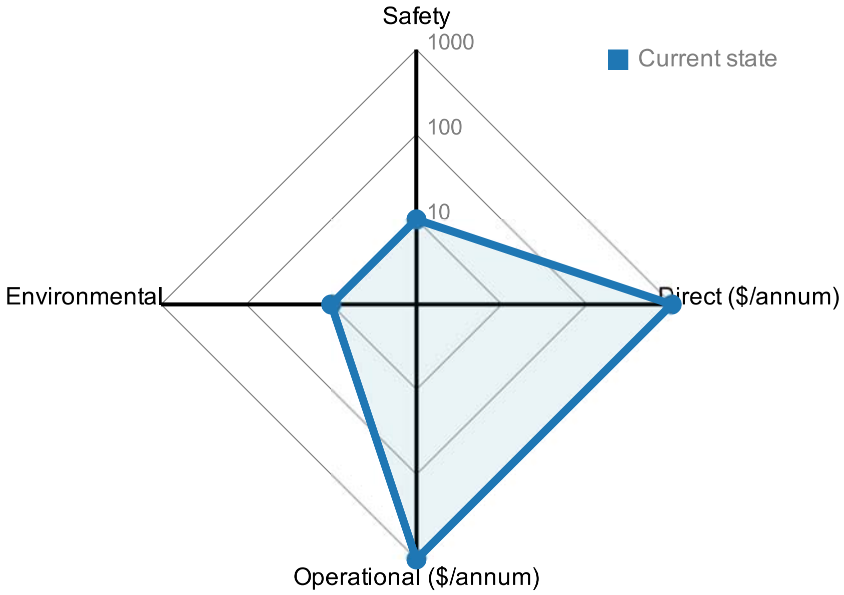
Measure Algiers emergency generator mitigation

Total One-Time Cost	$ 2500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 5000
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 5000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Raise the emergency generator above flood levels and hurricane proof building	One-time	2500000			2500000

Threat: Events: 500 year return period

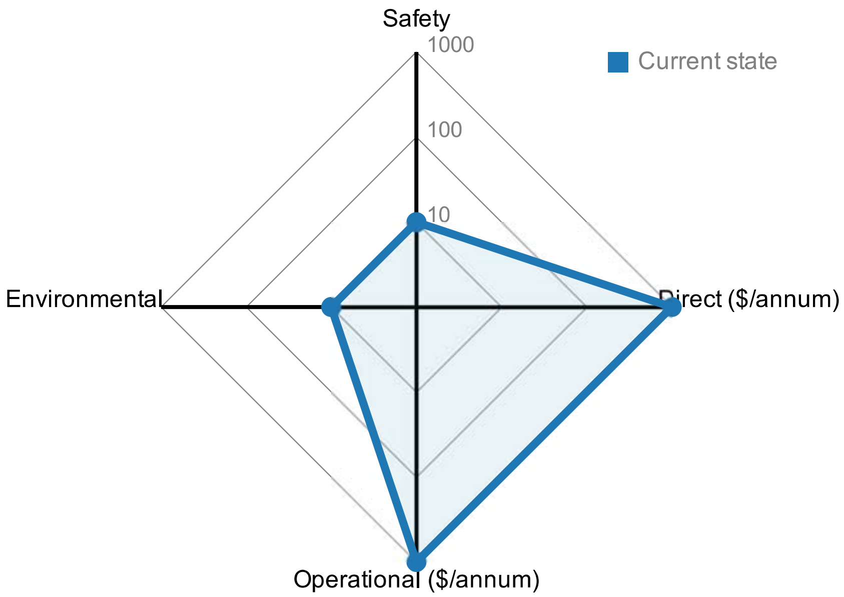
Comments	Potential flooding from overtopping and rainfall however USACE 500 year flood map displays no flooding in this area. Wind speeds could reach 130 mph causing possible damage to the buildings specifically roofs.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	Minimumal risk to personnel
Environmental	Flood waters are unlikely to flood building and be contaminated with oils or fuel
Operational ($/annum)	Generator would be available should Entergy or Carrollton power supplies fail
Direct ($/annum)	Minor water or wind damage

Threat: Hurricane < 100 years - Wind

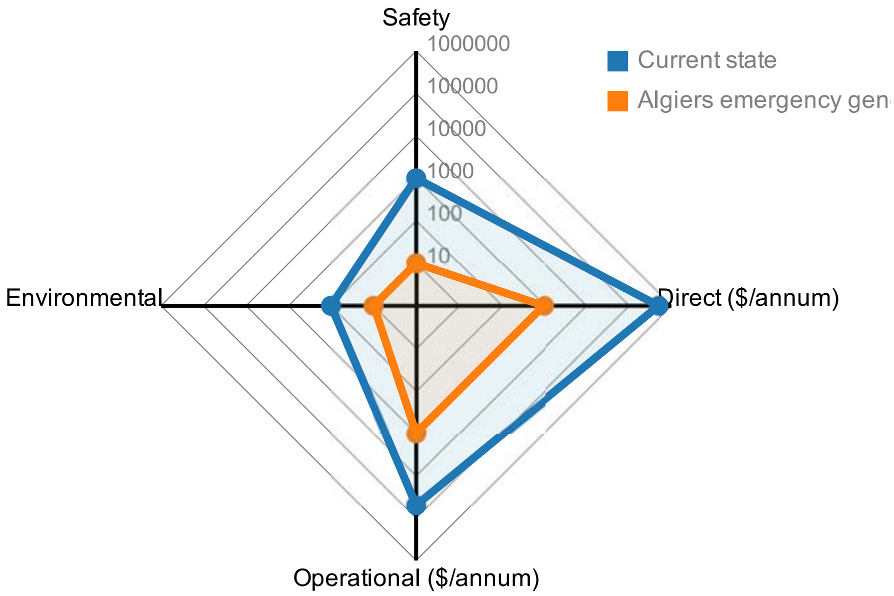
Comments	Historical wind damage limited to one metal roof that rolled up and blew off. The assumption is that Entergy and Carrollton power supply is lost and emergency generator is running.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	During a hurricane events Westbank Power control operations and maintenance personnel remain inside buildings that have been boarded up.
Environmental	The power generator is located inside Station C building therefore the likelihood of the generator sustaining any damage due to hurricane winds is remote. The diesel 10,000 gallon tank is located outside Station C building. The tank is surrounding by secondary containment in the event the tank or pipework is damaged by flying debris and leaks, diesel could leak and contaminate the surrounding area during a hurricane.
Operational ($/annum)	As this equipment is a back up of a back up and that it is monthly started the reliability is quite high
Direct ($/annum)	In normal use and even in case of wind as the equipment is inside the building, damages are limited to spare part replacement costs

Threat: Scenario: SR 100 years

Comments	Swiss Re flood levels could reach 10 ft to 12.5 ft. entire plant would be flooded. In the event of a flood of 10 ft to 12.5 ft. it is assumed the generator, worst case would be flooded and written off.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 6000000



Current Risk Type	Comments
Safety	Assumption emergency generator would be shut down in the event of flooding. Personnel could be exposed to flood waters
Environmental	Lubricating oils and generator fluids would leak into flooded waters.
Operational ($/annum)	Assuming Entergy and Carrollton would not be available, emergency generator will be the primary power supply.
Direct ($/annum)	Replacement cost of emergency generator

Measure Algiers emergency generator mitigation **SELECTED**

Total One-Time Cost	$ 2500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 10000
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the emergency generator above flood levels and hurricane proof building	One-time	2500000			2500000

High Lift Pump Station 1: Short Resilience Report

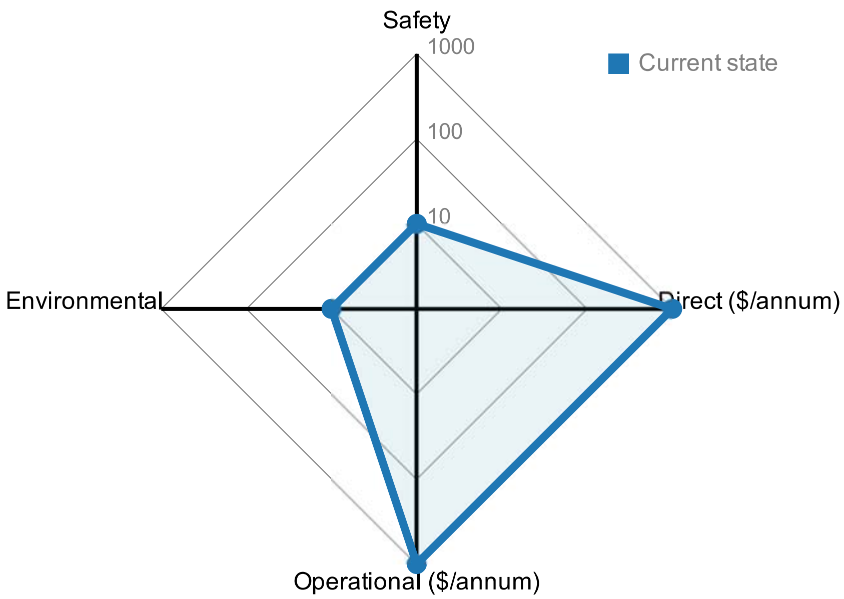
Location Description	900 Lamarque Street, New Orleans LA
Primary Function	To supply drinking water from the finished storage to the distribution system at a minimum of 5 MGD at 70 psi .
Context Information	Five 6 mgd high lift pumps, one 4 mgd high lift pump. All have 60 Hz motors. Operate one pump in service at a time. Draw finished water from Finished Water Storage Tanks through Clearwells 1&2. Building elevation is about 4 feet above ground level.
Full Replacement Cost	$ 5000000

High Lift Pump Station 1: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	There two high lift pumps stations onsite. Secondary power can be supplied from Carrollton Power Plant or from the West Bank emergency generator.	H
Supply chain strength	Aging equipment give cause for concern due to long lead times in either procuring parts or manufacturing parts internally. Delays corrective repairs.	L
Skills availability	The West Bank Power Control and pumping has 15 current employees with 2 vacancies. Power for continued operations of the water treatment systems requires staffing 24 hours per day, 7 days a week. Given the current levels of staffing, overtime is required to cover all the necessary areas within the West Power Control unit. Delays corrective repairs.	L
Ease of access	Easy road access during dry weather however during storm events streets are prone to flooding	M
Documentation and procedures	No documented SOPs, procedures. Apparently have O&M manuals. Need to revise maintenance strategies to include predictive technologies.	L
Flood protection	Building elevation is about 8 feet above ground level.	M
HAZMAT and Fire protection	Limited fire protection to hand held exstinguishers	L
Building code compliance	Building presumed to meet all local codes, limited storm proofing	M
ARI		**0.588**

Threat: Events: 100 year return period

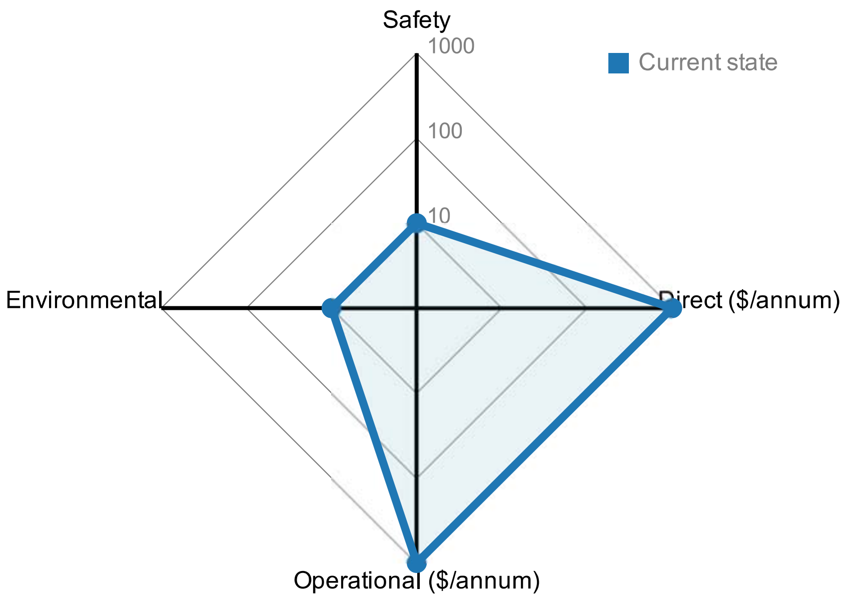
Comments	USACE 100 year flood map displays minimum flooding in this area. Wind speeds could reach 130 mph causing possible damage to the buildings specifically roofs.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	
Environmental	
Operational ($/annum)	
Direct ($/annum)	

Threat: Events: 500 year return period

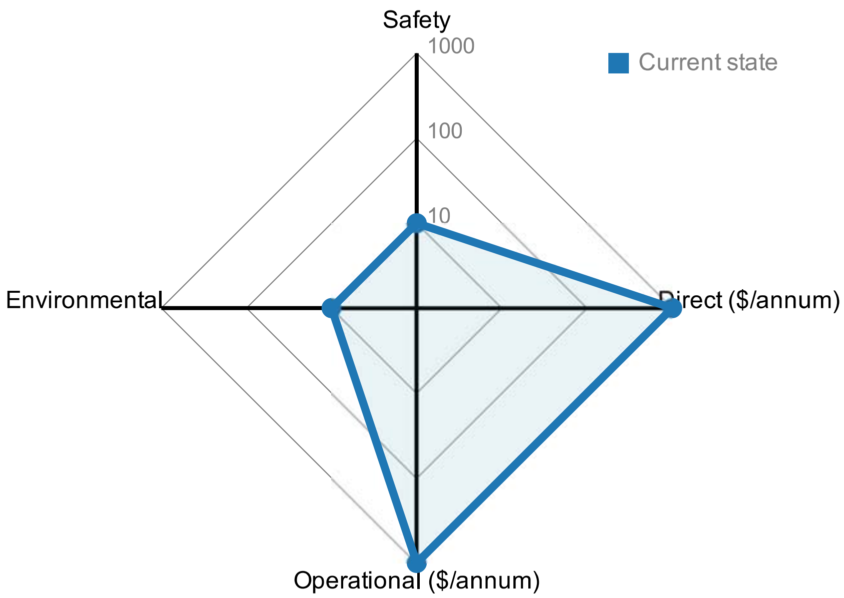
Comments	Potential flooding from overtopping and rainfall however USACE 500 year flood map displays minimum flooding in this area. Wind speeds could reach 130 mph causing possible damage to the buildings specifically roofs.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	Comments
Safety	
Environmental	
Operational ($/annum)	
Direct ($/annum)	

Threat: Hurricane < 100 years - Wind

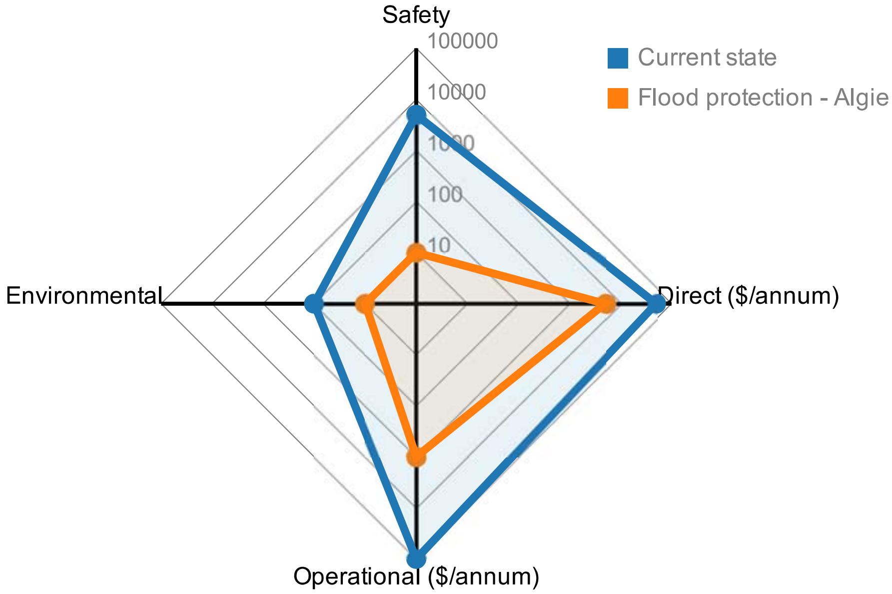
Comments	Wind speeds could reach 105 causing damage to the buildings specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	During a hurricane events Westbank Power control operations and maintenance personnel remain inside buildings that have been boarded up.
Environmental	No environmental consequences
Operational ($/annum)	High lift pumps would supply finished water to the system. Spare pump capacity should duty pump fail.
Direct ($/annum)	Wind damage repair costs

Threat: Scenario: SR 100 years

Comments	Storm flood levels would rise between 10 and 12,5 ft flooding the high lift pump building which is 8 ft above ground level. Power supply to the WTP, water distribution, sewerage pumps would be shutdown. Algiers residents would be without water. Fire hydrants would loose water and pressure.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 5000000



Current Risk Type	Comments
Safety	Personnel could be exposed to high flood levels causing possible fatalities
Environmental	High lift pump lubricating oils could cause minor contamination
Operational ($/annum)	High lift pumps would be flooded. Residents and fire hydrants would be without water
Direct ($/annum)	Recovery of high lift pumps

Measure Flood protection - Algiers plant - Individual building protection

Total One-Time Cost	$ 6500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 100000
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Protect specific installations via raising / elevating assets	One-time	1500000			1500000
Protect specific equipment via a wall	One-time	5000000			5000000

High Lift Pump Station 2: Short Resilience Report

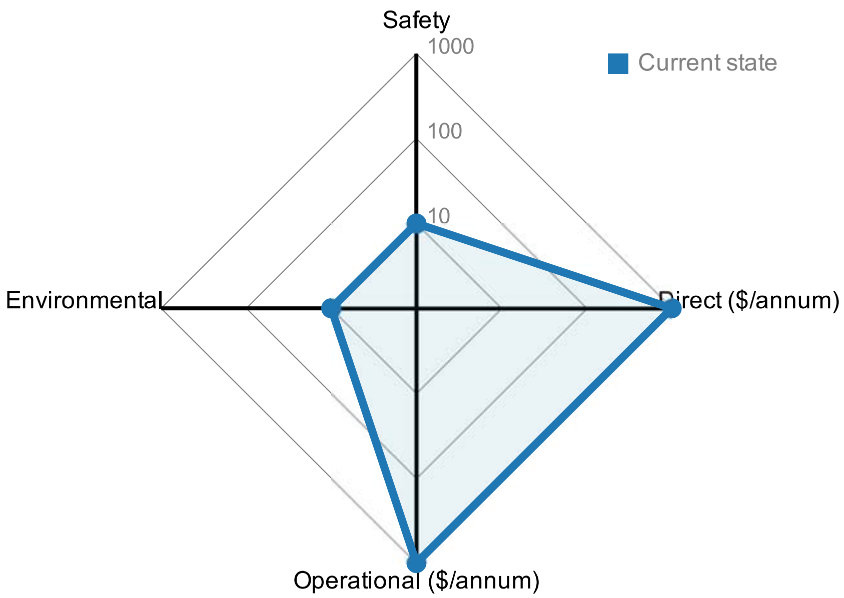
Location Description	900 Lamarque Street New Orleans
Primary Function	To supply drinking water from the finished storage to the distribution system at a minimum of 5 MGD at 70 psi .
Context Information	Four 7.5 mgd high lift pumps. All have 60 Hz motors. Operate one pump in service at a time. Draw finished water from Finished Water Storage Tanks through Clearwells 3&4. Building elevation is about 8 feet above ground level.
Full Replacement Cost	$ 7000000

High Lift Pump Station 2: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	There two high lift pumps stations onsite. Secondary power can be supplied from Carrollton Power Plant or from the West Bank emergency generator.	H
Supply chain strength	Aging equipment give cause for concern due to long lead times in either procuring parts or manufacturing parts internally. Delays corrective repairs.	L
Skills availability	The West Bank Power Control and pumping has 15 current employees with 2 vacancies. Power for continued operations of the water treatment systems requires staffing 24 hours per day, 7 days a week. Given the current levels of staffing, overtime is required to cover all the necessary areas within the West Power Control unit. Delays corrective repairs.	L
Ease of access	Easy road access during dry weather however during storm events streets are prone to flooding	M
Documentation and procedures	No documented SOPs, procedures. Apparently have O&M manuals. Need to revise maintenance strategies to include predictive technologies.	L
Flood protection	Building elevation is about 8 feet above ground level.	M
HAZMAT and Fire protection	Limited fire protection to hand held exstinguishers	L
Building code compliance	Building presumed to meet all local codes, limited storm proofing	M
ARI		**0.585**

Threat: Events: 100 year return period

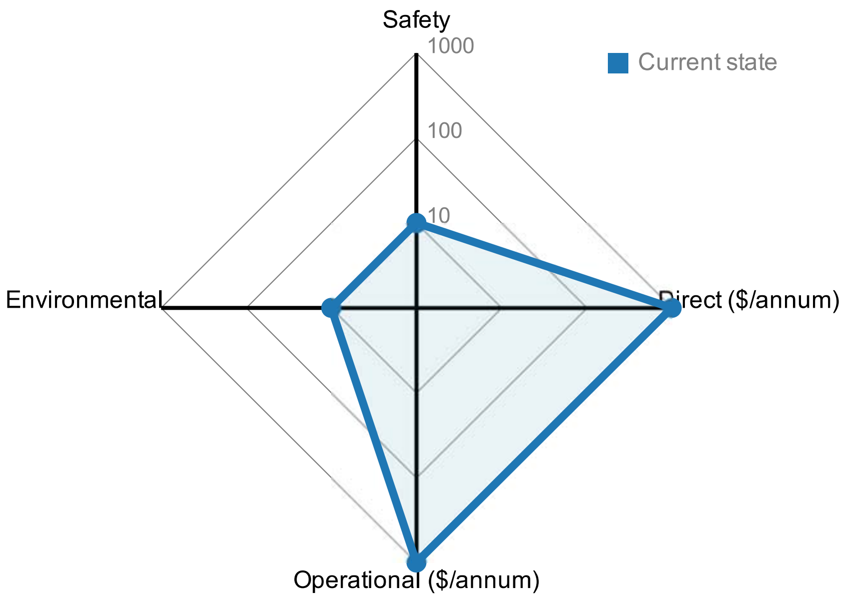
Comments	USACE 100 year flood map displays minimum flooding in this area. Wind speeds could reach 130 mph causing possible damage to the buildings specifically roofs.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	Comments
Safety	
Environmental	
Operational ($/annum)	
Direct ($/annum)	

Threat: Events: 500 year return period

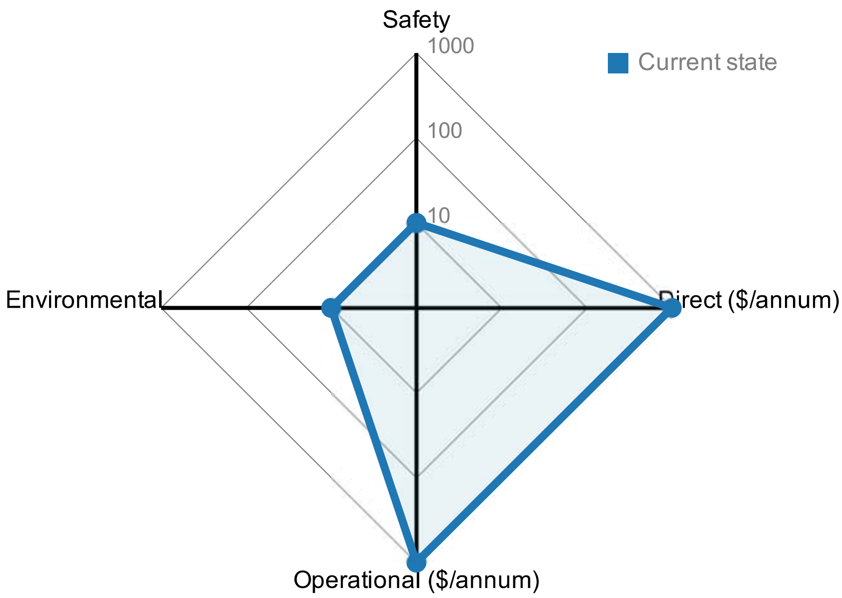
Comments	Potential flooding from overtopping and rainfall however USACE 500 year flood map displays minimum flooding in this area. Wind speeds could reach 130 mph causing possible damage to the buildings specifically roofs.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	Comments
Safety	
Environmental	
Operational ($/annum)	
Direct ($/annum)	

Threat: Hurricane < 100 years - Wind

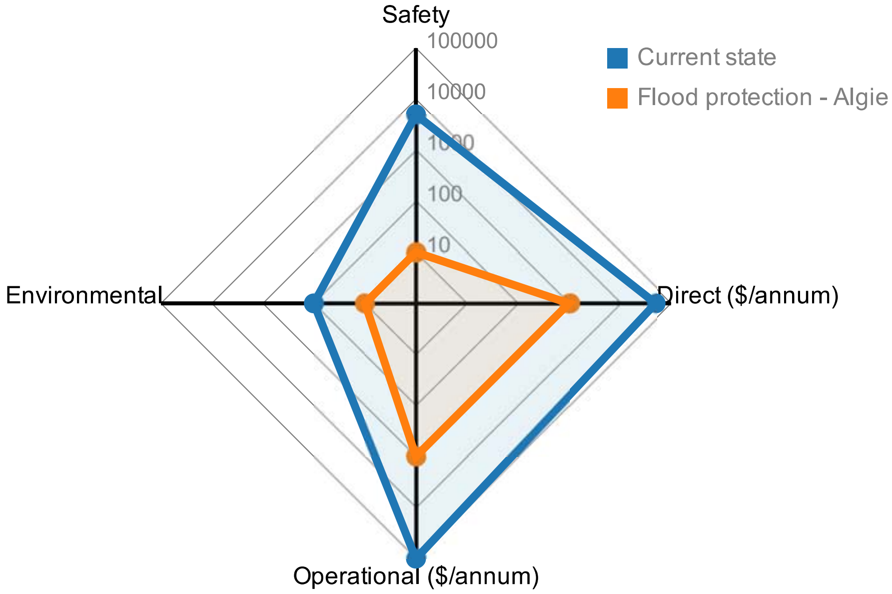
Comments	Wind speeds could reach 105 causing damage to the buildings specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	During a hurricane events operations and maintenance personnel remain inside buildings that have been boarded up.
Environmental	No environmental consequences
Operational ($/annum)	High lift pumps would supply finished water to the system. Spare pump capacity should duty pump fail.
Direct ($/annum)	Wind damage repair costs

Threat: Scenario: SR 100 years

Comments	Storm flood levels would rise between 10 and 12,5 ft flooding the control building which is 4 ft above ground level. Power supply to the WTP, water distribution, sewerage pumps would be shutdown. Algiers residents would be without water. Fire hydrants would loose water and pressure.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 5000000



Current Risk Type	Comments
Safety	Personnel could be exposed to high flood levels causing possible fatalities
Environmental	Lubricating oils could cause minor contamination
Operational ($/annum)	High lift pumps would be flooded. Residents and fire hydrants would be without water
Direct ($/annum)	Recovery of high lift pumps

Measure Flood protection - Algiers plant - Individual building protection

Total One-Time Cost	$ 6500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 100000
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Protect specific installations via raising / elevating assets	One-time	1500000			1500000
Protect specific equipment via a wall	One-time	5000000			5000000

West Bank Power Control Building: Short Resilience Report

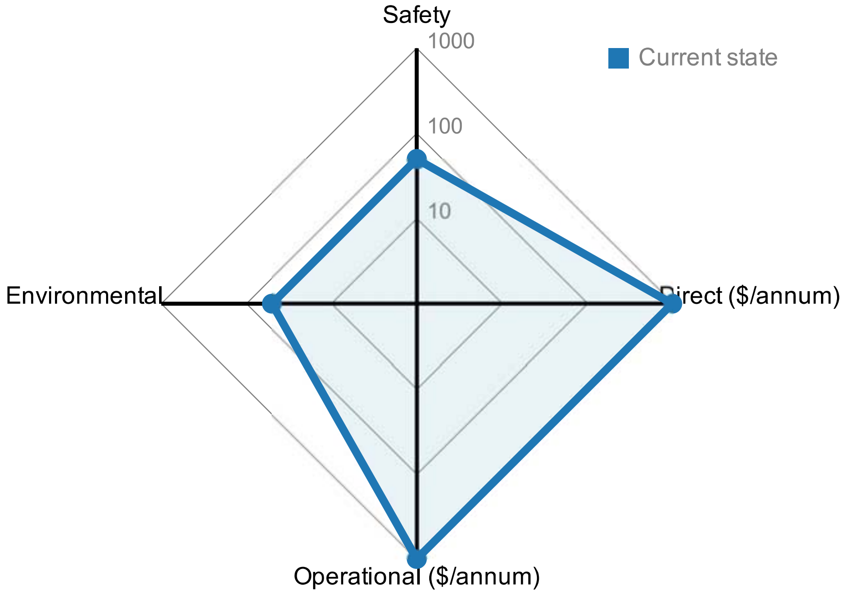
Location Description	900 Lamarque Street, New Orleans
Primary Function	To distribute 25 Hz and 60 Hz power for water purification operations, the distribution of treated water and sewerage pumps
Context Information	Westbank Power Control's (WPC) primary power is fed from Entergy via two 13.8 kV feeders, one select and the other standby. The 13.8 kV is stepped down to 4160 volts by two transformers in the yard. The select feeder can supply half or all of WPC, river stations and water purification needs. A secondary source of power is supplied from Station A on the east bank via two 25 Hz feeders (26 and 226) that cross the Mississippi River to the WPC building. One of the feeders (226) has been damaged by a dredger and is currently inoperable. The remaining feeder (26) supplies 6600 volts to the three frequency changers generating 60 Hz power capable of supplying power to 100% of the WPC, two river stations and the purification plant. Currently the water plant operates on a 50/50 power sharing supply between the Sewerage & Water board feeders and Entergy feeders. All the switch gear and one frequency converter No.3 (2200 kW) are housed in a secure building raised approximately 4 feet above the side walk elevation of 26.06'. The building metal roof was damaged during Katrina however it has a solid concrete ceiling which prevented water intrusion damaging the switch gear. In the event Entergy and S&WB power supply is lost WPC is capable of generating 60 cycle power using a diesel generator. The generator consumes approximately 2000 gallons of diesel a day. A 10,000 gallon diesel storage tank is located outside the generator building. The tank is surrounded by secondary containment in the event of a leak. During Katrina the supply of diesel became an issue especially when only dirty diesel was available causing fuel filters to plug up. This station is also capable of converting 60 Hz back to 25 Hz and supplying power back to the Carrollton facility via the remaining 25 Hz feeder that travels under the Mississippi River. The station also has responsibility to pump and distribute treated water to the public maintaining water pressure for the Fire Department. Any excess water is pumped to the storage tanks. There are two high lift pumping stations called Station C's high lift and the New High Lift Station. These are two 5,000,000 gallon storage tanks located within the facility, which are also used to assist purification back washing their filters and to equalize the water rate for the next day. A 2,000,000 gallon elevated water tank is located 4 miles away from the facility. The tank is used to maintain the water pressure across Algiers. Client stated that Entergy power is used primary for the Algiers WTP and averages one power loss per year. Central control power (Carrollton WTP) is secondary power if Entergy power is lost. The diesel generator onsite is the third power source as needed. SCADA is used for data acquisition only not for operations control. Chemical feed system reliability has been 100% historically. Treatment process and pumping reliability has been 100% historically. SCADA records are kept on the second floor of the WTP along with chemical feed and operating records. SCADA records also aer backed up and stored at the Carrollton plant. Maintenance activities are supported by the maintenance staff at the Carrollton WTP.
Full Replacement Cost	$ 100000000

West Bank Power Control Building: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	3 levels of redundancy; with Entergy as primary, S&WB as secondary, and the standby generator as tertiary. However Entergy power cables and power cables to the Old lift station pumps, Sewerage pumps and raw water intake pumps all reside in one cable tray.	M
Supply chain strength	During Katrina had to call out of state for diesel. Some diesel supplies were dirty plugging up filters. started to run out of diesel after 4 days. tank capacity 10,000. Have adequate supply of electrical spares, spare oil, oil filters, fuel filters.	M
Skills availability	The West Bank Power Control and pumping has 15 current employees with 2 vacancies. Power for continued operations of the water treatment systems requires staffing 24 hours per day, 7 days a week. Given the current levels of staffing, overtime is required to cover all the necessary areas within the West Power Control unit.	L
Ease of access	There are paved roads within the WTP that allow easy access to the different WTP processes, however some areas of the plant are more prone to flooding that others ranging from 6 inches to 3 feet.	M
Documentation and procedures	Many of the standard operating procedures (SOPs) and maintenance procedures are not documented which places emphasis on the skills and training of both operations and maintenance personnel to ensure best practices are followed. Electrical drawings are available for most of the equipment, however it is not organized for easy searches. Have operations and maintenance manuals for most equipment. Manually written procedures for electrical adjustments.	M
Flood protection	Power plant control and switch gear building is raised approximately 4 feet above the ground. Emergency generator is raised approximately 1 foot above the ground. Transformers are 6" above the ground.	M
HAZMAT and Fire protection	Diesel tank is surrounded by secondary containment. Hand held fire extinguishers inside switch gear room.	L
Building code compliance	All buildings built to code. Metal roof did get peeled back during Katrina however the ceiling is concrete and did not leak. Station C building roof has leaked before during hurricanes.	M
ARI		**0.629**

Threat: Events: 100 year return period

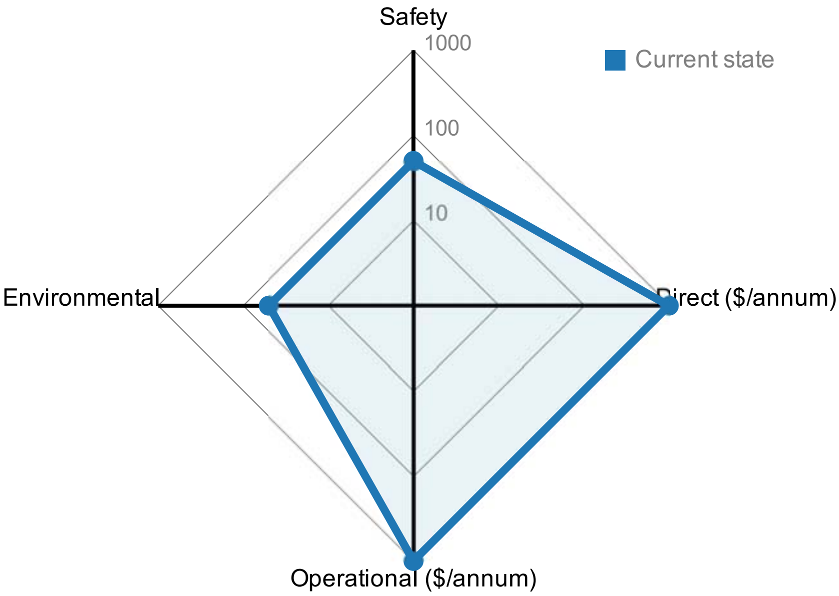
Comments	Wind speeds could reach 130 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy would be lost. 25 Hz power would be received from Station A.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	During a hurricane events Westbank Power control operations and maintenance personnel remain inside buildings that have been boarded up.
Environmental	The emergency generator diesel 10,000 gallon tank is located outside Station C building. The tank is surrounding by secondary containment in the event the tank or pipework leaks. Diesel could leak during a hurricane could contaminate the surrounding area.
Operational ($/annum)	No operational consequences with backup power being supplied from Station A
Direct ($/annum)	Minor flood damage costs

Threat: Events: 500 year return period

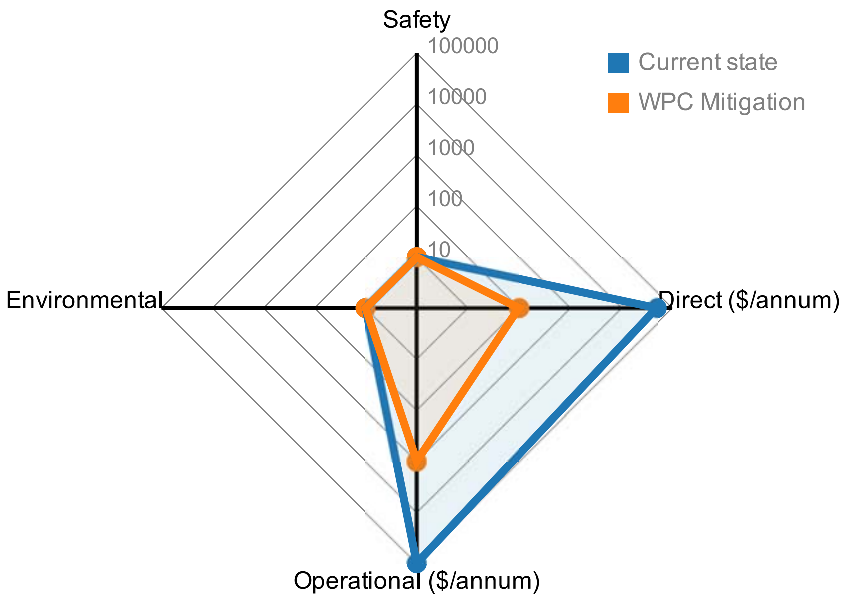
Comments	Major hurricane, wind speeds could reach 130 to 156 mph. causing possible damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. 25 Hz power would be supplied from Station A and converted to 60 Hz.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 1000



Current Risk Type	**Comments**
Safety	Control Building is boarded up during hurricanes to avoid flying debris from breaking windows, etc.
Environmental	The emergency generator diesel 10,000 gallon tank is located outside Station C building. The tank is surrounding by secondary containment in the event the tank or pipework leaks. Diesel leaks during a hurricane could cause minor contamination.
Operational ($/annum)	Backup power supply from Station A would allow operations to continue.
Direct ($/annum)	Minor wind and flood damage costs

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds up to 130 mph. cause damage to property and buildings specifically roofs. Power cable tray covers that are loose are vulnerable to hurricane winds causing them to fly off exposing the cables to flying debris and possibly cut. Minor flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Water purification plant would be partially shutdown until 25 Hz power is restored from Carrollton Power Plant.
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 2000000



Current Risk Type	**Comments**
Safety	During a hurricane events Westbank Power control operations and maintenance personnel remain inside buildings that have been boarded up.
Environmental	No environmental consequences
Operational ($/annum)	Above ground cable tray panels connecting Station C to West Power control blow off and flying debris could cut the power cables. Power supply to only 50% of the purification plant, 6 high lift pumps, 3 sewerage pumps, two frequency changers.
Direct ($/annum)	New cables would have to be installed for the high lift pumps, sewerage pumps and water intake pumps.

Measure WPC Mitigation **SELECTED**

Total One-Time Cost	$ 350000
Total Recurring Cost	$ 500
Annual Operating Cost Reduction	$ 5000
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Storm proof Station Control building roof	One-time	350000			350000
Check above ground cable tray for loose covers before a storm event	Scheduled	500	2 years	250	
Check diesel tank and pipework for leaks prior to storm event	Scheduled	500	2 years	250	

Threat: Scenario: SR 100 years

Comments	Storm flood levels would rise between 10 and 12,5 ft flooding the control building which is 4 ft above ground level. Power supply to the WTP, water distribution, sewerage pumps would be shutdown. Algiers residents would be without water. Fire hydrants would loose water and pressure.
Earliest Recovery of Function	2 weeks
Repair and recommissioning cost	$ 10000000

Current Risk Type	Comments
Safety	Personnel could be exposed to high flood levels causing possible fatalities
Environmental	The emergency generator diesel 10,000 gallon tank is located outside Station C building. The tank is surrounding by secondary containment in the event the tank or pipework leaks. Diesel leaks during a hurricane could cause minor contamination.
Operational ($/annum)	WTP shutdown would cause fire hydrants to be inoperable. Algiers residents would be without water for extended periods of time
Direct ($/annum)	Major flood damage to the facilities

Measure Flood protection Algiers WTP - Wall around plant scenario

Total One-Time Cost	$ 21000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 100000
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 0

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Construct a surge / flood protection perimeter wall around the entire site	One-time	21000000			21000000

Emergency Generator: Short Resilience Report

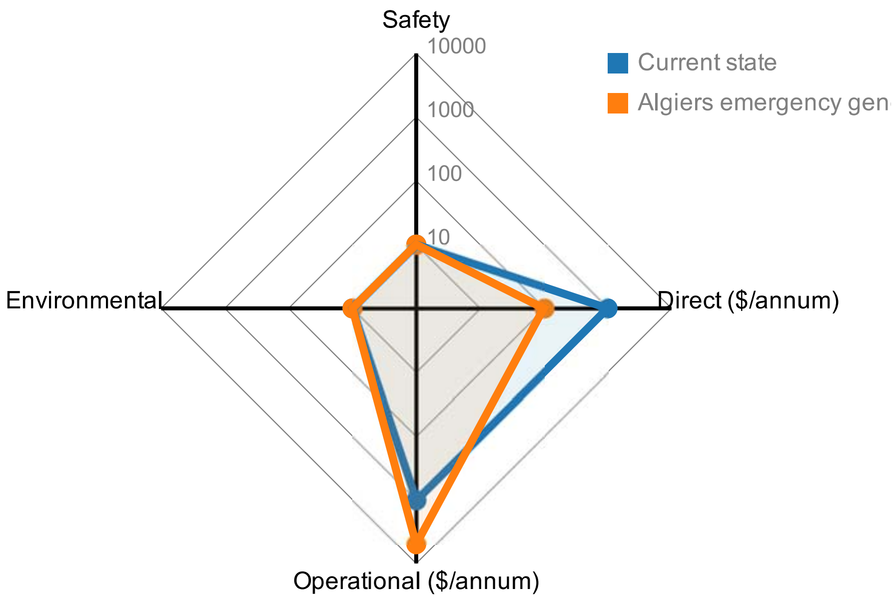
Location Description	900 Lamarque Street, New Orleans
Primary Function	To be capable of supplying 16,000 KW backup power to the entire Algiers WTP in the event Entergy and Carrollton power supplies fail or are lost during storm events
Context Information	The emergency generator is located in the Station C building Generator operated under full load 2 hours per month and then operated not loaded 30 minutes each week. Diesel consumption stated as 2,000 gallons per day fully loaded.
Full Replacement Cost	$ 6000000

Emergency Generator: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Provided full power for treatment plant operations in event of utility power outage. Also have power backup from Central control at Carrollton WTP.	H
Supply chain strength	During Katrina had to call out of state for diesel. Some diesel supplies were dirty plugging up filters. started to run out of diesel after 4 days. tank capacity 10,000. Have adequate supply of electrical spares, spare oil, oil filters, fuel filters. Spares are readily available.	M
Skills availability	Current skillsets are good, however there are concerns about an aging workforce and transfer of skills.	M
Ease of access	Plant has easy access by road however it is assumed that the road would be prone to flooding during hurricanes.	M
Documentation and procedures	No documented SOPs, procedures. Have O&M manuals available.	M
Flood protection	Some of the emergency generator equipment is raised approx. 4 feet however this is well below	L
HAZMAT and Fire protection	No automatic fire protection. Fire protection consists of hand held fire extinguishers. Emergency generator secondary containment for liquid leaks.	L
Building code compliance	Building meets existing building codes.	M
ARI		**0.664**

Threat: Events: 100 year return period

Comments	Wind speeds could reach 130 mph. causing minor damage to the building specifically roofs. Station C's roof has sustained hurricane damage before causing the roof to leak. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Carrollton is the secondary power supply
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	During a hurricane events Westbank Power control operations and maintenance personnel remain inside buildings that have been boarded up.
Environmental	Flood waters are unlikely to flood building and be contaminated with oils or fuel
Operational ($/annum)	Generator would be available should Entergy or Carrollton power supplies fail
Direct ($/annum)	Minor water or wind damage

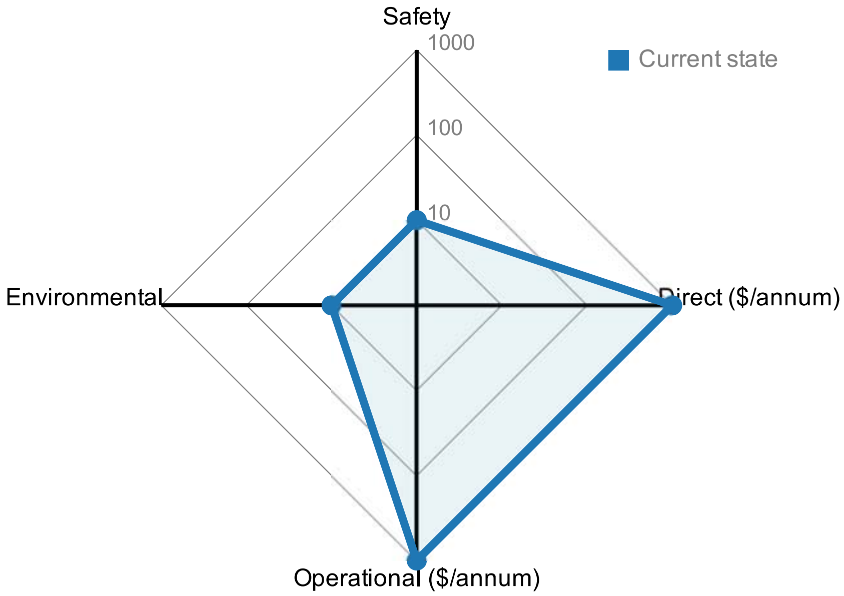
Measure Algiers emergency generator mitigation

Total One-Time Cost	$ 2500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 5000
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 5000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Raise the emergency generator above flood levels and hurricane proof building	One-time	2500000			2500000

Threat: Events: 500 year return period

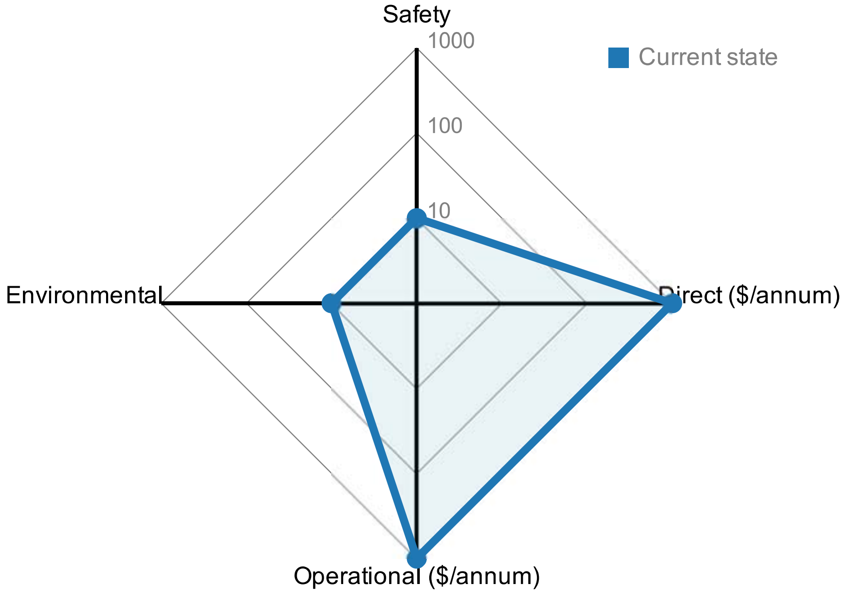
Comments	Potential flooding from overtopping and rainfall however USACE 500 year flood map displays no flooding in this area. Wind speeds could reach 130 mph causing possible damage to the buildings specifically roofs.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	Minimumal risk to personnel
Environmental	Flood waters are unlikely to flood building and be contaminated with oils or fuel
Operational ($/annum)	Generator would be available should Entergy or Carrollton power supplies fail
Direct ($/annum)	Minor water or wind damage

Threat: Hurricane < 100 years - Wind

Comments	Historical wind damage limited to one metal roof that rolled up and blew off. The assumption is that Entergy and Carrollton power supply is lost and emergency generator is running.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 1000



Powdered Activated Carbon Building: Short Resilience Report

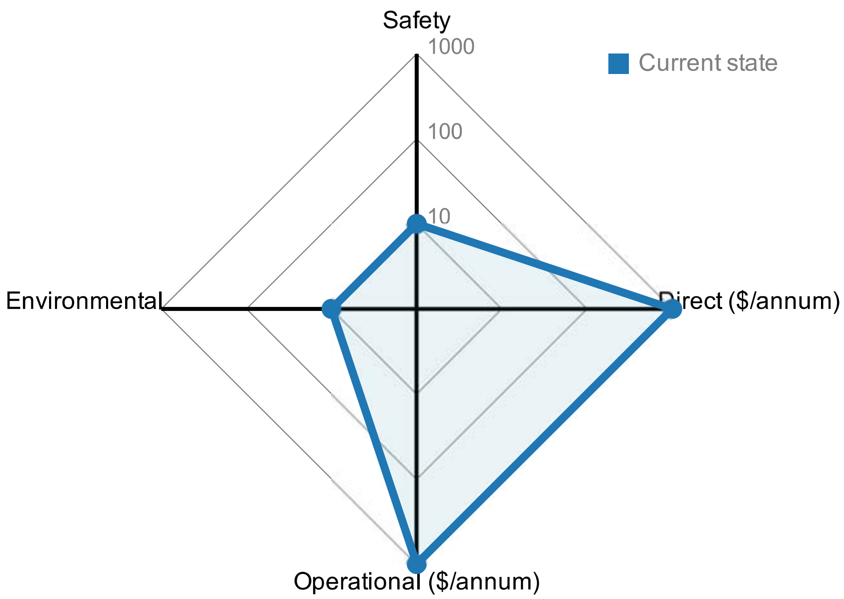
Location Description	
Primary Function	To be capable of supplying carbon slurry to the river water intake pumps in the event of an upstream oil or diesel spill
Context Information	Powdered Activated Carbon. Activated carbon is used to adsorb natural organic compounds, taste and odor compounds, and synthetic organic chemicals in drinking water treatment. In this application the activated carbon system is used when the Mississippi river has been polluted upstream of the river intakes. Carbon slurry storage tank elevated 20 feet (more or less) above ground level equipped with vertical mixer. Below storage tank are the re-circulation pumps and carbon feed pumps that discharge into either river intake pipe to the treatment plant. It has not been used in about 5 years and just fed carbon to get rid of old material. Carbon storage and feed is a non-critical system.
Full Replacement Cost	$ 3000000

Powdered Activated Carbon Building: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	There is only one activated carbon system used only when the upstream river has been polluted	M
Supply chain strength	Existing contracts and procedures ensure supplies are filled to capacity prior to any weather event.	M
Skills availability	Lack of staffing continues to be a major issue. Given the current levels of staffing, overtime is required to cover all the necessary areas within the facility.	L
Ease of access	Easy access during dry weather, however during storm events streets could to be flooded	L
Documentation and procedures	No documented SOPs and maintenance procedures. Need to revised maintenance strategies to include predictive technologies.	L
Flood protection	Protected by the river levee at approximately 15 feet high. Ground elevation is approximately 5 feet. No other flood protection.	M
HAZMAT and Fire protection	Hand held fire extinguishers only	L
Building code compliance	Buildings are of concrete block construction presume to meet building codes	M
ARI		**0.552**

Threat: Events: 100 year return period

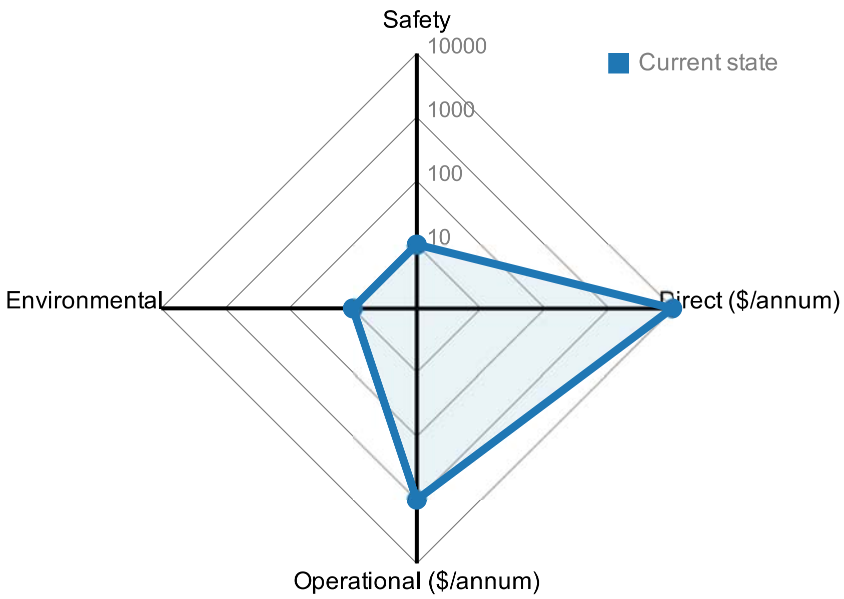
Comments	PAC building is protected by the river levee which is at approximately 15 feet. Limited street flooding. Very unlikely PAC building would be flooded.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	No personnel would are in the building during storm events. Organics would be absorbed by the carbon from the river water entering the WTP
Environmental	Carbon is contained within the building
Operational ($/annum)	In the event of a oil spill upstream PAC system would operate as normal
Direct ($/annum)	Minor water damage repairs

Threat: Events: 500 year return period

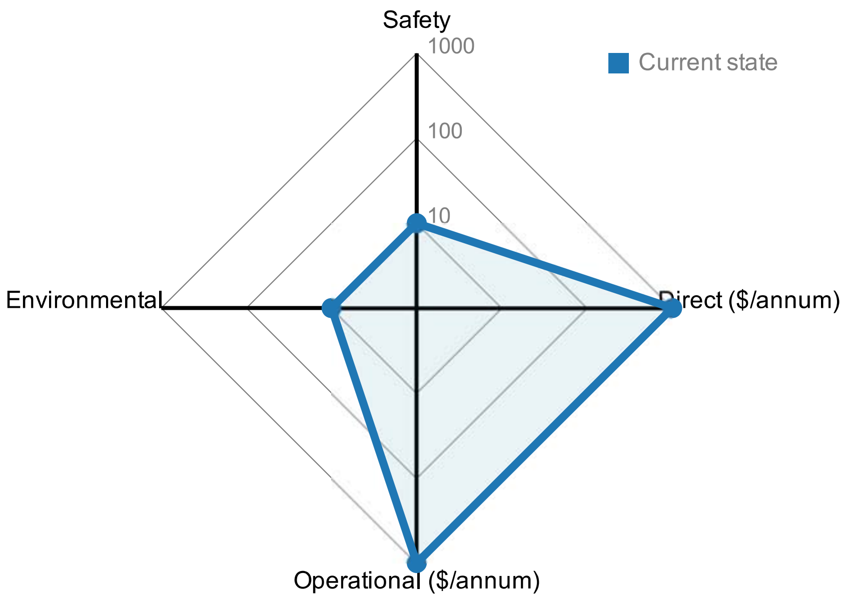
Comments	Potential flooding from overtopping and rainfall however 500 year flood map displays minimum flooding in this area. Wind speeds could reach 130 mph causing possible damage to the building specifically roofs. Power supply from Entergy will be lost however, power would be supplemented from either Carrollton or the emergency generator at the West Bank plant.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	No personnel would are in the building during storm events. Organics would be absorbed by the carbon from the river water entering the WTP
Environmental	Carbon is contained within the building
Operational ($/annum)	In the event of a oil spill upstream PAC system would operate as normal
Direct ($/annum)	Minor wind and flood damage possible

Threat: Hurricane < 100 years - Wind

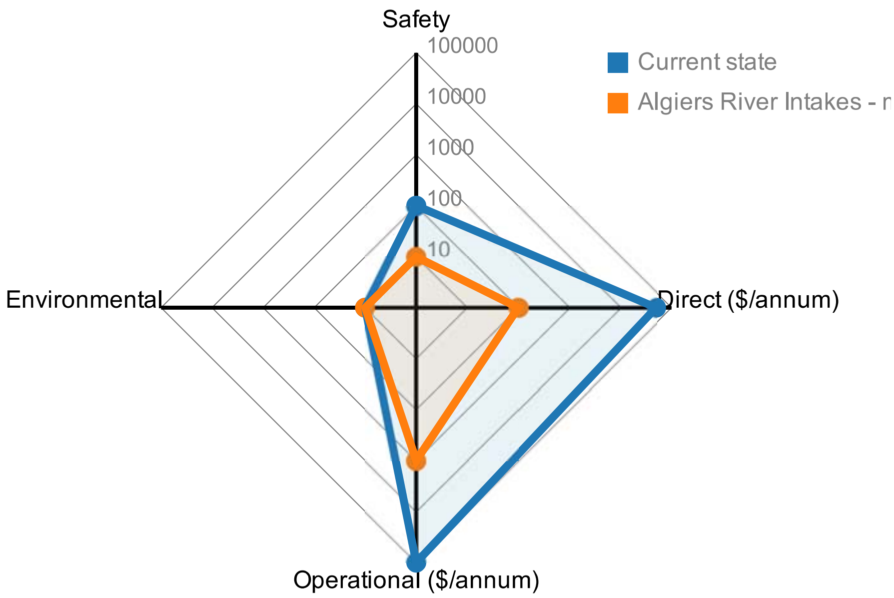
Comments	Wind speeds could reach 105 to 120 mph. causing damage to the buildings specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy to the West Bank plant would be lost, however, power would be supplemented from either Carrollton or the emergency generator at the West Bank plant. In the event activated carbon is needed the equipment would be available.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	No personnel would are in the building during storm events. Activated carbon system would be available if required to absorb organics from the river water entering the WTP
Environmental	Carbon is contained within the building
Operational ($/annum)	In the event of a oil spill upstream PAC would operate as normal
Direct ($/annum)	Minor wind damage repairs

Threat: Scenario: SR 100 years

Comments	Swiss RE are predicting a storm surge depth of 11 to 12.5 feet and wind speeds that could reach 105 mph. This could only occur with a levee break or severe overtopping and/or heavy rainfall. Wind damage to the building specifically roofs could occur. Powdered Activated Carbon building and River Intake pumps and associated equipment would be flooded and shutdown causing the water treatment plant to stop producing water. Agiers residents would be without drinking water within a day Fire Department would also have no water. Emergency generator would generate power for the entire Algiers WTP and some drainage stations.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 500000



Current Risk Type	Comments
Safety	People could be affected by the quality of the drinking water
Environmental	Powered carbon contained inside the building
Operational ($/annum)	No activated carbon added to the river water to absorb the organics from river pollution could affect the quality of the drinking water
Direct ($/annum)	Water damage to the PAC equipment

Measure Algiers River Intakes - medium cost mitigation **SELECTED**

Total One-Time Cost	$ 1000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 0

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Build a wall around infrastructure to exceed surge flood depths	One-time	1000000			1000000

Carrollton Water Purification Plant: Short Resilience Report

Location Description	8800 S Claiborne Avenue New Orleans 70118
Primary Function	To supply a minimum of 135 MGD of drinking water that meets or exceeds Federal drinking water standards to the East parishes (approximately 440,000 people) at 70 psi

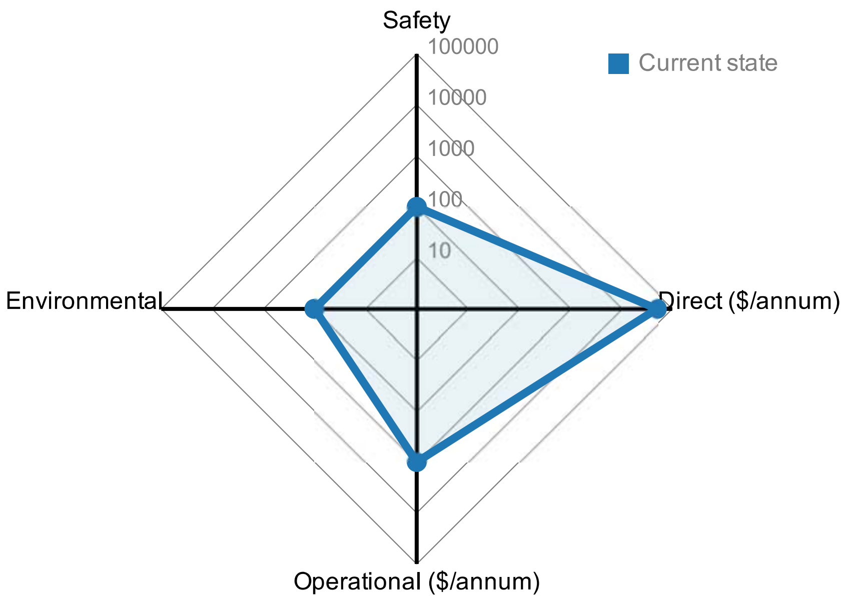
Context Information	The Carrollton Water Treatment Plant (WTP) has a design capacity of 235 MGD. and currently treats 135 MGD. Water is pumped from the Mississippi River to the WTP from two large river pumping stations through several large pipelines. Mississippi River water contains large amounts of suspended solids. The following sections describes the process in more detail. Step 1 - Coagulation As the river water enters the Carrollton Plant, the purification process begins with the addition of coagulant chemicals: ferric sulfate and polyelectrolyte. These chemicals are added to the process at very precise dosages and mixed rapidly with the river water to ensure efficient and complete coagulation. Coagulant chemicals cause the very fine particles that make up the suspended solids present in the river water to clump together, or coagulate. Ferric sulfate is our primary coagulant, and polyelectrolyte is used as a coagulant aid. Step 2 - Flocculation After the raw water has been coagulated, it is gently mixed by large mechanical paddles in a process called flocculation. Flocculation causes the fine, light particles that were created during the coagulation process to mature into larger, denser, stable particles that will settle quickly. Step 3 - Sedimentation The flocculated water then travels into primary settling basins or clarifiers. In the primary settling basins, the large, dense particles formed during the coagulation and flocculation processes settle allowing the clarified water to be separated and forwarded on through the remainder of the water treatment process. The settled particles form a sludge layer on the bottom of each primary settling basin. This sludge is periodically removed from the basins and returned to the Mississippi River through a permitted discharge. Step 4 - Disinfection After the clarified water leaves the settling basins, the disinfection process begins with the addition of chlorine. Ammonia is added following the chlorine addition, producing chloramine. The chloramine disinfected water passes through a second set of basins to provide detention time for the disinfection process to go to completion. Step 5 - pH Adjustment The next step in the process is adjustment of the pH of the water. Lime, also known as calcium oxide, is added during this step to achieve the desired target pH. Adjusting the pH makes the water more basic, and less corrosive to the pipes in our water distribution system and the plumbing in our customers' homes, as well as extends the life of the disinfectant residual in the distribution system. A small amount of polyphosphate solution is also added with the lime. Polyphosphate is used as a sequestrant, which helps to keep the lime in dissolved in the water. Step 6 - Fluoridation After the water exits the secondary settling basins, it is treated fluorosilicic acid. A small dose of fluorosilicic acid is added at this point in the treatment process, which adds fluoride to the drinking water to aid in the prevention of dental cavities. Step 7 - Filtration The final step in the purification process is filtration through rapid gravity filters. This type of filter uses granular filter media (sand and anthracite at our facilities) to remove any remaining suspended particles in the water. This step in the treatment process consists of passing the water through a filter at a controlled rate. Any particles remaining in the water adhere to the filter media and are removed from the water. After filtration, the purification process is complete. Filtered water is collected from the many filters in service and flows to one of several pumping stations located on the plant grounds, where it is pumped and delivered to our customers to provide water for drinking and for fire protection. The Carrollton plant normally yields about 135 million gallons per day of finished water for the east bank of Orleans Parish. The Algiers Plant, which serves the predominantly residential west bank portion of the parish, purifies about 11 million gallons per day of water. Combined, the two plants treat approximately 54 billion gallons of water per year, removing 18,000 tons of solid material from the raw river water. The treated water at the two plants is pumped through more than 1,610 miles of mains to more than 100,000 service connections. It is delivered to approximately 300,000 people on the east bank of Orleans Parish and approximately 53,000 people on the west bank.
Full Replacement Cost	$ 1200000000

Carrollton Water Purification Plant: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	Plant has excess capacity, design capacity 235 MGD, the current usage 135 MGD. Most of the processes have redundancy except the backwash tank MCC and sludge removal system which has only one pipeline to the Mississippi River. A second backwash line is in the design stage and should be completed around 2018. Based on chemicals consumption we can consider that Carrollton plant has a limited redundancy and storage capacity, 20 days for most chemicals except ferric sulfate 10 days and 14 days for phosphate. Filter backwash system has redundant pumps, however the pump MCC building could regarded as a single point of failure.	M
Supply chain strength	For chemicals the supply chain strength is quite good depending on which chemicals we are considering half a day from Houston. Deliveries would be dependent on the roads or railways being flood damaged. Regarding process spare parts majority of them is manufactured on Carrollton plant by SWB. There are few spare parts stored.	M
Skills availability	The Carrollton WTP has 40 current employees with 14 vacancies. Power for continued operations of the water treatment systems requires staffing 24 hours per day, 7 days a week. Given the current levels of staffing, overtime is required to cover all the necessary areas within the WTP unit.	L
Ease of access	There are paved roads within the WTP that allow easy access to the different WTP processes, however some areas of the plant are more prone to flooding that others ranging from 6 inches to 3 feet.	M
Documentation and procedures	Many of the standard operating procedures (SOPs) and maintenance procedures are not documented which places emphasis on the skills and training of both operations and maintenance personnel to ensure best practices are followed.	L
Flood protection	Very few of the WTP facilities have been water proofed. However during major hurricane events some buildings with sensitive and valuable equipment (laboratory) windows and some doors are boarded up. Flooding experienced during Katrina (due to levees being breached) within the WTP ranged from 6 inches to 3 feet around the power plant.	M
HAZMAT and Fire protection	All chemicals have secondary containment in the event of spills. Fire detection systems (smoke detectors, carbon monoxide detectors) and fire suppression systems are not present except for hand held fire extinguishers.	M
Building code compliance	WTP buildings meet the old State building code requirements. However the New Orleans now complies with the IBC	M
ARI		**0.625**

Threat: Events: 100 year return period

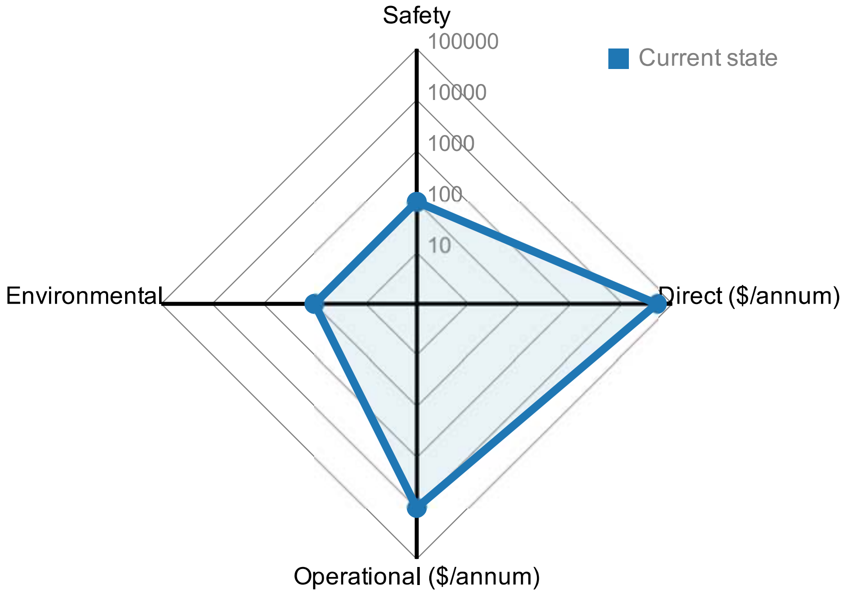
Comments	According to FEMA's scenario Critical assets of Carrollton plant would be protected by levees in case of 100 year event
Earliest Recovery of Function	12 hours
Repair and recommissioning cost	$ 2000000



Current Risk Type	Comments
Safety	During a hurricane events WTP operations and maintenance personnel are advised to remain within the buildings. However personnel may have to venture outside in the event of equipment failure and could be exposed to flying debris.
Environmental	Flying debris could puncture chemical tanks causing chemicals to leak into secondary containment or spray into the surrounding area and then into storm water drains. Chemicals would diluted by the storm water however environmental could still occur.
Operational ($/annum)	Based on FEMA this categorie of event would not cause a water purification process disruption at the plant level
Direct ($/annum)	Limited impact. Only damages due to the wind

Threat: Events: 500 year return period

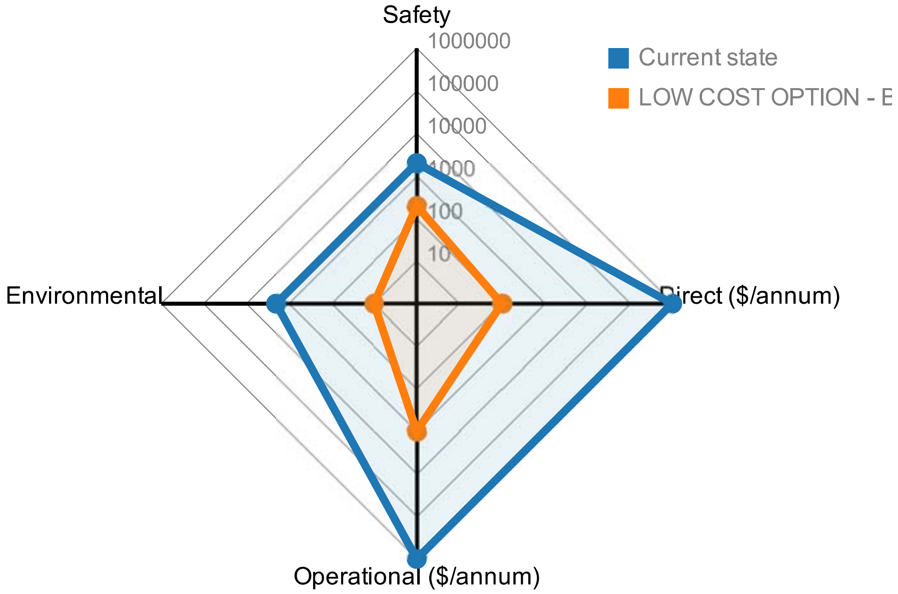
Comments	Based on FEMA's scenario and USACE critical assets should not be affected by a 500 year event as well with an exception for 2 assets but not directly linked to the purification process
Earliest Recovery of Function	12 hours
Repair and recommissioning cost	$ 20000000



Current Risk Type	**Comments**
Safety	During a hurricane events WTP operations and maintenance personnel are advised to remain within the buildings. However personnel may have to venture outside in the event of equipment failure and could be exposed to flying debris.
Environmental	Flying debris could puncture chemical tanks causing chemicals to leak into secondary containment or spray into the surrounding area and then into storm water drains. Chemicals would diluted by the storm water however environmental could still occur.
Operational ($/annum)	Based on FEMA this categorie of event would not cause a water purification process disruption at the plant level. Access to the plant could be limited due to flooding and storage capacity for some chemicals is limited but should exceed recede time
Direct ($/annum)	Limited impact. Only damages due to wind

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds up to 130 mph. cause damage to property and buildings specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Power plant would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	1 days
Repair and recommissioning cost	$ 5000000



Current Risk Type	Comments
Safety	During a hurricane events WTP operations and maintenance personnel are advised to remain within the buildings. However personnel may have to venture outside in the event of equipment failure and could be exposed to flying debris.
Environmental	Flying debris could puncture chemical tanks causing chemicals to leak into secondary containment or spray into the surrounding area and then into storm water drains. Chemicals would diluted by the storm water however environmental could still occur.
Operational ($/annum)	Hurricane winds damage buildings with metal roofs. Water ingress damages electrical equipment for example backwash MCC building. Sand filters cannot be backwashed causing water operations to be gradually shutdown.
Direct ($/annum)	Building roof repairs, electrical equipment replacement.

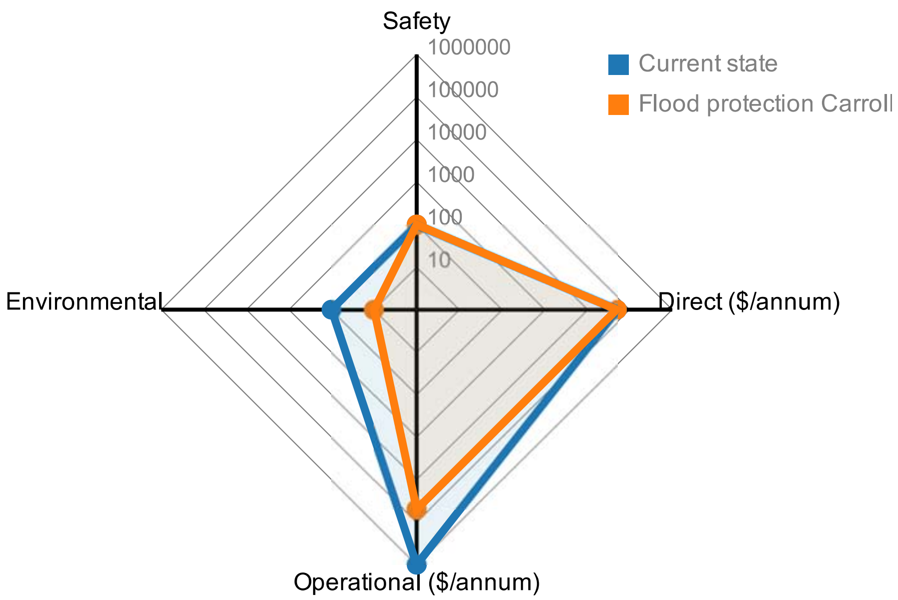
Measure LOW COST OPTION - BUILDING STORM PROOFING **SELECTED**

Total One-Time Cost	$ 5000000
Total Recurring Cost	$ 60000
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	0.5 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Storm Proof Buildings and structures subject to hurricane wind damage	One-time	5000000			5000000
Remove all loose debris, mobile structures from the site and surrounding area	Scheduled	5000	1 months	60000	

Threat: Scenario: SR 100 years

Comments	Based on Swiss Re's scenario (100 year event), levels of water would be limited as well (from 2.5 to 5 ft). Few installations would be affected
Earliest Recovery of Function	90 days
Repair and recommissioning cost	$ 5000000



Current Risk Type	Comments
Safety	During a hurricane events WTP operations and maintenance personnel are advised to remain within the buildings. However personnel may have to venture outside in the event of equipment failure and could be exposed to flying debris
Environmental	Flying debris could puncture chemical tanks causing chemicals to leak into secondary containment or spray into the surrounding area and then into storm water drains. Chemicals would diluted by the storm water however environmental could still occur.
Operational ($/annum)	Based on these levels of water some critical assets (chemical storage, steam powered pumps, backwash) could be flooded. Therefore the purification process could shut down. 80% of the city would be without fresh water. Bottles would be given out but the impact would be high on the local economy
Direct ($/annum)	Damages would be limited but based on the total value of this asset impact is high

Measure Flood protection Carrollton WTP - Critical asset protection **SELECTED**

Total One-Time Cost	$ 3200000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 10000
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 5000000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Construct a surge / flood protection wall around some critical assets	One-time	3200000			3200000

Carrollton WTP Admin and Maint. buildings: Short Resilience Report

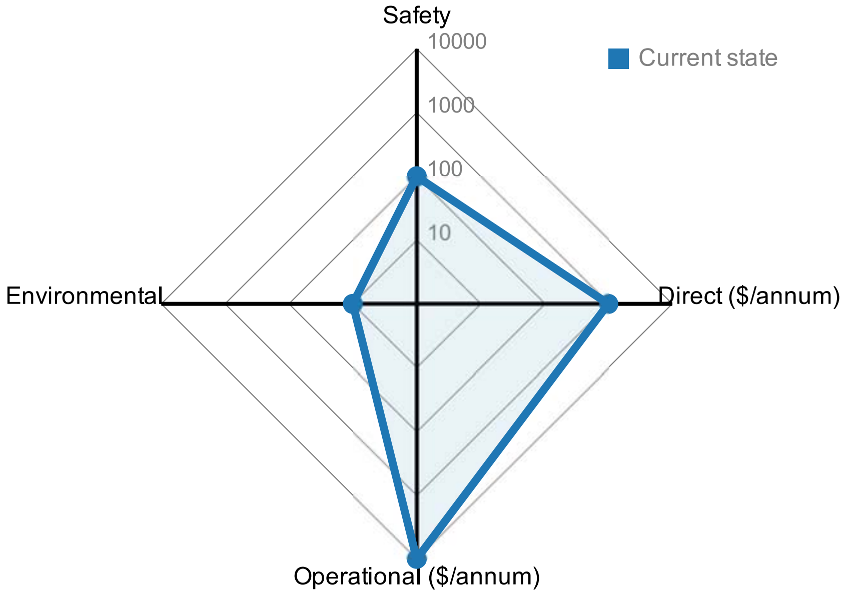
Location Description	8800 S Claiborne Avenue New Orleans 70118
Primary Function	To provide office space for all operations, engineering, maintenance management and laboratory personnel. In case of Hurricane, a crisis room is set up at the first floor of the Administration building
Context Information	All administration buildings, maintenance shop, welding shop and guard houses are at ground level. Based on FEMA &/or USACE scenarios, there is a little risk of flooding. But Swiss Re apparent flood levels stated as 2.5 feet to 5 feet. Based on Swiss Re scenario all ground level building and driveways could be flooded in an event resulting in no apparent access to these areas until flooding receded. No maintenance activities could be performed due to flooding of these areas. Except the administration building where a crisis room is set up in case of hurricane all other building are not considered as critical. Even if maintenance shop will have an impact on recovery time. Except in case of levee breach impact on the site would be limited. But area around the plant could be flooded. Only the Administrative building has been assessed
Full Replacement Cost	$ 205000000

Carrollton WTP Admin and Maint. buildings: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	This building is used in case of hurricane as crisis room.	H
Supply chain strength		H
Skills availability	No problem of skills currently. For crisis management, the problem is not the same as for operational activities. But recruitment process is clearly a weakness.	M
Ease of access	Plant would not be flooded but depending on the scenario access around the plant can be flooded	M
Documentation and procedures	Emergency Response Plan is well documented and tested	H
Flood protection	Crisis room is on the 1st floor. No risk of flooding	H
HAZMAT and Fire protection	Only fire extinghushers	M
Building code compliance		M
ARI		**0.852**

Threat: Events: 100 year return period

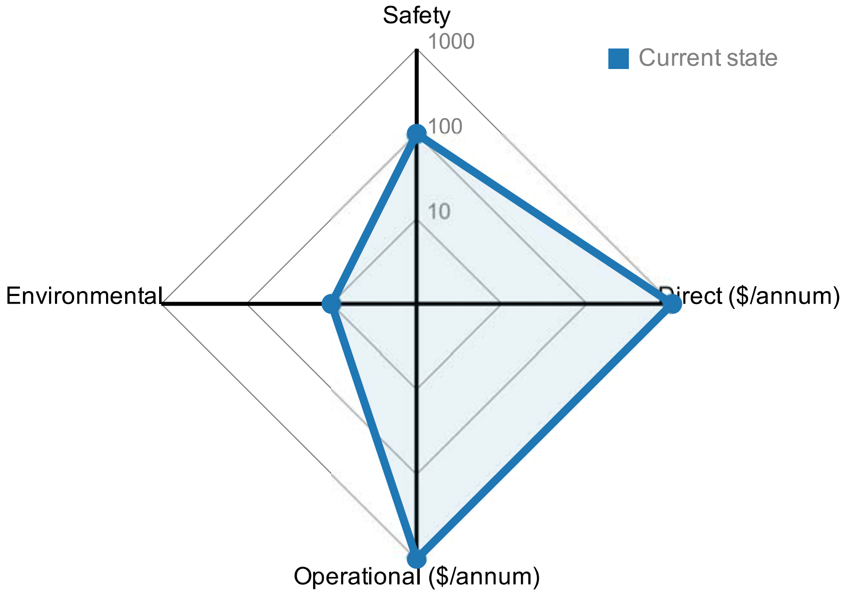
Comments	Low risk - Windows could blow to pieces as for the wind scenario
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	
Environmental	
Operational ($/annum)	Low impact on plant installations. However as city would be partially flooded water analysis should not be carried out
Direct ($/annum)	Damages to windows

Threat: Events: 500 year return period

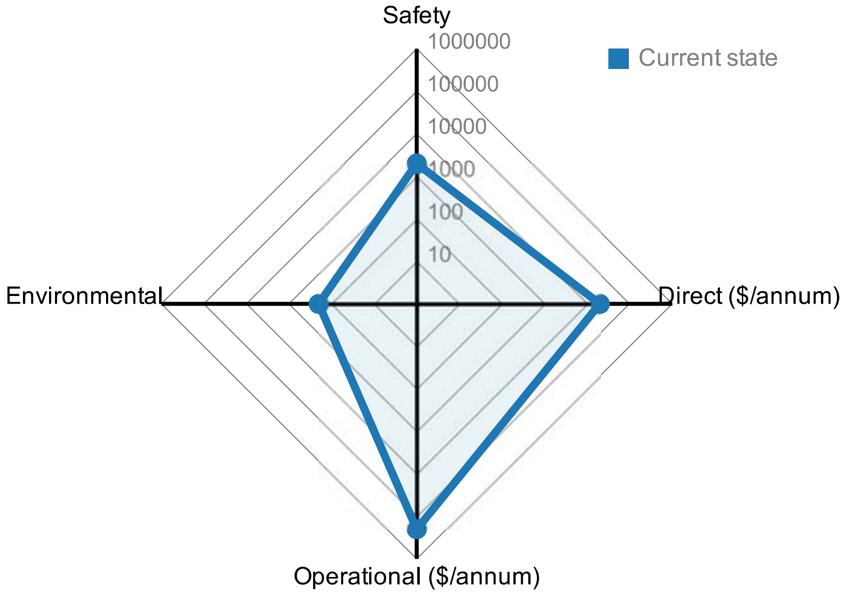
Comments	Low risk - Windows could blow to pieces
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	
Environmental	
Operational ($/annum)	Low impact on plant installations. However as city would be partially flooded water analysis should not be carried out
Direct ($/annum)	Damages to windows

Threat: Hurricane < 100 years - Wind

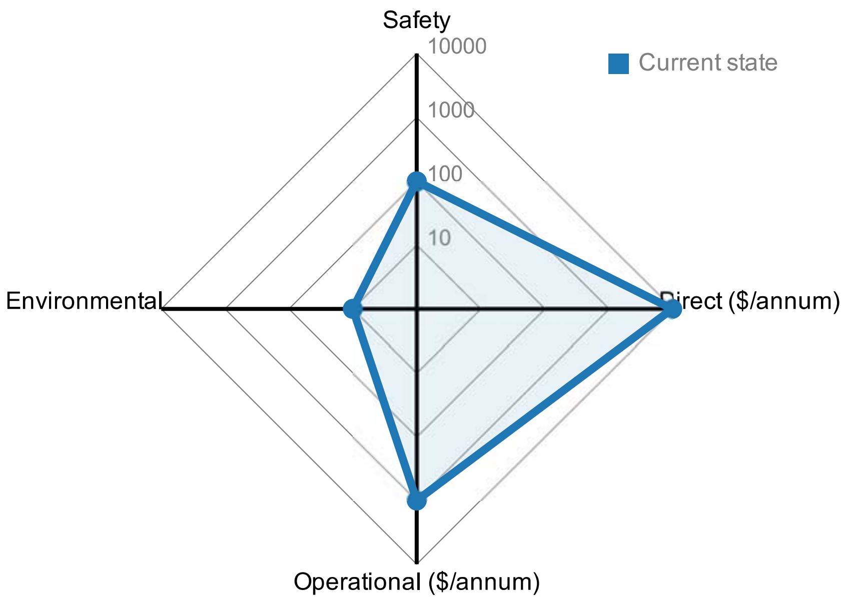
Comments	Windows could blow to pieces
Earliest Recovery of Function	
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	
Environmental	
Operational ($/annum)	This building has a limited impact on energy supply and drinking water treatment. The only issue would be water analysis which would be suspended during hurricanes
Direct ($/annum)	Damages to windows

Threat: Scenario: SR 100 years

Comments	According to SWB management there is no IT system at the ground floor. Building is elevated 2ft. So even if the ground floor was flooded impact would be limited and crisis management would not be affected
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 300000



Current Risk Type	Comments
Safety	
Environmental	
Operational ($/annum)	Low impact on plant installations. However as city would be partially flooded water analysis should not be carried out
Direct ($/annum)	Damages at ground level

Bacon Street River Intake and Pump Station: Short Resilience Report

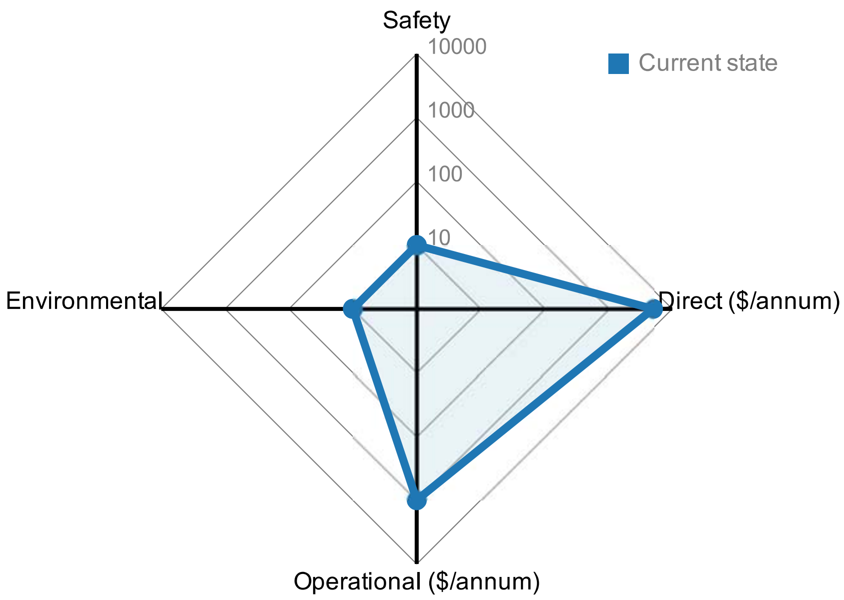
Location Description	Industrial Crescent, New Orleans, LA 70121
Primary Function	Supply river water for water production and pump to the Carrollton WTP. (Referred to as the new Pump Station.)
Context Information	One 72-inch river intake pipe goes over the levee and is protected by barges from river traffic. Manually-cleaned bar screen is provided at the intake pipe inlet to protect the pumps. Water sprayers are used to push oil spills away from intake pipe. Three vertical turbine pumps are used each with a VFD (speed control on rheostat on power panel). Three 70 mgd pumps providing a total pumping capacity of 210 mgd, firm capacity is 140 mgd (largest pump out of service). All pumps are 60 Hz using power from Entergy. Can run pumps on 60 Hz power from the Carrollton WTP. One operator mans the station 8 hours per day. The station is checked by operations in the evenings as needed. Two sets of discharge line route water from the station through the marsh to the Carrollton WTP. Two potable water booster pumps provide potable water to Oak Street and to Bacon Street river stations. No backup booster pumps are provided. Can draw potable water from Jefferson Parish for Bacon Street station if needed.
Full Replacement Cost	$ 12000000

Bacon Street River Intake and Pump Station: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Firm capacity meets about 1/2 design plant capacity with largest pump out of service. Only one intake pipe to river at this station. Backup provided by Oak Street station.	H
Supply chain strength	Aging equipment give cause for concern due to long lead times in either procuring parts or manufacturing parts internally.	L
Skills availability	Lack of staffing continues to be a major issue	L
Ease of access	Easy access from normal traffic streets, however streets could be prone to flooding	M
Documentation and procedures	No documented SOPs, procedures, O&M manuals.	L
Flood protection	Entire station is raised above flood level on the river levee.	H
HAZMAT and Fire protection	Hand held fire exstinguishers	L
Building code compliance	Building storm hardening after Katrina	M
ARI		**0.629**

Threat: Events: 100 year return period

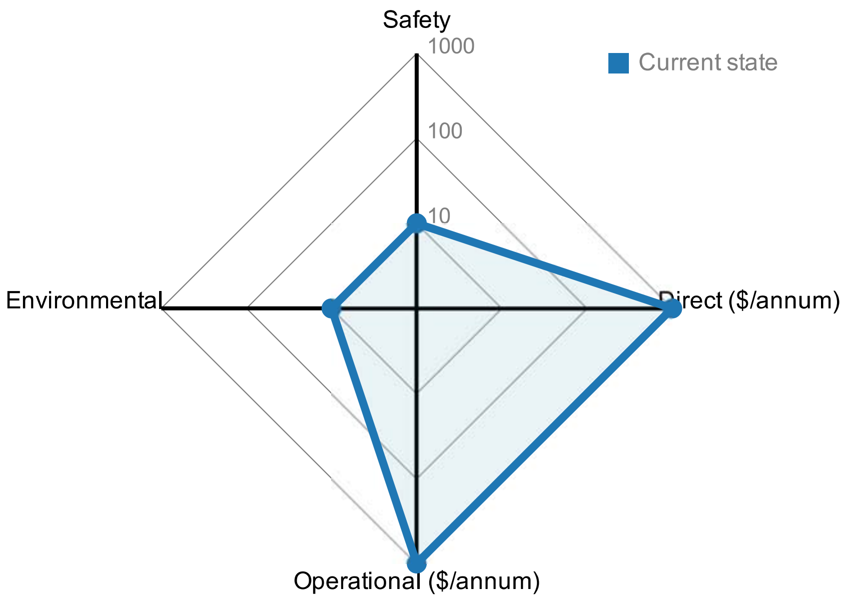
Comments	Pump Station is above the river levee elevation and would NOT likely be flooded in an event. Access to the station would be limited to boat traffic only in a flood event.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	Building has been storm proofed. Minor risk to personnel
Environmental	No damage to the environment
Operational ($/annum)	Pump station would operate as normal on emergency power from Carrollton WTP
Direct ($/annum)	Localized flood or wind damage

Threat: Events: 500 year return period

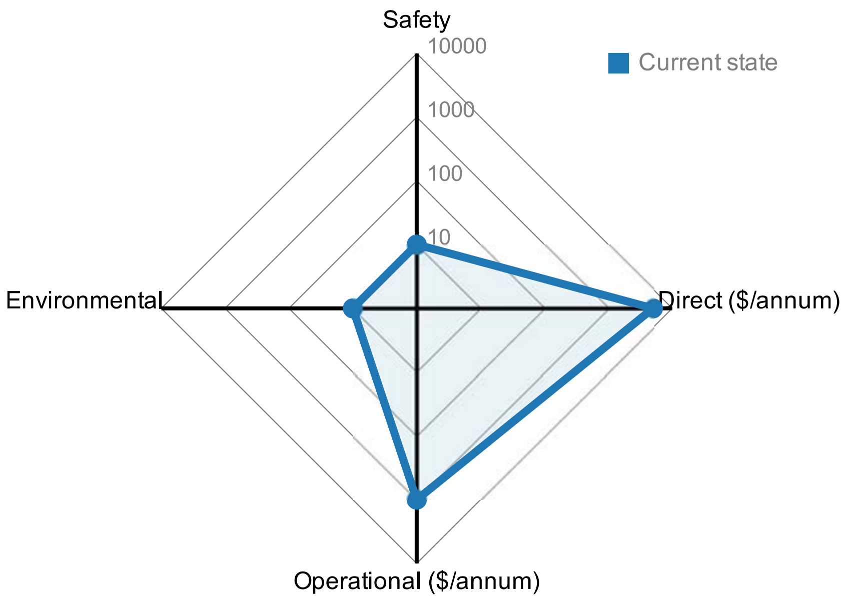
Comments	Major hurricane, wind speeds could reach 130 mph. causing possible damage to the buildings specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Emergency generator would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	Building has been storm proofed including reinforcing roofs, windows and doors reducing risk to personnel
Environmental	No damage to the environment
Operational ($/annum)	Pump station is above river levee and should operate as normal
Direct ($/annum)	Localized flood damage and may occur

Threat: Hurricane < 100 years - Wind

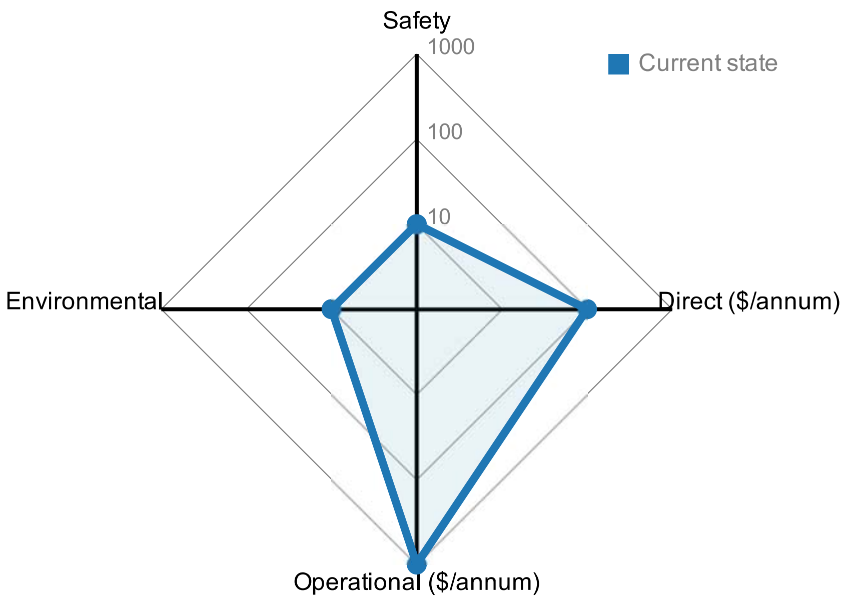
Comments	Major hurricane, wind speeds could reach 120 mph. causing possible damage to the buildings specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Emergency CT generator would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	Comments
Safety	Building windows and doors secured during storm events reduces risk to personnel
Environmental	No damage to the environment
Operational ($/annum)	Pump station would operate as normal
Direct ($/annum)	Localized minor wind or flood damage

Threat: Scenario: SR 100 years

Comments	Pump Station is above the river levee elevation and would NOT likely be flooded in an event. Access to the station would be limited to boat traffic only in a flood event.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	Building has been storm proofed. Minor risk to personnel
Environmental	No damage to the environment
Operational ($/annum)	Pump station would operate as normal on emergency power from Carrollton WTP
Direct ($/annum)	Localized flood or wind damage

Ammonia Storage/Feed System: Short Resilience Report

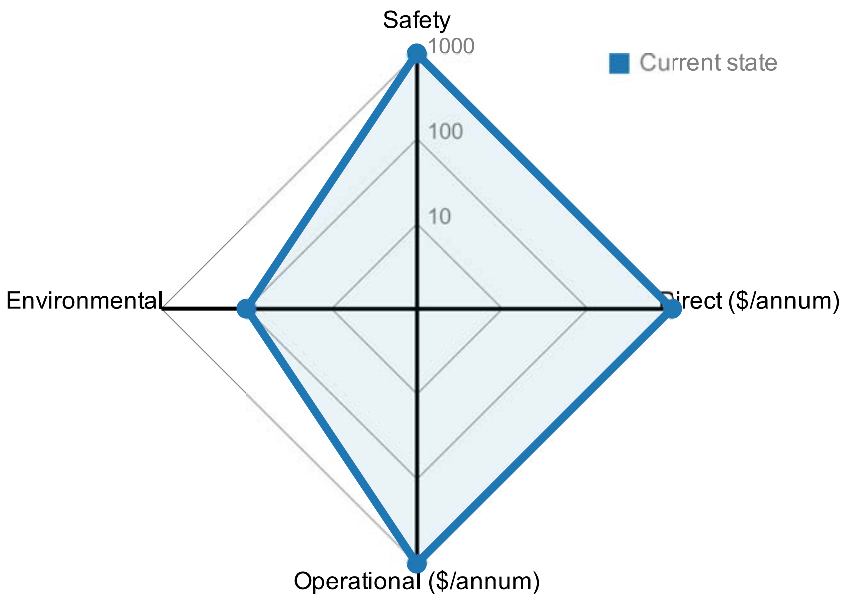
Location Description	8800 S Claiborne Avenue New Orleans 70118
Primary Function	Storage and application of ammonia for chloramination of the drinking water
Context Information	10,000 pounds storage of anhydrous ammonia feeds the ammonia building. Ammonia gas is then fed through the ammonia feeders to the application point in the channel between the sedimentation basins and the chlorine contact basins. Apparent 500 pounds per day feed rate provides about 20 days storage. Ten States Standards recommends 30 days storage for all critical chemicals. Ammonia feed is critical and needed for CT compliance, residual maintenance in system, and THM minimization. Liquid ammonia (possibly ammonium sulfate (LAS) is being considered for future use in chloramination to replace the anhydrous system.
Full Replacement Cost	$ 1000000

Ammonia Storage/Feed System: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	20 days storage does not meet Ten States Standards	M
Supply chain strength	Difficulty getting deliveries from long distance (Dallas, St. Louis, Florida)	L
Skills availability	Current skillsets are good, however there are concerns about an aging workforce and transfer of skills.	L
Ease of access	Easy access through treatment plant and to delivery point near the storage tank	H
Documentation and procedures	No documented SOPs, O&M manuals, procedures. Have a documented Risk Management Plan and recent updates conducted by Environmental Affairs Department for SWBNO.	L
Flood protection	Elevated above ground level by about 4 feet.	L
HAZMAT and Fire protection	All chemicals have secondary containment in the event of spills.	M
Building code compliance		L
ARI		**0.556**

Threat: Events: 100 year return period

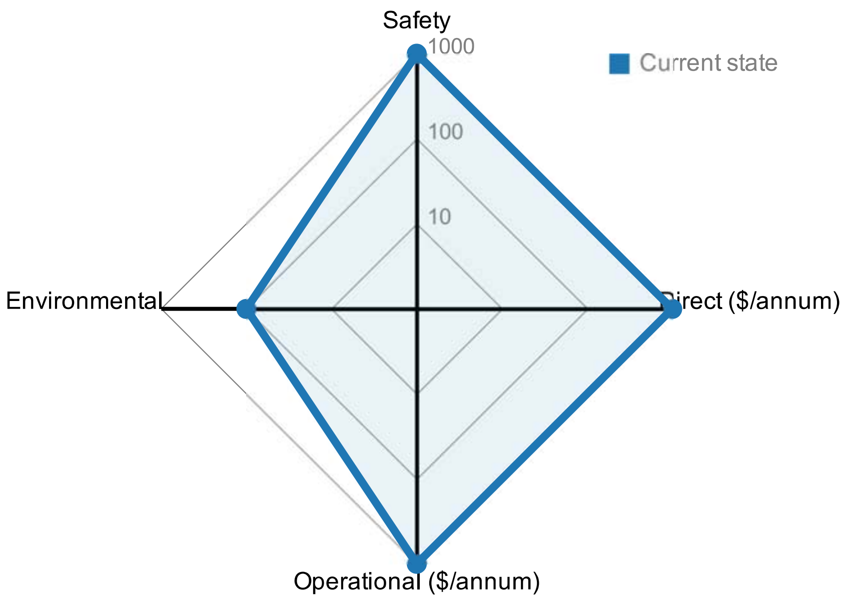
Comments	No risk of flooding according to FEMA's scenario
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 20000



Current Risk Type	**Comments**
Safety	Pressurized gas and normal safety protocols. Toxic gas in case of inhalation. Very corrosive gas. But in case of hurricane people would stay inside buildings
Environmental	Very low risk
Operational ($/annum)	Due to wind a flying piece could break a pipe. Unlikely to occur
Direct ($/annum)	Damages would be very low

Threat: Events: 500 year return period

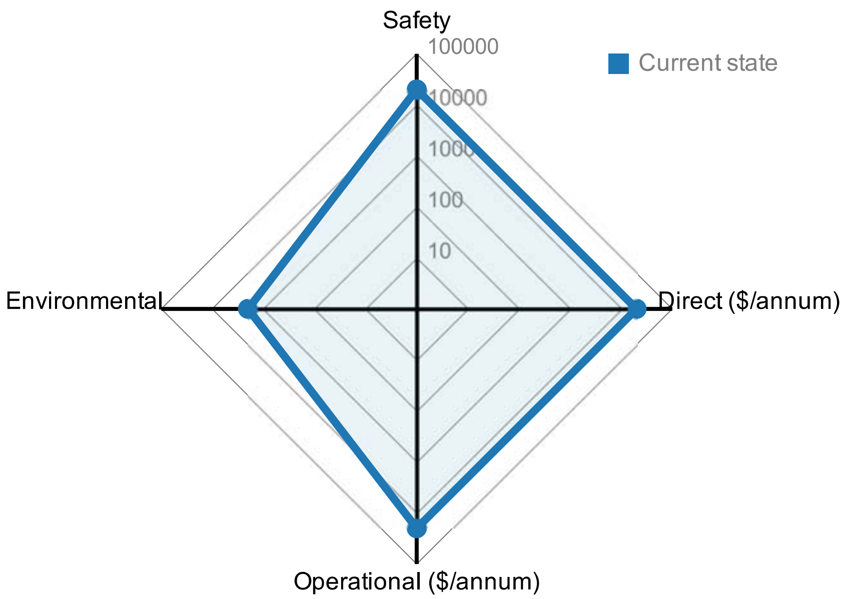
Comments	No risk of flooding according to FEMA's scenario
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 20000



Current Risk Type	**Comments**
Safety	Same as events: 100 year return period
Environmental	Same as events: 100 year return period
Operational ($/annum)	Same as events: 100 year return period
Direct ($/annum)	Same as events: 100 year return period

Threat: Hurricane < 100 years - Wind

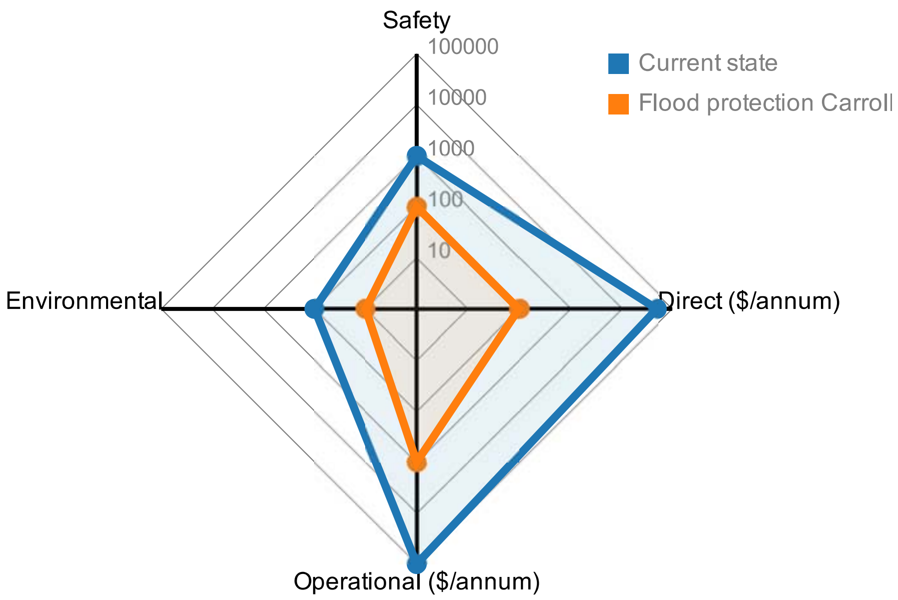
Comments	Currently risk of failure is low. But in case of hurricanes and due to wind speed it is likely to have flying pieces
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 20000



Current Risk Type	Comments
Safety	Pressurized gas and normal safety protocols. Toxic gas in case of inhalation. Very corrosive gas. Unloading process is one of the most hazardous process. Nobody from the SWB attends the unloading. Valves and safety devices are controlled
Environmental	The substance is biodegradable. Unlikely to persist. Toxic to aquatic life. Risk long term impact of a pollution is low
Operational ($/annum)	Flying pieces could break a pipe.
Direct ($/annum)	In case of leak could cause corrosion but damages would be limited

Threat: Scenario: SR 100 years

Comments	Based on Swiss Re 100 year scenarion apparent flood levels stated as 2.5 feet to 5 feet. With this level of water some parts of the facility would be affected
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 30000



Current Risk Type	**Comments**
Safety	Pressurized gas and normal safety protocols. Toxic gas in case of inhalation. Very corrosive gas. In case of a hurricane, staff should stay inside except to maintain or control some parts of the process
Environmental	Consequences in case of leak would be low
Operational ($/annum)	Pumps could be flooded. A process shutdown could occur. Impact on citizen would be limited but more than 50% of the city could affected
Direct ($/annum)	Damages would be limited to pumps

Measure Flood protection Carrollton WTP - Critical asset protection SELECTED

Total One-Time Cost	$ 3200000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 100
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 0

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Construct a surge / flood protection wall around some critical assets	One-time	3200000			3200000

Ferric Sulfate Storage/Feed System: Short Resilience Report

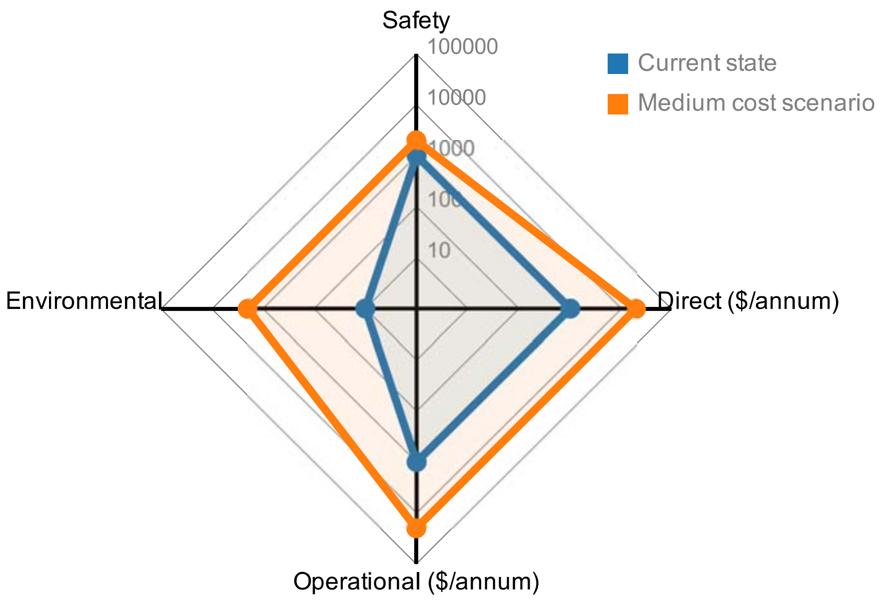
Location Description	8800 S Claiborne Avenue New Orleans 70118
Primary Function	Store and feed of ferric sulfate for primary coagulation.
Context Information	Two 8,000 gallon storage tanks with spill containment and two 10,000 gallon storage tanks with temporary spill containment provided (36,000 gallons total storage). Apparent storage capacity is about 10 days with 3,600 gpd consumption. Ferric sulfate supplied to the ferric feed building adjacent to storage. Building sets inside spill containment wall. Four ferric feed pumps provided to apply ferric sulfate to the static mixers at the beginning of each floc/sed basin for primary coagulation. Were within 10 hours of depleting coagulant storage during Katrina. During and after a hurricane consumption could increase due to the quality of influent
Full Replacement Cost	$ 1000000

Ferric Sulfate Storage/Feed System: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Redundant storage and feed pumps based on current water demands, only 10 days storage based on coagulant consumption.	M
Supply chain strength	Deliveries come long distance to treatment plant (Dallas, St. Louis, Florida) and deliveries have been problematic.	L
Skills availability	Current skillsets are good, however there are concerns about an aging workforce and transfer of skills.	M
Ease of access	Easy access to treatment plant and to storage facilities. But roads around the plant could be flooded	M
Documentation and procedures	No documented SOPs, O&M manuals, operations.	L
Flood protection	Spill containment wall could protect from most of the events. This plant is protected by levees as well	H
HAZMAT and Fire protection	Spill containment - No risk of fire	H
Building code compliance		L
ARI		**0.663**

Threat: Events: 100 year return period

Comments	This equipment is protected by levees and spill containment - According to FEMA the plant would not be flooded
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 10000



Current Risk Type	Comments
Safety	Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Personnel could be injured or seriously hurt by flying objects.
Environmental	Very low risk
Operational ($/annum)	Shutdown very unlikely
Direct ($/annum)	Wind damages only

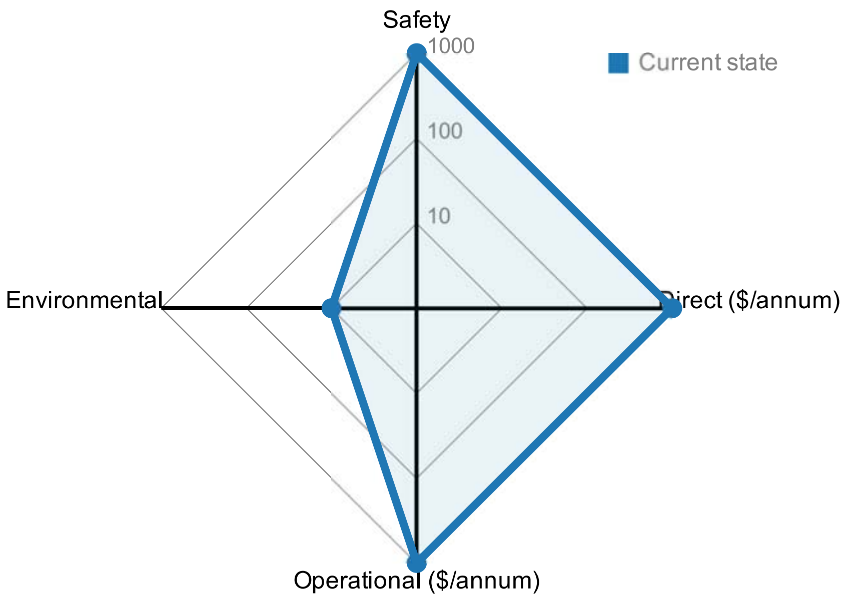
Measure Medium cost scenario

Total One-Time Cost	$ 0
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	
Earliest Recovery of Function	
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost

Threat: Events: 500 year return period

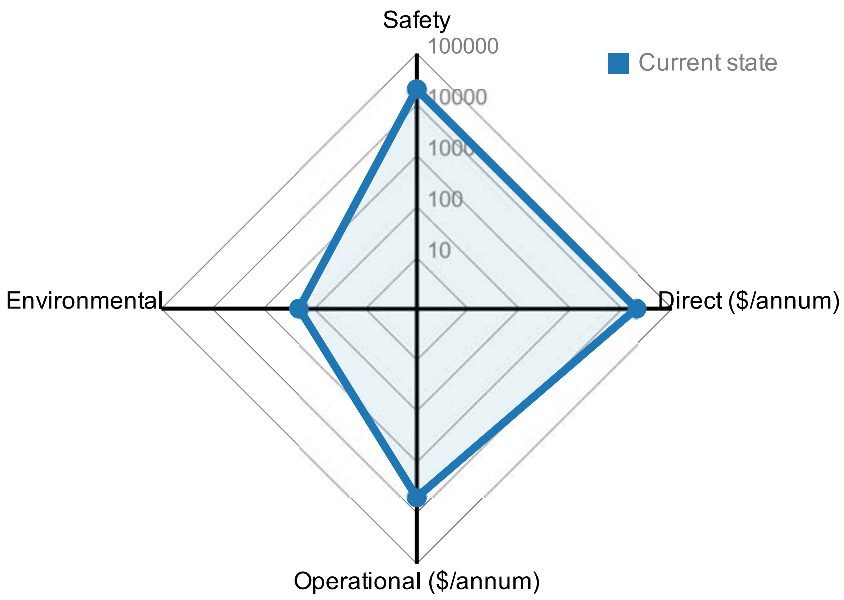
Comments	This equipment is protected by levees and spill containment - According to FEMA and USACE the plant would not be flooded - Risks are quite the same as "Events: 100 year period" except wind speed which should be higher
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 10000



Current Risk Type	Comments
Safety	
Environmental	
Operational ($/annum)	
Direct ($/annum)	

Threat: Hurricane < 100 years - Wind

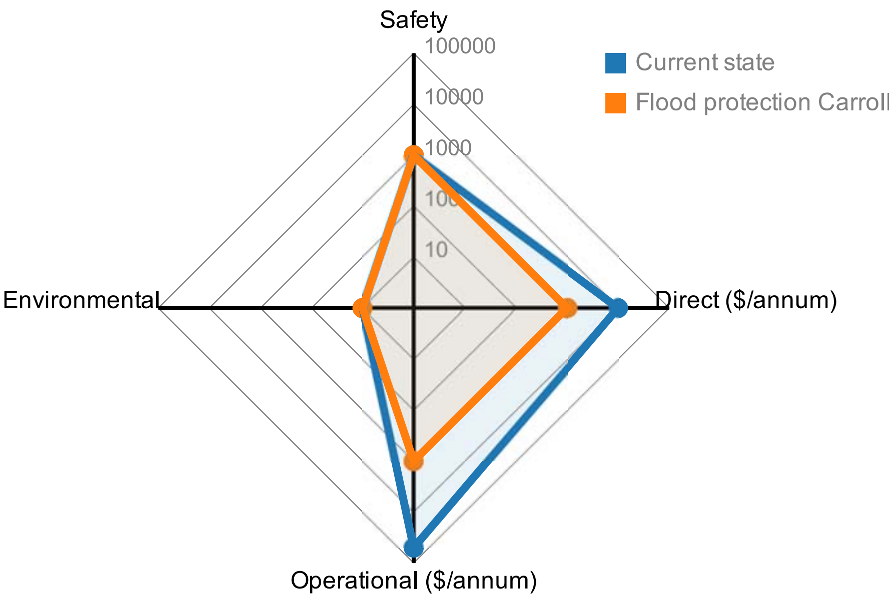
Comments	Winds would have a limited impact on this equipment
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 15000



Current Risk Type	**Comments**
Safety	Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Personnel could be injured or seriously hurt by flying objects.
Environmental	Low risk due to spill containment
Operational ($/annum)	Wind should not affect this equipment. Flying pieces could break a pipe but this is very unlikely
Direct ($/annum)	Flying pieces could cause damages

Threat: Scenario: SR 100 years

Comments	Swiss Re apparent flood levels stated as 2.5 feet to 5 feet. Spill containment walls surrounding storage tanks and feed building appear to be about 5 feet above ground level. May not be impacted by flooding.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 100000



Current Risk Type	**Comments**
Safety	Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. Personnel could be injured or seriously hurt by flying objects.
Environmental	Limited impact
Operational ($/annum)	Storage capacity is limited to 10 days - flooding impact would be limited on the equipment but the area around would be flooded and access would be limited
Direct ($/annum)	

Measure Flood protection Carrollton WTP - Critical asset protection **SELECTED**

Total One-Time Cost	$ 3200000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 100
Earliest Recovery of Function	0
Repair and recommissioning cost	$ 10000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Construct a surge / flood protection wall around some critical assets	One-time	3200000			3200000

Fluoride Storage/Feed System: Short Resilience Report

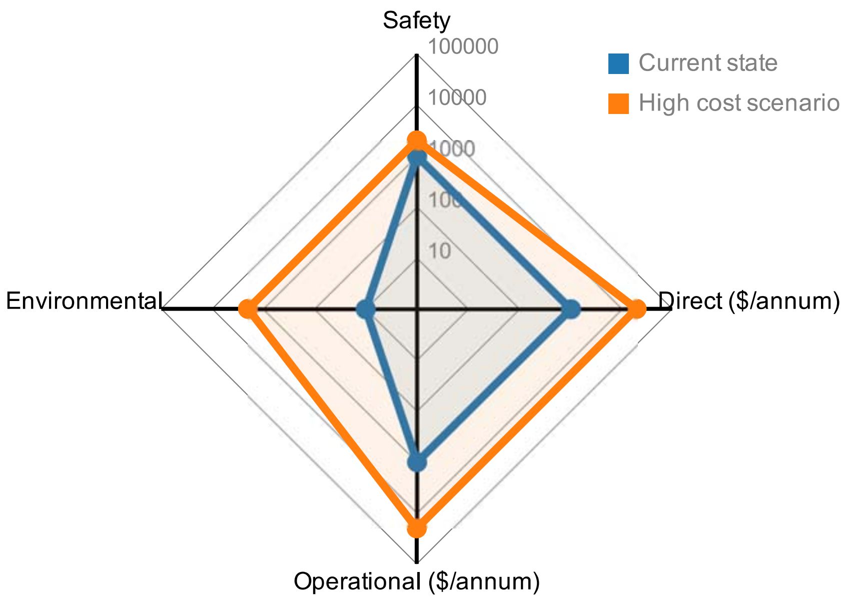
Location Description	8800 S Claiborne Avenue New Orleans 70118
Primary Function	Store and feed hydrofluorosilicic acid (liquid fluoride) for water production and tooth decay.
Context Information	One 9,000 gallon storage tank without spill containment feeds liquid to the fluoride feed pumps near the coagulant storage tanks. Apparent 20 days capacity at 450 gpd consumption. Four fluoride feed pumps apply fluoride to the chlorine contact tanks effluent. One supply line to each contact tank. Pumps are inside a concrete building
Full Replacement Cost	$ 500000

Fluoride Storage/Feed System: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Only one storage tank and 20 days storage capacity.	L
Supply chain strength	Chemical deliveries come from long distance to the treatment plant (Dallas, St. Louis, Florida).	M
Skills availability	Current skillsets are good, however there are concerns about an aging workforce and transfer of skills.	L
Ease of access	Facility easy to access but road around the plant could be flooded	M
Documentation and procedures	No documented SOPs, O&M manuals, operations.	L
Flood protection	Bottom of the equipment is around 1 ft elevated but pumps are around 3 ft	M
HAZMAT and Fire protection	Ground of the building where are pumps has been designed as a spill containment	M
Building code compliance		L
ARI		**0.554**

Threat: Events: 100 year return period

Comments	No flood risk according to FEMA
Earliest Recovery of Function	0.5 days
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	Corrosive and toxic product - may cause severe irritation
Environmental	In case of leak damages would be limited
Operational ($/annum)	Minor risk of process shutdown in case of wind
Direct ($/annum)	Only potential damages due to wind

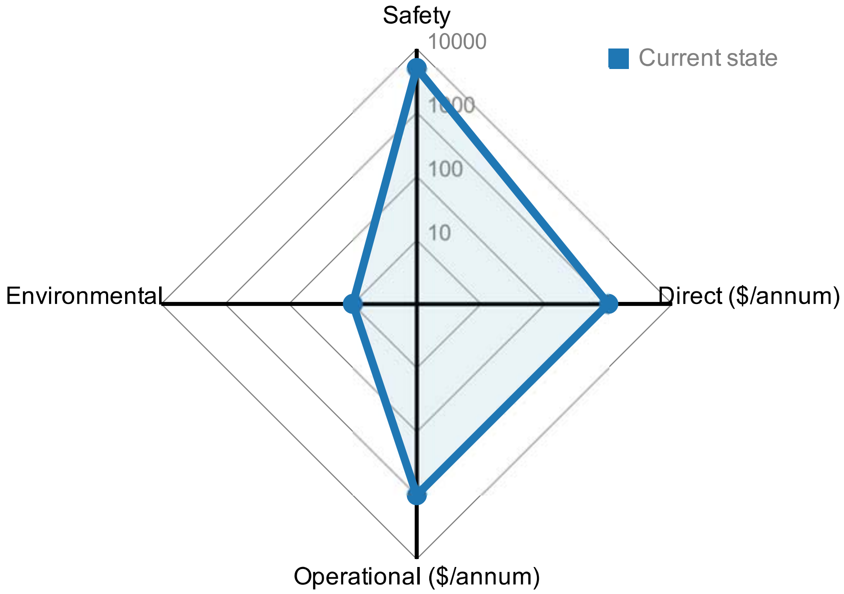
Measure High cost scenario

Total One-Time Cost	$ 0
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	
Earliest Recovery of Function	
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost

Threat: Events: 500 year return period

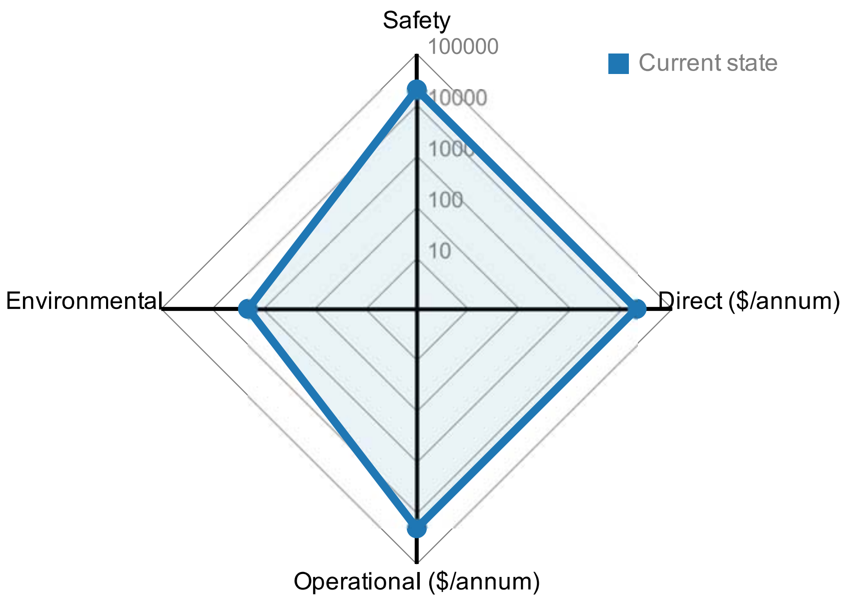
Comments	No flood risk according to FEMA and USACE
Earliest Recovery of Function	0.5 days
Repair and recommissioning cost	



Current Risk Type	Comments
Safety	Corrosive and toxic product - may cause severe irritation
Environmental	In case of leak damages would be limited
Operational ($/annum)	Minor risk of process shutdown in case of wind
Direct ($/annum)	Only potential damages from wind

Threat: Hurricane < 100 years - Wind

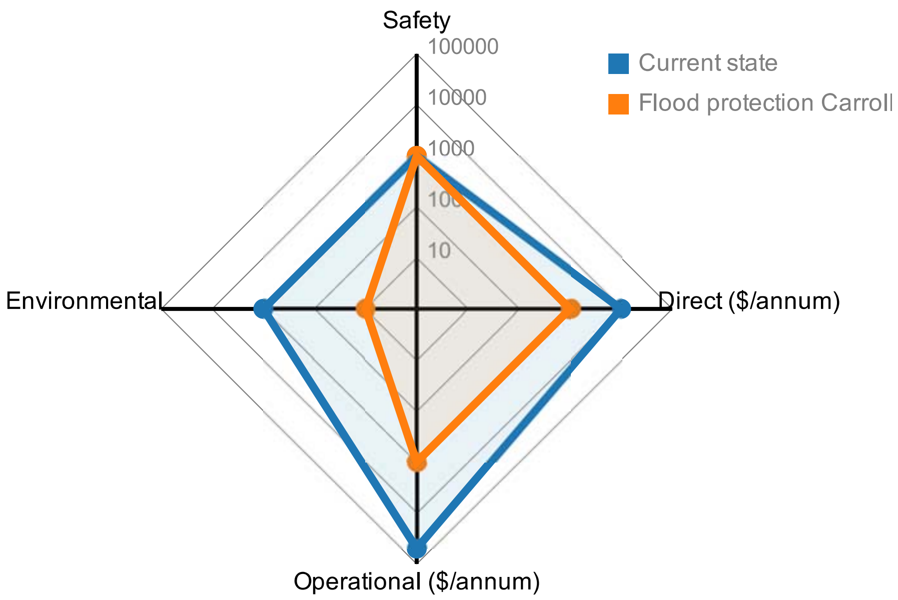
Comments	Wind speeds could reach more than 105 mph causing very minor damage to the concrete building
Earliest Recovery of Function	0.5 days
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	Corrosive and toxic product - may cause severe irritation
Environmental	In case of leak damages would be limited
Operational ($/annum)	Minor risk of process shutdown in case of wind
Direct ($/annum)	Damages would be very low

Threat: Scenario: SR 100 years

Comments	Swiss Re apparent flood levels stated as 2.5 feet to 5 feet. Fluoride fill pipe would be flooded not allowing deliveries. Fluoride feed pumps would be flooded and inoperable.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 200000



Current Risk Type	**Comments**
Safety	Corrosive and toxic product - may cause severe irritation
Environmental	As the feed pumps could be flooded we could expect a local pollution
Operational ($/annum)	A process disruption would occur
Direct ($/annum)	40% of the asset value could be affected

Measure Flood protection Carrollton WTP - Critical asset protection **SELECTED**

Total One-Time Cost	$ 3200000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 100
Earliest Recovery of Function	
Repair and recommissioning cost	$ 10000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Construct a surge / flood protection wall around some critical assets	One-time	3200000			3200000

Lime Storage/Feed System: Short Resilience Report

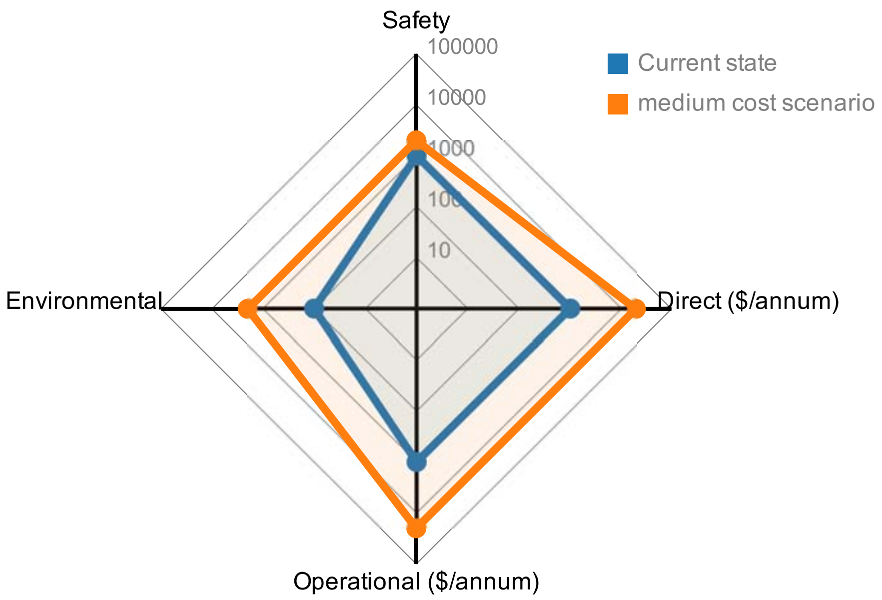
Location Description	8800 S Claiborne Avenue New Orleans 70118
Primary Function	Store, slake, and prepare lime solution for pH adjustment and corrosion control.
Context Information	Three concrete lime silos in chemical building adjacent to floc/sed basins. Total storage capacity of 1,600 tons of pebble lime. Apparent lime usage 22,500 pounds per day providing 142 days of storage. Lime delivered in rail cars to river and transported to treatment plant using mobile train car at the treatment plant site. Unloaded pneumatically to silos. Lime silo sets above each lime slaker used to make lime slurry. Slurry made into solution at each solution box. Solution boxes discharge into lime solution pit below slakers and is pumped to the feed point. three solution pumps draw fro solution pit pump through solution lines to the sedimentation basin effluent for pH adjustment. Some pumps and solution lines are abandoned in place.
Full Replacement Cost	$ 40000000

Lime Storage/Feed System: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Redundant storage and feed systems, very high storage capacity.	H
Supply chain strength	Deliveries come a long distance to the treatment plant (Dallas, St. Louis, Florida)	M
Skills availability	Current skillsets are good, however there are concerns about an aging workforce and transfer of skills.	M
Ease of access	Significant handling and preparation to make lime solution.	M
Documentation and procedures	No documented SOPs, O&M manuals, operations.	L
Flood protection	Low protection inside building	L
HAZMAT and Fire protection	Low risk	H
Building code compliance		L
ARI		**0.666**

Threat: Events: 100 year return period

Comments	Based on FEMA's scenario building is protected by the levees for a 100 year event - No more risk than for wind scenario
Earliest Recovery of Function	1 days
Repair and recommissioning cost	$ 70000



Current Risk Type	Comments
Safety	Contact can cause irritation to eyes,skin, respiratory system
Environmental	This material is alkaline and if released into water or moist soil will cause an increase in pH
Operational ($/annum)	Very minor impact
Direct ($/annum)	Only damages due to wind

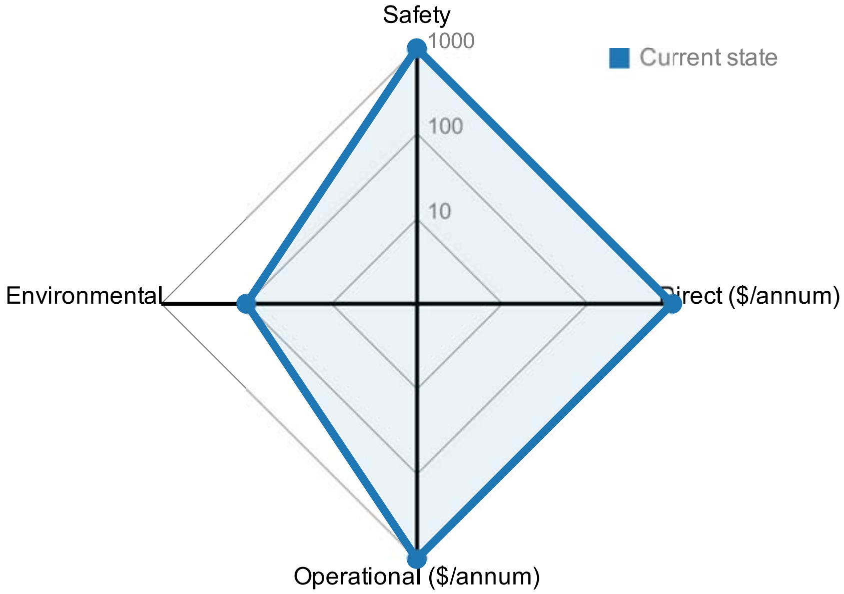
Measure medium cost scenario

Total One-Time Cost	$ 0
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	
Earliest Recovery of Function	
Repair and recommissioning cost	

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**

Threat: Events: 500 year return period

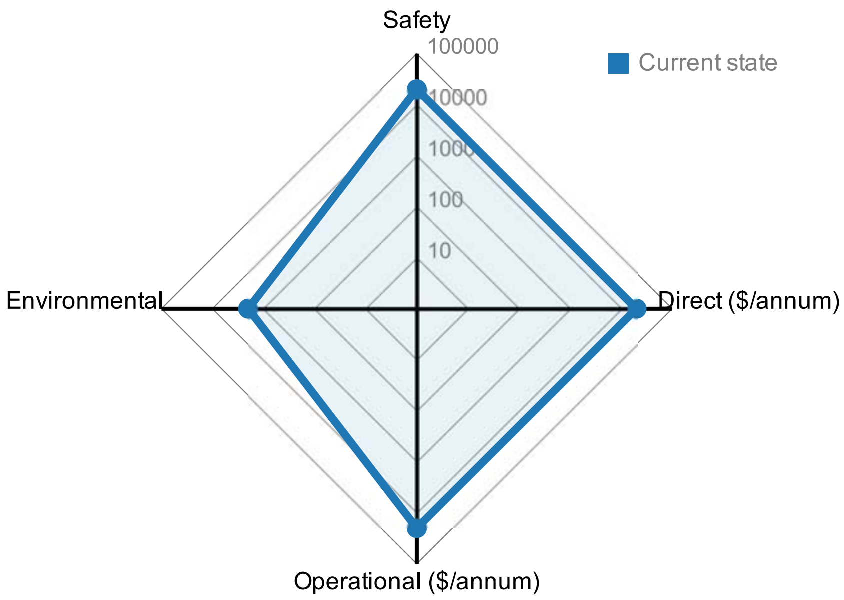
Comments	Based on FEMA's scenario building is protected by the levees for a 500 year event - No risk based on USACE for a 500 year return period event - No more risk than for wind scenario
Earliest Recovery of Function	1 days
Repair and recommissioning cost	$ 70000



Current Risk Type	**Comments**
Safety	Contact can cause irritation to eyes,skin, respiratory system
Environmental	This material is alkaline and if released into water or moist soil will cause an increase in pH
Operational ($/annum)	Very minor impact
Direct ($/annum)	Only potential damages due to wind

Threat: Hurricane < 100 years - Wind

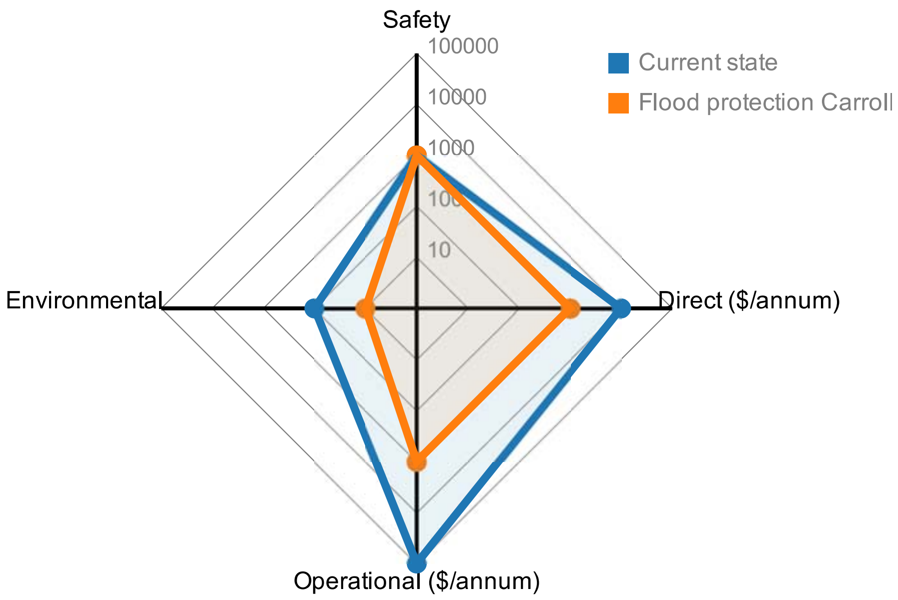
Comments	Equipment is inside a building - windows of the building could blow up but with minor damages to the process
Earliest Recovery of Function	1 days
Repair and recommissioning cost	$ 70000



Current Risk Type	**Comments**
Safety	Contact can cause irritation to eyes,skin, respiratory system
Environmental	This material is alkaline and if released into water or moist soil will cause an increase in pH
Operational ($/annum)	Very minor risk of process shutdown due to wind
Direct ($/annum)	Minor damages

Threat: Scenario: SR 100 years

Comments	Swiss Re apparent flood levels stated as 2.5 feet to 5 feet. Lime storage silos and slakers are about 8 feet above ground level. May not be impacted by flooding. Lime slurry pit and slurry pumps are at ground level and would become inoperable due to flooding. This would prevent lime feed into the water for treatment and lead to violation of corrosion control treatment requirements.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 400000



Current Risk Type	Comments
Safety	Flood would not increase considerably the risk
Environmental	We could have a risk of local pollution
Operational ($/annum)	In case of flooding, SWB would be obliged to stop water treatment and water distribution
Direct ($/annum)	Expected loss around 10% of the asset value

Measure Flood protection Carrollton WTP - Critical asset protection **SELECTED**

Total One-Time Cost	$ 3200000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 100
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 200000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Construct a surge / flood protection wall around some critical assets	One-time	3200000			3200000

Sodium Hypochlorite Storage/Feed System: Short Resilience Report

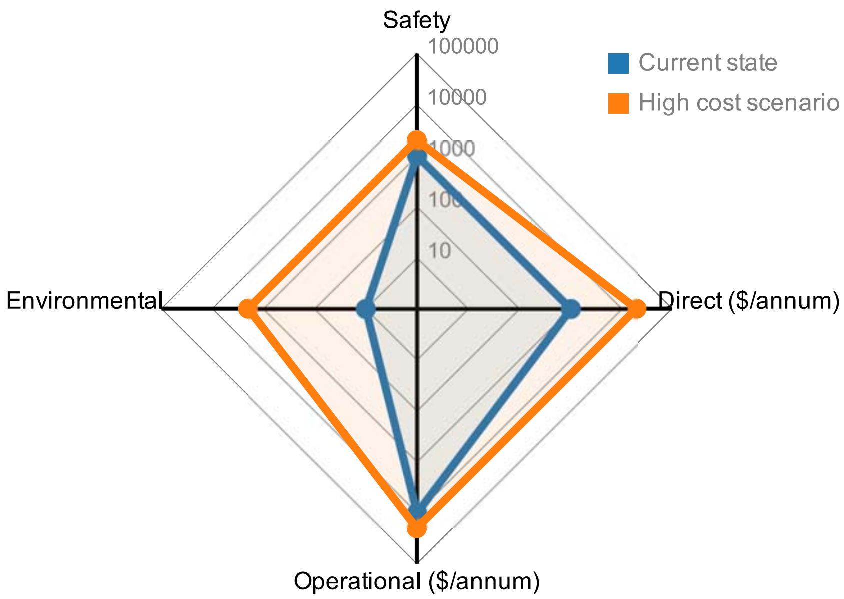
Location Description	8800 S Claiborne Avenue New Orleans 70118
Primary Function	Storage and feed of liquid sodium hypochlorite for primary disinfection.
Context Information	Eight 15,000 gallon storage tanks with fill station, level sensors, and overhead roof structure supplying liquid hypochlorite to the feed pumps in the building adjacent to the storage facility. Usually fill half of he tanks to reduce off-gassing and thermal degradation. Can easily top off all storage tanks in the event of a pending hurricane. hypochlorite feed to the sedimentation basin effluent for primary disinfection. Apparent maximum storage capacity 20 days assuming 6,000 gallons per day consumption.
Full Replacement Cost	$ 3000000

Sodium Hypochlorite Storage/Feed System: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Redundant tanks available, but storage capacity limited to 20 days at current water demands.	M
Supply chain strength	Hypochlorite deliveries can be readily made to top off the storage tanks in the event of a pending hurricane.	H
Skills availability	Current skillsets are good, however there are concerns about an aging workforce and transfer of skills.	L
Ease of access	Easy access the storage and feed facility from ground level.	H
Documentation and procedures	No documented SOPs, O&M manuals, procedures.	L
Flood protection	Building is 3 ft elevated	M
HAZMAT and Fire protection	Tanks and all the facility is on a spill containment - No risk of fire	H
Building code compliance	Newly built	M
ARI		**0.740**

Threat: Events: 100 year return period

Comments	No flood risk according to FEMA - Only wind impact
Earliest Recovery of Function	1 days
Repair and recommissioning cost	$ 100000



Current Risk Type	**Comments**
Safety	Very hazardous in case of skin or eye contact and in case of ingestion - In case of hurricane staff should remain inside building
Environmental	All the facility is on a spill containment - limited risk of pollution
Operational ($/annum)	Minor risk of disruption
Direct ($/annum)	Only damages due to wind

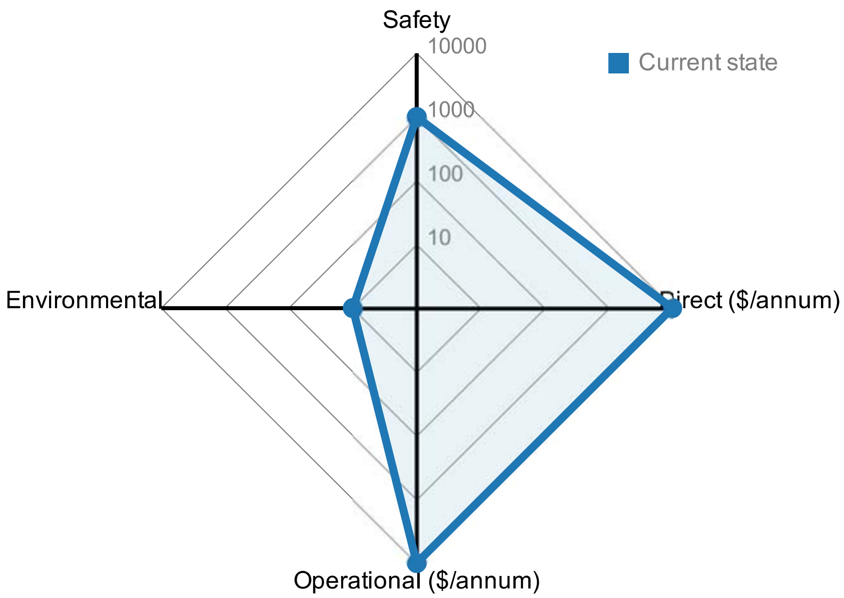
Measure High cost scenario

Total One-Time Cost	$ 0
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	
Earliest Recovery of Function	0
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost

Threat: Events: 500 year return period

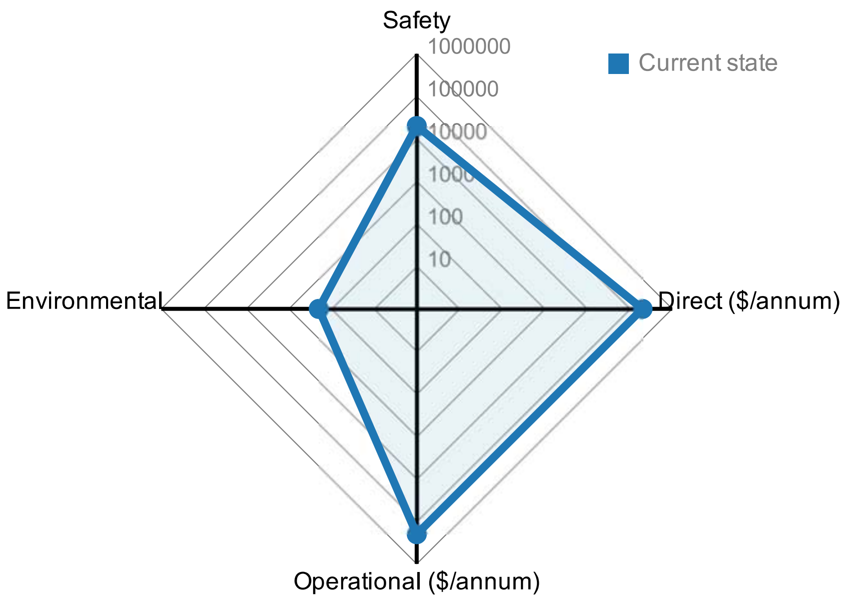
Comments	No flood risk according to FEMA and USACE
Earliest Recovery of Function	1 days
Repair and recommissioning cost	$ 300000



Current Risk Type	Comments
Safety	Very hazardous in case of skin or eye contact and in case of ingestion - In case of wind staff should remain inside building
Environmental	All the facility is on a spill containment - limited risk of pollution
Operational ($/annum)	Minor risk of disruption
Direct ($/annum)	Only damages due to wind

Threat: Hurricane < 100 years - Wind

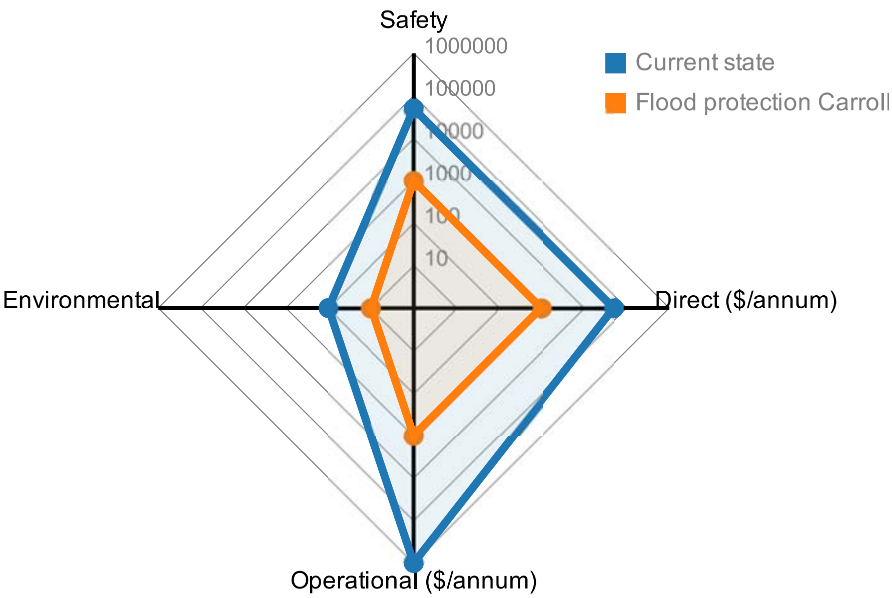
Comments	Tanks are under a metallic roof and pumps are inside a concrete building
Earliest Recovery of Function	1 days
Repair and recommissioning cost	$ 100000



Current Risk Type	**Comments**
Safety	Very hazardous in case of skin or eye contact and in case of ingestion
Environmental	All the facility is on a spill containment - limited risk of pollution
Operational ($/annum)	Flying metallic panel could break a pipe - but this risk is low - Pumps are inside a concrete building - So minor risk in case of wind
Direct ($/annum)	Wind could damage the roof

Threat: Scenario: SR 100 years

Comments	Swiss Re apparent flood levels stated as 2.5 feet to 5 feet. The hypochlorite storage tanks and fill lines are about 5 feet above ground level and may not be impacted during a flood event. The hypochlorite feed building and feed pumps are about 1.5 feet above ground level and could be flooded during an event. This would prevent the feed of hypochlorite for disinfection leading to violations of the surface water treatment rules, disinfection retirements, and residual maintenance, requirements.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 800000



Current Risk Type	Comments
Safety	In case of flooding water would not be treated and water would not be distributed to public - Risk for sensitive people - Suspension of operating permit - But if Carrollton is flooded most of East bank would be flooded
Environmental	A local pollution could occur but due to dilution this one would be limited
Operational ($/annum)	Process disruption would occur with an impact on more than 50% of the city - Economy would be impacted
Direct ($/annum)	25% of the asset value could be impacted

Measure Flood protection Carrollton WTP - Critical asset protection **SELECTED**

Total One-Time Cost	$ 3200000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 100000
Earliest Recovery of Function	
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Construct a surge / flood protection wall around some critical assets	One-time	3200000			3200000

Backwash Equalization Tank and Recycle Pumps: Short Resilience Report

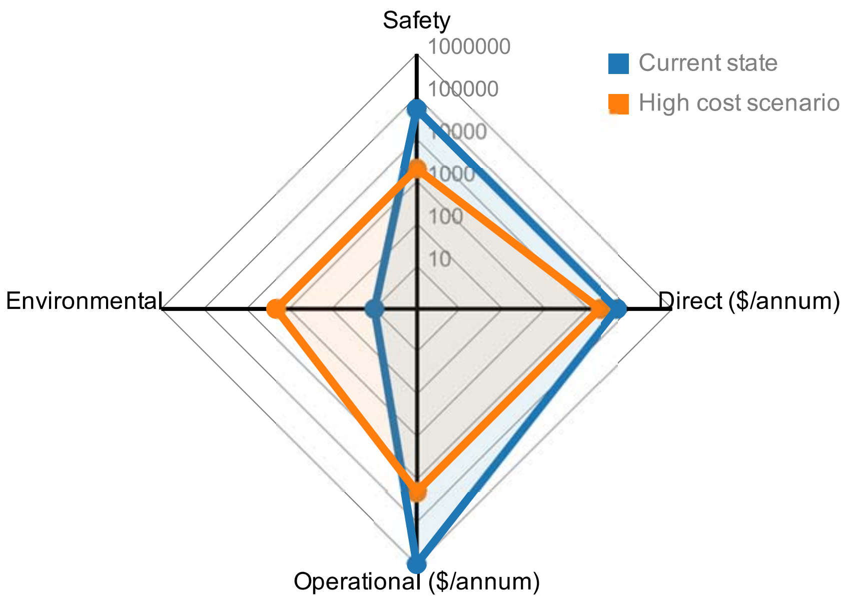
Location Description	8800 S Claiborne Avenue New Orleans 70118
Primary Function	Backwash Equalization basin collects filter backwash and pumps to the head of the treatment plant for recycle.
Context Information	2 MG Backwash Equalization basin and five 5 mgd recycle pumps with 200 Hp motor dedicated for filter wash water collection and recycle. Four pumps are above ground. A MCC building houses all the switch gear for the pumps. A backup pipe is being planned for disposal of wash water to the river rather than recycle.
Full Replacement Cost	$ 3000000

Backwash Equalization Tank and Recycle Pumps: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Only one Equalization basin providing approximately one day storage of wash water for recycle. There are five 5 MGD pumps of which one is used under normal operations. Possible weak link is the MCC switch gear is housed in a building that is vulnerable to wind damage and rain.	L
Supply chain strength	Strong in-house skills to maintain old equipment but an equipment failure puts the component (pumps, motors, etc.) out of service until facility maintenance can repair or manufacture the needed components. We can not consider supply chain	M
Skills availability	Current skillsets are good, however there are concerns about an aging workforce and transfer of skills.	L
Ease of access	At ground level near entrance to the treatment plant. But road to access could be flooded	M
Documentation and procedures	No documented SOPs, O&M manuals, or operations.	L
Flood protection	Limited	L
HAZMAT and Fire protection	No fire protection but very low risk	M
Building code compliance		L
ARI		**0.514**

Threat: Events: 100 year return period

Comments	According to FEMA there is no risk of flooding. Wind risk still exist. Same scenanrio as Hurricane < 100 years - Wind
Earliest Recovery of Function	29 days
Repair and recommissioning cost	$ 3000000



Current Risk Type	Comments
Safety	
Environmental	
Operational ($/annum)	
Direct ($/annum)	

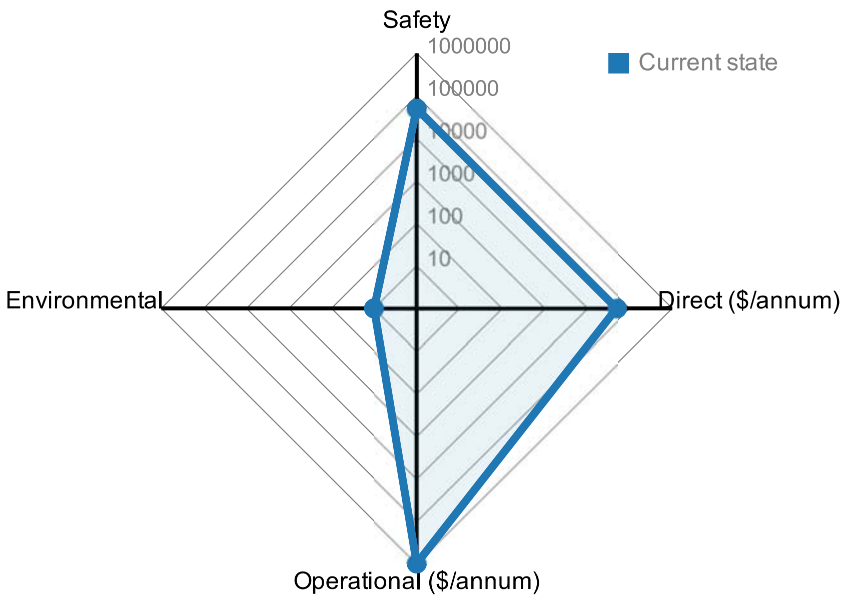
Measure High cost scenario

Total One-Time Cost	$ 0
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	
Earliest Recovery of Function	
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost

Threat: Events: 500 year return period

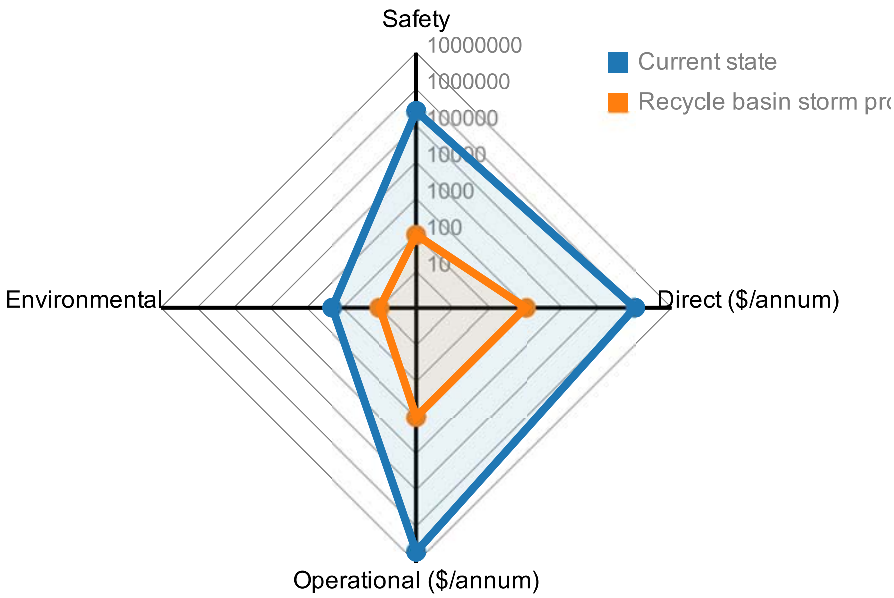
Comments	According to FEMA there is no risk of flooding. Wind risk still exist. Same scenanrio as Hurricane < 100 years - Wind
Earliest Recovery of Function	29 days
Repair and recommissioning cost	$ 3000000



Current Risk Type	Comments
Safety	
Environmental	
Operational ($/annum)	
Direct ($/annum)	

Threat: Hurricane < 100 years - Wind

Comments	The Recycle Basin MCC is located in a concrete building raised approximately one foot off the ground. The roof of the MCC building is metal. During major hurricane events wind speeds can reach between 120 to 156 mph causing severe damage to buildings more specifically their metal roofs, pealing them away exposing the MCC to the elements. The rain causes the electrical equipment to short and either trip the circuit breakers or cause fires. The Recycle Basin MCC could be destroyed. The recycle basin pumps will be unable to backwash the sand filters. Eventually the WTP would be shut down after one day. Residents and businesses would be without water
Earliest Recovery of Function	29 days
Repair and recommissioning cost	$ 3000000



Current Risk Type	Comments
Safety	Limited risk for the SWB's staff but in case of a 29 days shutdown of the recycle basin MCC could stop fresh water distribution and could have an impact on sensitive people health.
Environmental	
Operational ($/annum)	Service diruption - Distribution of bottles of water
Direct ($/annum)	Between 80 to 100 % of the building could be damaged

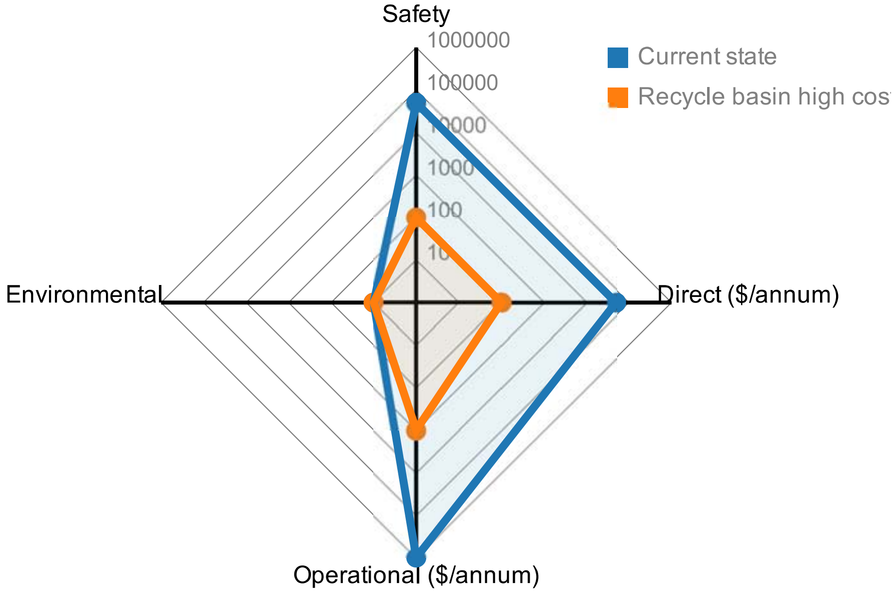
Measure Recycle basin storm proofing **SELECTED**

Total One-Time Cost	$ 357000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	
Repair and recommissioning cost	$ 10000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Storm proof the building	One-time	357000			357000

Threat: Scenario: SR 100 years

Comments	Swiss Re apparent flood levels stated as 2.5 feet to 5 feet. Backwash EQ basin would be flooded and unusable for filter operations. Effectively could shut the plant down due to filter operations being stopped because backwashes could not be performed. Backwash recycle pumps may be flooded. In addition wind risk is still valid and it is the main threat
Earliest Recovery of Function	29 days
Repair and recommissioning cost	$ 4000000



Current Risk Type	Comments
Safety	Limited risk for the SWB's staff but in case of a 29 days shutdown of the recycle basin MCC could stop fresh water distribution and could have an impact on sensitive people health
Environmental	Very low risk
Operational ($/annum)	Service disruption
Direct ($/annum)	80% to 100% of the building would be damaged

Measure Recycle basin high cost protection **SELECTED**

Total One-Time Cost	$ 3557000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	0
Repair and recommissioning cost	$ 10000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Storm proof the building	One-time	357000			357000
Build a flood protection around the building	One-time	3200000			3200000

Claiborne High Lift Pump Station: Short Resilience Report

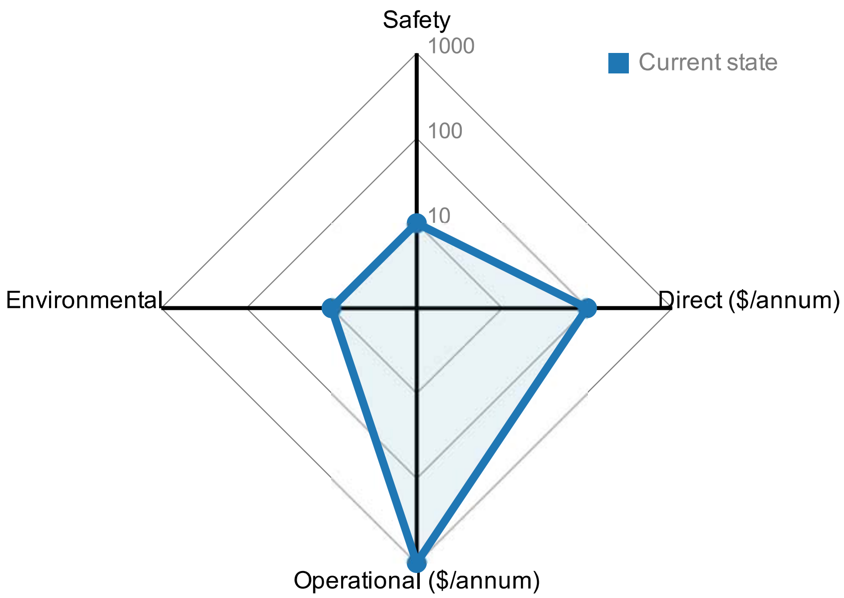
Location Description	8800 S Claiborne Avenue New Orleans 70118
Primary Function	To pump filtered water to the Finished Water Storage Tanks or to the distribution system.
Context Information	Four 40 mgd high lift pumps, two 25 Hz and two 60 Hz motors. Operate one 25 Hz and one 60 Hz pump together in service at a time. Draw finished water from Finished Water Storage Tanks. 2 vertical turbine transfer pumps draw water from suction wells below station and pump to the Finished Water Storage Tanks or to the distribution network. One pump appears to be 60 mgd (350 hp), the second pump appears to be 85 mgd (450 hp). A balancing valve is provided to feed from the finished storage tank to the high lift pumps as needed. Claiborne High Lift Pump Station is about 8 feet above ground level. Building ground elevation is 4.6 ft.
Full Replacement Cost	$ 80000000

Claiborne High Lift Pump Station: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	There are 4 pumps 2 X 25 Hz and 2 X 60 Hz pumps. Normal operations 1 X 25 Hz and 1 X 60 Hz pump in service. Remaining pumps are in standby. Panola High Lift Station pumps can used as a backup. Three 25 Hz power supply feeders.	H
Supply chain strength	Pump and motor parts machined by machine shop, little spare parts.	L
Skills availability	The SWBNO has an aging workforce; therefore, there is an immediate need to hire and train personnel for the future sustainability of plant operations. Inadequate number of staff based on current needs. Personnel work overtime to maintain system operation. Significant portion of SWBNO leadership will retire within the next five years.	L
Ease of access	Easy access from the WTP. Claiborne Street prone to flooding.	H
Documentation and procedures	No documented SOPs, procedures, O&M manuals.	M
Flood protection	Building is approximately 8 feet above ground level	H
HAZMAT and Fire protection	No fire sprinkler systems, gas detection, or smoke alarms. Have handheld fire extinguishers	L
Building code compliance	Building did not sustain damage from hurricane Katrina. Building windows are boarded up prior to a hurricane	M
ARI		**0.700**

Threat: Events: 100 year return period

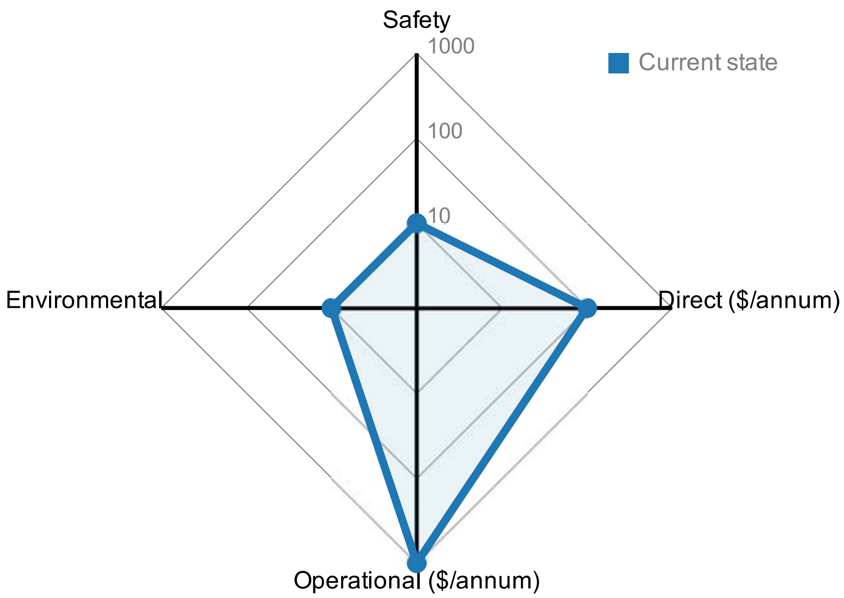
Comments	Hurricane winds between 100 and 119 mph would be expected to have minimal impact on the building, no flooding of the building, however minor flooding would occur on Claiborne Avenue restricting access to the plant.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	Building has been storm proofed including reinforcing roofs, windows and doors, reducing risk to personnel
Environmental	No environmental damage
Operational ($/annum)	Pumps would continue to supply water to the New Orleans water distribution network
Direct ($/annum)	Clean up costs and possible minor repairs to building

Threat: Events: 500 year return period

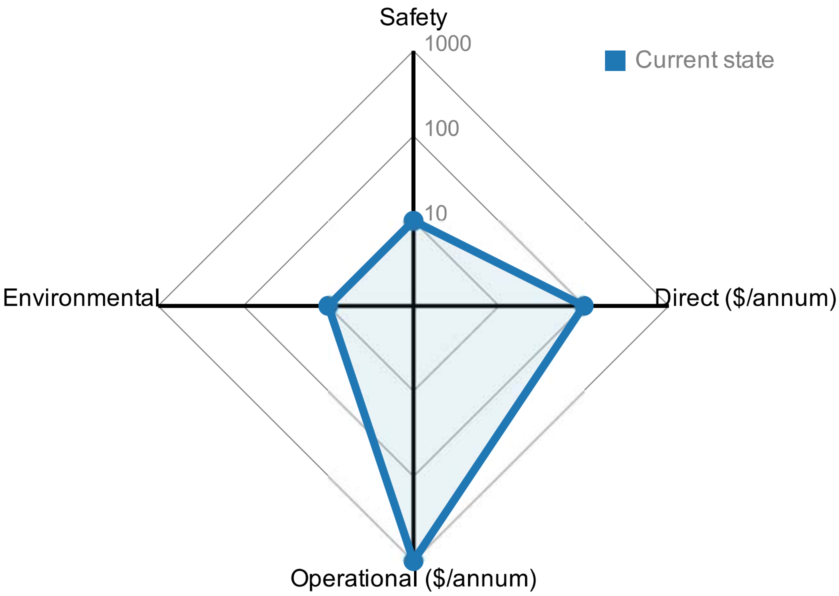
Comments	Based on the USACE 500 year flood map the Carrollton WTP is outside of flood zone. However during major hurricanes, wind speeds could reach 130 mph. causing possible damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Emergency generator would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 10000



Current Risk Type	Comments
Safety	Building has been storm proofed including reinforcing roofs, windows and doors reducing risk to personnel
Environmental	No damage to the environment
Operational ($/annum)	Pump station would operate as normal
Direct ($/annum)	Minor wind or flood damage

Threat: Hurricane < 100 years - Wind

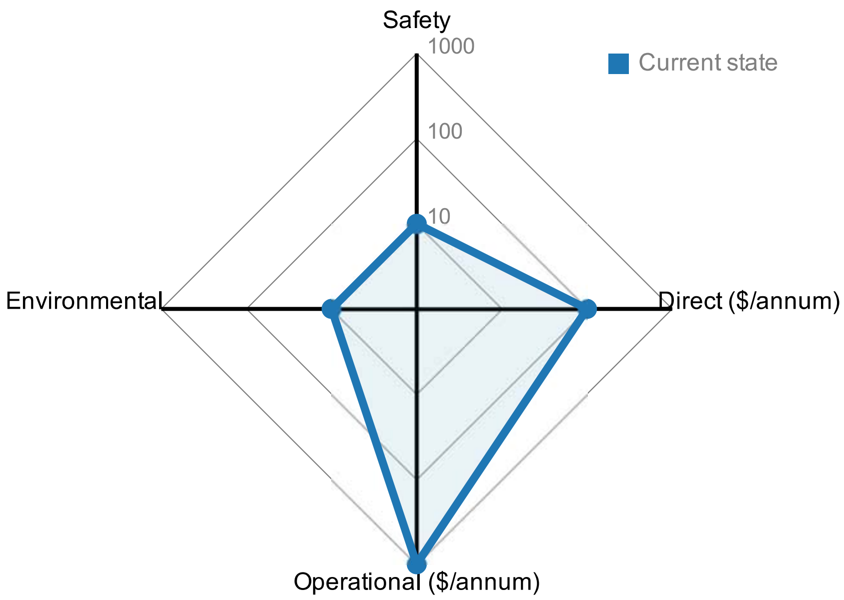
Comments	Hurricane winds between 100 and 119 mph would have minimal impact on the building and minor flooding would occur on Claiborne Avenue
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 10000



Current Risk Type	Comments
Safety	Building has been storm proofed including reinforcing roofs, windows and doors
Environmental	No environmental damage
Operational ($/annum)	Pumps continue to supply water to the water distribution network
Direct ($/annum)	Clean up costs and possible minor repairs to building

Threat: Scenario: SR 100 years

Comments	Swiss RE predicts winds could reach up to 105 mph with a storm surge flood depth between 2.5 to 5 feet. Claiborne High Lift Station building is elevated 8 feet above ground level.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	Building has been storm proofed including reinforcing roofs, windows and doors, reducing risk to personnel
Environmental	No environmental damage
Operational ($/annum)	Pump station would operate as normal during a storm event. Panola High Lift Station would backup Claiborne in the event Claiborne failed
Direct ($/annum)	Minor wind or flood damage

Steam Pumps A&B High Lift Pump Station: Short Resilience Report

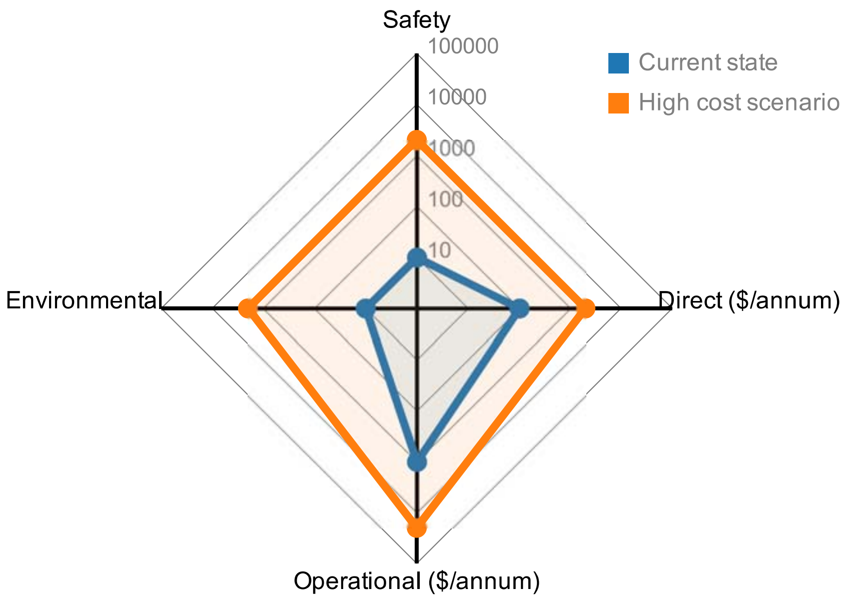
Location Description	8800 S Claiborne Avenue New Orleans 70118
Primary Function	To pump finished water from the plant to the distribution system
Context Information	Two 40 mgd steam-driven pumps draw finished water from plant production and pump it to the distribution system. Both pumps used normally providing 80 mgd of finished water. Critical pumping system operated and monitored by SCADA. Pump A rehabilitation was completed in March 2014, and Pump B was completed in the second quarter of 2015. In the event both Steam pumps fail for whatever reason the pumps at Panola Station can be used to supply water to the distribution network.
Full Replacement Cost	$ 30000000

Steam Pumps A&B High Lift Pump Station: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	Panola High Lift Station pumps can used as a backup. Pumps A and B have recently been refurbished to restore original capacity.	H
Supply chain strength	Aging equipment gives cause for concern due to long lead times in either procuring parts or manufacturing parts internally. Pump and motor parts machined by machine shop, little spare parts.	L
Skills availability	The SWBNO has an aging workforce; therefore, there is an immediate need to hire and train personnel for the future sustainability of plant operations. Inadequate number of staff based on current needs. Personnel work overtime to maintain system operation. Significant portion of SWBNO leadership will retire within the next five years.	L
Ease of access	Easy access near the generating facility, but could be prone to flooding at ground level.	M
Documentation and procedures	No documented SOPs or O&M manuals.Review reliability strategies.	L
Flood protection	Tiger Dams have been purchased to reduce the impact of flooding up to height of 36" for the Power Building	M
HAZMAT and Fire protection	No fire sprinkler systems, gas detection, or smoke alarms. Have handheld fire extinguishers	L
Building code compliance	Storm-proofing for the power buildings include reinforcing the walls, roofing, doors, and windows. Additional hurricane damage-related work primarily includes valve replacement and repair to electrical components and controls. Related items for the Water Pumping and Power unit are in various stages of design or construction.	M
ARI		**0.589**

Threat: Events: 100 year return period

Comments	During a major hurricane flooding could occur in certain low lying areas especially some streets. Power building No 3 ground elevation is approximately 2.5 ft. Flooding unlikely due to the deployment of the tiger dams. Power supply from Entergy will more than likely be lost. Emergency CT generator would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	Building has been storm proofed including reinforcing roofs, windows and doors, reducing risk to personnel
Environmental	No environmental damage
Operational ($/annum)	Pumps would operate as normal
Direct ($/annum)	Minor localized flood damage

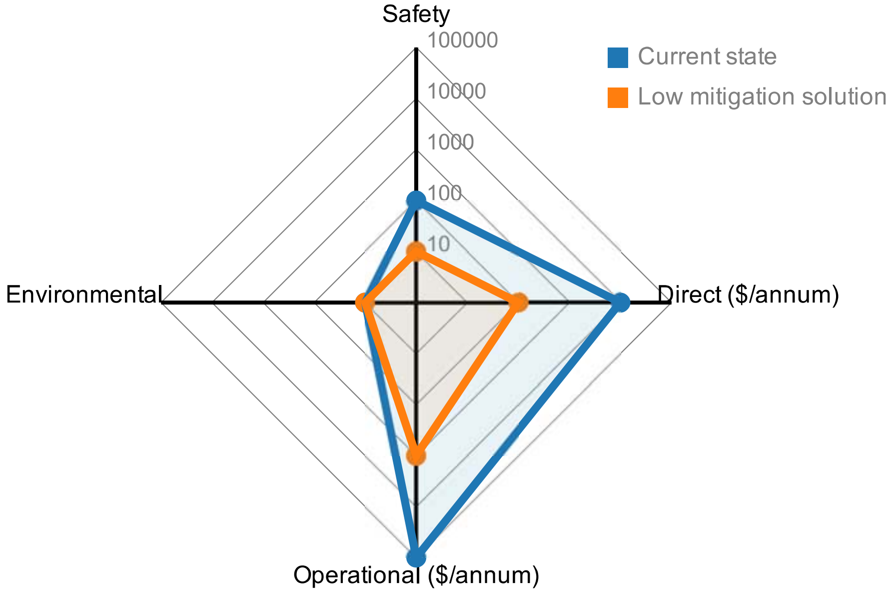
Measure High cost scenario

Total One-Time Cost	$ 0
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	
Earliest Recovery of Function	
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost

Threat: Events: 500 year return period

Comments	Based on the USACE 500 year flood map the Carrollton WTP is outside of flood zone. However during major hurricanes, wind speeds could reach 130 mph. causing possible damage to the building specifically roofs. Flooding unlikely due to the deployment of the tiger dam, however rain water can accumulate within the tiger dam. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Emergency generator would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 100000



Current Risk Type	Comments
Safety	Building has been storm proofed, however water could seep into the building from water accumulating in the tiger dams and create a possible hazard
Environmental	No environmental damage
Operational ($/annum)	Water could accumulate within the tiger dams and seep into the building causing operations to shutdown the steam pumps
Direct ($/annum)	Water damage to equipment

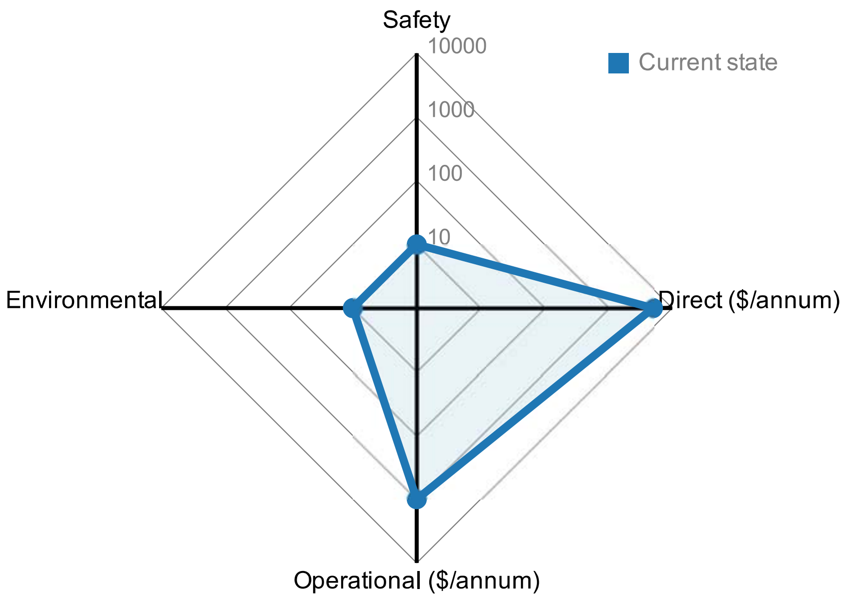
Measure Low mitigation solution - tiger dam sump pump **SELECTED**

Total One-Time Cost	$ 10000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 200
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Drain tiger dams with sump pump	One-time	10000			10000

Threat: Hurricane < 100 years - Wind

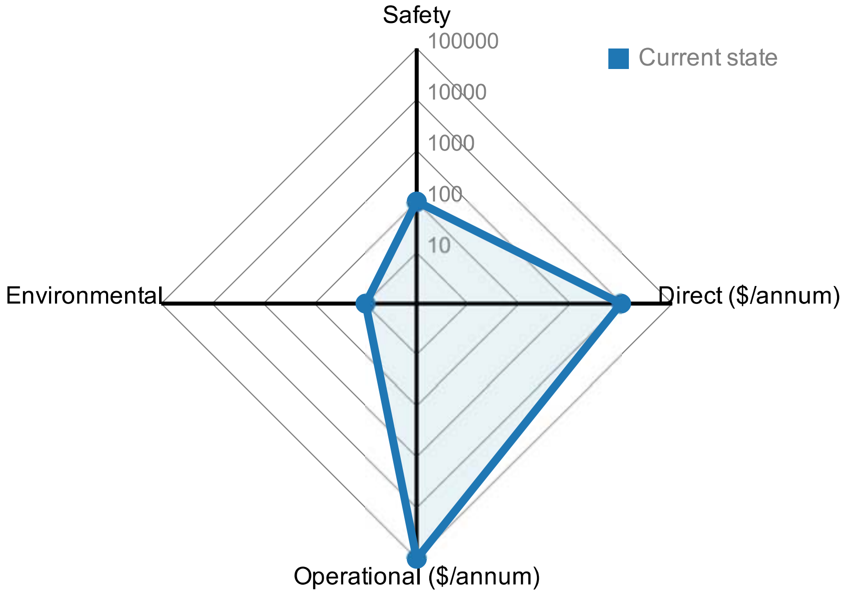
Comments	Wind speeds could reach 130 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 5000



Current Risk Type	Comments
Safety	Building has been storm proofed including reinforcing roofs, windows and doors, reducing risk to personnel
Environmental	No environmental damage
Operational ($/annum)	Pumps continue to supply water to the water distribution network
Direct ($/annum)	Clean up costs and possible minor repairs to building

Threat: Scenario: SR 100 years

Comments	Swiss RE predicts winds could reach up to 105 mph with a storm surge flood depth between 2.5 to 5 feet. Power building is elevated 8 feet above ground level. During storm events tiger dams are deployed around the building raising height to approximately 54 inches. May have partial flooding due to seepage
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 100000



Current Risk Type	**Comments**
Safety	Building has been storm proofed, however water could seep into the building from water accumulating in the tiger dams and create a possible hazard.
Environmental	No environmental consequences
Operational ($/annum)	Water could accumulate within the tiger dams and seep into the building causing operations to shutdown the steam pumps
Direct ($/annum)	Minor localized flood / water damage

Central Control & Switchgear: Short Resilience Report

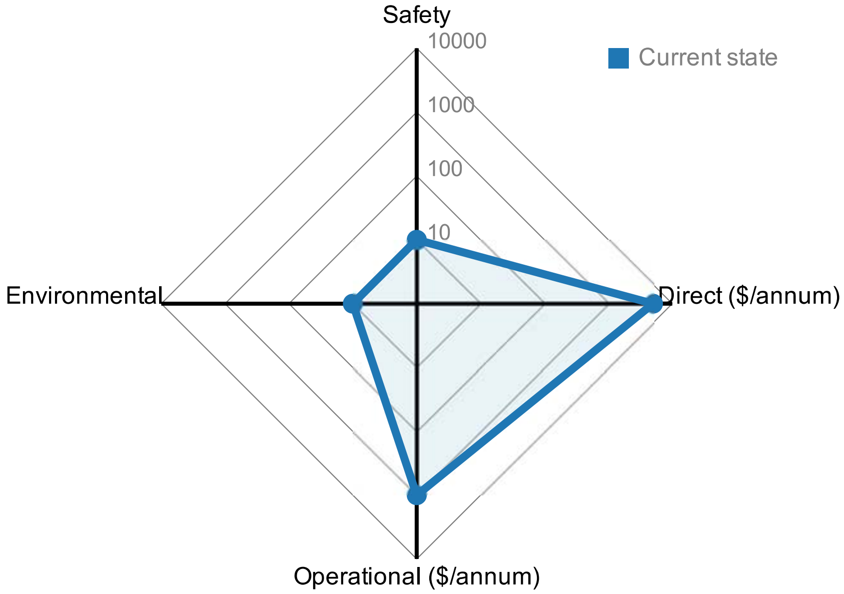
Location Description	8800 S Claiborne Av New Orleans LA 70118
Primary Function	The Central Control Power Dispatching Department is primarily responsible for the distribution of an adequate supply of Board generated electrical power within the power distribution system, the continuous monitoring of the operational status of all electrical switchgear, and the testing of related electrical feeders and equipment.
Context Information	Central Control is responsible for verifying and enforcing the Board's safety clearance procedures and associated clearances within the power distribution system. In addition, Central Control monitors local and regional weather to provide advance warning of storms which could affect power generation requirements for the drainage and sewerage systems. Coordination of various power supplies, including alternative backup power supplies such as diesel generators and frequency changers, also comprise part of this Department's responsibilities. The Central Control Power Dispatching Department plays a vital role in many emergency operational situations. Serving as a hub of communications, Central Control informs the Board's management and senior level staff of changes in conditions that will affect the Board's ability to provide adequate sewerage, water, and drainage services. Central Control also provides valuable information during emergencies such as hurricanes, floods, freezes, etc., to the Office of Emergency Preparedness (OEP) through established Board protocols. Tiger Dams have been purchased to reduce the impact of flooding for the Central Control Operations at a cost of $58,000. Lack of staffing continues to be a major issue for this Department.
Full Replacement Cost	$ 300000000

Central Control & Switchgear: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Power feeder control can switched to Pump Station D within 15 minutes	M
Supply chain strength	Aging switch gear, spares availability in the future could be an issue	M
Skills availability	Lack of staffing continues to be a major issue for this Central Control	L
Ease of access	Easy access near the generating facility, but could be prone to flooding at ground level.	H
Documentation and procedures	Visibility of power distribution is entirely manual. Telephone and radios are used to communicate with pump stations	M
Flood protection	Tiger Dams have been purchased to reduce the impact of flooding for the Central Control Operations for a cost of $58,000	M
HAZMAT and Fire protection	No hazardous materials. Fire protection consists of hand held fire exstinguishers	M
Building code compliance	Building was not damaged during Katrina. Building windows are boarded up prior to a hurricane	M
ARI		**0.703**

Threat: Events: 100 year return period

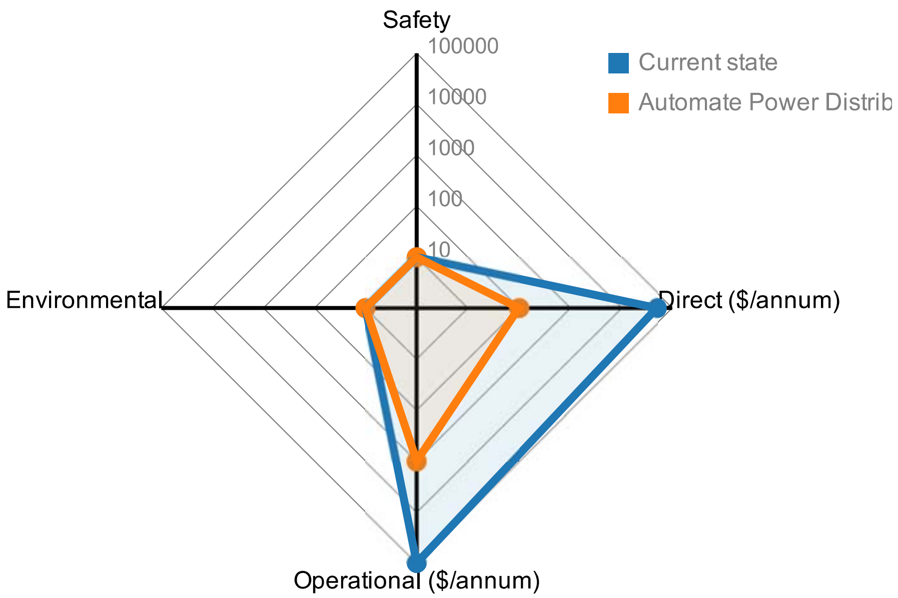
Comments	Wind speeds could reach 105 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Power plant would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	Control Building is boarded up during hurricanes to avoid flying debris from breaking windows, etc.
Environmental	No damage to the environment
Operational ($/annum)	Central Control would operate as normal, manually maintaining 25 Hz power distribution across WTP and the drainage stations.
Direct ($/annum)	Clean up costs and possible minor wind and flood damage repairs to building and surrounding area.

Threat: Events: 500 year return period

Comments	Major hurricane, wind speeds could reach 130 mph causing possible damage to the building specifically roofs. Flooding could occur in certain low lying areas and within the Central Control tiger dams causing water to seep into the building. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Power plant would generate power for the entire WTP and some drainage stations. Communications to drainage pump stations could be lost.
Earliest Recovery of Function	0.25 hours
Repair and recommissioning cost	$ 50000



Current Risk Type	**Comments**
Safety	Control Building is boarded up during hurricanes to avoid flying debris from breaking windows, etc.
Environmental	No environmental damage
Operational ($/annum)	Possible minor flooding of the building and loss of telephone and radio communications. Unable to communicate with drainage stations
Direct ($/annum)	Repair of telephone and radio communications

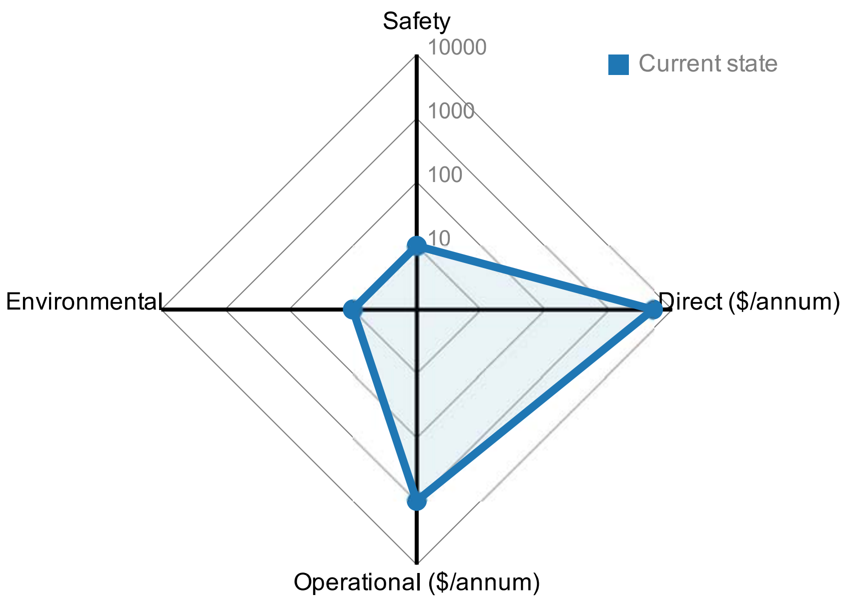
Measure Automate Power Distribution Visibility **SELECTED**

Total One-Time Cost	$ 510000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 5000
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 0

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Automate Central Control power distribute visibility	One-time	500000			500000
Tiger dam pumps	One-time	10000			10000

Threat: Hurricane < 100 years - Wind

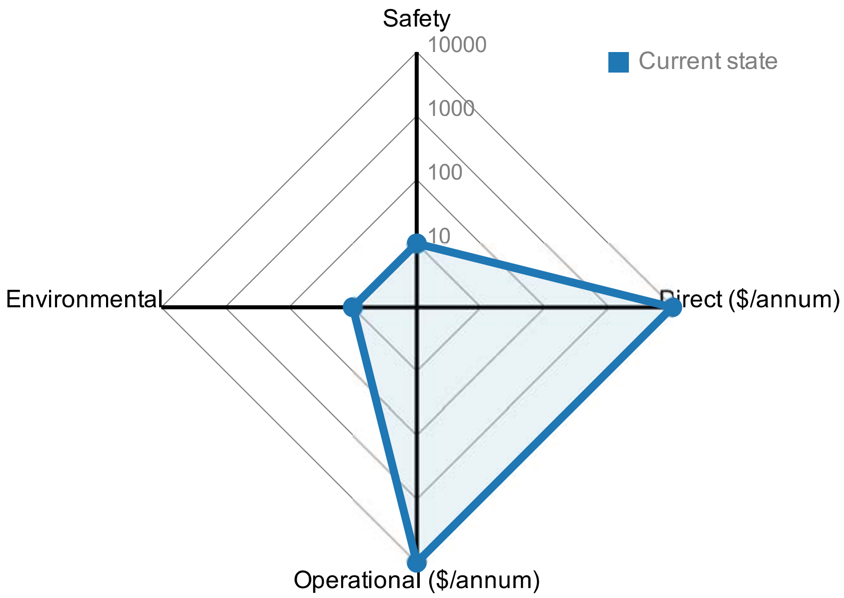
Comments	Wind speeds could reach 130 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Power plant would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 5000



Current Risk Type	Comments
Safety	Control Building is boarded up during hurricanes to avoid flying debris from breaking windows, etc.
Environmental	No damage to the environment
Operational ($/annum)	Central Control would operate as normal, manually maintaining 25 Hz power distribution across WTP and the drainage stations
Direct ($/annum)	Clean up costs and possible minor wind and flood damage repairs to building and surrounding area

Threat: Scenario: SR 100 years

Comments	Swiss RE predicts winds could reach up to 105 mph with a storm surge flood depth between 2.5 to 5 feet. Switchgear building is elevated 3.2 feet. During storm events tiger dams are deployed around the building raising height to approximately 54 inches. May have partial flooding due to seepage
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 10000



Current Risk Type	Comments
Safety	Control Building is boarded up during hurricanes to avoid flying debris from breaking windows, etc.
Environmental	No environmental damage
Operational ($/annum)	Possible minor flooding of the building
Direct ($/annum)	Clean up costs and possible minor wind and flood damage repairs to switchgear, building and surrounding area.

Power House No 2: Short Resilience Report

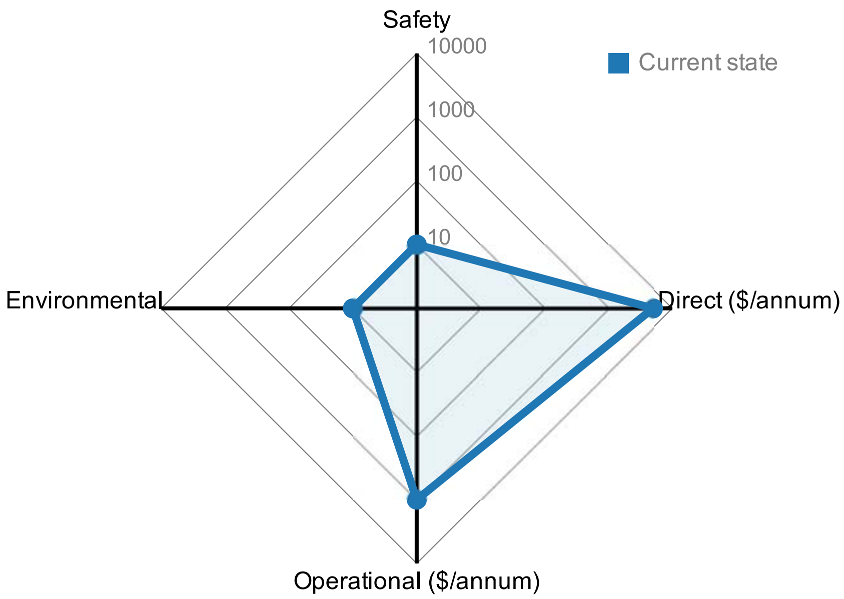
Location Description	8800 S Claiborne Avenue, New Orleans 70118
Primary Function	To supply 25 Hz power to DPS, Water, 25 Hz pumps
Context Information	The board's 25 cycle Power Generation System, located at the Carrollton Water Plant, provides power for portions of the Water Purification Plant, two large vertical sewer units at the main central business district sewage pumping station and powers approximately 60 percent of the system's drainage pumps. The benefit of the board's own power generation is that the feeders to the multiple pump stations are underground and during storms when commercial power lines are down the system is still up and running. There are six boilers with a total capacity of 650,000 pounds of steam per hour which supply steam to the three steam turbine generators (STGs) and two steam driven pumps pumps. The doors have been replaced with storm doors, and the roof has been replaced. All exhaust fans and intakes were be modified or replaced with roll type shutters. Buttresses would be constructed to ensure the walls withstand the wind loading scenario.
Full Replacement Cost	$ 500000000

Power House No 2: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Have 61 MW in capacity	M
Supply chain strength	Boilers that supply the steam are dual fuel, gas and oil or a mixture of the two. Two fuel storage tanks, with a total capacity of one million gallons of oil, provide reserve fuel supplies. Local suppliers are available during storm events. Aging steam turbines and generators give cause for concern due to long lead times in either procuring parts or manufacturing parts internally.	M
Skills availability	Lack of staffing continues to be a major issue	L
Ease of access	Access roads allow for easy access, nearby street flooding is possible	M
Documentation and procedures	Very little documentation. Maintenance procedures need reviewing.	L
Flood protection	Tiger dams will give a 3 to 4 foot flood barrier	M
HAZMAT and Fire protection	Secondary containment for fuel oil. Hand held fire exstinguishers	M
Building code compliance	Building meets local codes and has been storm proofed	M
ARI		**0.623**

Threat: Events: 100 year return period

Comments	During a major hurricane flooding could occur in certain low lying areas especially some streets. Power House No 2 building ground elevation is approximately 3 ft. Flooding unlikely due to the deployment of the tiger dams. Power supply from Entergy will more than likely be lost. Emergency CT generator would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 5000



Current Risk Type	Comments
Safety	Building storm proofed, no risk to personnel
Environmental	None
Operational ($/annum)	Steam turbines and combustion turbines would be able to operate normally
Direct ($/annum)	Minor localized flood / water damage

Power House No 3 Turbine No 6: Short Resilience Report

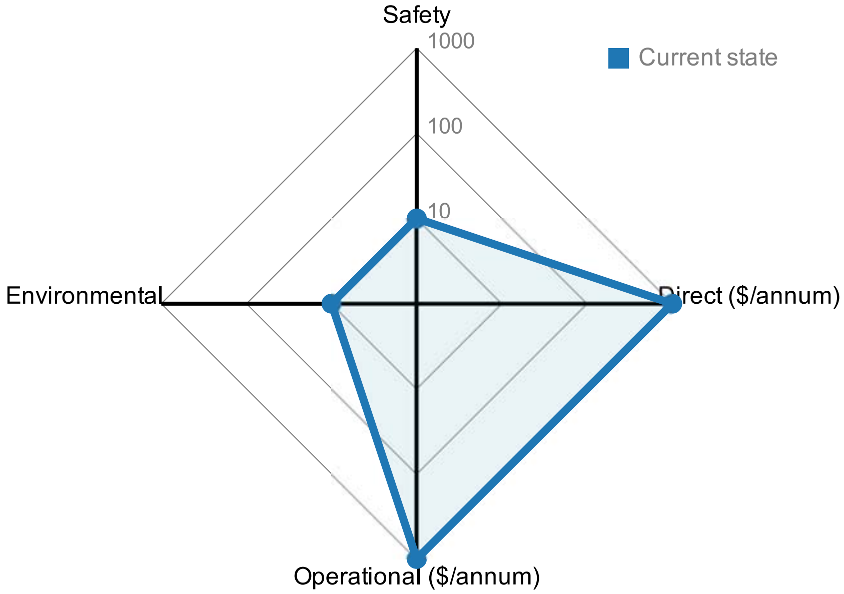
Location Description	8800 S Claiborne Avenue, New Orleans 70118
Primary Function	To be capable of supplying 15 MW at 60 Hz to the drainage, sewerage and water pumping systems in the event 60 Hz commercial power is lost.
Context Information	This specially-designed GE LM-2500 Combustion turbine powers a 15-megawatt generator. The generator gives the S&WB's Division of Pumping and Power the capability to improve the operation of its drainage, sewerage and water pumping systems in emergencies. Combustion turbine generator (CTG) provides power through a 60Hz underground feeder (to be constructed by USACE) to run two pumps at DPS 1. Secondly, if for any reason the 25 Hz system is completely down and does not have Entergy power available, this generator also has "black start" capability which will enable the generator to start without any outside power source and then both through the Central Control Building and the existing on-site 25 Hz/ 60 Hz frequency changer to run the water plant and river intake pumps to provide water for the 25 Hz generator boilers which will in turn run the 25 Hz drainage pumps throughout the New Orleans area via the existing underground 25 Hz feeder system.
Full Replacement Cost	$ 32000000

Power House No 3 Turbine No 6: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Provides black start capability in the event commercial power is lost	H
Supply chain strength	Dual fuel combustion turbine, natural gas supply line and 1 million gallon diesel reserve. Local suppliers for the diesel.	H
Skills availability	Have had problems trying to securing OEM personnel to maintain the CT	L
Ease of access	Access roads allow for easy access, nearby street flooding is possible	M
Documentation and procedures	OEM manuals available. Need to review maintenance strategies to address high cost of maintenance	L
Flood protection	Recently built building addresses DFL	H
HAZMAT and Fire protection	Diesel Tank berms protects the environment from diesel tank leaks. Local hand held fire exstingushers	M
Building code compliance	New building meets building codes and hurricane proofing	H
ARI		**0.776**

Threat: Events: 100 year return period

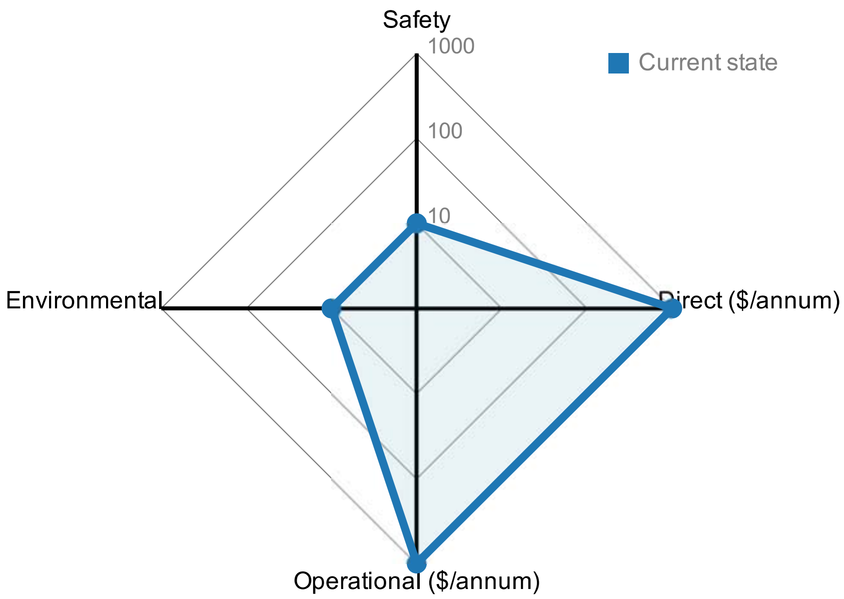
Comments	During a major hurricane flooding could occur in certain low lying areas especially some streets. Power building No 3 ground elevation is approximately 1 ft. Flooding unlikely. Power supply from Entergy will more than likely be lost. Emergency CT generator would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	Building storm proofed
Environmental	Diesel tanks have secondary containment to prevent any leaks from reaching storm water drains
Operational ($/annum)	In the event commercial power is lost CT would generate power to supply WTP, Station A and Drainage Stations
Direct ($/annum)	Minor flood damage repairs

Threat: Events: 500 year return period

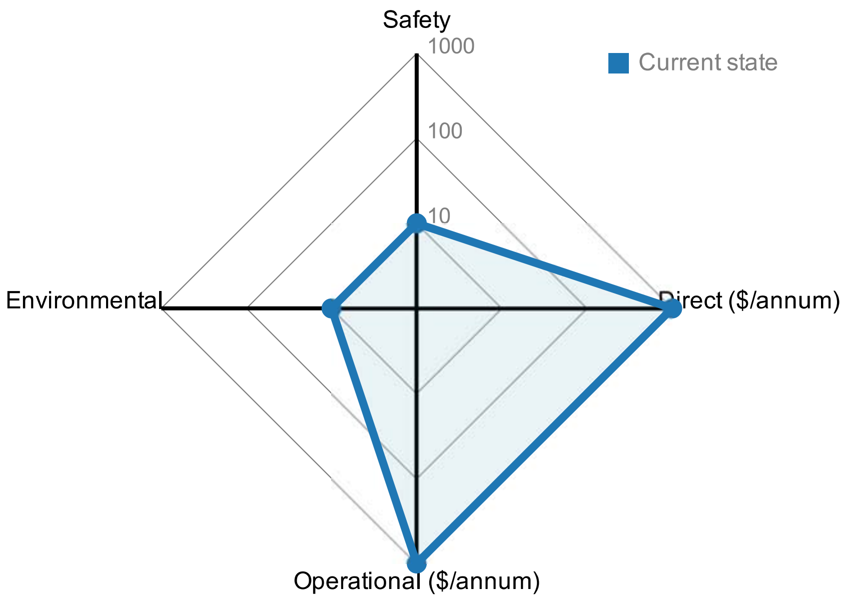
Comments	Not in a 500 year flood zone although during a major hurricane flooding could occur in certain low lying areas especially some nearby streets. Power building No 3 ground elevation is approximately 1 ft. Flooding unlikely. Power supply from Entergy will more than likely be lost. Emergency CT generator would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	Building storm proofed
Environmental	Diesel tank secondary containment would contain any leaks
Operational ($/annum)	In the event commercial power is lost Emergency CT would supply power to the WTP, Station A pumps, and some drainage stations
Direct ($/annum)	Localized minor flood damage

Threat: Hurricane < 100 years - Wind

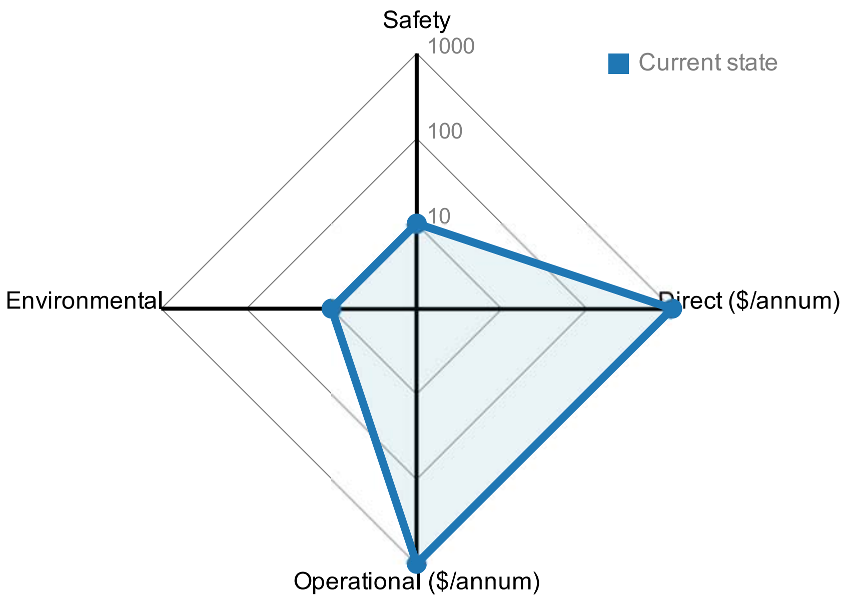
Comments	Major hurricane, wind speeds could reach 120 mph. causing possible damage to the buildings specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Emergency CT generator would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	Building storm proofed
Environmental	Diesel tanks have secondary containment to prevent any leaks from reaching storm water drains
Operational ($/annum)	In the event commercial power is lost CT would generate power to supply WTP, Station A and Drainage Stations
Direct ($/annum)	Minor wind damage localized to the building

Threat: Scenario: SR 100 years

Comments	Swiss RE predicts winds could reach up to 105 mph with a storm surge flood depth between 2.5 to 5 feet. Power House No3 building is elevated 0.9 feet. Building is storm proofed, flooding unlikely
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	Building storm proofed no risk to personnel
Environmental	Diesel tanks have secondary containment to prevent any leaks from reaching storm water drains
Operational ($/annum)	In the event commercial power is lost CT would generate power to supply WTP, Station A and Drainage Stations
Direct ($/annum)	Minor flood / water damage repairs

Boiler Room: Short Resilience Report

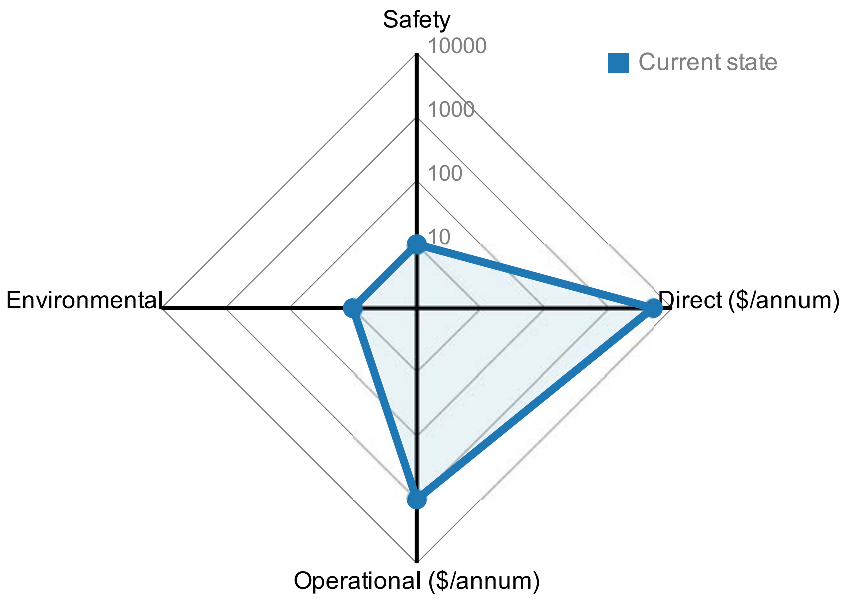
Location Description	8800 S Claiborne Avenue, New Orleans 70118
Primary Function	To supply steam to the steam turbines and steam driven pumps
Context Information	There are six boilers with a total capacity of 650,000 pounds of steam per hour which supply steam to the three steam turbine 25 Hz generators (STGs) and two steam driven pumps A and B. The board's 25 cycle Power Generation System, located at the Carrollton Water Plant, provides power for portions of the Water Purification Plant, two large vertical sewer units at the main central business district sewage pumping station and powers approximately 60 percent of the system's drainage pumps. The benefit of the board's own power generation is that the feeders to the multiple pump stations are underground and during storms when commercial power lines are down the system is still up and running. The Power building doors have been replaced with storm doors, and the roof has been replaced. All exhaust fans and intakes were modified or replaced with roll type shutters. Buttresses would be constructed to ensure the walls withstand the wind loading scenario. Three foot tiger dams are deployed during storms to prevent the building from being flooded.
Full Replacement Cost	$ 70000000

Boiler Room: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	There are six boilers, not all are required to meet STG steam demand during a storm event. Excess capacity.	M
Supply chain strength	Boilers are dual fuel, gas and oil or a mixture of the two. Two fuel storage tanks, with a total capacity of one million gallons of oil, provide reserve fuel supplies. Local suppliers are available during storm events. Aging boilers give cause for concern due to long lead times in either procuring parts or manufacturing parts internally.	M
Skills availability	Lack of staffing continues to be a major issue	L
Ease of access	Access roads allow for easy access, nearby street flooding is possible	M
Documentation and procedures	Very little documentation. Maintenance procedures need reviewing.	L
Flood protection	Tiger dams will give a 3 to 4 foot flood barrier	M
HAZMAT and Fire protection	Secondary containment for fuel oil. Fire protection consists of hand held fire exstinguishers	M
Building code compliance	Building meets local codes and has recently been storm proofed	M
ARI		**0.623**

Threat: Events: 100 year return period

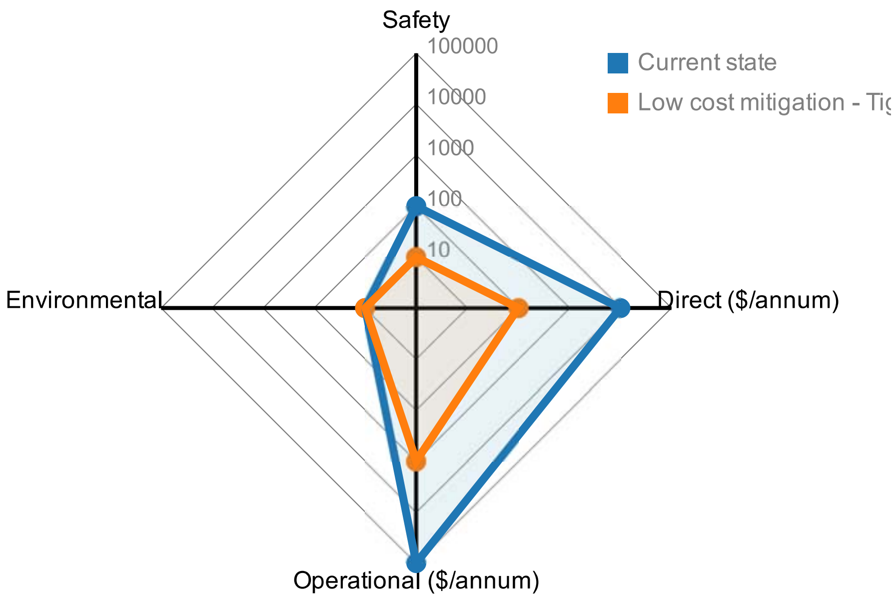
Comments	During a major hurricane flooding could occur in certain low lying areas especially some streets. Boiler building ground elevation is approximately 3 ft. Flooding unlikely due to the deployment of the tiger dams. Power supply from Entergy will more than likely be lost. Emergency Combustion Turbine generator would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	Building storm proofed, risk to personnel small
Environmental	None
Operational ($/annum)	Boilers would be able to operate normally
Direct ($/annum)	Minor localized flood damage

Threat: Events: 500 year return period

Comments	Major hurricane, wind speeds could reach 130 mph. causing possible damage to the building specifically roofs. Flooding could occur in certain low lying areas. rain water could accumulate within the Power Building tiger dams causing water to seep into the building. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Emergency combustion turbine generator would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 100000



Current Risk Type	**Comments**
Safety	Building has been storm proofed, however water could seep into the building from water accumulating in the tiger dams and create a possible hazard
Environmental	None
Operational ($/annum)	Boilers would be able to operate normally initially, however water could accumulate in the tiger dams and flood the building disrupting boiler operation and 25 Hz power supply.
Direct ($/annum)	Water damage to boilers

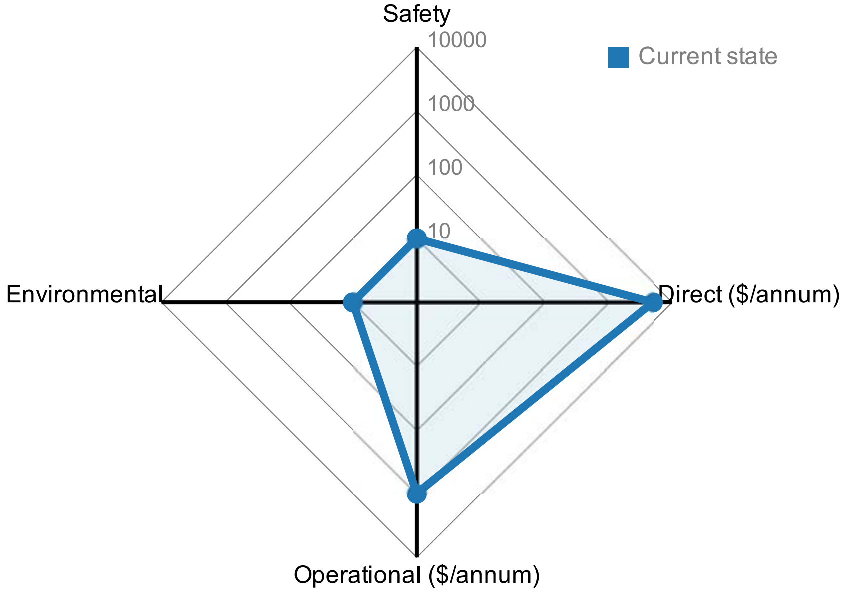
Measure Low cost mitigation - Tiger dam pumps **SELECTED**

Total One-Time Cost	$ 10000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 200
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 5000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Install tiger dam sump pumps when tiger dams deployed	One-time	10000			10000

Threat: Hurricane < 100 years - Wind

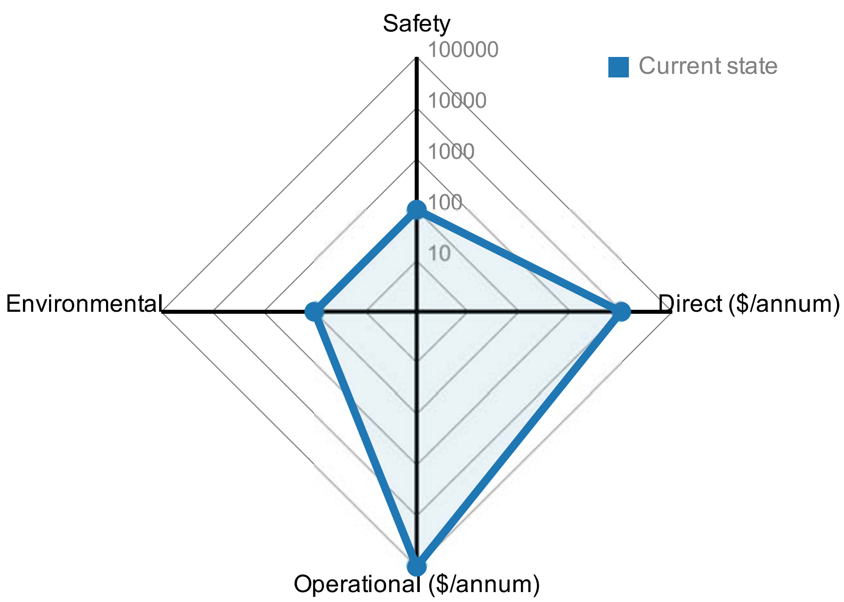
Comments	Wind speeds could reach 120 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Emergency generator would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 5000



Current Risk Type	Comments
Safety	As the building has been storm proofed, no risk to personnel
Environmental	None
Operational ($/annum)	Boilers would be able to operate normally
Direct ($/annum)	Minor wind damage repairs

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE are predicting water depths between 2.5 and 5 feet. The area immediately around the power house would be flooded causing rain water to overflow into the Tiger dams surrounding the building. Water would migrate into the building through the storm doors. Depending on accumulated water levels operations may shutdown the boilers, steam turbines and generators and the steam driven water pumps. Power would be supplied from the 15 MW 60 Hz emergency generator.
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 100000



Current Risk Type	Comments
Safety	Building has been storm proofed, however water could seep into the building from water accumulating in the tiger dams and create a possible hazard.
Environmental	None
Operational ($/annum)	Boiler room would be flooded. Boilers shutdown
Direct ($/annum)	Repair or replacement of flood damaged assets and clean up costs

Plant Frequency Converter Building: Short Resilience Report

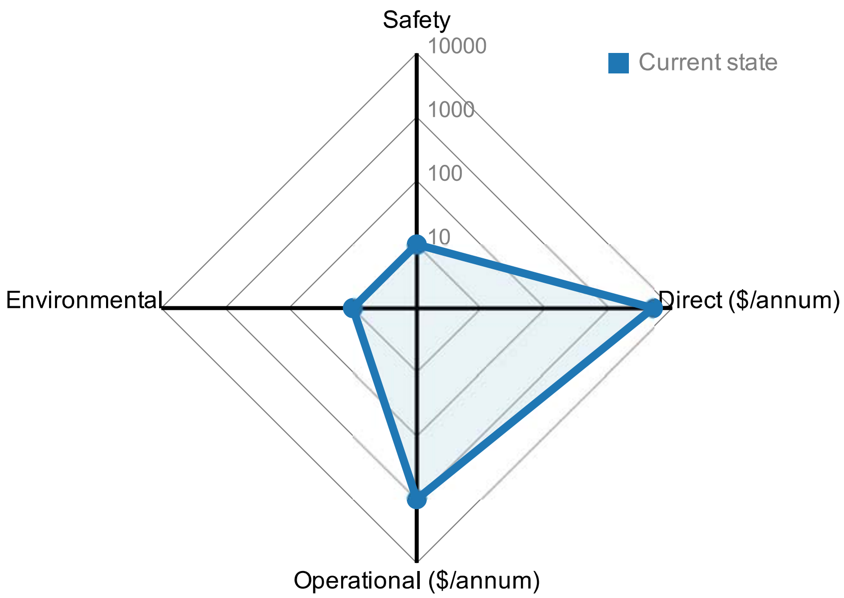
Location Description	8800 S Claiborne Av New Orleans LA 70118
Primary Function	To convert 25 Hz power received from Generator 5 to 60 Hz for distribution and vice versa in the event 60 Hz power is lost to the Carrollton Frequency Converter
Context Information	One frequency converter located in a building elevated approximately 4 ft above ground elevation of 1.5 ft. Building was storm proofed after Katrina.
Full Replacement Cost	$ 15000000

Plant Frequency Converter Building: Asset Resilience Indicator

Parameter	**Comments**	**Score (L/M/H)**
Redundancy/Excess capacity	Only one plant frequency converter. Backup to Carrllton Frequency Converter when Entergy 60 Hz power supply is lost	L
Supply chain strength	Many of the parts are either no longer made or too expensive to job out or buy “off the shelf” for the aging equipment, thus relying on the Electrical or Fabrication Shop to manufacture parts.	M
Skills availability	Lack of staffing continues to be a major issue	L
Ease of access	Access roads available, nearby street flooding possible	M
Documentation and procedures	Training manuals readily available	M
Flood protection	Building is 4 to 5 feet above ground level. Permanent sump pumps. Building storm proofed.	H
HAZMAT and Fire protection	Portable fire extinguishers available	L
Building code compliance	Building storm proofed after Katrina	M
ARI		**0.627**

Threat: Events: 100 year return period

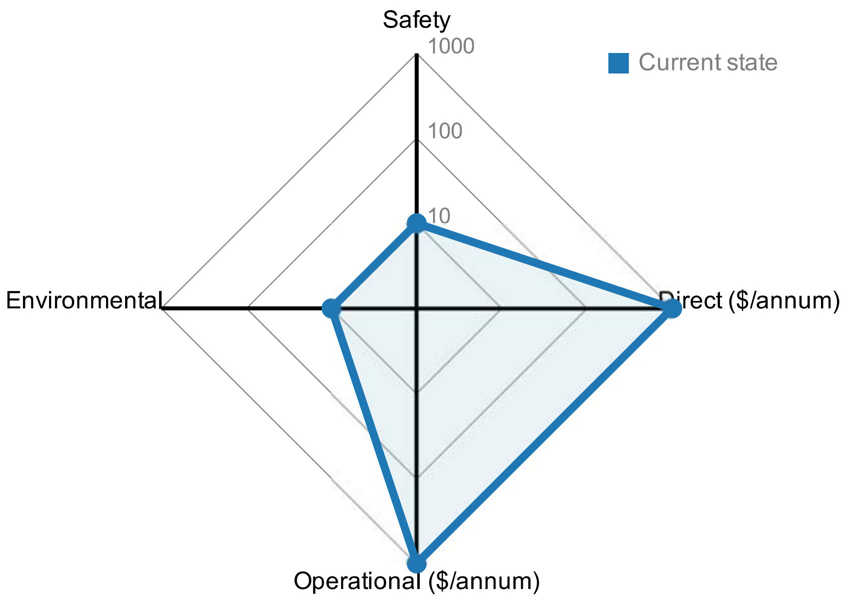
Comments	Minor flooding could occur in certain low lying areas. Power supply from Entergy will be lost. Power plant would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	As the building has been storm proofed, personnel inside the building can be considered to be safe
Environmental	No damage to the environment
Operational ($/annum)	Plant frequency converter would operate as normal
Direct ($/annum)	Clean up costs and possible minor wind and flood damage repairs to building and surrounding area

Threat: Events: 500 year return period

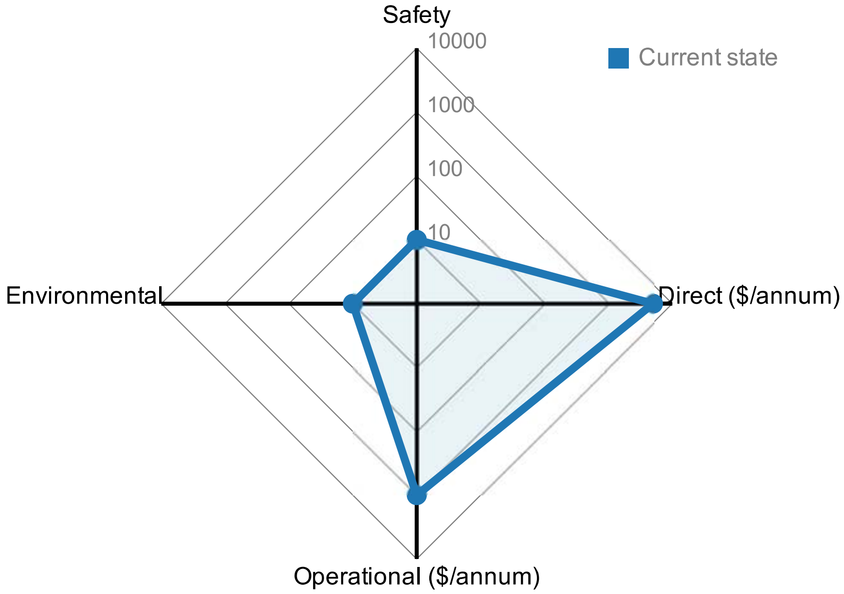
Comments	Winds could reach 130 mph. Flooding could occur in certain low lying areas specifically the streets but would not effect the Plant Frequency Converter building. Power supply from Entergy will be lost. Carrollton Frequency Converter would be out of operation requiring Plant Frequency Converter to take over. Power plant would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 1000



Current Risk Type	**Comments**
Safety	Plant frequency converter building is boarded up during hurricanes to avoid flying debris from breaking windows, etc. This building has been storm proofed
Environmental	No damage to the environment
Operational ($/annum)	Plant frequency converter would take over from Carrollton Frequency Converter when 60 Hz Entergy power is lost
Direct ($/annum)	Minor flood damage repairs

Threat: Hurricane < 100 years - Wind

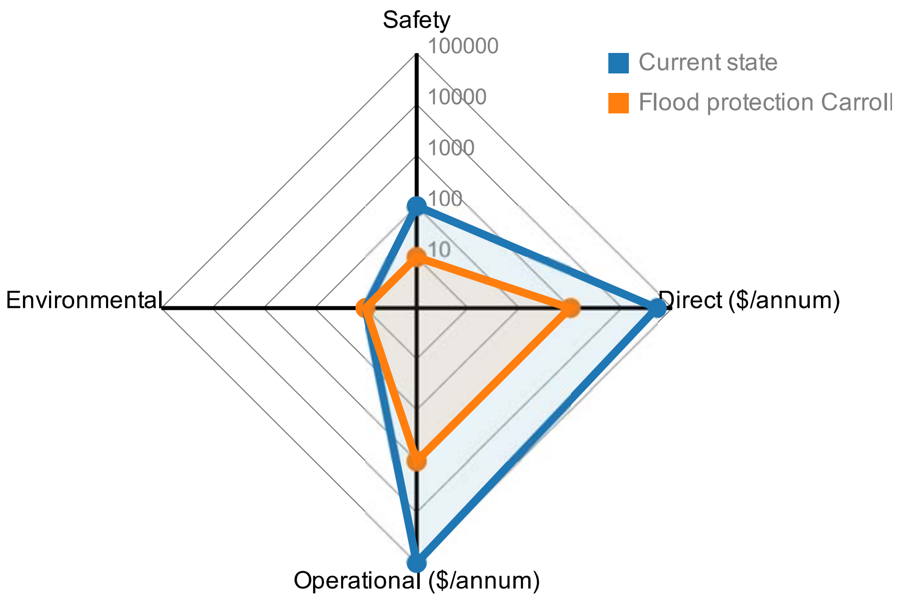
Comments	Wind speeds could reach 105 mph. causing minor damage to the building specifically roofs. Minor flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Power plant would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 5000



Current Risk Type	**Comments**
Safety	As the building has been storm proofed, personnel inside the building can be considered to be safe
Environmental	No environmental damage
Operational ($/annum)	Plant frequency converter would supply 25 Hz or 60 Hz power in the event Carrollton frequency lost Entergy 60 Hz power
Direct ($/annum)	Clean up costs and possible minor wind and flood damage repairs to building and surrounding area

Threat: Scenario: SR 100 years

Comments	Swiss RE predicts winds could reach up to 105 mph with a storm surge flood depth between 2.5 to 5 feet. Frequency building is elevated 4 feet. Partial flooding of the building could occur. May have to shutdown frequency converter
Earliest Recovery of Function	15 days
Repair and recommissioning cost	$ 100000



Current Risk Type	Comments
Safety	Personnel could be exposed to flood waters
Environmental	No environmental consequences
Operational ($/annum)	Single frequency converter could be exposed to flood waters and shutdown
Direct ($/annum)	Cost to repair frequency and rebake

Measure Flood protection Carrollton WTP - Critical asset protection

Total One-Time Cost	$ 3200000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 32000
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 0

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Construct a surge / flood protection wall around some critical assets	One-time	3200000			3200000

DPS 01**: Short Resilience Report

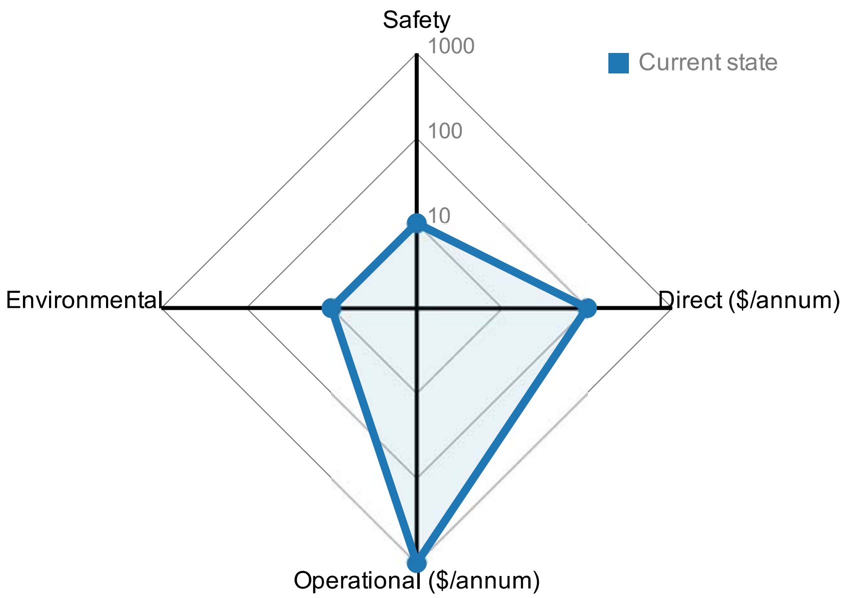
Location Description	2507 S. Broad Street, New Orleans
Primary Function	This station pumps water from the Melpomene and Broad Avenue Canals + Napoleon avenue into the Palmetto Canals (Melpomene downstream of DPS1). Drains the entire uptown area (South of DPS1 - NW to SW quadrant). 2 constant duty pumps (one is out of service) pump from DPS 1 into Broad Ave canal then goes to DPS2. The Constant duty pump that is out of service can pump to DPS2 via Broad Street canal or DPS6 via Palmetto canal. From Melpomene canal upstream of DPS1, water can be bypassed and enter the Broad Ave canal if DPS1 is out of service. There is a gate that allows water to bypass DPS1 from Broad avenue directly into Melpomene canal (Palmetto) in case DPS2 is not in operation. Can let it bypass to DPS 2 and DPS 6, but it would likely flood uptown area - not a preferred scenario
Context Information	11 Pumps, 7 horizontal, 2 vertical, 2 constant duty originally Station pumping capacity 6,825 cfs, or 3,063,282 GPM 25 Hz 4,625 cfs, or 2,075,850 GPM 60 Hz 2,200 cfs, or 987,431 GPM Building Value:$200,000,000.00 Contents Value: $1,000,000.00 (Cost of rewire is estimated at 300K per motor) 60 Hz: 2 pumps=2500HP each fed by Entergy - They are fed with the Carrolton 60Hz production capacity as a backup feeder system 25Hz: 3 pumps=1200HP each 2 pumps=600HP each 2 pumps =400HP each (vertical pumps) 1 pump=125HP out of service - constant duty 1 pump=40HP - constant duty Discharges mostly to DPS 6 and also some to DPS 2. No generator for the pumps 60Hz - backup from the 60Hz at the Carrolton WTP One house generator fed by 3000 Gal fuel tank Waterproofing materials have been used to seal the brick and mortar for half of the building. Doors and windows have been replaced with hurricane rated ones - The roof was replaced with a hurricane rated roof. Removable barriers were installed in front of the openings of doors (around 3 ft above floor level). Electric sump pumps can be used powered by the house generator.
Full Replacement Cost	$ 201000000

DPS 01**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	No redundant station for the same catchment area, but can divert inlet flow to DPS 02 and DPS 6 if inlet levels get high enough - this is not desired though as the higher inlet levels can result in flooding around DPS 01's catchment area. Redundant electrical feeds - 60Hz from the Entergy grid, and 25Hz from S&WB's 25Hz distribution, but no ability to convert frequency at the station itself though so some pumping capacity will be lost if only one feed is available. S&WB staff indicated that providing an additional 60Hz feed from the Carrollton water treatment plant has been planned, but it is uncertain when this will be implemented. No onsite backup electrical power generation for pumps (though there is a small generator for station lighting, A/C, sump pumps, etc.).	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Station is manned 24/7 During hurricane event, 8 staff are assigned to the facility. Skill level was not evaluated, needs deeper dive. Individual skill-sets were not assessed	L
Ease of access	Road access only. Multiple roads to access the facility - all low elevation. Not assessed Ease of access was not assessed in details	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	small sump pumps designed for minor infiltration. half of the building is sealed.	M
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	Not assessed, needs deeper dive.	L
ARI		**0.506**

Threat: Events: 100 year return period

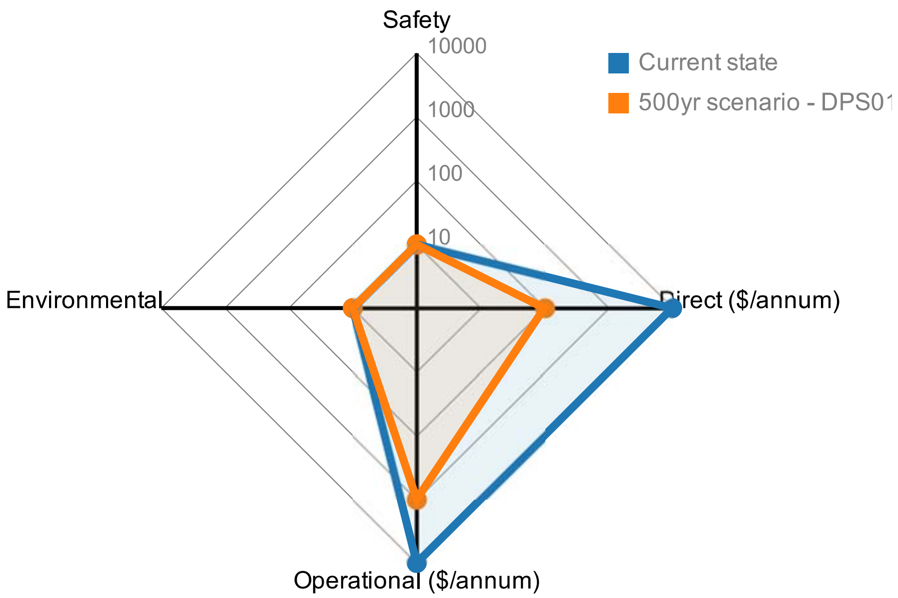
Comments	During a major hurricane flooding could occur in certain low lying areas especially some streets. Pump building sits below seal level. Power supply from Entergy will more than likely be lost. Emergency Combustion Turbine generator would generate power for the entire WTP and some drainage stations. The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 100



Current Risk Type	**Comments**
Safety	As the building has been storm proofed, no risk to personnel
Environmental	No environmental damage
Operational ($/annum)	Pump would operate as normal.
Direct ($/annum)	Minor water damage

Threat: Events: 500 year return period

Comments	a 500 yr return period event would lead to 0-2 ft of water according to FEMA / USACE The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	21 days
Repair and recommissioning cost	$ 10000



Current Risk Type	Comments
Safety	As the building has been storm proofed, no risk to personnel
Environmental	No environmental damage
Operational ($/annum)	Pump station would continue to remove water from DPS 01 drainage area
Direct ($/annum)	Water and wind damage repairs

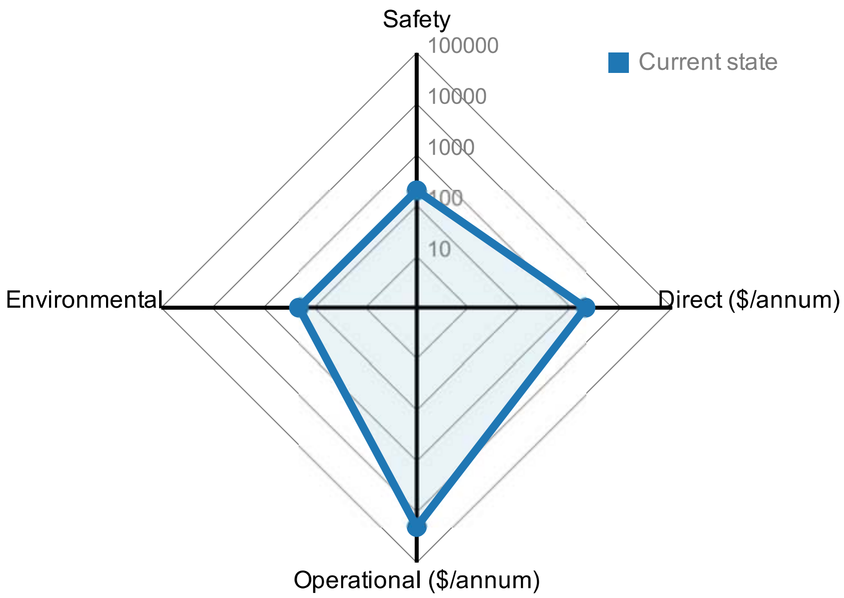
Measure 500yr scenario - DPS01 **SELECTED**

Total One-Time Cost	$ 18513
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 200
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 100

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Complete the waterproofing of the building	One-time	18513			18513

Threat: Hurricane < 100 years - Wind

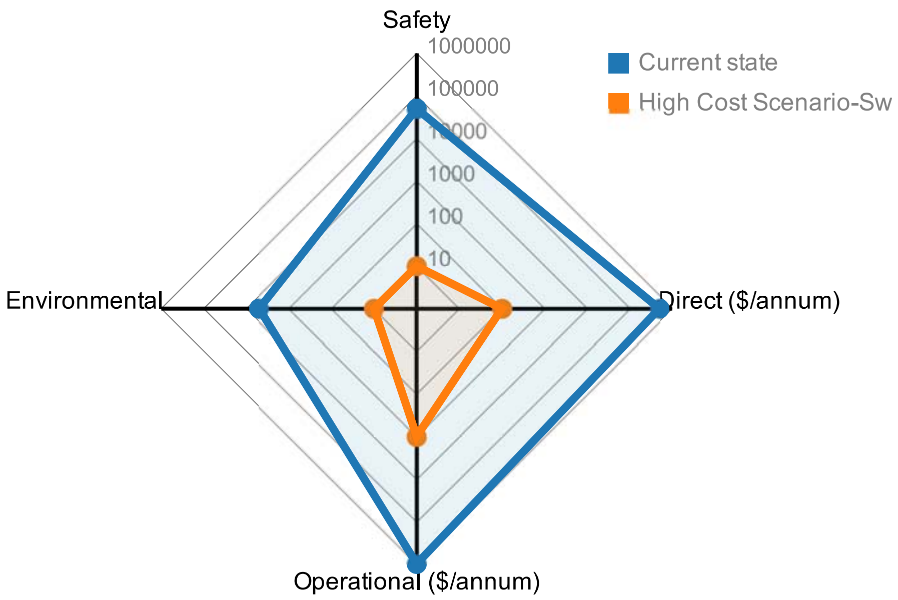
Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost and DPS 01 will be supplied 60 Hz and 25 Hz from Carrollton Power Plant.
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 2000



Current Risk Type	Comments
Safety	As the building has been storm proofed, no risk to personnel
Environmental	No environmental damage
Operational ($/annum)	House generator would be used for lights / AC / Sump Pumps / computers Communications would be ok (phone / radio / cellphones) No secondary water source for cooling / priming the pumps, but it is considered very unlikely that the drinking water network would be shut down under the wind scenario
Direct ($/annum)	Minor wind damage repairs

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE are predicting flood levels to rise between 7.5 and 10 ft. with peak wind gusts of 100 mph. Pump station and drainage residential and NO downtown areas would be flooded
Earliest Recovery of Function	7 weeks
Repair and recommissioning cost	$ 500000



Current Risk Type	**Comments**
Safety	Entire New Orleans downtown area would be flooded. Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damages to the environment could be important due to the fact that the whole area surrounding the station would be under water
Operational ($/annum)	Majority of equipment is under water at the levels provided by Swiss-re
Direct ($/annum)	Motors would have to be rewound, pump bearings replaced, etc.

Measure High Cost Scenario-Swiss Re-DPS01 **SELECTED**

Total One-Time Cost	$ 71900000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 0

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the whole pump station above NOLA study level	One-time	71900000			71900000

DPS 02**: Short Resilience Report

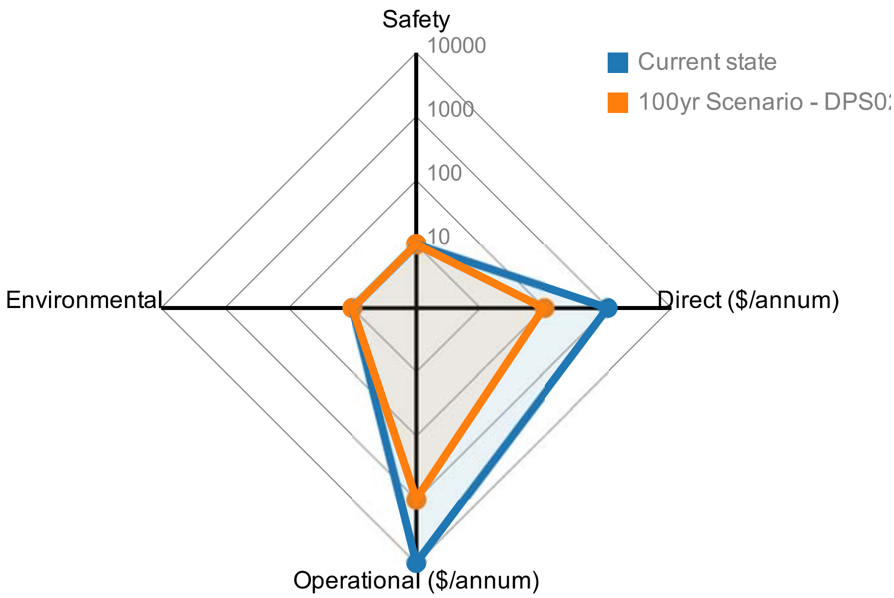
Location Description	444 N. Broad St. New Orleans LA 70119
Primary Function	DPS 2 station pumps water from the St. Louis and the Broad Street Canal to the Orleans Avenue Canal or down Broad Avenue to station DPS 3.Dries the CBD area and the French Quarter area.
Context Information	6 Pumps, 4 horizontal, 2 constant duty. Station pumping capacity 3,150 cfs 25 Hz 3,150 cfs Building Value $90,000,00.00 Contents Value $100,000.00 The wooden doors have been replaced with storm doors, and the rollup door is hurricane rated. The doorways have been modified to accept an approved flood barrier. The entire roof system has been replaced, and the roof trusses are tied down to the foundation by a tethering system. All windows and exhausts are hurricane-rated. Dry run sump pumps are installed in the Pump A and B motor pits to remove any leakage. At DPS 2, the basement is utilized as a leakage collection sump and houses sump pumps. The water booster pump is at floor level to allow for operating of the hydraulic suction basin bypass gate in the event of the loss of all pumping capacity. All conduits that penetrate the building below the DFL are sealed.
Full Replacement Cost	$ 90100000

DPS 02**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	The catchment area for this station is largely pumped solely by this station, though there is the ability to divert flow to DPS 01 and / or DPS 06 if inlet level becomes high enough but it is not preferred. Station relies solely on the S&WB's 25Hz grid, but electrical feeds can come from DPS 01 and / or the Carrolton Frequency Changer station. No onsite backup electrical power generation for pumps (though there is a small generator for station lighting, A/C, sump pumps, etc.).	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Station is manned 24/7 During hurricane event, 8 staff are assigned to the facility. Skill level was not evaluated, needs deeper dive.	M
Ease of access	Multiple roads subject to flooding	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS. None of the documents were reviewed.	M
Flood protection	Flood protection is limited to the installation of flood barriers. All the equipment would be under water in case of major flooding	M
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	Not assessed, needs deeper dive.	L
ARI		**0.543**

Threat: Events: 100 year return period

Comments	During a major hurricane flooding could occur in certain low lying areas especially some streets. Pump building sits below seal level. Power supply from Entergy will more than likely be lost. Emergency Combustion Turbine generator would generate power for the entire WTP and some drainage stations. The 100yr scenario would have a very limited impact on the facility according to FEMA / USACE flood map The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Majority of the pumps in the pump station would continue to operate during the storm event
Direct ($/annum)	Minor water or wind damage repairs

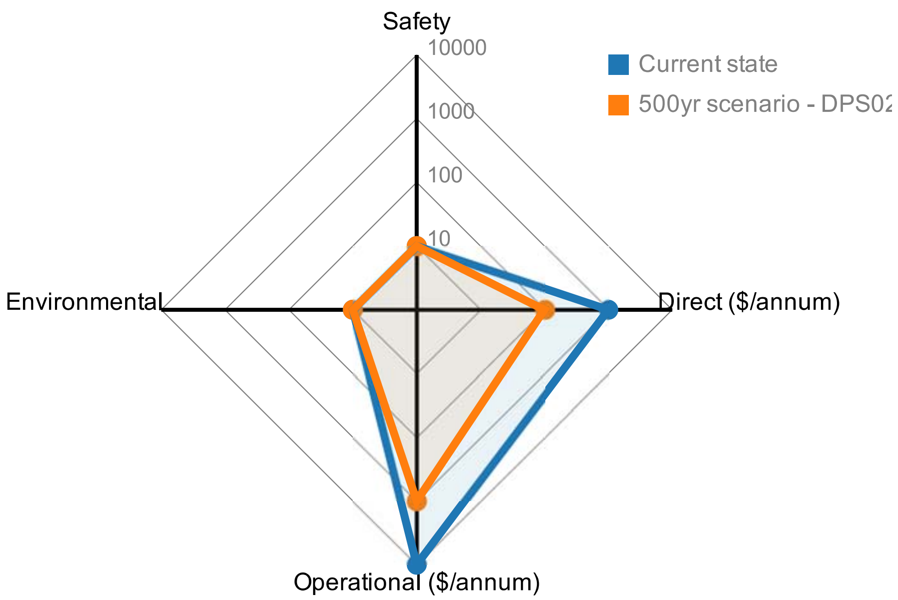
Measure 100yr Scenario - DPS02

Total One-Time Cost	$ 5000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 100
Earliest Recovery of Function	1 days
Repair and recommissioning cost	$ 100

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Seal the conduits in the basement	One-time	5000			5000

Threat: Events: 500 year return period

Comments	The 500yr scenario lead to 0-2ft of water according to FEMA / USACE The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	5 days
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Majority of the pumps in the pump station would continue to operate during the storm event
Direct ($/annum)	Minor water or wind damage repairs

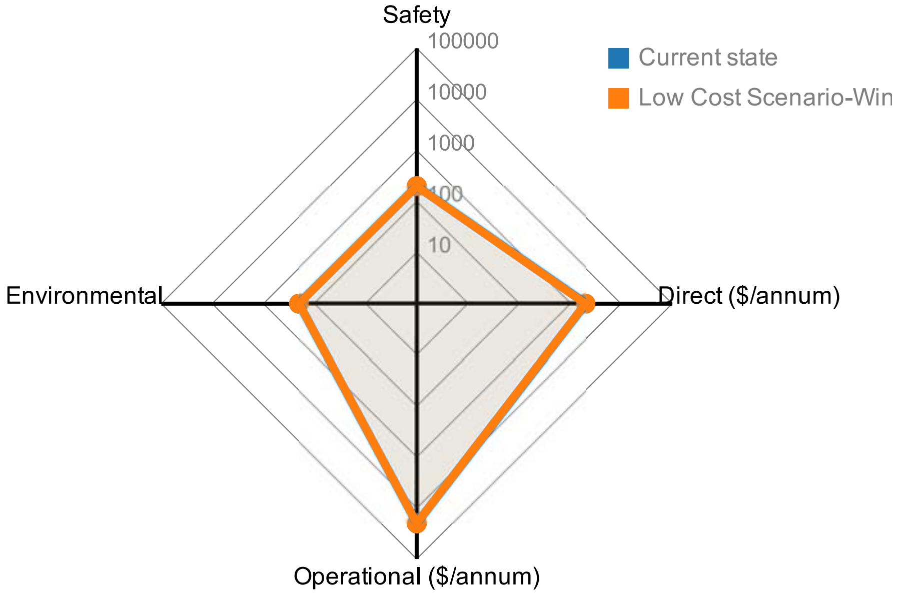
Measure 500yr scenario - DPS02 **SELECTED**

Total One-Time Cost	$ 5000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 100
Earliest Recovery of Function	1 days
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Seal the conduits in the basement	One-time	5000			5000

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. DPS would get power from Carrollton power plant.
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 2000



Current Risk Type	Comments
Safety	Pump station has been storm proofed. There is always a risk of having personnel injured.
Environmental	No major threat for the environment identified at DPS2 under the Hurricane <100 years - Wind scenario
Operational ($/annum)	The station is entirely powered by the 25Hz power supply from Carrolton WTP and/or from the Carrolton frequency changer. Therefore, it is anticipated to be electrically functional under the Hurricane <100 years - Wind scenario. No secondary water source for cooling / priming the pumps, but it is considered very unlikely that the drinking water network would be shut down under the wind scenario
Direct ($/annum)	Minor wind damage repairs

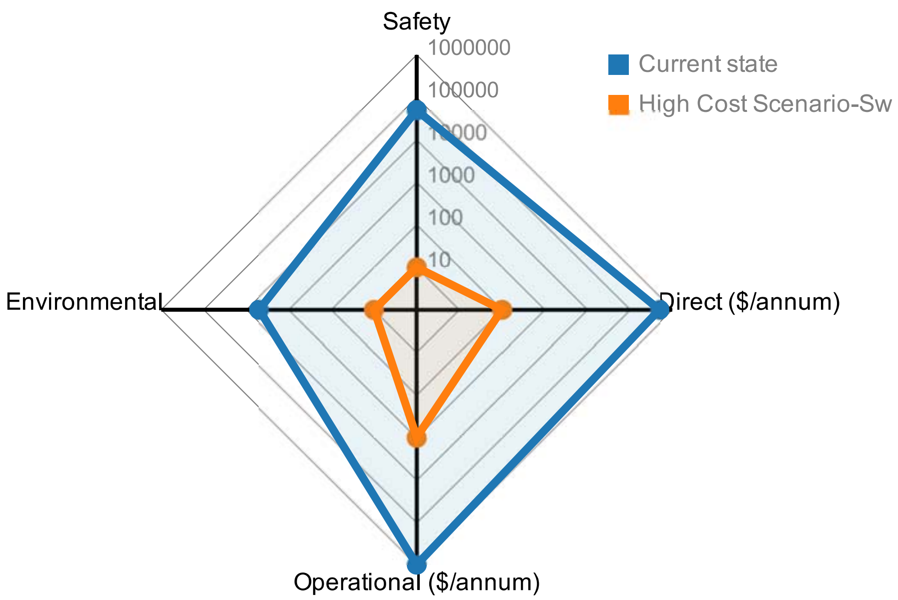
Measure Low Cost Scenario-Wind-DPS02

Total One-Time Cost	$ 200000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 2000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Implement a secondary water source for pump cooling / vacuum pumps	One-time	200000			200000

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 7.5 and 10 ft. with peak wind gusts of 105 mph. Drainage pump stallion would be flooded.
Earliest Recovery of Function	7 weeks
Repair and recommissioning cost	$ 500000



Current Risk Type	Comments
Safety	Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damages to the environment could be important due to the fact that the whole area surrounding DPS02 would be under water
Operational ($/annum)	Under the Swiss-Re scenario, the majority of the equipment will be under water which will cause a complete shutdown of DPS02
Direct ($/annum)	The vast majority of the equipment (pumps, electricals...) would have to be repaired / replaced.

Measure High Cost Scenario-Swiss Re-DPS02 **SELECTED**

Total One-Time Cost	$ 22000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 200000
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 100

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the critical equipment above 10 ft elevation to prevent flooding.	One-time	22000000			22000000

DPS 03**: Short Resilience Report

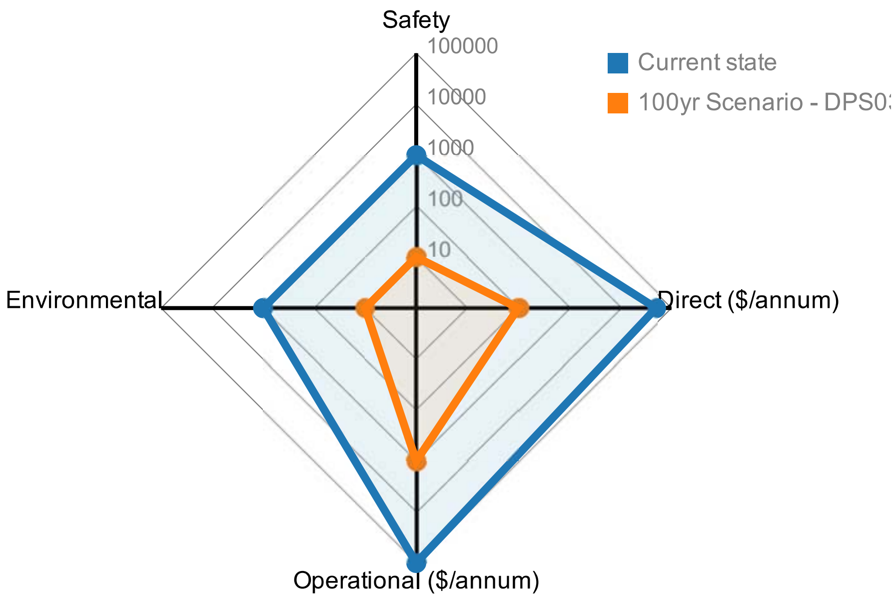
Location Description	2251 N. Broad St. New Orleans LA 70119
Primary Function	This station pumps water from the Broad Avenue and Florida Avenue Canals to the London Avenue Canal. It can also pump dry weather flow by a force main from other stations such as DPS 6 and DPS 7. DPS 4 constant duty pumps pump directly into upstream of DPS3 into a canal. There is a siphon on that canal that redirects the flow to DPS 4 which relieves flooding at DPS 3. All flow goes into London Ave Canal.
Context Information	This pump station takes drainage from DPS 2 via broad street canal. It has Nine 25 Hz pumps, 5 horizontal and 4 constant duty, and has a design capacity of 4,260 cfs or approximately 1,912,026.73 GPM. Building Value $125,000,00.00 Contents Value $125,000.00 10 25 Hz feeders 3750 kW 60 Hz house generator (not sure of the capacity of that generator) to operate the sump pumps and another one for the comms system. The wooden doors have been replaced with storm doors, and the rollup doors are hurricane rated units. The doorways and window openings have been modified to accept an approved flood barrier. The entire roof system has been replaced and the roof trusses secured to the foundation by a tethering system. All exhaust fans and intakes have been modified or replaced with roll type shutters. Buttresses have been constructed to ensure the walls withstand the wind loading scenario. Dry run sump pumps have been installed in the Pump A and B pits to remove any leakage. The basement would be utilized as a leakage collection sump. There are sump pumps for that area also. There is a sump pit next to the Constant Duty pumps that also houses a submersible pump. D pump motor is protected against flooding (encased). A small sump pump is installed to remove any leakage from C pump motor pit. All conduits that penetrate the building below the DFL are sealed. A 3750 kW generator has been installed.
Full Replacement Cost	$ 125125000

DPS 03**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	Redundant 25 Hz feeders into the station. Nine pumps all in service. All 25 Hz electrical is in basement but can pass power to other stations overhead. Pump D gets its power from a building above flood level and its motor has been water sealed up to a certain height, but it doesn't have its bearing sealed. Water can be siphoned from DPS 03 to catchment of DPS 04 but the water level has to be above 11ft Cairo depth. DPS 17 and DPS 19 also provide redundancy for this station via Florida Avenue Canal.	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Station is manned 24/7 During hurricane event, 8 staff are assigned to the facility. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Multiple roads subject to flooding	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	All the 25Hz equipment is located in the basement There is a certain level of flood protection up to 3 feet above ground level + there are sump pumps installed Pump D would be able to run until water reaches its bearings	M
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	Not assessed, needs deeper dive.	L
ARI		**0.514**

Threat: Events: 100 year return period

Comments	Part of the electrical is in the basement which makes it vulnerable to flooding, even if there is no surface flooding The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	42 days
Repair and recommissioning cost	



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed
Environmental	
Operational ($/annum)	As the electrical is in the basement, even if surface flooding doesn't occur or is very limited, there is a potential risk of basement flooding
Direct ($/annum)	

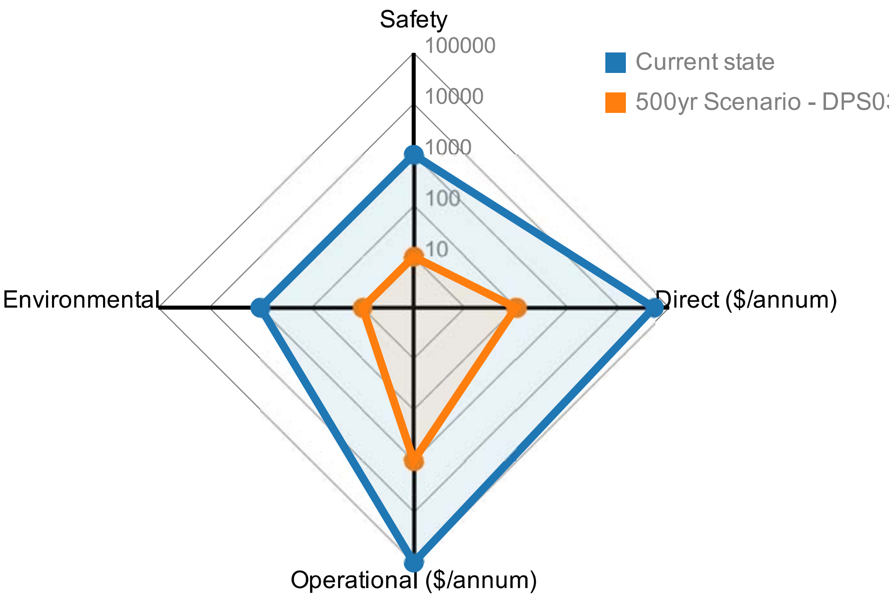
Measure 100yr Scenario - DPS03 **SELECTED**

Total One-Time Cost	$ 402911
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Relocate electrical out of the basement	One-time	397911			397911
Seal conduits in the basement	One-time	5000			5000

Threat: Events: 500 year return period

Comments	Part of the electrical is in the basement which makes it vulnerable to flooding, even if there is no surface flooding The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	42 days
Repair and recommissioning cost	



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	
Operational ($/annum)	As the electrical is in the basement, even if surface flooding doesn't occur or is very limited, there is a potential risk of basement flooding
Direct ($/annum)	

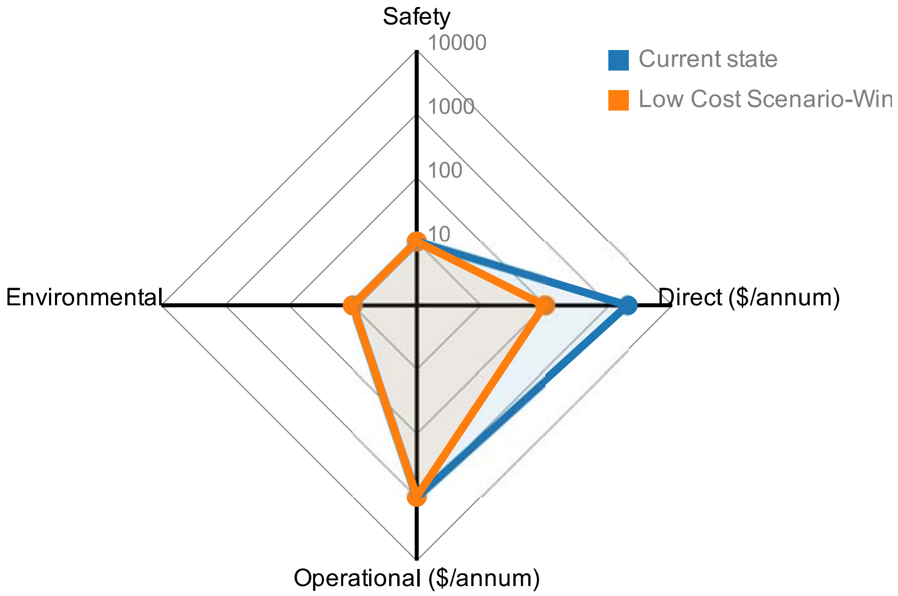
Measure 500yr Scenario - DPS03 **SELECTED**

Total One-Time Cost	$ 402911
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Relocate electrical out of the basement	One-time	397911			397911
Seal conduits in the basement	One-time	5000			5000

Threat: Hurricane < 100 years - Wind

Comments	Station depends entirely on 25Hz - no impact of wind 60Hz is used for house / small electrical and backed by a house generator
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 2000



Current Risk Type	Comments
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	no environmental conseqiences
Operational ($/annum)	No secondary water source for cooling / priming the pumps, but it is considered very unlikely that the drinking water network would be shut down under the wind scenario
Direct ($/annum)	Wind damage

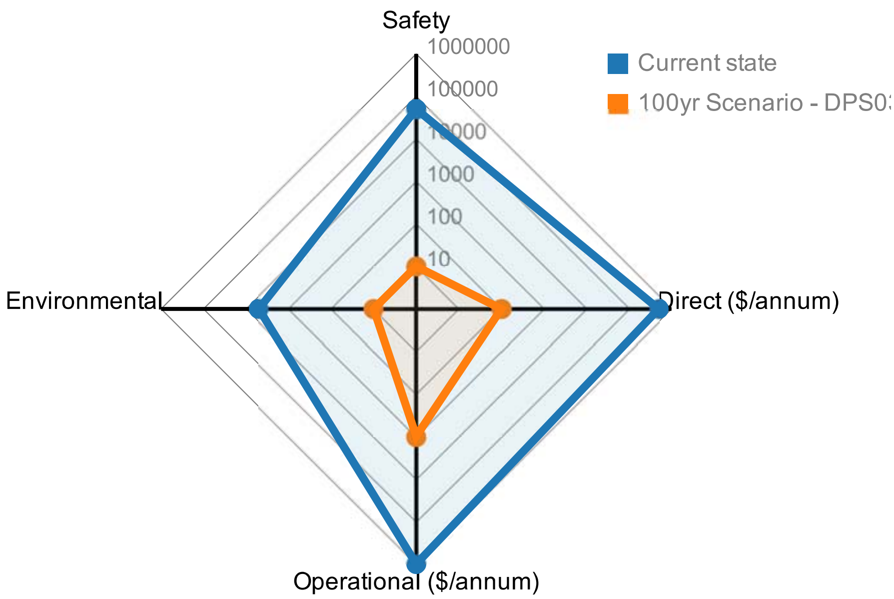
Measure Low Cost Scenario-Wind-DPS03

Total One-Time Cost	$ 50000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 0

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Implement a secondary water source for pump cooling / vacuum pumps	One-time	50000			50000

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 7.5 and 10 ft. with peak wind gusts of 105 mph. Pump station would be flooded
Earliest Recovery of Function	5 weeks
Repair and recommissioning cost	$ 500000



Current Risk Type	Comments
Safety	Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damages to the environment could be important due to the fact that the whole area surrounding the station would be under water
Operational ($/annum)	Station is under water at the levels provided by Swiss-Re
Direct ($/annum)	

Measure 100yr Scenario - DPS03 **SELECTED**

Total One-Time Cost	$ 402911
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Relocate electrical out of the basement	One-time	397911			397911
Seal conduits in the basement	One-time	5000			5000

DPS 04**: Short Resilience Report

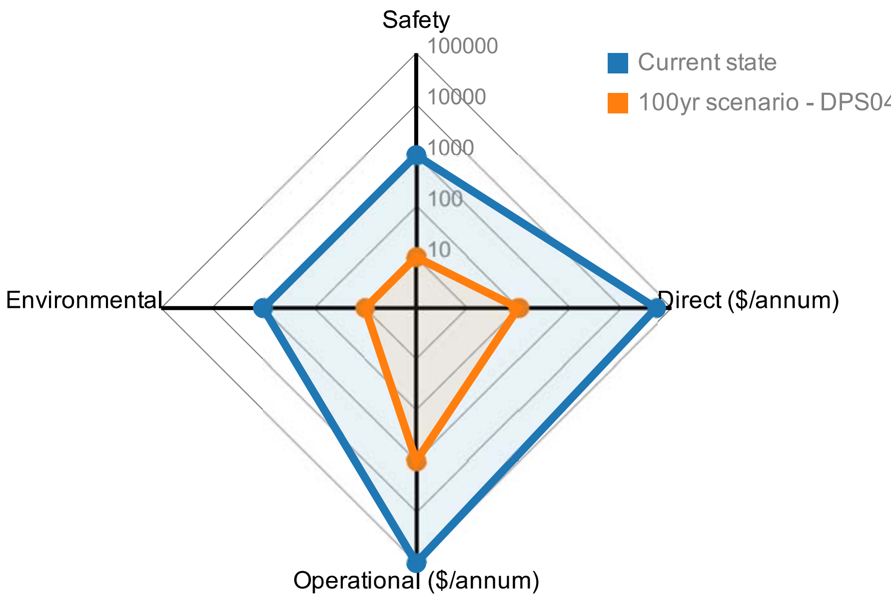
Location Description	5700 Warrington Dr New Orleans LA 70122
Primary Function	This station pumps water from the St. Anthony Avenue and Prentiss Avenue Canals to the London Avenue Canal. It dries the area bounded by lake Ponchartrain, I610 and France Road. DPS4 is also connected to some degree to DPS 17 DPS 19 and DPS 3 by Peoples and Broad Ave Canals
Context Information	6 Pumps, 3 horizontal (C and D E), 2 vertical, 1 constant duty. Station pumping capacity 3,720 cfs, or 1,669,657.14 GPM 25 Hz 3,080 cfs, or 1,382,404.30 GPM 60 Hz 640 cfs, or 287,252.84 GPM Building Value:$110,000,000.00 Contents Value: $100,000.00 The wooden doors have been replaced with storm doors, and the rollup doors is a hurricane rated units. The doorways and window openings have been modified to accept an approved flood barrier. The entire roof system has been replaced and the roof trusses secured to the foundation by a tethering system. All windows are hurricane-rated. Buttresses have been constructed to ensure the walls withstand the wind loading scenario. There are sumps pumps in the basement and in the constant duty pits.
Full Replacement Cost	$ 110100000

DPS 04**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	6 Pumps in total (3 constant duty / 3 bigger pumps). 25 Hz power supply is supplied to C D and E through DPS 03 from Caroolton WTP and the frequency changer. Supplies 4 pumps (3 big+1 constant duty). 60Hz supplies two 700HP pumps - no backup generator. One house generator only for lighting, sump pumps, etc. Station D (DPS 17) 19, and 3 can provide some backup for DPS 04 but level would have to raise up past a weir and would likely mean local flooding in the surrounding residence. the 6 pumps discharge into the London Ave canal and ultimately to Lake Ponchartrain.	L
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Station is manned 24/7 During hurricane event, 8 staff are assigned to the facility. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Accessible by road. Prone to flooding.	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	The wooden doors have been replaced with storm doors, roll-up doors with a hurricane rated units. The doorways and window openings have been modified to accept an approved flood barrier. All windows have manually operated hurricane shutters installed and all exhaust fans and intakes have been modified or replaced with roll type shutters. No specific flood protection of the equipment.	L
HAZMAT and Fire protection	Potable hand held fire extinguishers.	L
Building code compliance	The entire roof system has been replaced and the roof trusses secured to the foundation by a tethering system. Buttresses have been constructed to ensure the walls withstand the wind loading. Not assessed, needs deeper dive.	L
ARI		**0.442**

Threat: Events: 100 year return period

Comments	Part of the electrical is in the basement which makes it vulnerable to flooding, even if there is no surface flooding The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	42 days
Repair and recommissioning cost	$ 50000



Current Risk Type	**Comments**
Safety	Pump station has been storm
Environmental	
Operational ($/annum)	As the electrical is in the basement, even if surface flooding doesn't occur or is very limited, there is a potential risk of basement flooding
Direct ($/annum)	

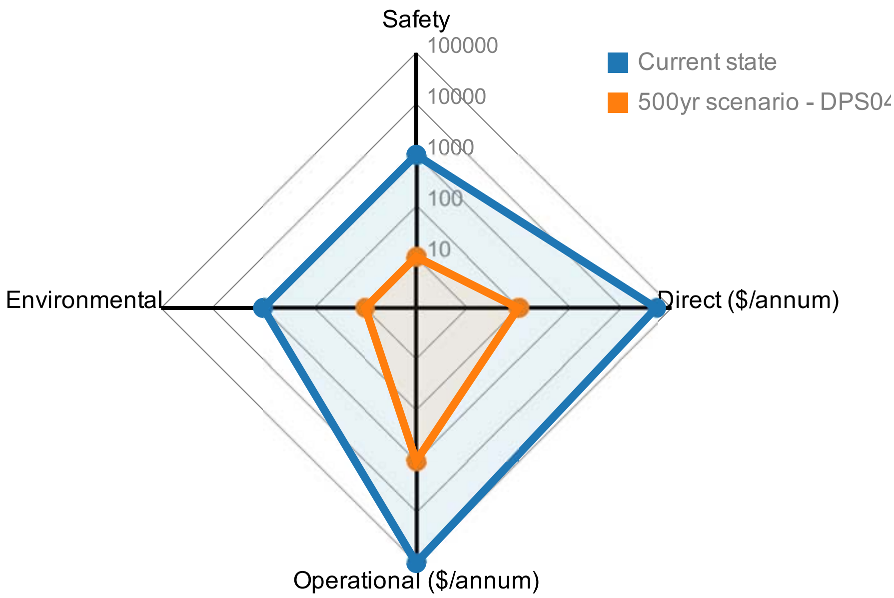
Measure 100yr scenario - DPS04 **SELECTED**

Total One-Time Cost	$ 400000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Relocate electrical out of basement	One-time	400000			400000

Threat: Events: 500 year return period

Comments	Part of the electrical is in the basement which makes it vulnerable to flooding. According to the FEMA/USACE data, flood levels would be between 0-2ft, The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	42 days
Repair and recommissioning cost	$ 50000



Current Risk Type	Comments
Safety	Pump station has been storm proofed.
Environmental	
Operational ($/annum)	As the electrical is in the basement, even if surface flooding doesn't occur or is very limited, there is a potential risk of basement flooding, It is considered unlikely that flood level would threaten the other equipment of the facility as they seem high enough.
Direct ($/annum)	Water damage to equipment

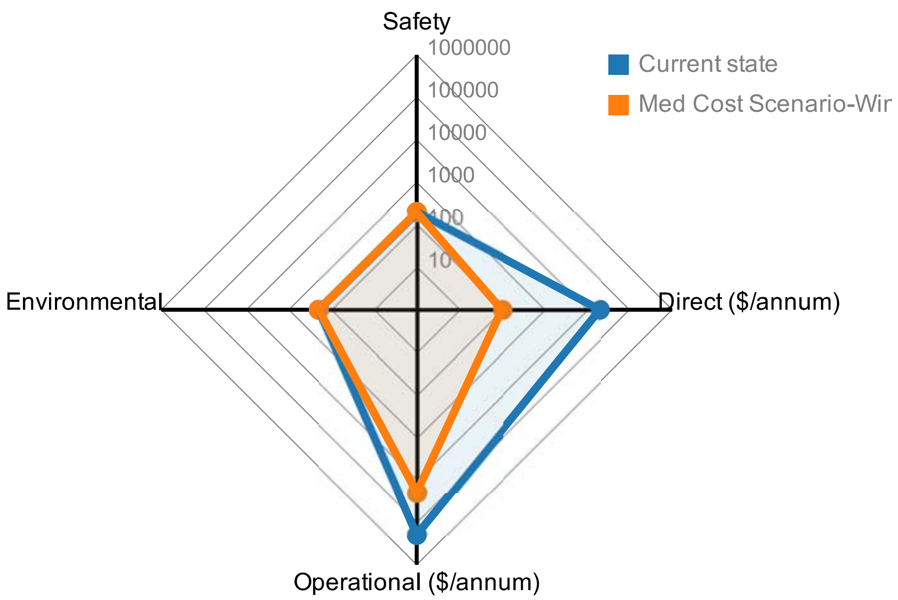
Measure 500yr scenario - DPS04

Total One-Time Cost	$ 397911
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 2000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Relocate electrical out of basement	One-time	397911			397911

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds could reach 120 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Emergency power would be supplied from Carrollton.
Earliest Recovery of Function	2 days
Repair and recommissioning cost	$ 20000



Current Risk Type	Comments
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	Minimal environmental consequences
Operational ($/annum)	Entergy 60Hz power would likely be lost + there's no generator which would put 2 constant duty pumps out However the 25Hz pumps would still be functional. No secondary water source for cooling / priming the pumps, but it is considered very unlikely that the drinking water network would be shut down under the wind scenario
Direct ($/annum)	Wind damage

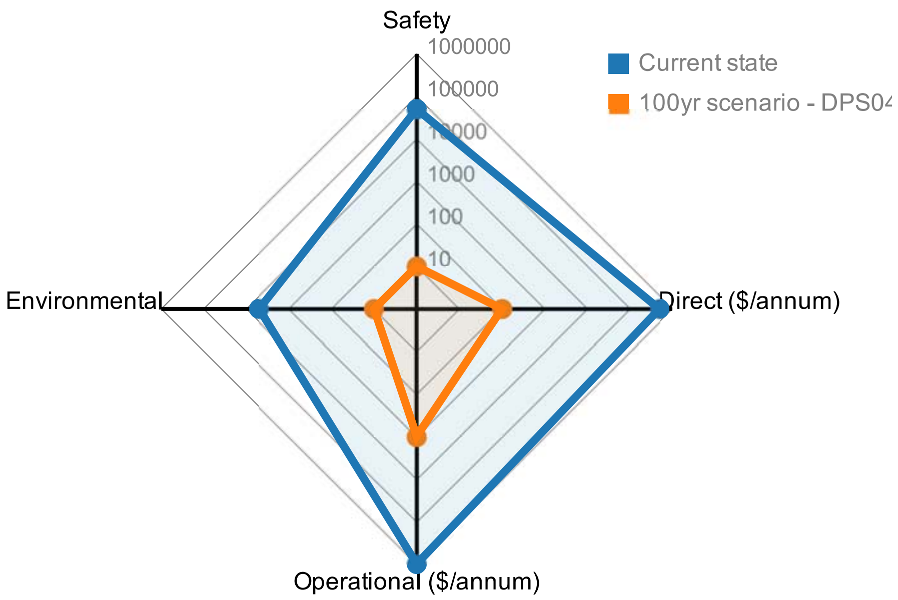
Measure Med Cost Scenario-Wind-DPS04 **SELECTED**

Total One-Time Cost	$ 3935694
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 40000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Install one 3750kW generator with foundations, ATS and 10KGal fuel storage	One-time	3935694			3935694

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 12.5 and 15 ft. with peak wind gusts of 115 mph. Station would be flooded
Earliest Recovery of Function	2 months
Repair and recommissioning cost	$ 500000



Current Risk Type	**Comments**
Safety	Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damages to the environment could be important due to the fact that the whole area surrounding the station would be under water
Operational ($/annum)	The whole station would be under water. Everything would have to be replaced
Direct ($/annum)	

Measure 100yr scenario - DPS04 **SELECTED**

Total One-Time Cost	$ 400000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Relocate electrical out of basement	One-time	400000			400000

DPS 05**: Short Resilience Report

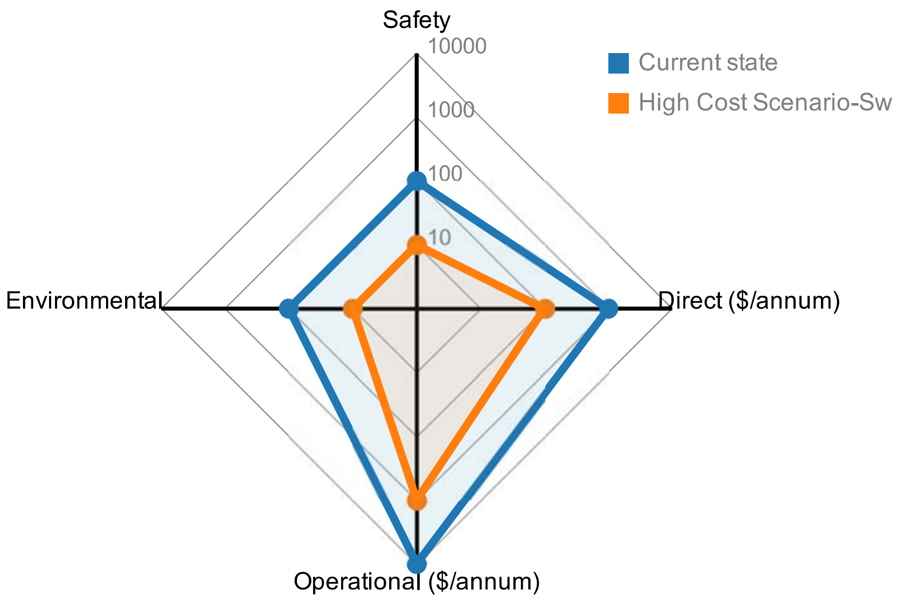
Location Description	4841 Florida Ave New Orleans La 70117
Primary Function	This station pumps water from the Florida Avenue and Jourdan Avenue Canals to Bayou Bienvenue. This pump station is the sole pump station that drains the Lower 9th Ward.
Context Information	8 Pumps, 2 horizontal, 2 vertical, 4 constant duty. Station pumping capacity 1860 cfs, or 834,828.57 GPM 25 Hz 1260 cfs, or 565529.03 GPM 60 Hz 600 cfs, or 269299.54 GPM Building Value:$60,000,000.00 Contents Value: $60,000.00 Since the DFL projects nine feet of water on the existing older station pump floor, it was not deemed safe or feasible to provide enhanced water protection for the station superstructure to the full extent of the DFL. It is possible to protect against lower levels of flooding, and that level would be determined during the detailed design phase. DPS 5 is listed as historically significant and is eligible for nomination to the NRHP; therefore, specialized design measures may be required by the State Historic Preservation Office. The old building doesn't have any hurricane / flooding graded improvements. The new building is hurricane graded and elevated to about 12 ft above ground level. DPS No. 5 is composed of two pumping configurations on this site. The first is the older station consisting of 1,260 cfs pumping capacity. The second is a single 1000 cfs horizontal pump. This second configuration was built later along with a siphon under the Inner Harbor Navigational Canal (IHNC) to connect the west side of the IHNC to the intake basin of 1000 cfs DPS 5. This siphon allowed drainage water to be diverted to DPS 5 from the west side of the IHNC during heavy rain events. After DPS 19 was fully constructed the need to divert water was greatly diminished. Subsequently the Florida Avenue railroad bridge was reconstructed. During this reconstruction process it was necessary to drive the bridge footing foundations at locations that required the demolition of this siphon. Consequently the need for the 1000 cfs pump at DPS 5 was minimized. Although this 1000 cfs pump was connected to the suction basin of DPS 5, the ability to deliver full flow to this pump due to suction basin geometric/hydraulic configurations is limited. After the submergence of DPS 5 by storm water from Hurricane Katrina all the pumps at DPS 5 were damaged. The pump was not repaired after Hurricane Katrina because it was anticipated that it would be replaced during the storm proofing work with vertical pumps housed on an elevated structure. The 25 HZ 1,000 cfs Pump D was replaced with two new 60 Hz 300 cfs each vertical pumps housed in a separate building along with one big generator (2.5 or 3 MW) and a house generator.
Full Replacement Cost	$ 60060000

DPS 05**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	8 pumps in total, all operational. 2 60Hz pumps with emergency generator in new building - transformer at ground level 6 25Hz pumps in an old building No redundancy in terms of other pump stations - DPS 5 is the only station draining the lower 9th ward.	L
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Station is manned 24/7 During hurricane event, 8 staff are assigned to the facility. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Road access only. Multiple roads to access the facility - all low elevation.	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	New building is well above flood levels Old building is not protected	M
HAZMAT and Fire protection	Potable hand held fire extinguishers.	L
Building code compliance	Not assessed but old building is probably not compliant	M
ARI		**0.515**

Threat: Events: 100 year return period

Comments	The 100yr scenario would have a very limited impact on the facility according to FEMA / USACE flood map The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Pumps would drain the ninth Ward
Direct ($/annum)	Minor water related damage

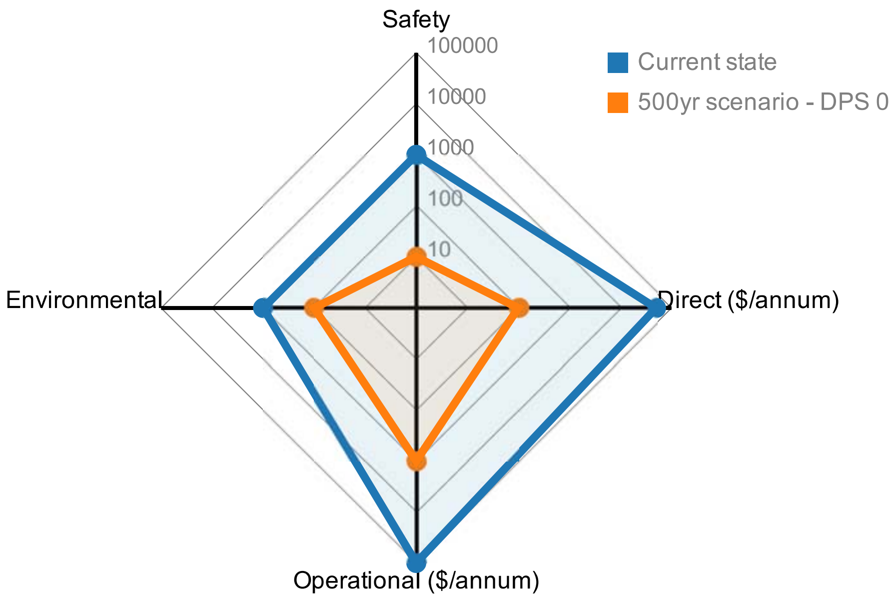
Measure High Cost Scenario-Swiss Re-DPS05

Total One-Time Cost	$ 20700000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 100
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 100

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the whole pump station above NOLA study level	One-time	20700000			20700000

Threat: Events: 500 year return period

Comments	The 500yr scenario would lead to 2-4ft of water in the surroundings of the facility according to FEMA / USACE flood map The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 50000



Current Risk Type	Comments
Safety	
Environmental	
Operational ($/annum)	The transformer would likely be affected as well as the entire pump station that houses the 25Hz pumps
Direct ($/annum)	Repairs to transformers and station equipment

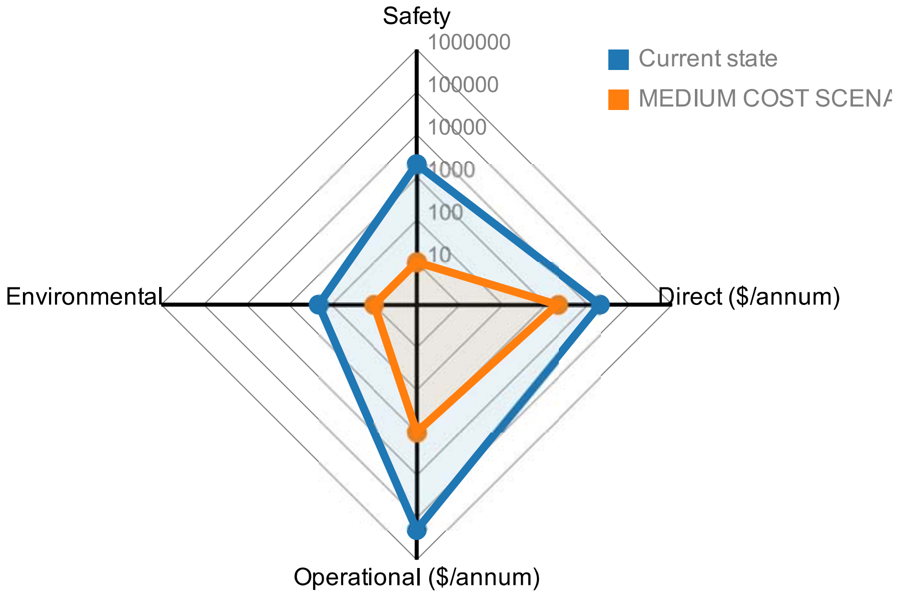
Measure 500yr scenario - DPS 05 **SELECTED**

Total One-Time Cost	$ 1129614
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the transformer platform - Add a new transformer - Build a wall around the old pump station (600ftx8ft + 3 door openings)	One-time	1129614			1129614

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. DPS 05 emergency generator would supply 60 Hz and 25 Hz would be supplied form Carrollton Power Plant.
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	



Current Risk Type	Comments
Safety	
Environmental	
Operational ($/annum)	Old building may be damaged by high winds, which could impact the operation of the station No secondary water source for cooling / priming the pumps, but it is considered very unlikely that the drinking water network would be shut down under the wind scenario
Direct ($/annum)	Old building would likely be damaged

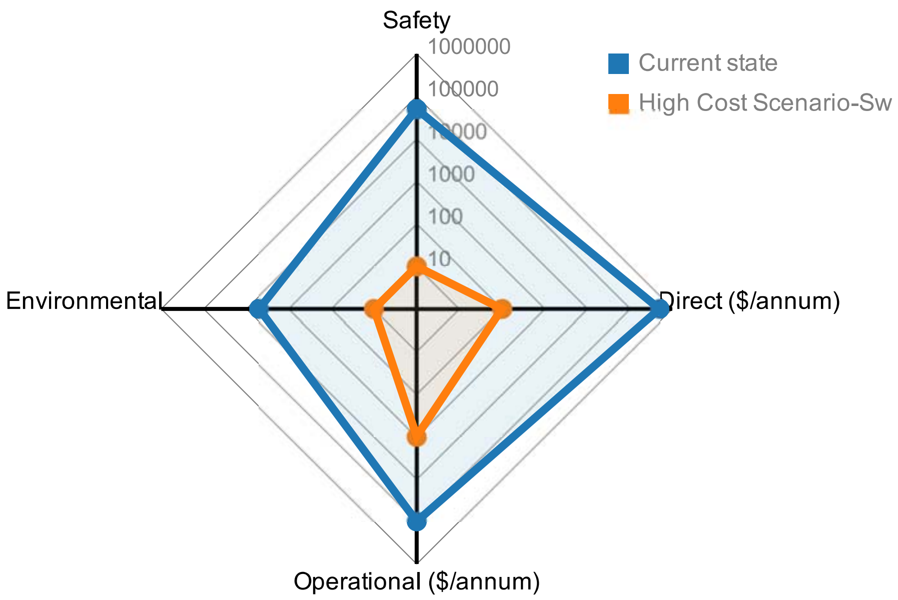
Measure MEDIUM COST SCENARIO (structure) **SELECTED**

Total One-Time Cost	$ 2000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 2000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Reinforce the structure of the building	One-time	2000000			2000000

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 10 and 12.5 ft. with peak wind gusts of 115 mph. Station would be flooded.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 500000



Current Risk Type	Comments
Safety	Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damages to the environment could be important due to the fact that the whole area surrounding the station would be under water
Operational ($/annum)	All the 25 Hz pumps in the old building would be flooded. New building should withstand those extreme water levels
Direct ($/annum)	Repair 25 Hz pumps and motors

Measure High Cost Scenario-Swiss Re-DPS05 **SELECTED**

Total One-Time Cost	$ 20700000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Raise the whole pump station above NOLA study level	One-time	20700000			20700000

DPS 06**: Short Resilience Report

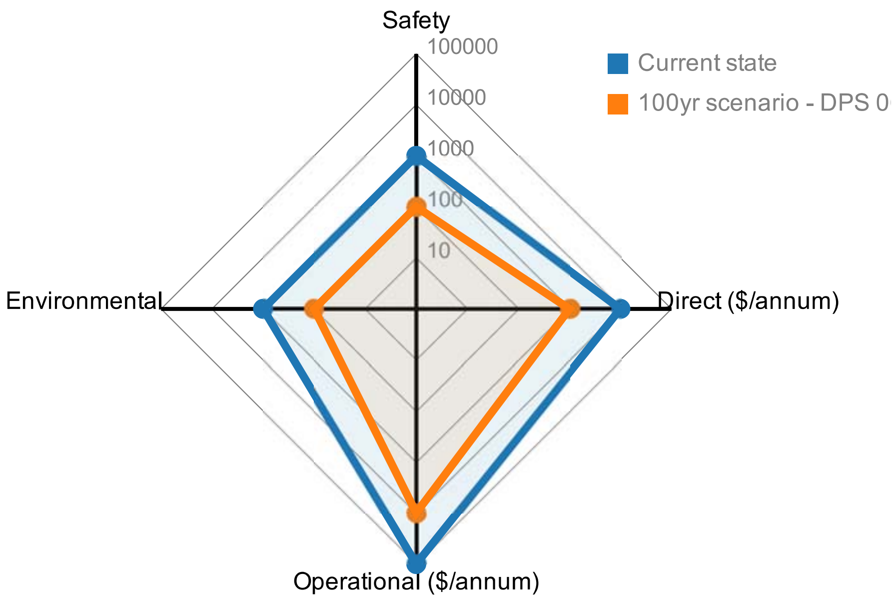
Location Description	345 Orpheum New Orleans LA 70005 (Lake Ave?)
Primary Function	This station pumps water from the Palmetto Canal to the 17th Street Canal. It also pumps water from Old Metairie. In addition DPS 6 can also evacuate water from DPS 7 and DPS 12 by means of interconnected canals and culverts. DPS 6 can pump constant duty to DPS 3 through the drainage force main,
Context Information	15 Pumps, 9 horizontal, 4 vertical (60Hz), 2 constant duty. Station pumping capacity 9,480 cfs, or 4,254,932.72 GPM 25 Hz 6,280 cfs, or 2,818,668.51 GPM 60 Hz 3,200 cfs, or 1,436,264.21 GPM (H and I horizontal pumps + the 4 vertical) Building Value:$300,000,000.00 Contents Value: $1,000,000.00 The wooden doors have been replaced with storm doors, and the rollup door has been replaced with a hurricane rated unit. The doorways and window openings have been modified to accept an approved flood barrier. The entire roof system from the 1980 expansion has been replaced, and the roof trusses are secured to the foundation by a tethering system. The standing seam metal panels in the remaining portion of the station have been replaced with stronger corrugated panels that are further secured with gasketed screws. All windows are hurricane rated, and all exhaust fans and intakes have been modified or replaced with roll type shutters. Buttresses are constructed to ensure the walls withstand the wind loading scenario. Dry run sump pumps are installed in the Pump A and B pits to remove any water leakage. The various existing pits or low points are utilized as water leakage collection sumps. Constant Duty pits 1 and 2, the basement, the rheostat pit for Pump D, and a new sump in the area of Pump G house larger submersible leakage removal pumps. In addition, run dry sump pumps are placed in or adjacent to the six horizontal synchronous motor pits. Permanent curbs or walls are installed around the perimeter of the motor pits for Pumps C, D, E, and F. A small sump pump is installed in the reactor pit to remove any leakage. Two 60 Hz back-up generators supply power the 60 Hz pumps only. The size of generators is 3,750 kW. These generators are located within the 1980 expansion portion of the building. Included with the generators are a radiator and two approximate 30,000 gallon fuel tanks installed in the northwest corner of the pump station property. Earthen berms and/or fuel containment structures were constructed in full compliance with applicable regulations to prevent fuel spills or leaks. A pump station building generator supplies 60 Hz power to the station leakage removal pumps. This generator is located inside the existing facility.
Full Replacement Cost	

DPS 06**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	DPS 06 has a degree of redundancy via DPS 07 and DPS 12 which can pull from the same catchment area, but this is not complete redundancy given the size of the catchment area and DPS 06's capacity far exceeding that of DPS 07 and DPS 12 combined. The station pumping capacity is split between the 60 Hz (45%) and 25 Hz (55%) power supplies. 25 Hz supply has 5 feeders that come from Central Control and other pump stations. The feeders are buried. The 60 Hz power supply comes from Entergy, however the station has 2 X 3.75 MW Caterpillar Emergency Generators in the event Entergy power supply is lost. A smaller Building Emergency Generator supplies 60 Hz power to the sump pumps. 15 pumps in total, 2 constant duty pumps out of service.	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Station is manned 24/7 During hurricane event, 8 staff are assigned to the facility. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Paved road access and railway line access. Road may be prone to flooding.	M
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	Doors, windows, roof structures have all been replaced to meet hurricane standards. See Context for details. Sump pumps have been placed in the basement and in the motor pits to reduce the risk of flooding the 25 Hz motors.	M
HAZMAT and Fire protection	There is minimal fire protection. Operators would use hand held fire extinguishers to suppress any fires	L
Building code compliance	This building has been brought up to building codes	M
ARI		**0.587**

Threat: Events: 100 year return period

Comments	The effects of the 100yr scenario would be very limited However, there is a risk of flooding the electrical located in the basement
Earliest Recovery of Function	3 weeks
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Electrical located in the basement could be affected by the flood
Direct ($/annum)	Repairs to basement electrics

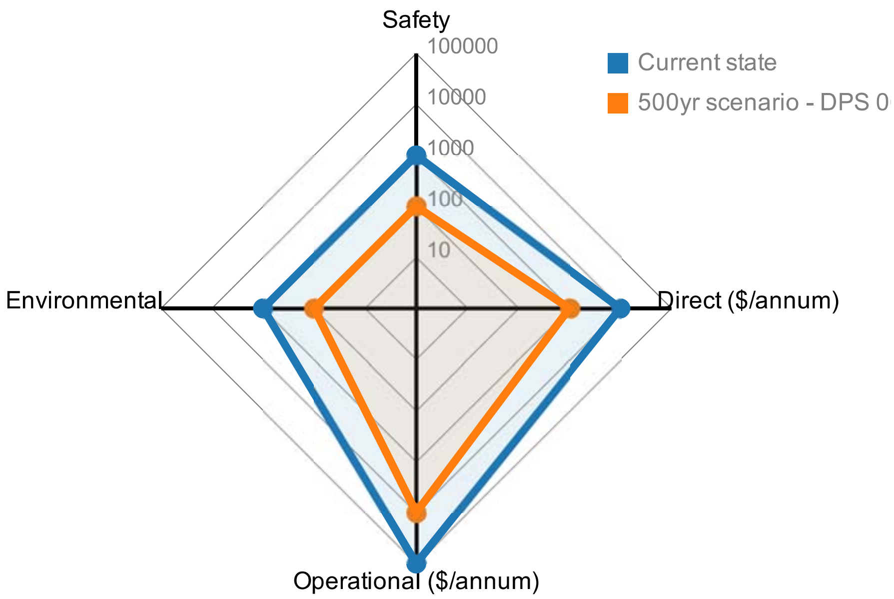
Measure 100yr scenario - DPS 06 **SELECTED**

Total One-Time Cost	$ 397911
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 20000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Relocate electrical out of basement	One-time	397911			397911

Threat: Events: 500 year return period

Comments	The effects of the 500yr scenario would be very limited However, there is a risk of flooding the electrical located in the basement
Earliest Recovery of Function	3 weeks
Repair and recommissioning cost	$ 10000



Current Risk Type	Comments
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Electrical located in the basement could be affected by the flood
Direct ($/annum)	Repairs to basement electrics

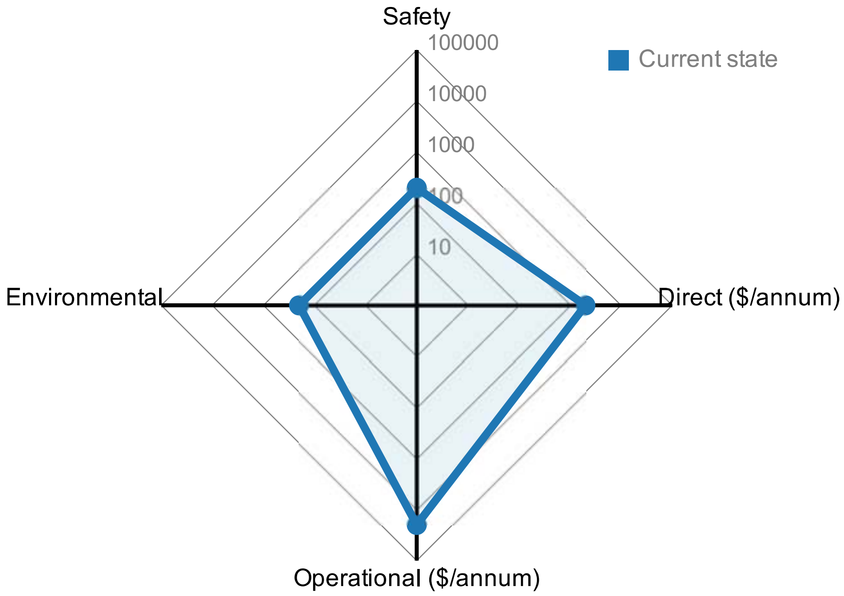
Measure 500yr scenario - DPS 06 **SELECTED**

Total One-Time Cost	$ 397911
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 2000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Relocate electrical out of basement	One-time	397911			397911

Threat: Hurricane < 100 years - Wind

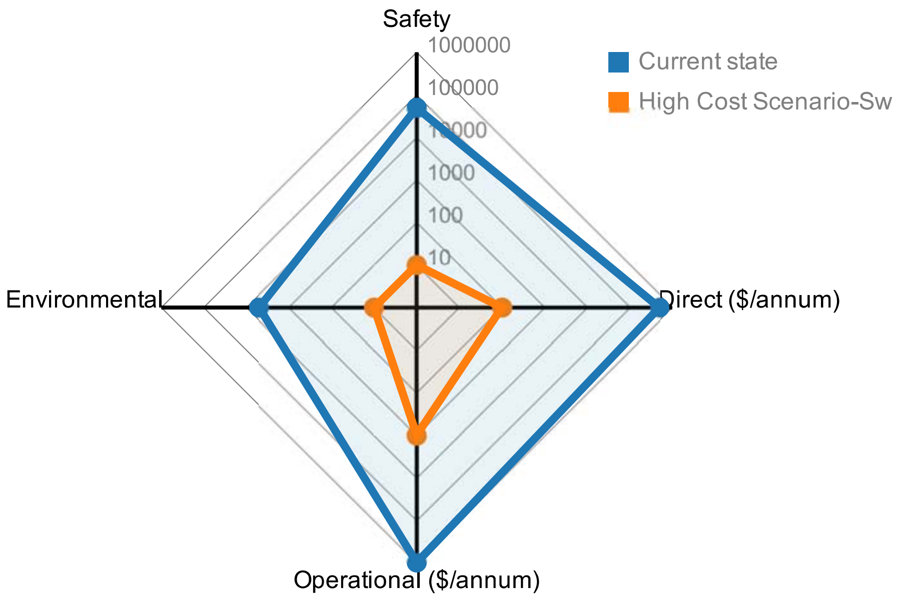
Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. DPS 06 emergency generator would supply 60 Hz and 25 Hz would be supplied form Carrollton Power Plant.
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	



Current Risk Type	Comments
Safety	Pump station has been storm proofed. There is always a risk of having personnel injured.
Environmental	No environmental damage
Operational ($/annum)	60Hz power supply would be lost due to high winds, but the generators would kick in. There is a separate potable water supply from the Jefferson parish system for cooling/priming/lubricating. No need for an alternative source of water
Direct ($/annum)	Wind damage repairs

Threat: Scenario: SR 100 years

Comments	SwissRE predicts flood levels to rise between 5 and 7.5 ft. with peak wind gusts of 105 mph. Station would be flooded
Earliest Recovery of Function	4 weeks
Repair and recommissioning cost	$ 500000



Current Risk Type	Comments
Safety	Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damages to the environment could be important due to the fact that the whole area surrounding the station would be under water
Operational ($/annum)	The whole station would be under water.
Direct ($/annum)	Major repairs to the station

Measure High Cost Scenario-Swiss Re-DPS06 **SELECTED**

Total One-Time Cost	$ 160640000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1600
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the whole pump station above NOLA study level	One-time	160640000			160640000

DPS 07**: Short Resilience Report

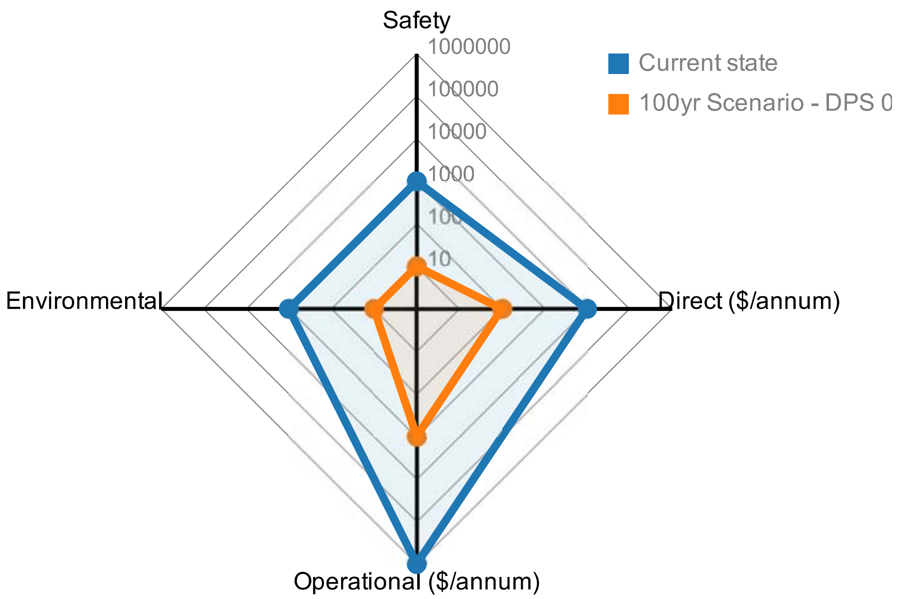
Location Description	5741 Orleans Ave. New Orleans LA 70124 Small bunker PS
Primary Function	This station pumps water from the Kennilworth / Orleans Avenue Canal (needs to be checked - Gerald doesn't know what kennilworth canal is) to the Orleans Avenue Canal. DPS 2 pumps water to DPS 7. DPS 7 is also linked to DPS 6 and DPS 12 through interconnected canals. DPS 7 can also pump to DPS 3 (constant duty through the drainage force main).
Context Information	5 Pumps, 3 horizontal (A and C 25 Hz / D 60Hz), 0 vertical, 2 constant duty. Station pumping capacity 2690 cfs, or 1,207,359.60 GPM 25 Hz 1690 cfs, or 758,527.04 GPM 60 Hz 1000 cfs, or 1,436,264.21 GPM Building Value:$90,000,000.00 Contents Value: $100,000.00 DPS 7 is located in the Orleans Avenue Canal, just south of I-610, between I-610 and the railroad tracks. This station pumps water from the Kenilworth Canal to the Orleans Avenue Canal. DPS 7 is listed as historically significant and is eligible for nomination to the NRHP. The north face of the building adjacent to the discharge canal, including the concrete catwalk, was coated below the DFL to the discharge canal waterline. In the north wall, adjacent to the ‘pancake pump’ pits, an area of the existing brick mortar masonry was sealed. Three pits were sealed and waterproofed. The wooden doors were replaced with storm doors, and the rollup doors were replaced with hurricane rated units. The doorways were modified to accept an approved flood barrier. The standing seam metal panels were replaced with stronger corrugated panels and was further secured with gasketed screws. The roof trusses were secured to the foundation by a tethering system. All windows are hurricane proof, and all exhaust fans and intakes were modified or replaced with shutters. Buttresses were constructed to ensure the walls withstand the wind loading scenario.
Full Replacement Cost	$ 90100000

DPS 07**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	DPS 07 has some redundancy via sharing catchment areas with DPS 06 and DPS 12, but DPS 7 also receives flow from DPS 02 as well as its own catchment area. 5 pumps in total, all operational. 4 are fed from the 25Hz grid while the remaining is a 60Hz pump supplied by the 60Hz Entergy grid. Station received a major 60Hz electrical upgrade via the addition of a separate elevated building to house a backup generator to supply the large 60Hz pump (D pump).	L
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Station is manned 24/7 During hurricane event, 8 staff are assigned to the facility. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Road access only. Multiple roads to access the facility - all low elevation.	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	Walls have been coated with waterproofing materials. Cracks have been filled with hydrophilic polyurethane or low-modulus epoxy material. Wooden doors have been replaced with storm doors, and the rollup doors replaced with hurricane rated units. The doorways have been modified to accept an approved flood barrier. All windows have manually operated hurricane shutters installed, and all exhaust fans and intakes have roll type shutters.	M
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	The standing seam metal panels have been replaced with stronger corrugated panels and secured with gasketed screws. The roof trusses are secured to the foundation by a tethering system. Buttresses constructed to ensure the walls withstand the wind loading scenario.	M
ARI		**0.509**

Threat: Events: 100 year return period

Comments	The 100yr scenario would lead to around 6ft of water in the surroundings of DPS 7 according to FEMA / USACE
Earliest Recovery of Function	42 days
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Pump D may be able to function but the electrical in the basement would likely be flooded
Direct ($/annum)	Repair basement electrics

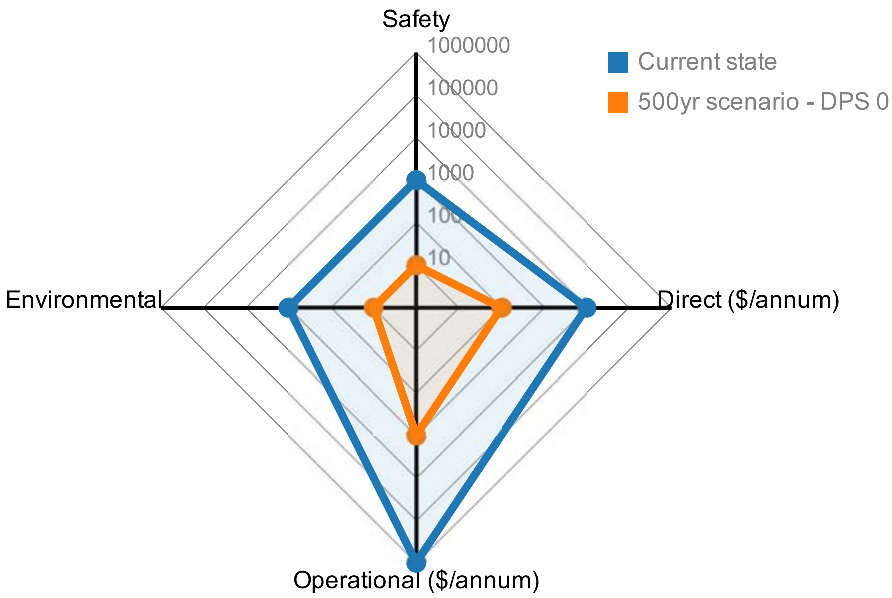
Measure 100yr Scenario - DPS 07 **SELECTED**

Total One-Time Cost	$ 597911
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 2000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Relocate electrical out of basement - Implement a leakage pump system in the 25Hz building	One-time	597911			597911

Threat: Events: 500 year return period

Comments	The 500yr scenario would lead to 0 to 10ft of water in the surroundings of DPS 7 according to FEMA / USACE
Earliest Recovery of Function	42 days
Repair and recommissioning cost	$ 10000



Current Risk Type	Comments
Safety	Pump station has been storm proofed. There is always a risk of having personnel injured.
Environmental	No damage to the environment
Operational ($/annum)	Pump D may be able to function but the electrical in the basement would likely be flooded
Direct ($/annum)	Repair basement electrical switchgear, etc.

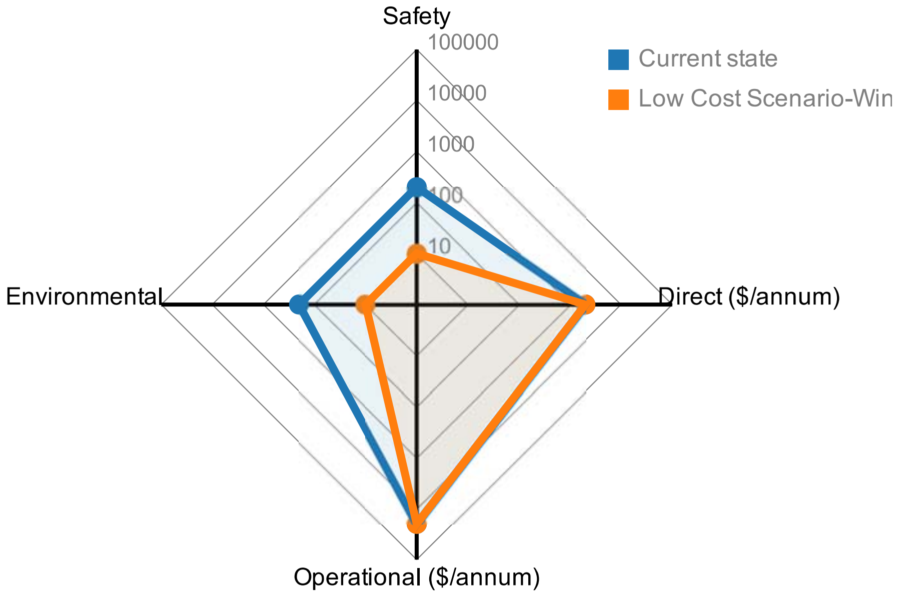
Measure 500yr scenario - DPS 07 **SELECTED**

Total One-Time Cost	$ 597911
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 20000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Relocate electrical out of basement Implement a leakage pump system in the 25Hz building	One-time	597911			597911

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. DPS 07 emergency generator would supply 60 Hz and 25 Hz would be supplied form Carrollton Power Plant.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 2000



Current Risk Type	Comments
Safety	Pump station has been storm proofed. There is always a risk of having personnel injured.
Environmental	No environmental damage
Operational ($/annum)	Potential loss of the 60Hz feed but generators would be used. The other 25Hz pumps would likely not be affected by the wind scenario since the feeders are underground. No secondary water source for cooling / priming the pumps, but it is considered very unlikely that the drinking water network would be shut down under the wind scenario
Direct ($/annum)	Wind damage repairs

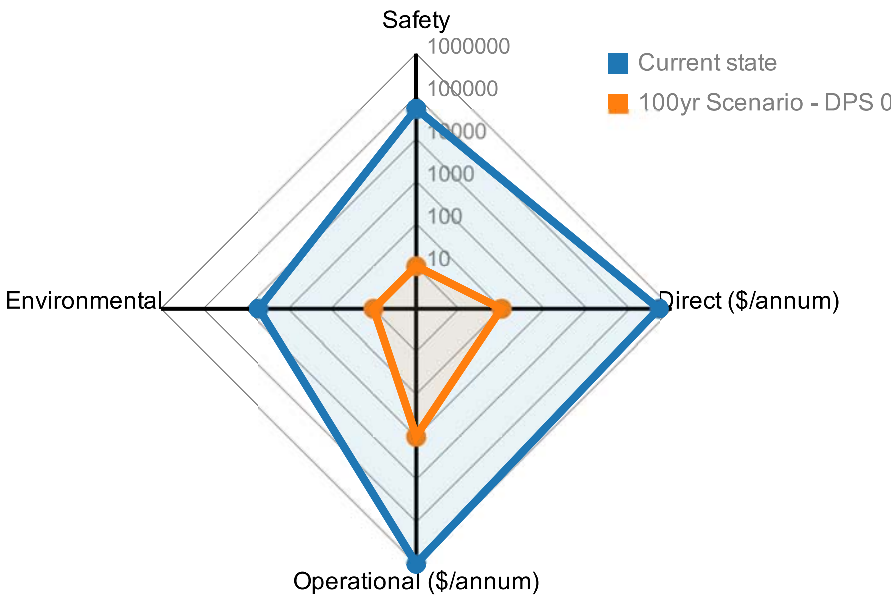
Measure Low Cost Scenario-Wind-DPS07

Total One-Time Cost	$ 50000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 50
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 2000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Implement a secondary water source for pump cooling / vacuum pumps	One-time	50000			50000

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 7.5 and 10 ft. with peak wind gusts of 105 mph. Station would be flooded
Earliest Recovery of Function	8 weeks
Repair and recommissioning cost	$ 5000000



Current Risk Type	**Comments**
Safety	Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damages to the environment could be important due to the fact that the whole area surrounding the station would be under water
Operational ($/annum)	The pumps and the associated electrical would be under water
Direct ($/annum)	Major station repairs

Measure 100yr Scenario - DPS 07 SELECTED

Total One-Time Cost	$ 597911
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 0

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Relocate electrical out of basement - Implement a leakage pump system in the 25Hz building	One-time	597911			597911

DPS 10 (Citrus)**: Short Resilience Report

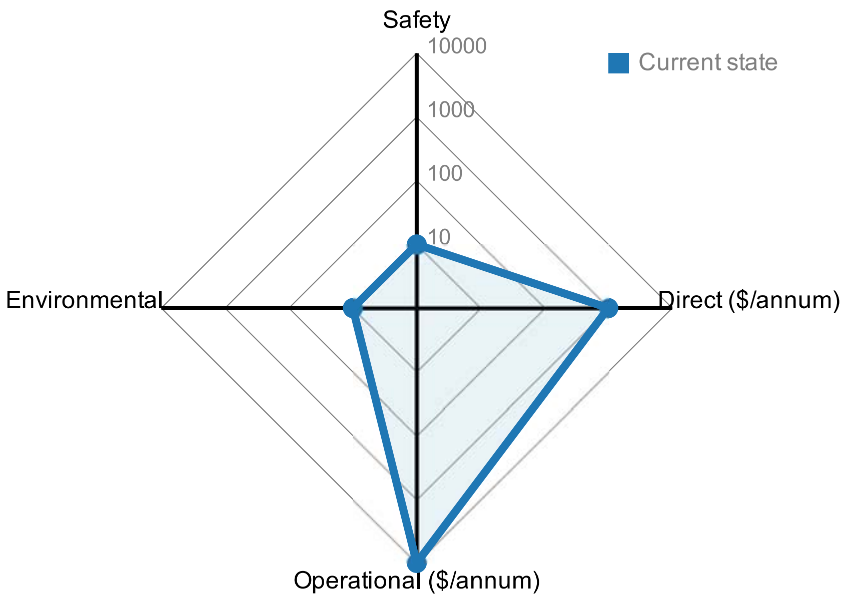
Location Description	9600 Haynes Blvd New Orleans La 70127 Medium Pump Station
Primary Function	This station pumps water from the Citrus Canal into Lake Pontchartrain. This pump station is designed to be placed on automatic control without operator presence. Operators are still needed when there's rain events and hurricanes obviously. There is redundancy both hydraulically (DPS 14, DPS 16, DPS Dwyer) and electrically (60 Hz feeder #10-14 from 14 and feeder #10-16 from 16). Interconnected with 14 16 and Dwyer by Morrison and Dwyer Rd Canals. Drains the NO East area (same as 14, 16 and Dwyer).
Context Information	4 Pumps, 0 horizontal, 4 vertical, 0 constant duty. Station pumping capacity 1000 cfs, or 1,436,264.21 GPM 60 Hz 1000 cfs, or 1,436,264.21 GPM Building Value:$30,000,000.00 Contents Value: $50,000.00 The building is not hurricane rated, There is no generator, but the station can be fed by 10 and 14. Flood protection is inexistent, however all the electrical is on the 2nd floor except transformer.
Full Replacement Cost	$ 30050000

DPS 10 (Citrus)**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	Redundancy for this station is provided via DPS 14, DPS 16 and DPS Dwyer which all pull from a common canal system. Four 60 Hz pumps in total, all in service. No backup electrical power generation capability on-site, but this site can receive 60Hz power from DPS 14 and / or DPS 16 if needed. No extra power though so pumps would have to be turned off at 14 and/or 16 to feed DPS 10. Both DPS 14 and DPS 16 have backup electrical power generation on-site.	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Unmanned site, Few skilled workers deployed during hurricane events. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Road access only. Multiple roads to access the facility - all low elevation.	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	Wooden doors have been replaced with storm doors, and the rollup doors replaced with hurricane rated units. The doorways have been modified to accept an approved flood barrier. All windows have manually operated hurricane shutters installed, and all exhaust fans and intakes have roll type shutters. All the critical electric equipment is raised up to around 10ft.	H
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	The entire roof system has been replaced, and the roof trusses would be tied down to the foundation by a tethering system. The existing concrete roof on the operator room has been thickened with the addition of concrete panels up to a maximum of 15” thick. The local controls for the screen cleaners has been raised above the DFL.	M
ARI		**0.591**

Threat: Events: 100 year return period

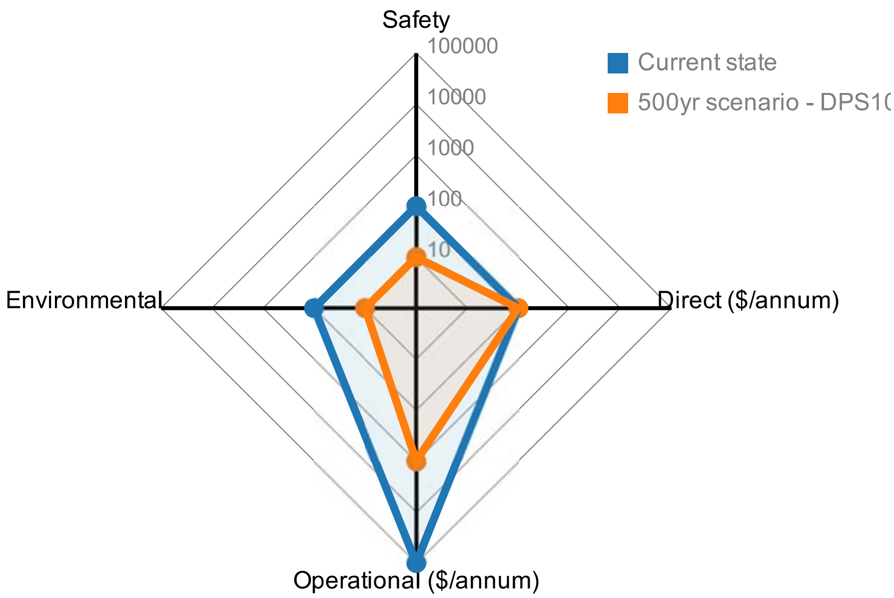
Comments	The 100yr scenario would have a very limited impact on the facility according to FEMA / USACE The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Pump station would continue operations during the storm
Direct ($/annum)	Minor water damage repairs

Threat: Events: 500 year return period

Comments	According to the FEMA/USACE data, flood levels at DPS10 wouldn't be significant. However, we suggest raising the transformer by 5ft to secure it in case of flooding. The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	



Current Risk Type	Comments
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No damage to environment
Operational ($/annum)	
Direct ($/annum)	

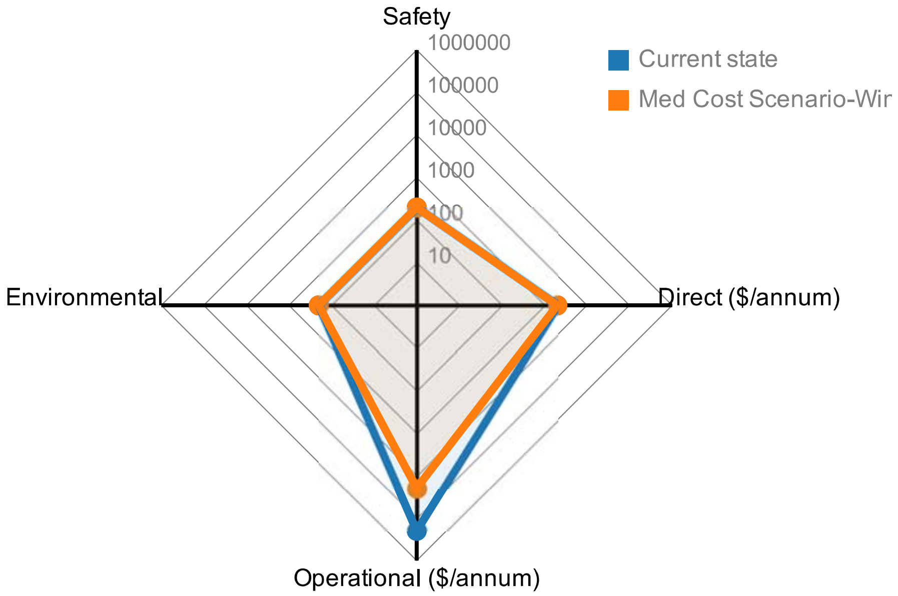
Measure 500yr scenario - DPS10 **SELECTED**

Total One-Time Cost	$ 378453
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 100

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the transformer platform by 5ft and install a new transformer	One-time	378453			378453

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. 60 Hz and 25 Hz would be supplied form Carrollton Power Plant.
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 2000



Current Risk Type	Comments
Safety	Pump station has been storm proofed. There is always a risk of having personnel injured.
Environmental	No environmental damage
Operational ($/annum)	60Hz from entergy would likely be shut down no backup generator on site but possibility to get power from the 60Hz generators at DPS14 and/or 16. However, the performance of the 3 stations would be affected. The building is not hurricane rated, however, it has never been impacted by hurricanes. No secondary water source for cooling / priming the pumps, but it is considered very unlikely that the drinking water network would be shut down under the wind scenario
Direct ($/annum)	Wind damage repairs

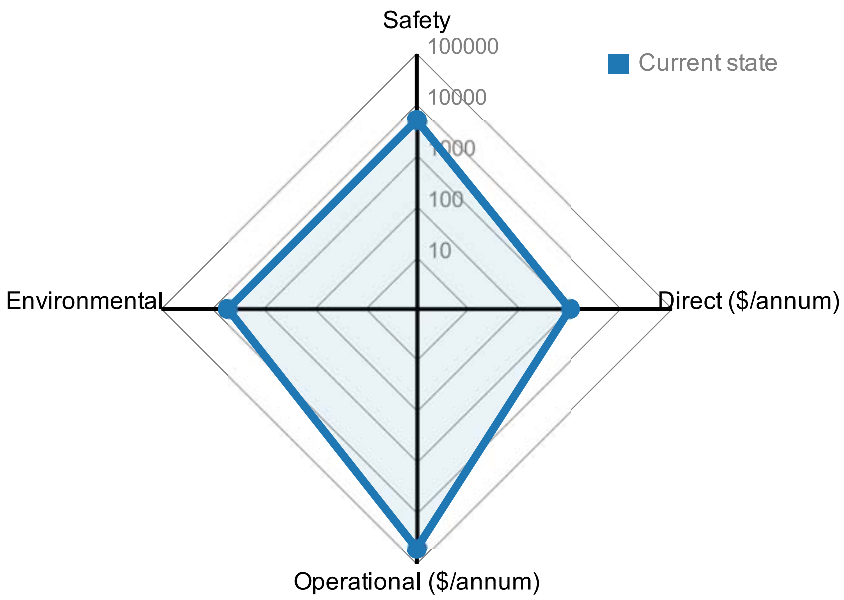
Measure Med Cost Scenario-Wind-DPS10 **SELECTED**

Total One-Time Cost	$ 4354613
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 3000
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 2000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Add a new 3750kW Generator + fuel storage + implement hurricane resistance measures	One-time	4354613			4354613

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 7.5 and 10 ft. with peak wind gusts of 115 mph. Station would be flooded
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	**Comments**
Safety	Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damages to the environment could be important due to the fact that the whole area surrounding the station would be under water
Operational ($/annum)	The 60 Hz transformer would be under water. However power can be supplied by 14 and 16. The other equipment is located on the second floor therefore wouldn't be affected by a major flooding.
Direct ($/annum)	Transformer repairs

DPS 11**: Short Resilience Report

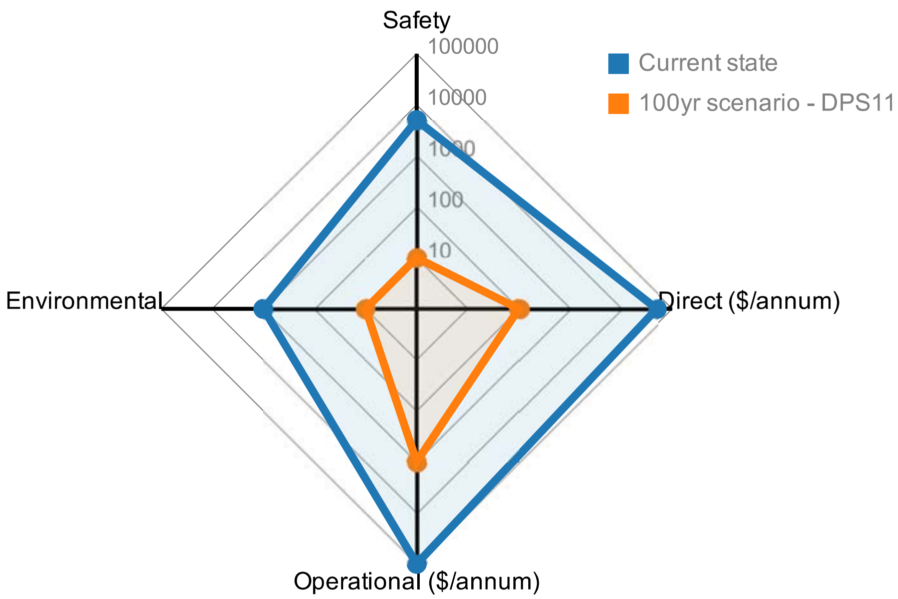
Location Description	Belle Chase, New Orleans LA 70131
Primary Function	This station pumps water from the Intake Canal to the Intracoastal Waterway. It drains Lower Coast Algiers / English Turn areas. There is no hydraulic redundancy, which makes DPS 11 a critical station.
Context Information	5 Pumps, 4 horizontals, 1 constant duty. Station pumping capacity 1670 cfs 25 Hz 500 cfs 60 Hz 1170 cfs Building Value:$90,000,000.00 Contents Value: $100,000.00 Not sure if the building is hurricane rated. Not been flood proofed either. There are sump pumps - one under each of the 60Hz pumps. One of the 60Hz pumps is out of service at this time. The 25Hz is out of service right now - there is onsite 25Hz generator that gives ability to operate at least one of the 25Hz pump at a time. There is no house generator. There is a 60Hz and a 25Hz generator. Sluice gates were installed at the outfall to prevent water from siphoning back to the pumps.
Full Replacement Cost	$ 50000000

DPS 11**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	No redundancy from other stations - this is the only station serving this side of the intercoastal waterway. Single 60Hz electrical supply from Entergy. The station had a 25Hz supply from the S&WB's 25Hz grid, but this failed some time ago and to date has not been repaired (meaning that 25Hz equipment can only be run from a relatively small 25Hz generator on-site). Two backup generators on-site, one is a relatively small 25Hz unit which can only power a single 400hp 25Hz pump, the other is a relatively large 60Hz unit which can power a single 1250hp 60Hz pump. Station has 5 pumps total (3 are 25Hz, 2 are 60Hz). One of the large 60Hz units has been out of service for some time. Station has 4 mechanical bar screens, all but one have failed meaning that there is no redundancy on the one unit that is still in service.	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Unmanned site, Few skilled workers deployed during hurricane events. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Road access only. Multiple roads to access the facility - all low elevation.	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	generator exhausts, 60Hz transformer, electrical equipment are elevated. However, if the Swiss-Re levels are reached, the whole station would be under water.	M
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	Not assessed, needs deeper dive.	L
ARI		**0.517**

Threat: Events: 100 year return period

Comments	DPS 11 doesn't appear to be hurricane resistant
Earliest Recovery of Function	21 days
Repair and recommissioning cost	$ 50000



Current Risk Type	Comments
Safety	The building could be affected by high winds - if it happens, there could be some serious injuries of the personnel
Environmental	No environmental damage
Operational ($/annum)	The building could be affected by high winds- if it happens, there would be major damage Also, one of the 60Hz pumps has been out of service for quite some time
Direct ($/annum)	Repairs to pump station infrastructure

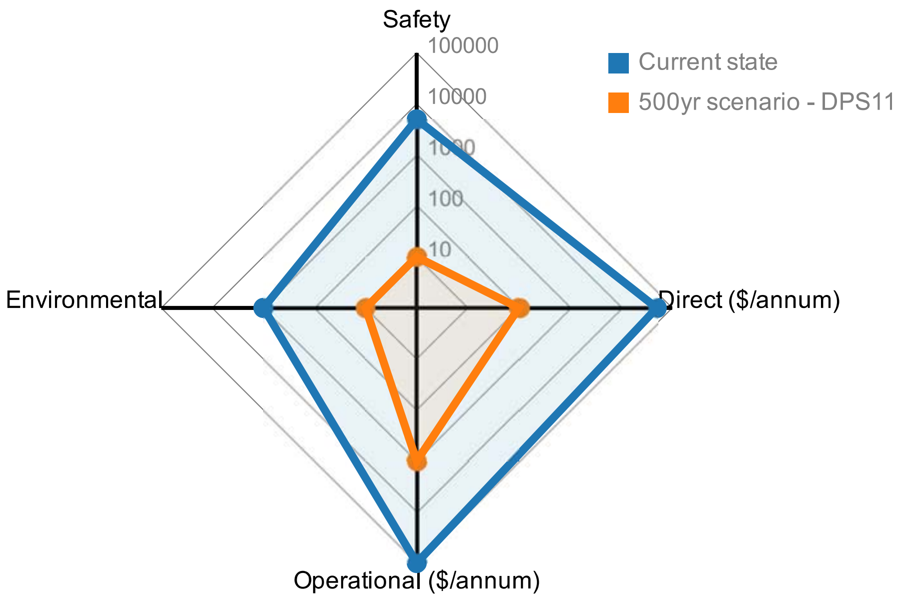
Measure 100yr scenario - DPS11 **SELECTED**

Total One-Time Cost	$ 618919
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 3000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 100

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Hurricane resistance + return the 60Hz pump back to service	One-time	618919			618919

Threat: Events: 500 year return period

Comments	The mitigation measures would be the same as the ones for the 100yr return period scenario
Earliest Recovery of Function	21 days
Repair and recommissioning cost	$ 50000



Current Risk Type	Comments
Safety	The building could be affected by high winds - if it happens, there could be some serious injuries of the personnel
Environmental	No damage to the environment
Operational ($/annum)	The building could be affected by high winds- if it happens, there would be major damage Also, one of the 60Hz pumps has been out of service for quite some time
Direct ($/annum)	Repairs to pump station infrastructure

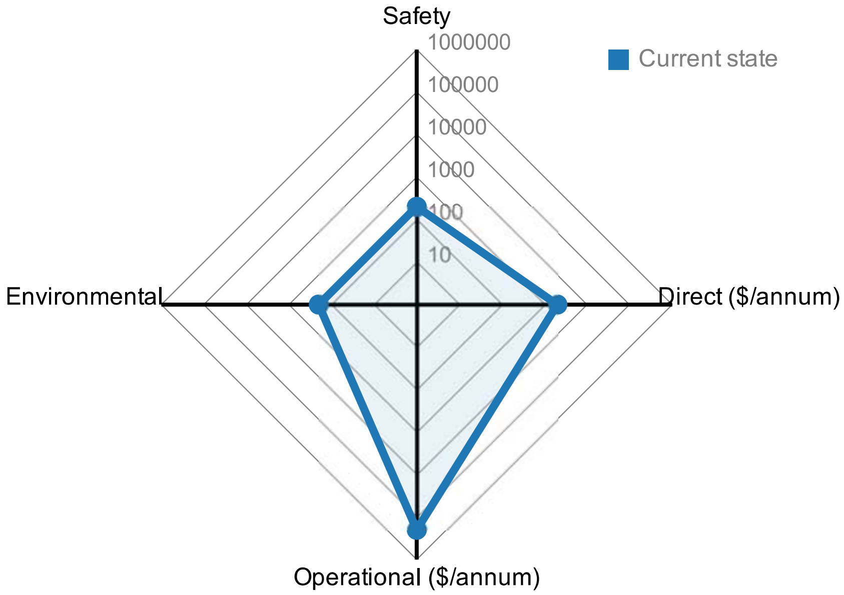
Measure 500yr scenario - DPS11 **SELECTED**

Total One-Time Cost	$ 618919
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 3000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Hurricane resistance + return the 60Hz pump back to service	One-time	618919			618919

Threat: Hurricane < 100 years - Wind

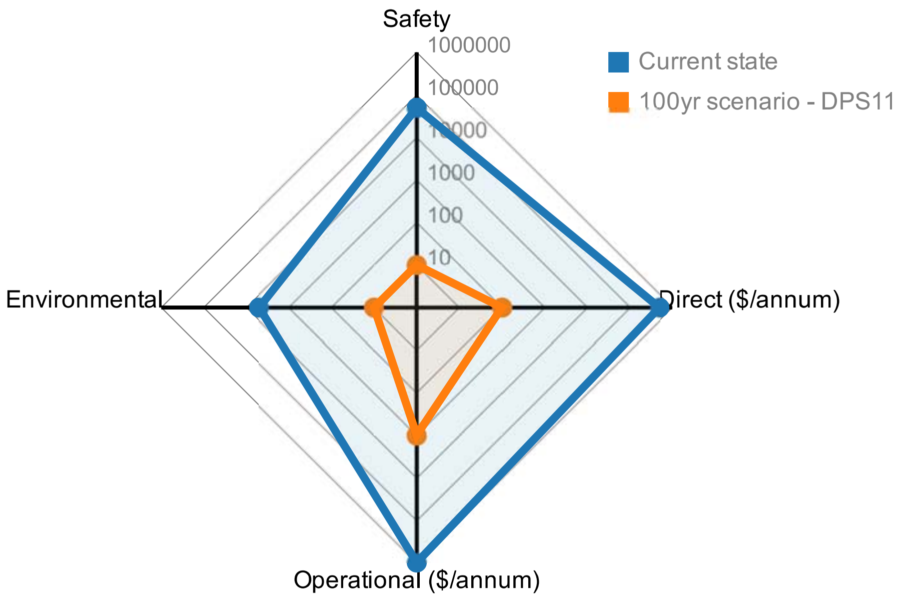
Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. DPS 11 emergency generator would supply 60 Hz and 25 Hz would be supplied form Carrollton Power Plant.
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 2000



Current Risk Type	Comments
Safety	Pump station has been storm proofed. There is always a risk of having personnel injured.
Environmental	No environmental damage
Operational ($/annum)	Station is entirely autonomous. 25Hz pumps are running on a 25Hz generator 60Hz pumps which are running primarily on 60Hz grid from Entergy would be supplied by a 60Hz generator. There's a redundant water source for cooling and priming the pumps.
Direct ($/annum)	Wind damage repairs

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 7.5 and 10 ft. with peak wind gusts of 105 mph. Station would be flooded
Earliest Recovery of Function	2 months
Repair and recommissioning cost	$ 500000



Current Risk Type	Comments
Safety	Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damages to the environment could be important due to the fact that the whole area surrounding the station would be under water
Operational ($/annum)	The entire station would be 4-6 ft under water. However, it is worth noticing that DPS 11 has not been affected at all by Katryna The transformers are already elevated
Direct ($/annum)	Major station infrastructure repairs

Measure 100yr scenario - DPS11 **SELECTED**

Total One-Time Cost	$ 618919
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Hurricane resistance + return the 60Hz pump back to service	One-time	618919			618919

DPS 13**: Short Resilience Report

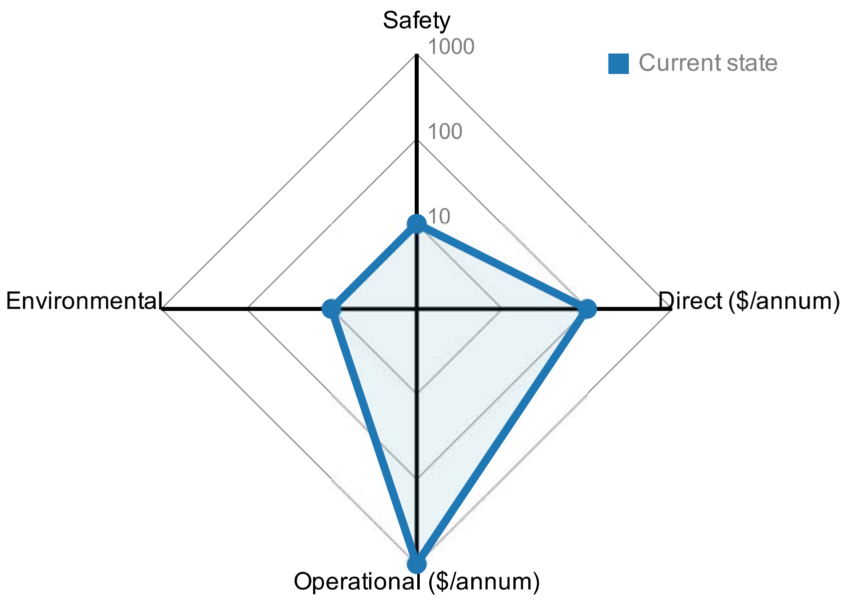
Location Description	4201 Tall Spruce New Orleans LA 70131 Large Pump Station
Primary Function	DPS 13 is located near Algiers on the west bank of the Mississippi River, west side of the Intracoastal Waterway. It pumps the entire area West of Intracoastal waterway and Algiers. It pumps into the Intracoastal Waterway,
Context Information	7 Pumps, 4 horizontal, 2 vertical, 1 constant duty. Station pumping capacity 4650 cfs, or 2,087,071.43 GPM Diesel 2000 cfs, or 897,665.13 GPM 60 Hz 2650 cfs, or 1,189,406.30 GPM Building Value:$140,000,000.00 Contents Value: $150,000.00 DPS 13 is hurricane-proof and flooding protection measures were implemented. Flood wall was constructed inside of the station to protect the pumps 4 and 5 diesel pumps -> they don't rely on the grid. The 2 60Hz pumps are elevated along with the switchgear, and have diesel generator backups for each of them located in a new building. On the East side of the building, flood wall and submarine doors were installed. The diesel tanks are flood protected. Each of the diesel pumps' controls power is fed from one of two house generators that are elevated.
Full Replacement Cost	$ 140000000

DPS 13**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	No redundancy from other stations - this is the only station serving this side of the intercoastal waterway. Single 60Hz electrical supply from Entergy. There is a total of 4 diesel backup units on-site - Two large backup generators and two large diesel engine driven pump units. Station has 7 pumps total of varying size, including the two diesel engine driven units mentioned above as well as five 60Hz electric motor driven units.	M
Supply chain strength	90000 gal of diesel fuel tank capacity, Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time. On-site raw water source.	L
Skills availability	24 hour manned site, 8 persons assigned during hurricane events. Skill level was not evaluated, needs deeper dive.	L
Ease of access	One single road in and out of site	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	Well elevated building housing generators, submarine doors at lower levels, Transformer elevated out of flood area.	H
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	Not assessed, needs deeper dive.	L
ARI		**0.554**

Threat: Events: 100 year return period

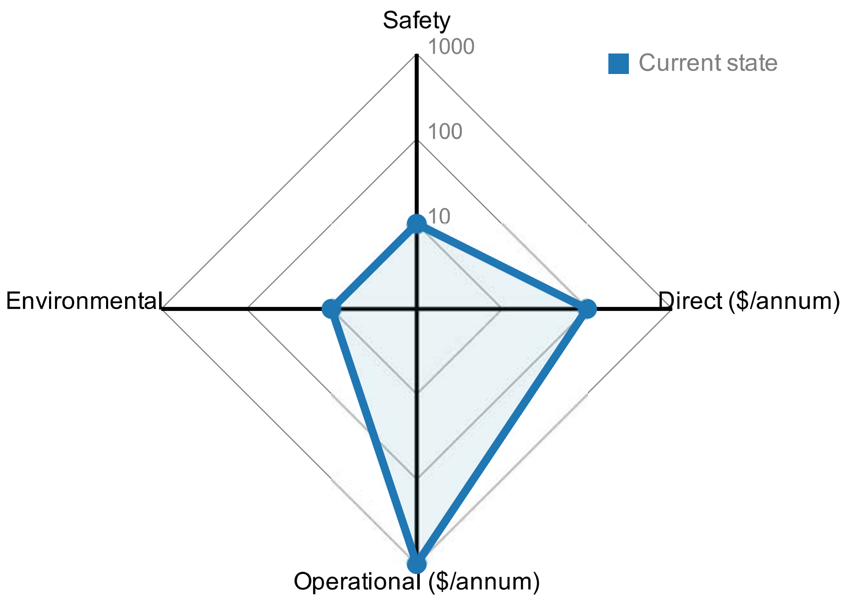
Comments	The 100yr scenario would lead to around 6ft of water in the surroundings of DPS 13 according to FEMA / USACE
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 100



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Pump station would be able to continue operations
Direct ($/annum)	Minor wind water damage

Threat: Events: 500 year return period

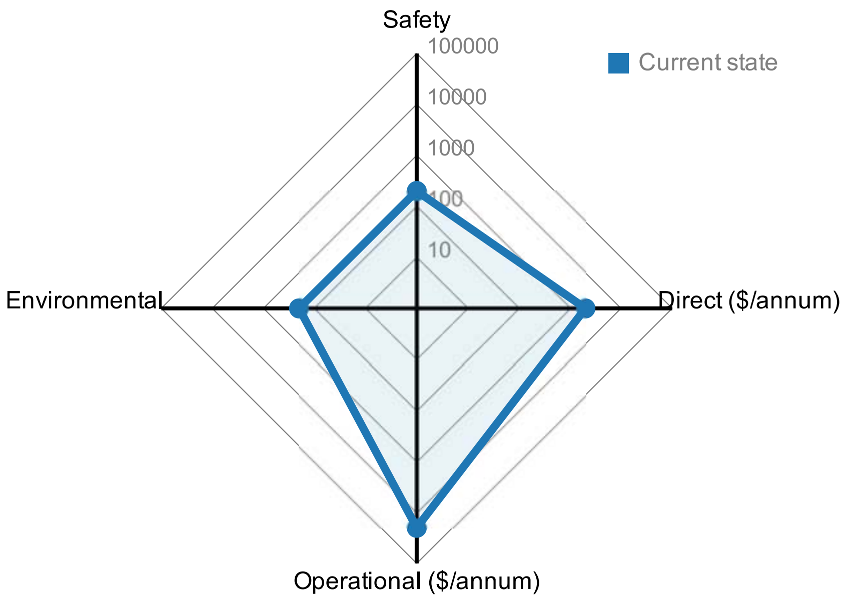
Comments	The 500yr scenario for DPS 13 leads to 0-4ft of water according to FEMA / USACE However the station would likely not be affected by those levels
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 100



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Pump station would be able to continue operations
Direct ($/annum)	Minor wind and water damage

Threat: Hurricane < 100 years - Wind

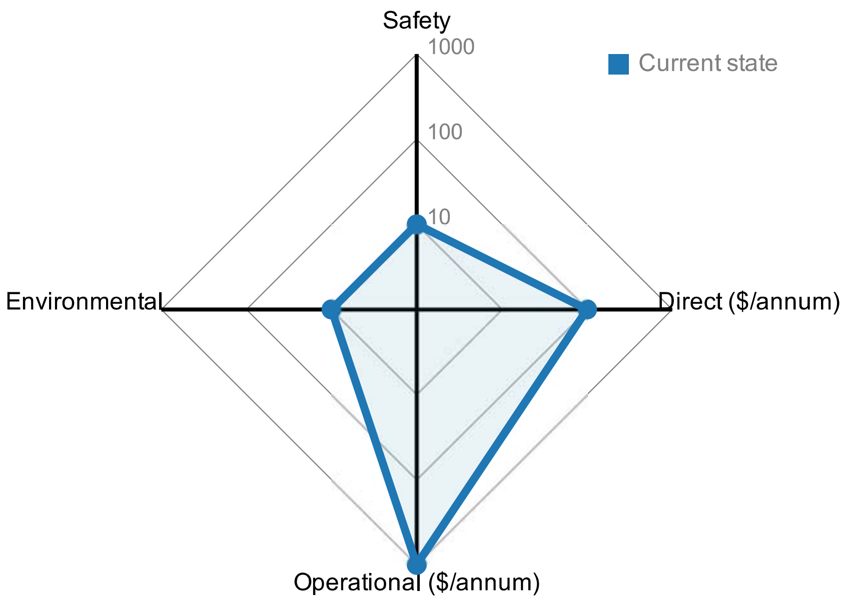
Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. DPS 13 emergency generator would supply 60 Hz and 25 Hz would be supplied form Carrollton Power Plant.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed. There is always a risk of having personnel injured.
Environmental	No environmental damage
Operational ($/annum)	The 60Hz power supply may be down, but there are 60Hz generators. In addition some pumps are diesel pumps, therefore they don't need any power to function.
Direct ($/annum)	Wind damage repairs

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between <2.5 ft. with peak wind gusts of 110 mph. Station would be flooded
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	It is anticipated that the entire pump station would be functional under the Swiss-Re scenario.
Direct ($/annum)	Minor wind and water damage

DPS 14 (Janke)**: Short Resilience Report

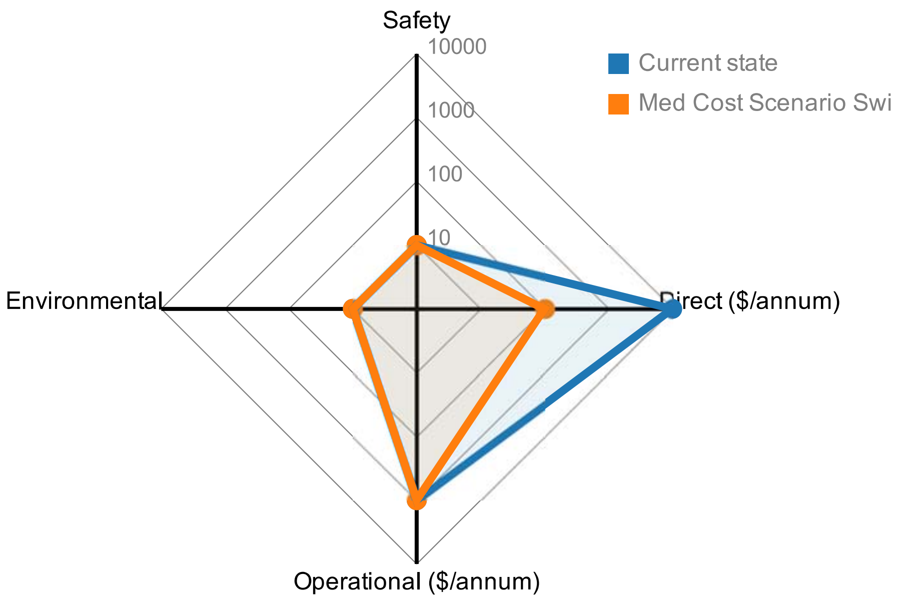
Location Description	12200 Haynes Blvd New Orleans LA 70128 Medium Pump Station
Primary Function	DPS 14 is located east of Lakefront Airport along Hayne Boulevard (see Map). This station pumps water from the Morrison and Jahncke Canals to Lake Pontchartrain. This pump station is designed to be placed on automatic control without maintaining operator presence. Operators are still needed when there's rain events and hurricanes obviously. DPS 14 is connected to DPS 16, DPS 10 and DPS Dwyer via the Morrison Avenue Canal. Power can be sent to DPS 10 from DPS 14 on a one for one trade off basis.
Context Information	4 Pumps, 4 vertical, Station pumping capacity 1200 cfs, or 538,599.08 GPM 60 Hz 1200 cfs, or 538,599.08 GPM Building Value:$40,000,000.00 Contents Value: $50,000.00 All windows were replaced with hurricane graded windows and the door glass was replaced with hurricane rated impact resistant glass. To allow refueling of the diesel fuel tanks, the perimeter fence would be modified to allow tanker access through a higher elevation area that is less likely to flood.
Full Replacement Cost	$ 40050000

DPS 14 (Janke)**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	Redundancy for this station is provided via DPS 10, DPS 16 and DPS Dwyer which all pull from a common canal system. Single 60Hz power feed from Entergy. Backup generator on-site which can supply entire station. This station can also supply 60Hz power to DPS 10 if needed, but would need to reduce power load on-site to accommodate. Four pumps in total, all appeared to be in service.	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Unmanned site, Few skilled workers deployed during hurricane events. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Road access only. Multiple roads to access the facility - all low elevation.	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	Majority of the electrical equipment is located more than 18 feet above ground, except for the 60Hz transformer	H
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	Not assessed, needs deeper dive.	L
ARI		**0.556**

Threat: Events: 100 year return period

Comments	DPS 14 would not be affected by a 100 yr return period event and continue to operate during storm event
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 10000



Current Risk Type	Comments
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Station would continue to operate during storm event
Direct ($/annum)	Minor water damage repairs

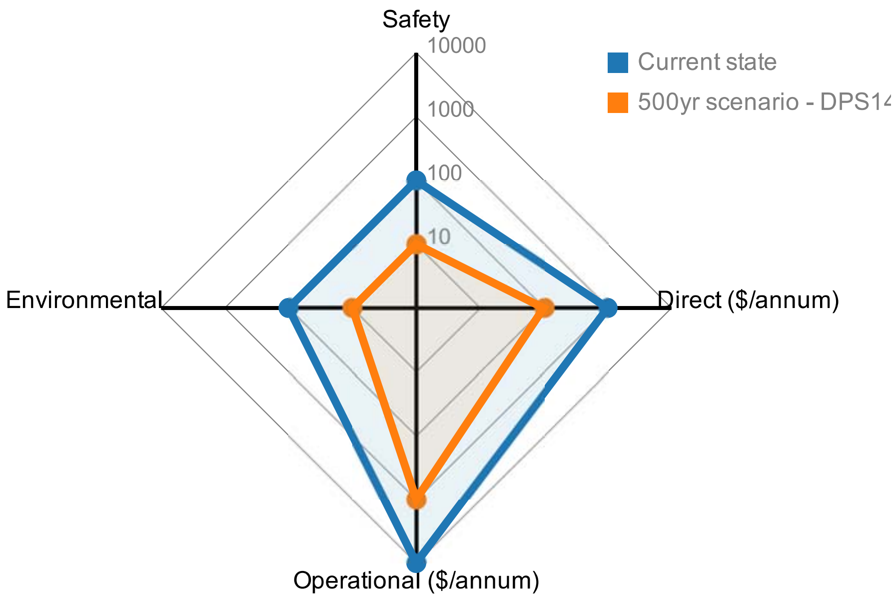
Measure Med Cost Scenario Swiss Re-DPS14

Total One-Time Cost	$ 500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 50
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the 60Hz transformer above the SwissRe levels	One-time	500000			500000

Threat: Events: 500 year return period

Comments	According to the FEMA/USACE data, flood levels at DPS10 wouldn't be significant. However, we suggest raising the transformer by 5ft to secure it in case of small flooding.
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Pump station would continue to operate during storm events
Direct ($/annum)	Minor water and wind damage

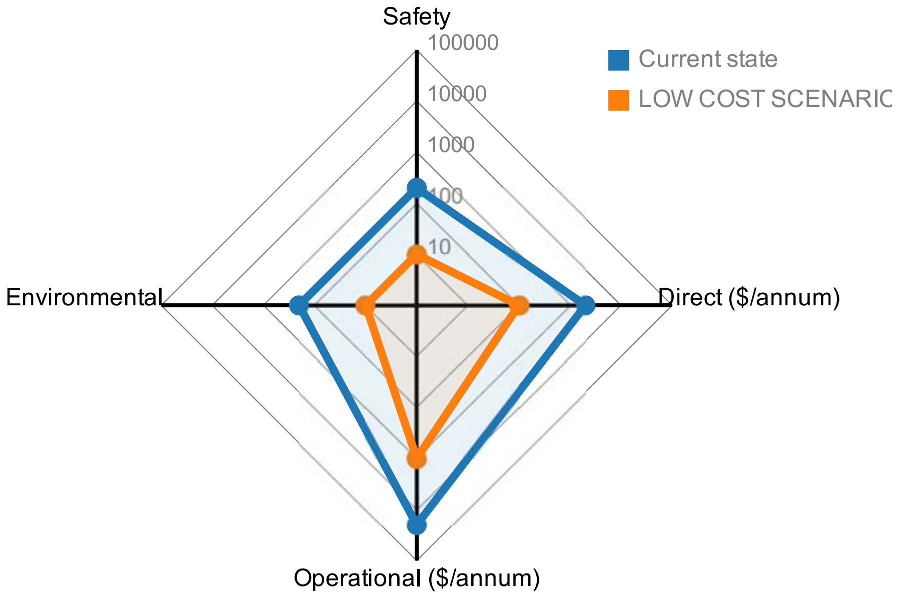
Measure 500yr scenario - DPS14 **SELECTED**

Total One-Time Cost	$ 378453
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 10000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the transformer platform by 5ft and install a new transformer	One-time	378453			378453

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. Emergency generator would supply 60 Hz and 25 Hz would be supplied form Carrollton Power Plant.
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	



Current Risk Type	Comments
Safety	Pump station has been storm proofed. There is always a risk of having personnel injured.
Environmental	No environmental damage
Operational ($/annum)	Entergy 60Hz supply is backed up by an onsite generator No secondary water source for cooling / priming the pumps, but it is considered very unlikely that the drinking water network would be shut down under the wind scenario
Direct ($/annum)	Wind damage repairs

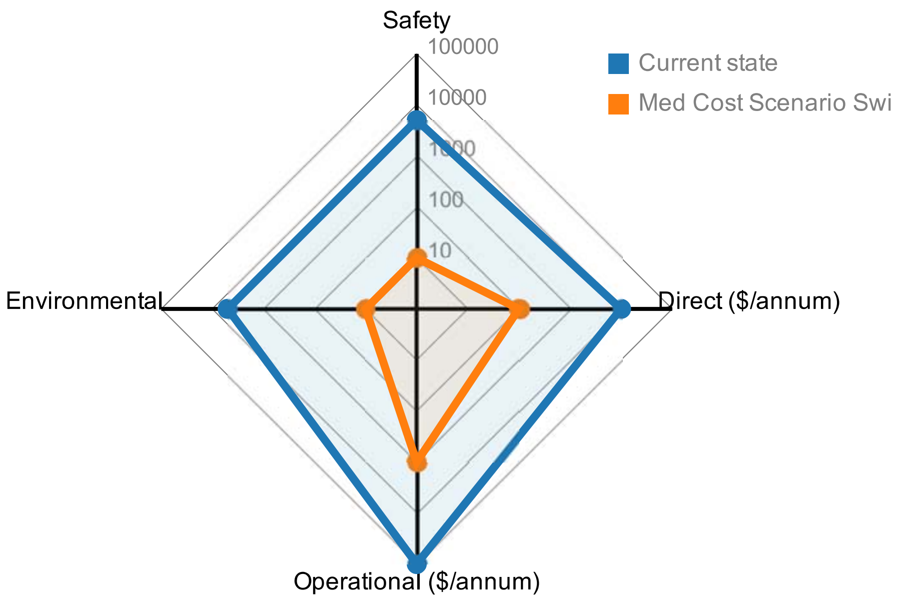
Measure LOW COST SCENARIO (Water)

Total One-Time Cost	$ 50000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 50
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 0

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Implement a secondary water source for pump cooling / vacuum pumps	One-time	50000			50000

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 15 and 17.5 ft. with peak wind gusts of 125 mph. Station would be flooded
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damages to the environment could be important due to the fact that the whole area surrounding the station would be under water
Operational ($/annum)	All the equipment would withstand Swiss-Re predicted water levels as they are located above 17.5ft. However, the Entergy 60 Hz transformer and the fuel tanks that supply fuel to the generator would be under water.
Direct ($/annum)	Repair transformer and other flood damaged equipment

Measure Med Cost Scenario Swiss Re-DPS14 **SELECTED**

Total One-Time Cost	$ 500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 500
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 100

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Raise the 60Hz transformer above the SwissRe levels	One-time	500000			500000

DPS 16 (ST. Charles)**: Short Resilience Report

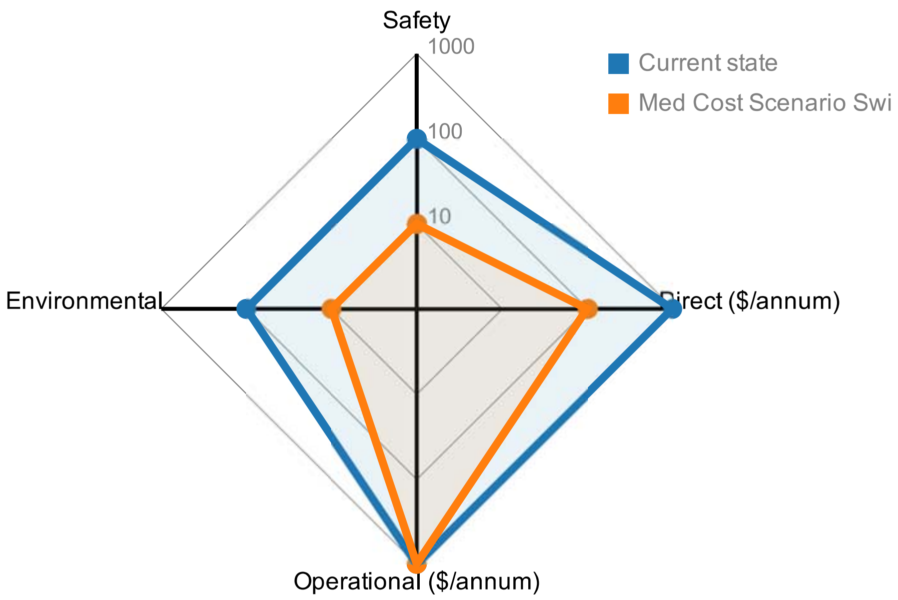
Location Description	7200 Wales St New Orleans LA 70126 Medium Pump Station
Primary Function	This station pumps water from the St. Charles and Morrison Avenue Canals to Lake Pontchartrain. This pump station is designed to be placed on automatic control without maintaining operator presence. However the automation is out of service now. Operators are still needed when there's rain events and hurricanes obviously. DPS 16 is connected to DPS 14, DPS 10 and DPS Dwyer via the Morrison Avenue Canal. Power can be sent from DPS 16 to DPS 10. DPS 16 is the backup for DPS 10.
Context Information	DPS 16 is located east of Lakefront Airport at the intersection of Wales Street and Danube Road (see Map). 4 Pumps, 4 Vertical, Station pumping capacity 1000 cfs, or 448,832.57 GPM 60 Hz 1000 cfs, or 448,832.57 GPM Building Value:$35,000,000.00 Contents Value: $50,000.00
Full Replacement Cost	$ 30050000

DPS 16 (ST. Charles)**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	Redundancy for this station is provided via DPS 10, DPS 14 and DPS Dwyer which all pull from a common canal system. Single 60Hz power feed from Entergy. Backup generator on-site which can supply entire station. This station can also supply 60Hz power to DPS 10 if needed, but would need to reduce power load on-site to accommodate. Four pumps in total, all appeared to be in service.	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Unmanned site, Few skilled workers deployed during hurricane events. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Road access only. Multiple roads to access the facility - all low elevation.	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	Majority of the electrical equipment is located more than 18 feet above ground, except for the 60Hz transformer	H
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	Not assessed, needs deeper dive.	L
ARI		**0.554**

Threat: Events: 100 year return period

Comments	DPS 16 wouldn't be affected by a 100yr return period event
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Pump station would continue draining the drainage area during a storm
Direct ($/annum)	Minor water or wind damage

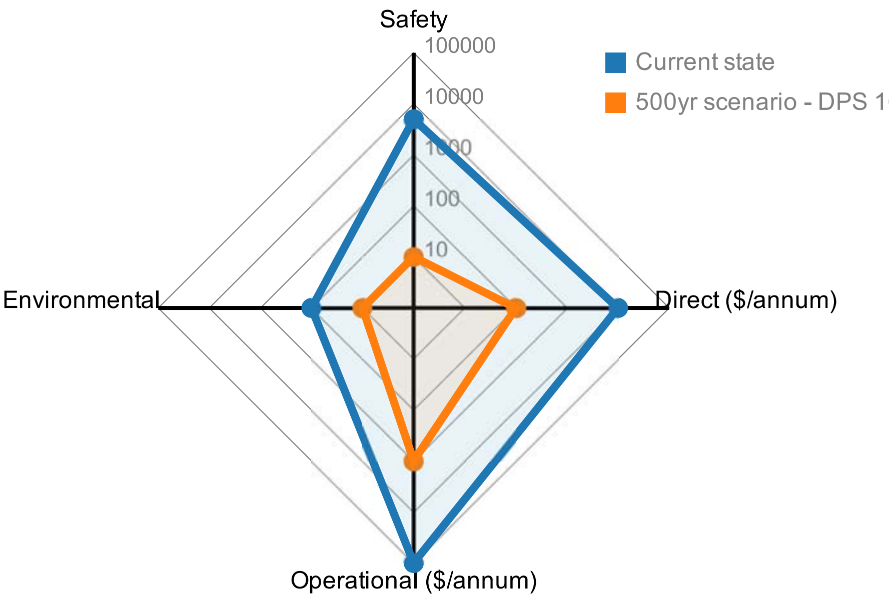
Measure Med Cost Scenario Swiss Re-DPS16

Total One-Time Cost	$ 500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 50
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the 60Hz transformer above the SwissRe levels	One-time	500000			500000

Threat: Events: 500 year return period

Comments	According to the FEMA/USACE data, flood levels at DPS16 wouldn't be significant. However, we suggest raising the transformer by 5ft to secure it in case of flooding. Also, high winds would affect the structure of the building
Earliest Recovery of Function	10 days
Repair and recommissioning cost	$ 10000



Current Risk Type	Comments
Safety	if the building does not withstand the high winds, it could be dangerous for the personnel and the surroundings of the station DPS16
Environmental	No environmental damage
Operational ($/annum)	if the building does not withstand the high winds, the operation would be affected
Direct ($/annum)	Building wind damage

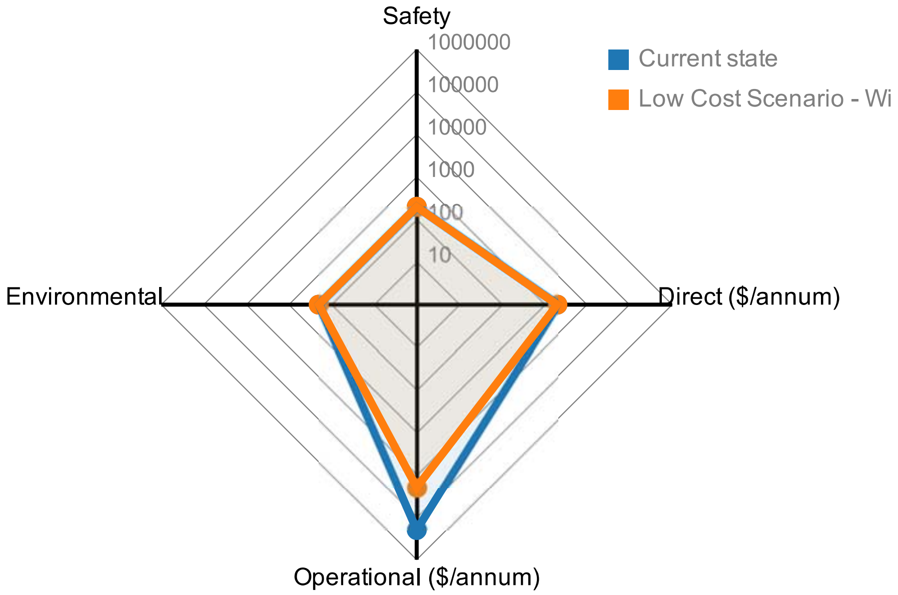
Measure 500yr scenario - DPS 16 **SELECTED**

Total One-Time Cost	$ 797372
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 200
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Install one (1) 50KW house generator - Implement hurricane resistance measures - Raise the transformer platform by 5ft - Add a new transformer	One-time	797372			797372

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. Emergency power would supply 60 Hz and 25 Hz would be supplied form Carrollton Power Plant.
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	



Current Risk Type	Comments
Safety	Pump station has been storm proofed. There is always a risk of having personnel injured.
Environmental	No environmental damage
Operational ($/annum)	The 60Hz power grid from Entergy would be out of service but the station would be supplied by the 60Hz generator. No secondary water source for cooling / priming the pumps, but it is considered very unlikely that the drinking water network would be shut down under the wind scenario
Direct ($/annum)	Wind damage repairs

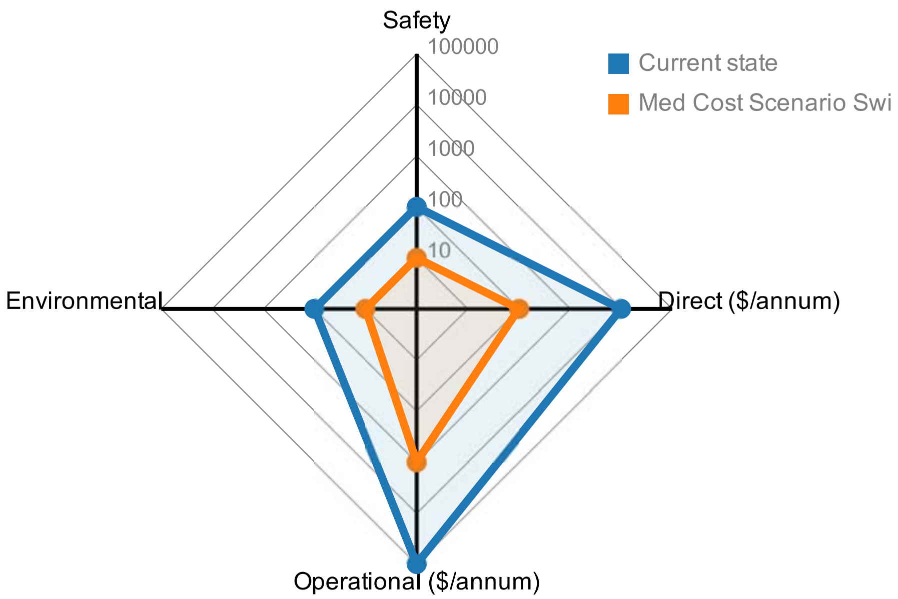
Measure Low Cost Scenario - Wind - DPS16

Total One-Time Cost	$ 50000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 50
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Implement a secondary water source for pump cooling / vacuum pumps	One-time	50000			50000

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 12.5 and 15 ft. with peak wind gusts of 115 mph. Station would be flooded
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	All the equipment would withstand Swiss-Re predicted water levels as they are located above 15 ft. The Entergy 60 Hz transformer would likely be under water. The pumps would still be able to run as there is a 60Hz generator on site.
Direct ($/annum)	Repair water damage to transformer

Measure Med Cost Scenario Swiss Re-DPS16 **SELECTED**

Total One-Time Cost	$ 500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 50
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the 60Hz transformer above the SwissRe levels	One-time	500000			500000

DPS 17**: Short Resilience Report

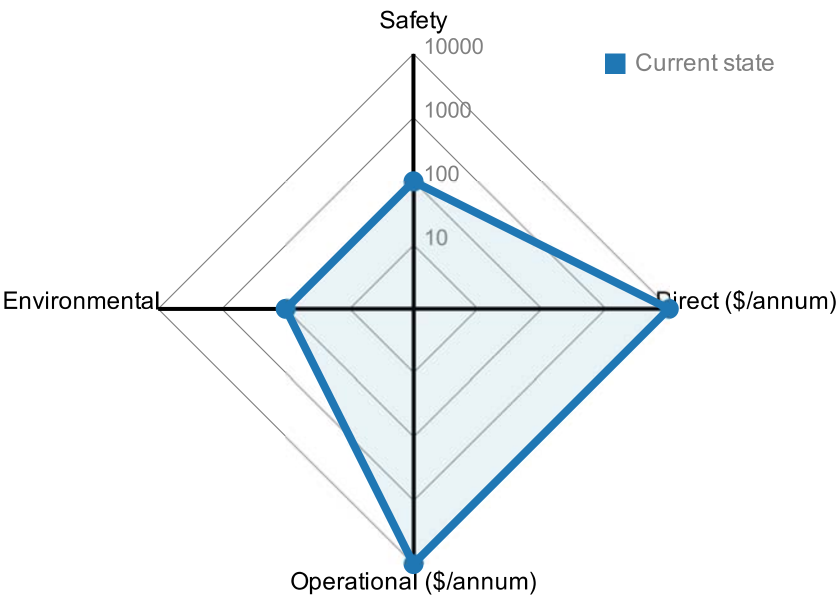
Location Description	2800 Florida Ave New Orleans LA 70117
Primary Function	This station pumps water from the Peoples and Florida Avenue Canals to the Mississippi River. It also houses the sanitary sewer pump station "D". It can evacuate water from DPS 3, 19 via the Florida Ave Canal and DPS 4 via Peoples Avenue Canal. In addition, it houses two frequency changers (60Hz to 25Hz) and provides redundant power to the drainage pumping stations: DPS 1, 2, 3, 4, 5, 6, 7.
Context Information	2 pumps for drainage pumping. Drainage Station pumping capacity 300 cfs, or 134,649.77 GPM 60 Hz 1000 cfs, or 134,649.77 GPM Building Value:$3,000,000.00 Contents Value: $50,000.00 DPS 17 is listed as historically significant and is eligible for nomination to the NRHP. Hurricane and flooding protection work was planned and started but has never been completed.
Full Replacement Cost	$ 300000000

DPS 17**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	Station has redundancy from DPS 19 which pulls from the same canal. DPS 3 also provides a degree of redundancy (with manual opening of certain gate valves to connect catchment areas). Station has two 60Hz supplies from Entergy and is also connected into the S&WB's 25Hz grid. Frequency changers can be used to take 60Hz grid power and supply the S&WB's 25Hz grid as a backup. There is also a small backup generator unit on-site, though it can only power the small sewer pump that is located at this same site (during the hurricane season). Two pumps in total which are driven from a common 60Hz electric motor - the motor and both pump units are in service, but there is no redundancy for the motor itself. The only redundancy is coming from the 2 60Hz feeders from Entergy.	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Station is manned 24/7 During hurricane event, 8 staff are assigned to the facility. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Road access only. Multiple roads to access the facility - all low elevation.	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	Majority of the electric equipment is located in the basement, including the 25-60Hz converters No flood protection.	L
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	Not assessed, needs deeper dive.	L
ARI		**0.481**

Threat: Events: 100 year return period

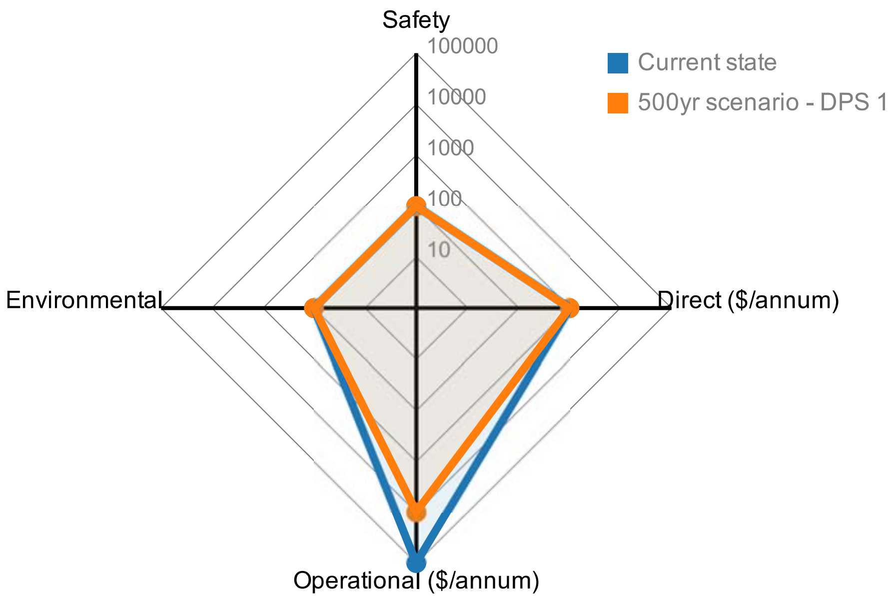
Comments	The 100yr scenario for DPS 17 leads to limited to no flooding according to FEMA / USACE
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No damage to the environment
Operational ($/annum)	Pump station continues to operate during a storm event
Direct ($/annum)	Water damage

Threat: Events: 500 year return period

Comments	The 500yr scenario for DPS 17 leads to limited to no flooding according to FEMA / USACE However the station could be affected as part of the electrical is located at ground level
Earliest Recovery of Function	2 weeks
Repair and recommissioning cost	$ 1000



Current Risk Type	**Comments**
Safety	No risk to personnel
Environmental	No environmental damage
Operational ($/annum)	There is no backup generator part of the electrical is located at ground level The building is not fully stormproofed The transformer is at ground level
Direct ($/annum)	Repair water damaged electrical switchgear

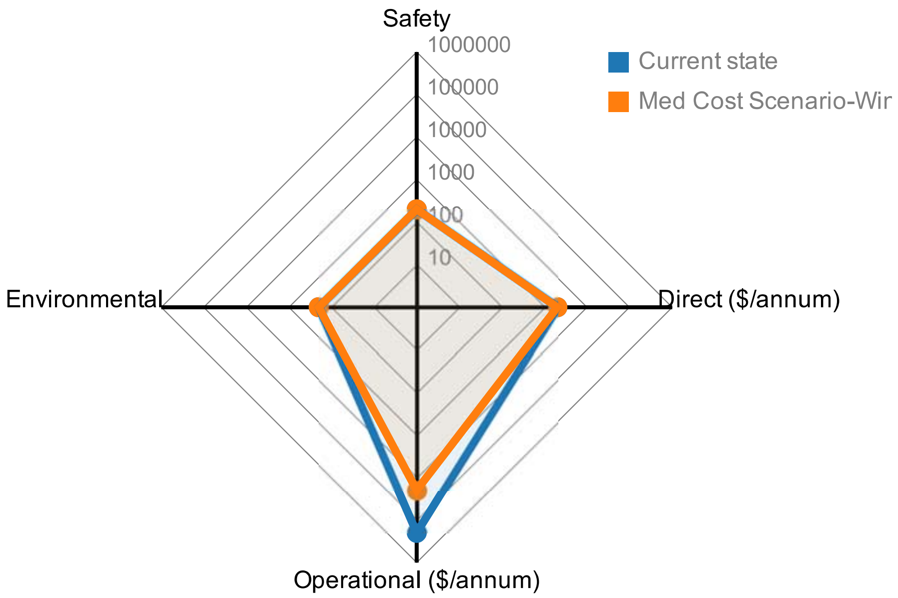
Measure 500yr scenario - DPS 17 **SELECTED**

Total One-Time Cost	$ 5130977
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the transformer platform - Add a new transformer	One-time	378453			378453
Install one (1) 3750KW generators with foundations, ATS 10K gal storage - Implement hurricane resistance measures -Relocate frequency changers and other electrical to the 2nd floor	One-time	4752524			4752524

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. Emergency generator would supply 60 Hz and 25 Hz would be supplied form Carrollton Power Plant.
Earliest Recovery of Function	48 hours
Repair and recommissioning cost	$ 2000



Current Risk Type	Comments
Safety	Pump station has been storm proofed. There is always a risk of having personnel injured.
Environmental	No environmental damage
Operational ($/annum)	In case of high winds, the 60Hz power grid provided by Entergy could be shut down. There is no 60Hz backup generator on site. Therefore, the pump station would be down.
Direct ($/annum)	Wind damage repairs

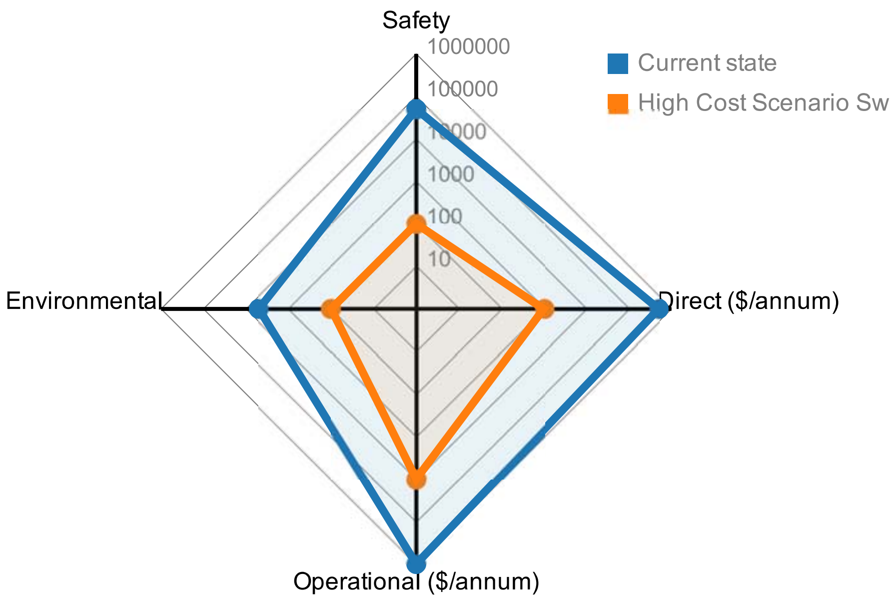
Measure Med Cost Scenario-Wind-DPS17 **SELECTED**

Total One-Time Cost	$ 8000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 2000
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 2000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Add a new 60Hz Generator	One-time	4000000			4000000
Reinforce the roof and structure	One-time	4000000			4000000

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 10 and 12.5 ft. with peak wind gusts of 105 mph. Station would be flooded
Earliest Recovery of Function	1 months
Repair and recommissioning cost	$ 500000



Current Risk Type	Comments
Safety	Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damages to the environment could be important due to the fact that the whole area surrounding the station would be under water
Operational ($/annum)	The pump station would likely be under water. There is no 60Hz generator that has the capacity to feed the 60Hz storm pumps.
Direct ($/annum)	Repair flood damage equipment

Measure High Cost Scenario Swiss Re-DPS17 **SELECTED**

Total One-Time Cost	$ 42000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 4200
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the whole pump station above NOLA study level	One-time	42000000			42000000

DPS 19**: Short Resilience Report

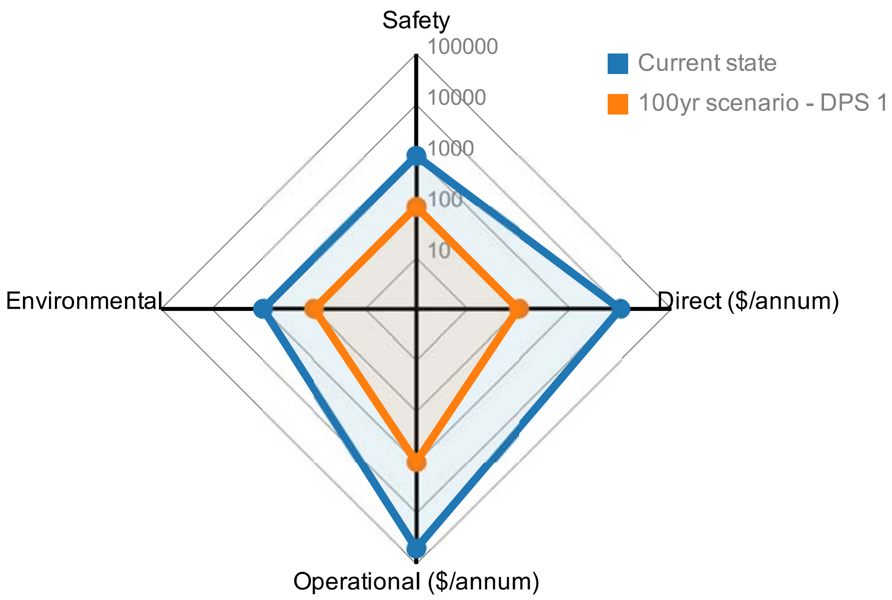
Location Description	4500 Florida Ave New Orleans LA 70117 Medium Pump Station
Primary Function	This station pumps water from the Florida Avenue Canal to the Inner Harbor Navigation Canal (IHNC). DPS 19 drains the area considered the Upper Ninth Ward including Bywater and the Marigny. DPS 19 is connected to DPS 17 and DPS 3 through Florida Ave Canal. It is also connected to DPS 4 via the Peoples and Florida Avenue Canal.
Context Information	DPS 19 is located on the east side of the IHNC at Florida Avenue (see Map). 5 Pumps, 3 Horizontal, 2 Vertical, Station pumping capacity 3650 cfs, or 1,638,238.87 GPM 60 Hz 3650 cfs, or 1,638,238.87 GPM Building Value:$120,000,000.00 Contents Value: $125,000.00 Two 2.5 MW generators are on site and able to power the existing pumping equipment that would run alternately.
Full Replacement Cost	$ 120125000

DPS 19**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	Redundancy for DPS 19 includes DPS 3 and DPS 17 which either pull from the same canal (Florida Ave Canal) and DPS 4 from Peoples and Florida Ave Canal. Station is fed by 60Hz electrical power coming from both Entergy and the two large backup diesel generator units located in another building adjacent to the station. Five pumps in total all in service. Has a raw water source on the outfall side of the station.	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	M
Skills availability	Station is manned 24/7 During hurricane event, 8 staff are assigned to the facility. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Road access only. Multiple roads to access the facility - all low elevation.	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	Generator building elevated control panels are at ground level 60Hz transformer is at ground level	L
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	Not assessed, needs deeper dive.	L
ARI		**0.517**

Threat: Events: 100 year return period

Comments	The 100yr scenario would lead to water levels of about 6ft in the surroundings of the facility according to FEMA / USACE
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	generators would supply emergency power to the pump station when commercial power failed
Direct ($/annum)	Water damage

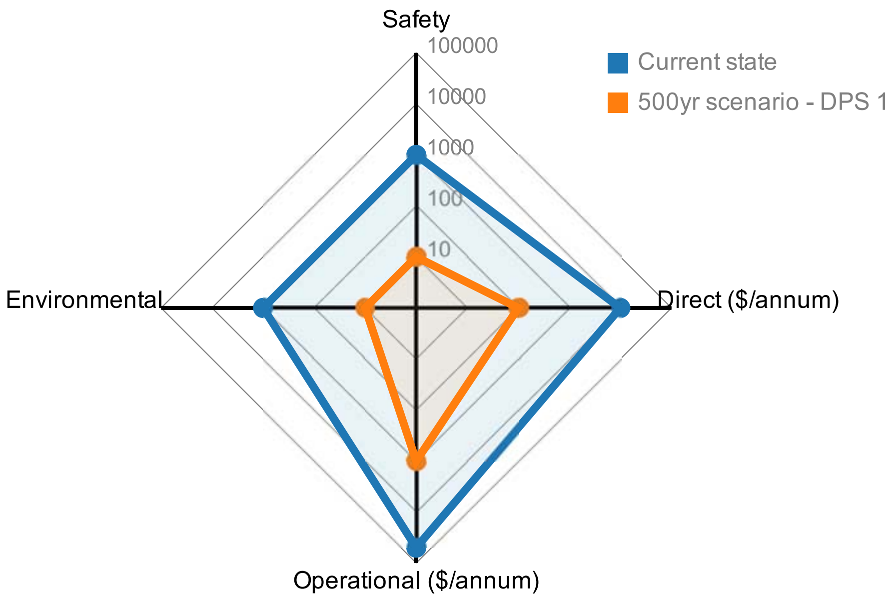
Measure 100yr scenario - DPS 19 **SELECTED**

Total One-Time Cost	$ 378453
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Raise the transformer platform - Add a new transformer	One-time	378453			378453

Threat: Events: 500 year return period

Comments	The 500yr scenario would lead to water levels of about 6ft in the surroundings of the facility according to FEMA / USACE
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	**Comments**
Safety	No risk to personnel
Environmental	No environmental damage
Operational ($/annum)	generators would supply power to the pump station
Direct ($/annum)	Water and wind damage

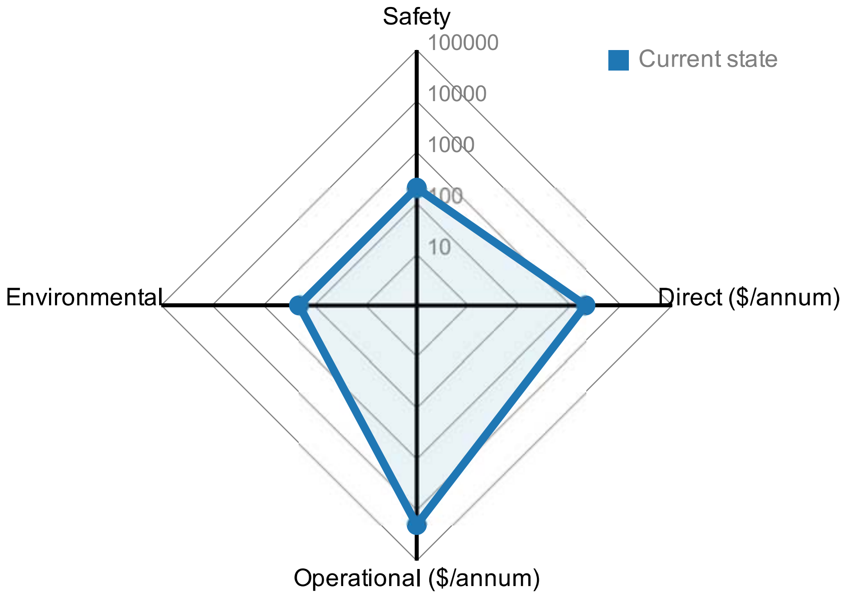
Measure 500yr scenario - DPS 19

Total One-Time Cost	$ 378453
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 2000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the transformer platform Add a new transformer	One-time	378453			378453

Threat: Hurricane < 100 years - Wind

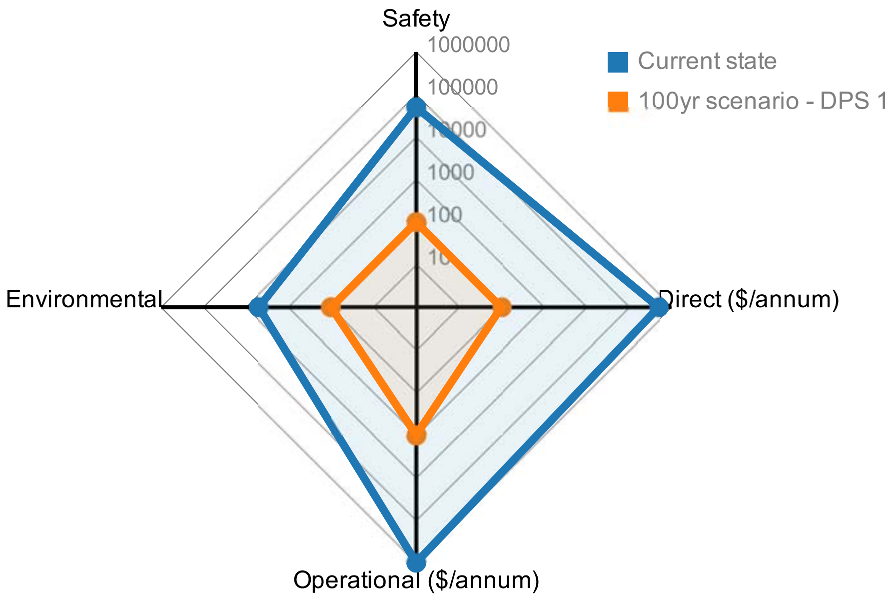
Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. Emergency power would supply 60 Hz and 25 Hz would be supplied form Carrollton Power Plant.
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 2000



Current Risk Type	Comments
Safety	Pump station has been storm proofed. There is always a risk of having personnel injured.
Environmental	No environmental damage
Operational ($/annum)	60Hz from Entergy would be shut down. However, the generators in the adjacent building would be able to supply power to the pumps City water is primarily used for cooling / feeding the equipment. Raw water can be used in case the drinking water network is down. The building may be damaged by high winds, however it withstood past hurricanes including Katryna.
Direct ($/annum)	Wind damage repairs

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 10 and 12.5 ft. with peak wind gusts of 105 mph. Station would be flooded
Earliest Recovery of Function	2 weeks
Repair and recommissioning cost	$ 500000



Current Risk Type	Comments
Safety	Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damages to the environment could be important due to the fact that the whole area surrounding the station would be under water
Operational ($/annum)	The electrical equipment inside the building and the generators would not be damaged by the water. However the electrical switch-gear located at street level would be damaged. The transformer would be under water.
Direct ($/annum)	Water and wind damage

Measure 100yr scenario - DPS 19 **SELECTED**

Total One-Time Cost	$ 378453
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the transformer platform - Add a new transformer	One-time	378453			378453

DPS 20**: Short Resilience Report

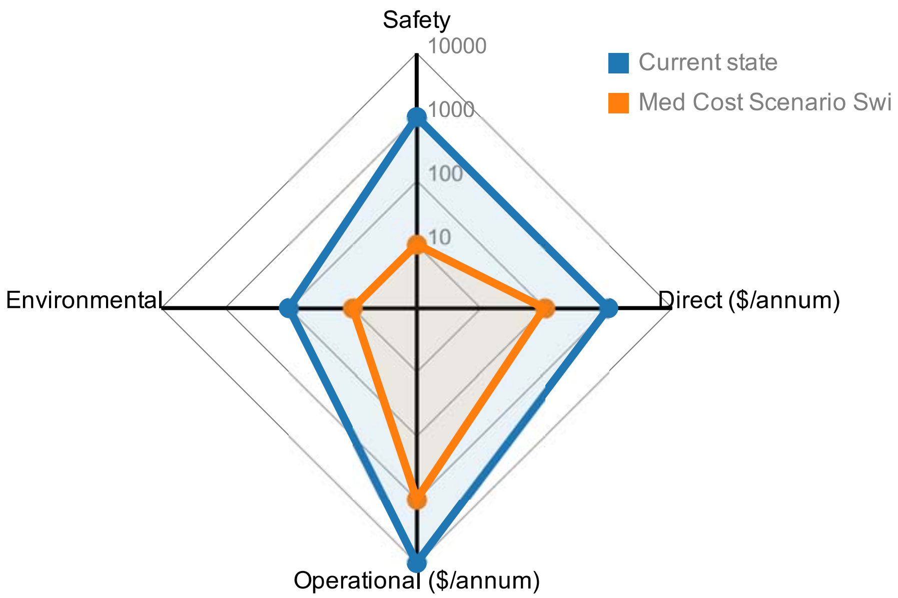
Location Description	6300 Intercoastal Water Way New Orleans La 70129
Primary Function	This station pumps water from Canal Number 1 to the Intracoastal Waterway. This pump station is designed to be placed on automatic control without maintaining operator presence. Operators are still needed when there's rain events and hurricanes obviously
Context Information	DPS 20 is located in New Orleans East on the north side of the Intracoastal Waterway east of the IHNC south of Almonaster Boulevard (see Map). 2 Pumps, 2 Vertical, one os those pmps is out of service at this time. Station pumping capacity 500 cfs, or 1,224,416.28 GPM 60 Hz 3650 cfs, or 1,224,416.28 GPM Building Value:$15,000,000.00 Contents Value: $50,000.00 All windows are hurricane rated. The generator is elevated. A new building was elevated, a new fuel tank was installed along with a new house generator and day tank. The fuel tank can be filled from up top.
Full Replacement Cost	$ 15050000

DPS 20**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	Redundancy from this station includes DPS Elaine which provides a degree of overlap in catchment areas, but not true redundancy. Station has a single 60Hz Entergy mains supply, as well as a refurbished generator on-site for redundant 60Hz power. Two pumps in service, one operational, one out of service. Staff indicate that returning the failed unit to service is a high priority, but that it has been out for some time.	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Unmanned site, Few skilled workers deployed during hurricane events. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Road access only. Multiple roads to access the facility - all low elevation.	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	Majority of the electrical equipment is located more than 18 feet above ground, except for the 60Hz transformer	H
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	Not assessed, needs deeper dive.	L
ARI		**0.554**

Threat: Events: 100 year return period

Comments	The 100yr scenario would have a very limited impact on the facility according to FEMA / USACE The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Pump station continues to operate during storm event
Direct ($/annum)	Water and wind damage

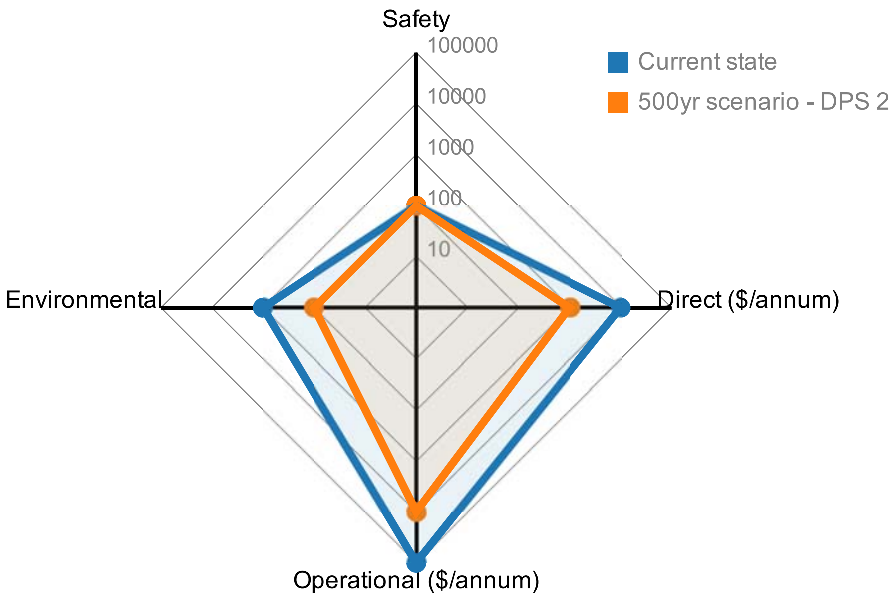
Measure Med Cost Scenario Swiss Re-DPS20

Total One-Time Cost	$ 500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 100
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the 60Hz transformer above the SwissRe levels	One-time	500000			500000

Threat: Events: 500 year return period

Comments	The 500yr scenario would lead to 0-2ft of water in the surroundings of the facility according to FEMA / USACE The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	No risk to personnel
Environmental	No environmental consequences
Operational ($/annum)	The transformer could be under water, but it wouldnt affect the DPS in the short term as the generators would supply power to the pumps
Direct ($/annum)	Water and wind damage

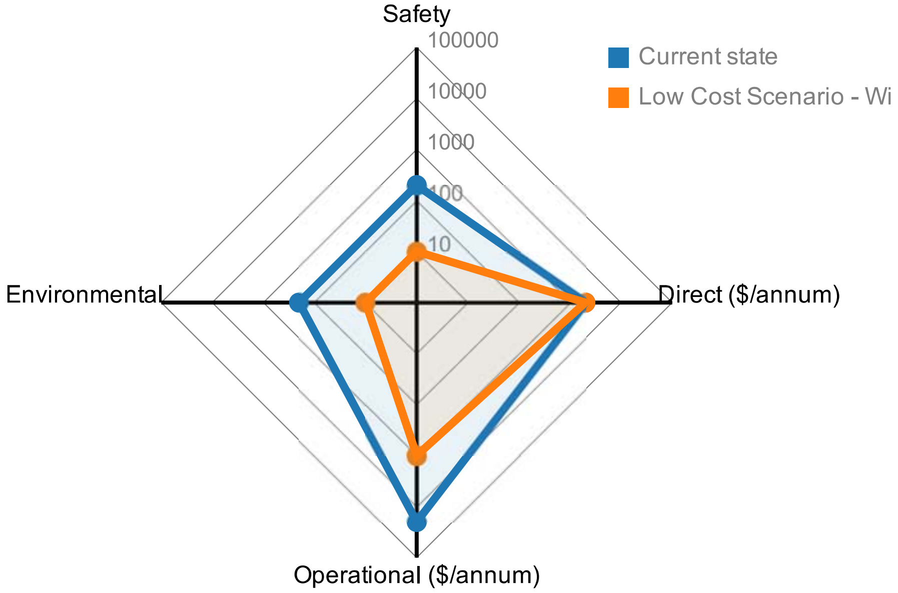
Measure 500yr scenario - DPS 20 **SELECTED**

Total One-Time Cost	$ 378453
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Raise the transformer platform - Add a new transformer	One-time	378453			378453

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. Emergency power would supply 60 Hz and 25 Hz would be supplied form Carrollton Power Plant.
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 2000



Current Risk Type	Comments
Safety	Pump station has been storm proofed. There is always a risk of having personnel injured.
Environmental	No environmental damage
Operational ($/annum)	The entergy 60Hz transformer would be down. However the pumps would be fed by the onsite generators. No secondary water source for cooling / priming the pumps, but it is considered very unlikely that the drinking water network would be shut down under the wind scenario. One pump is out and needs to be put back in service.
Direct ($/annum)	Wind damage repairs

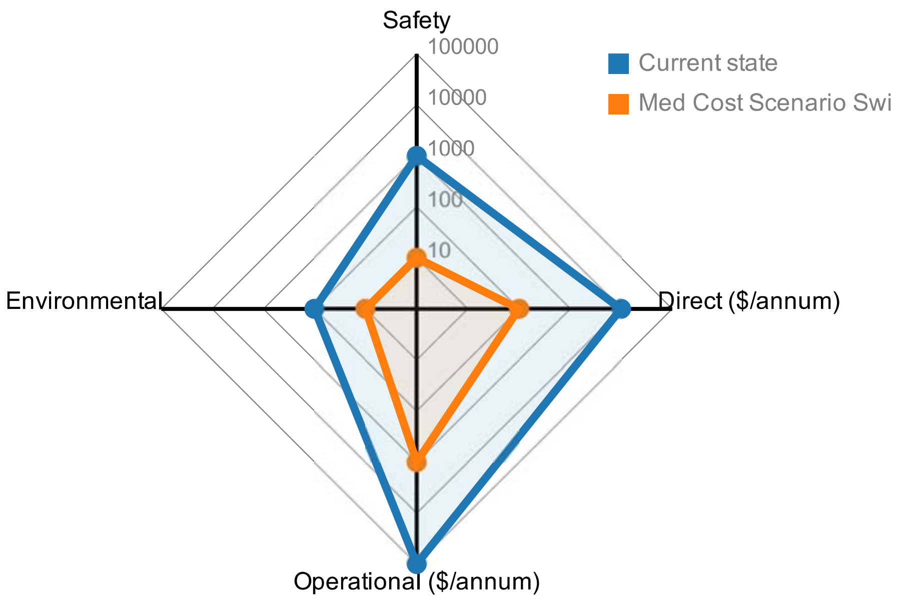
Measure Low Cost Scenario - Wind - DPS20 **SELECTED**

Total One-Time Cost	$ 200000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 200
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 2000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Return failed pump to service	One-time	200000			200000

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 12.5 and 15 ft. with peak wind gusts of 110 mph. Station would be flooded
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 10000



Current Risk Type	**Comments**
Safety	People could be serious injured
Environmental	Minor environmental damage
Operational ($/annum)	All the equipment would withstand Swiss-Re predicted water levels as they are located above 15 ft. However, the Entergy 60 Hz transformer would be under water.
Direct ($/annum)	Water damage to transformer

Measure Med Cost Scenario Swiss Re-DPS20 **SELECTED**

Total One-Time Cost	$ 500000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 500
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the 60Hz transformer above the SwissRe levels	One-time	500000			500000

DPS Dwyer**: Short Resilience Report

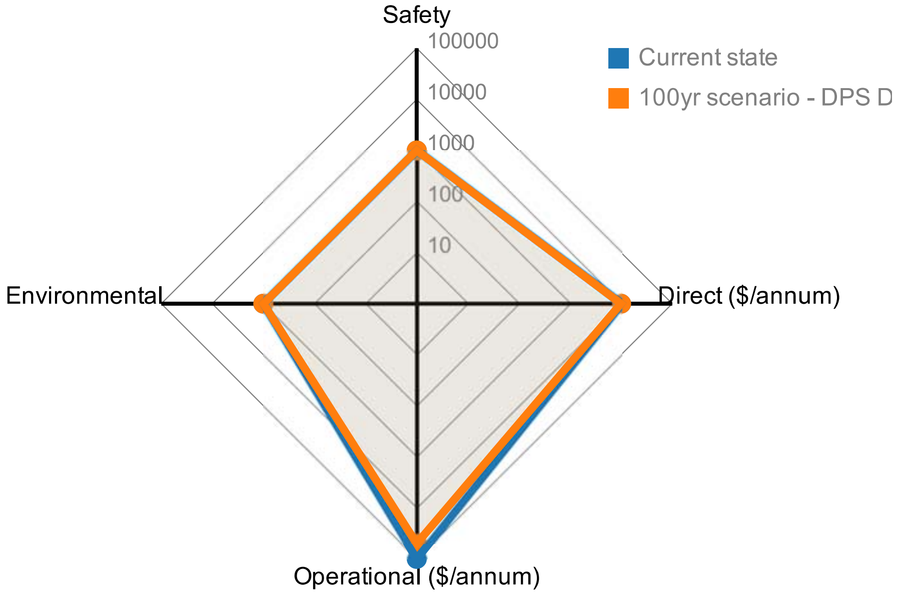
Location Description	4500 Dwyer Rd New Orleans LA 70126
Primary Function	Dwyer is North of interstate 10 and East of the IHNC Dwyer pumps water into the IHNC. DPS 10, DPS 14 and DPS 16 all provide hydraulic redundancy for this station as they pull from the same canal system. Dwyer pulls from the Dwyer Avenue canal and is interconnected with 10 16 14 via the Dwyer Road and Morrison Road Canal. Dwyer drains the New Orleans East area bounded by Chefs Menteur Highway, lake ponchartrain and I510.
Context Information	3 Pumps, 3 vertical Station pumping capacity ?? cfs, or ?? GPM 60 Hz 9?? cfs, or ?? GPM Building Value:$30,000,000.00 Contents Value: $50,000.00 All the pumps are 60Hz. The building is recent. There is no possibility to install flood barriers but some of the equipment is elevated (pumps, pump breakers...). The building could probably withstand high winds but there is no proof of that. There is a generator that is not functioning. Transformer is on the ground outside and there is no electrical redundancy from the other facilities. This station is also one of only a few that have a redundant seal, cooling, etc. water supply but it is subject to possible flooding as it is located at the first floor of the station.
Full Replacement Cost	$ 30050000

DPS Dwyer**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	DPS 10, DPS 14 and DPS 16 all provide redundancy for this station as they pull from the same canal system. Station has a single 60Hz Entergy mains supply. There is a backup generator unit located at the site, but staff indicate that it has been out of service for a long time. They indicate that returning it to service is highly desired, but they weren't sure when / if this is going to happen. Three pumps in total, all in service. This station is also one of only a few that have a redundant seal, cooling, etc. water supply.	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Station is manned 24/7 During hurricane event, 8 staff are assigned to the facility. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Road access only. low elevation.	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	Electric equipment is not elevated and would be affected by flooding Main transformer would be under water	L
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	Not assessed, needs deeper dive.	L
ARI		**0.481**

Threat: Events: 100 year return period

Comments	The 100yr scenario would have a very limited impact on the facility according to FEMA / USACE. However some of the secondary electrical is in the basement, The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	6 weeks
Repair and recommissioning cost	$ 1000



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Some of the secondary electrical equipment is located in the basement and could be impacted by subsurface flooding
Direct ($/annum)	Wind and water damage

Measure 100yr scenario - DPS Dwyer **SELECTED**

Total One-Time Cost	$ 397911
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Relocate secondary electrical equipment	One-time	397911			397911

Threat: Events: 500 year return period

Comments	The 500yr scenario would lead to 0 to 2ft of water in the surroundings of the facility according to FEMA / USACE However some of the secondary electrical is in the basement, The suggested mitigation measures regarding this threat come in addition to the Hurricane < 100 years - wind measures if any
Earliest Recovery of Function	6 weeks
Repair and recommissioning cost	$ 1000

Current Risk Type	Comments
Safety	No risk to personnel
Environmental	No environmental consequences
Operational ($/annum)	Some of the secondary electrical equipment is located in the basement and could be impacted by subsurface flooding The transformer at ground level would likely be affected by water.
Direct ($/annum)	Water and wind damage

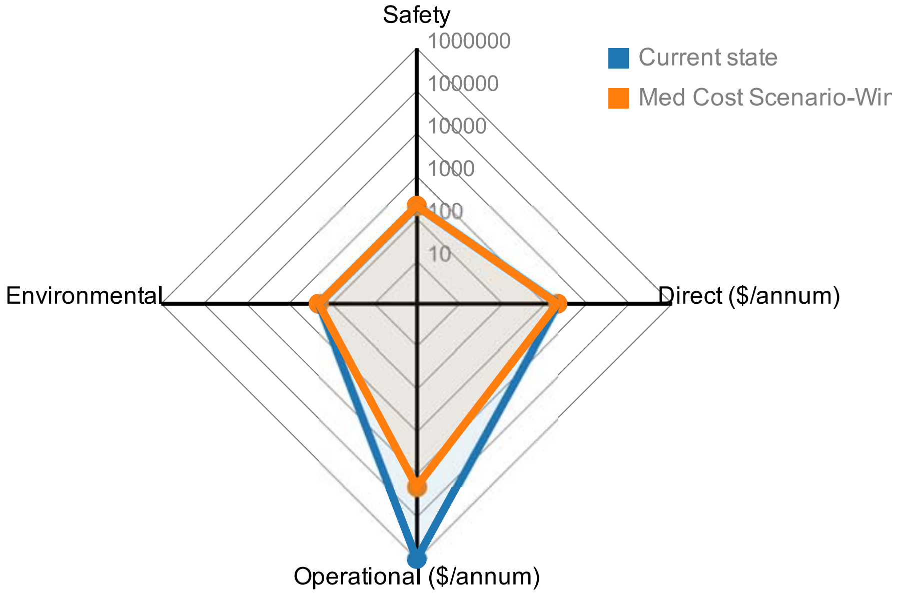
Measure 500 yr scenario - DPS Dwyer

Total One-Time Cost	$ 776364
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 2000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the transformer platform by 5ft above ground - Add a new transformer	One-time	378453			378453
Relocate secondary equipment	One-time	397911			397911

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. Emergency generator would supply 60 Hz and 25 Hz would be supplied form Carrollton Power Plant.
Earliest Recovery of Function	48 hours
Repair and recommissioning cost	$ 2000



Current Risk Type	Comments
Safety	Pump station has been storm proofed. There is always a risk of having personnel injured.
Environmental	No environmental damage
Operational ($/annum)	the 60Hz power supplied by Entergy would likely be out of service and there is no backup generator right now that's functioning (the one that's in the building is out of service and needs to be repaired). But as there is hydraulic redundancy with 14 10 and 16, it limits the impacts of a failure of DPS Dwyer.
Direct ($/annum)	Wind damage repairs

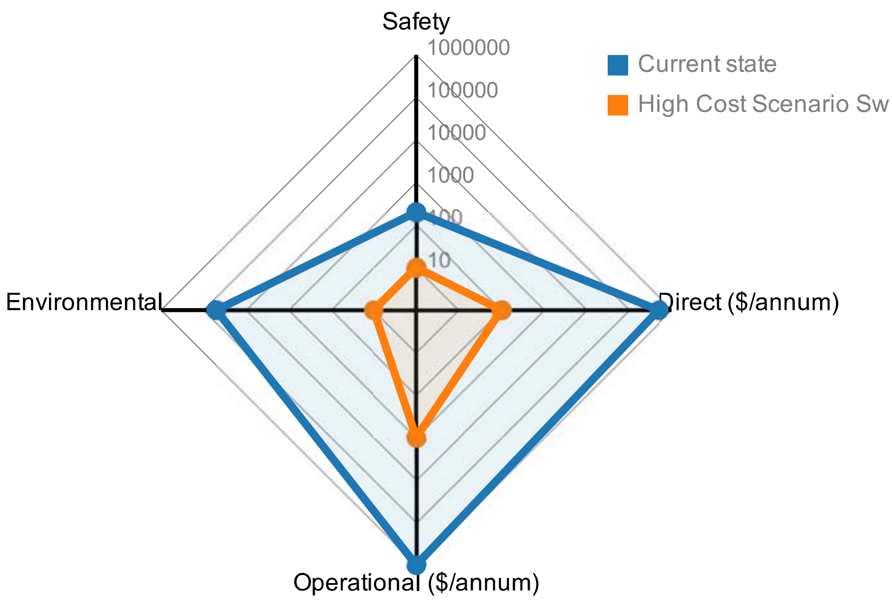
Measure Med Cost Scenario-Wind-DPS Dwyer **SELECTED**

Total One-Time Cost	$ 200000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 100
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 2000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Return failed generator to service	One-time	200000			200000

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 7.5 and 10 ft. with peak wind gusts of 110 mph. Station would be flooded
Earliest Recovery of Function	4 months
Repair and recommissioning cost	$ 500000



Current Risk Type	Comments
Safety	Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damage to the environment could be important due to the fact that the whole area surrounding the station would be under water
Operational ($/annum)	The motors and the switch gear would be out of water (they are on the second level) The transformer, the generator and some other electrical equipment (compressors, raw water controls, screens controls...) would be under water.
Direct ($/annum)	Wind and water damage

Measure High Cost Scenario Swiss Re-DPS Dwyer **SELECTED**

Total One-Time Cost	$ 32000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the whole pump station above NOLA study level	One-time	32000000			32000000

DPS I-10 (Pontchartrian)**: Short Resilience Report

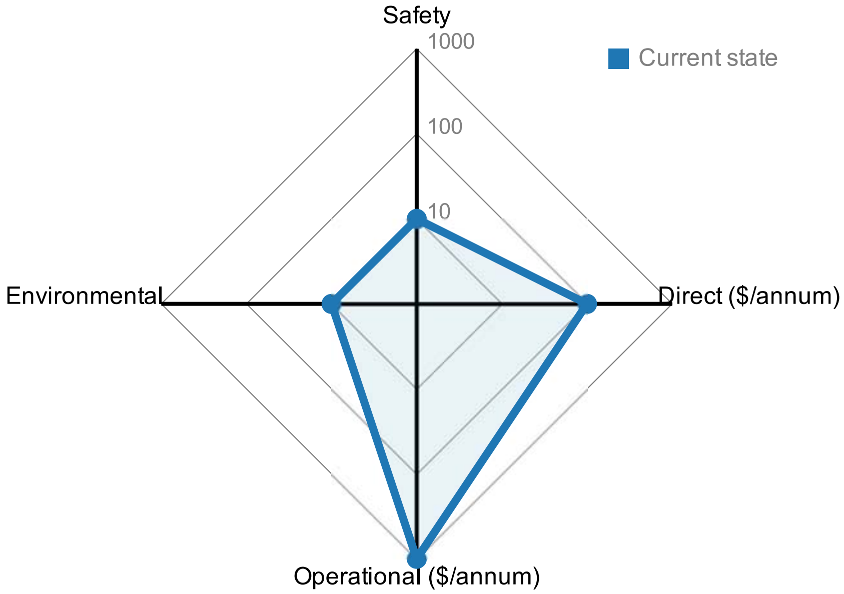
Location Description	DPS I-10 is located on the west side of I-10 south of the I-10/I-610 split
Primary Function	This station pumps water from the I-10 underpass at the railroad to the 17th Street Canal. This pump station is designed to be placed on automatic control without maintaining operator presence.
Context Information	DPS I-10 is located on the west side of I-10 south of the I-10/I-610 split (see page A-20). 4 Pumps, 4 vertical, Station pumping capacity 860 cfs, or 385,996.00 GPM 60 Hz 860 cfs, or 385,996.00 GPM Building Value:$25,000,000.00 Contents Value: $25,000.00 The roof has been replaced. All windows have manually operated hurricane shutters installed, and all exhaust fans and intakes have be modified or replaced with roll type shutters. Emergency fuel piping is installed along the drainage pump discharge piping to the high point on I-10 as it crosses the 17th Street Canal to allow for remote fuel filling. The junction box for the sump pump, a pressure transducer, and the exterior lights are raised. A pump station building generator supplies 60 HZ power for control room, instrumentation, recorder panels, lighting, communication, and station air conditioning. This would allow the larger generators to be shut down when pumping is not required and allows the station to be powered quickly during the period it takes the operator to bring the main generators on line. This generator would be located inside the existing facility. A water well (approximately 200 – 700 foot deep) would be drilled within the existing pump station property to supply backup water for equipment cooling and lubrication.
Full Replacement Cost	$ 25025000

DPS I-10 (Pontchartrian)**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	No redundancy in terms of other SWBNO operated facilities that pull from the same catchment area around the major rail crossing of I-10. There is however another station for this catchment area operated by another authority that does technically provide redundancy if SWBNO could coordinate operations with the other authority. Station has a single 60Hz Entergy mains supply as well as two large on-site backup generator units capable of powering the entire station. Four pumps total, 4 pumps operational. Staff indicate that even in very heavy rain they have rarely needed more than 1 of the 4 pump units to run which could indicate that the pumping capacity redundancy of this station is likely at least 2 or 3 times the flows seen in very heavy rainfall events.	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	L
Skills availability	Unmanned site, Few skilled workers deployed during hurricane events. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Road access only. Multiple roads to access the facility - all low elevation.	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	All of the electrical equipment is located more than 18 feet above ground,	H
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	Not assessed, needs deeper dive, but has a modern structure	M
ARI		**0.591**

Threat: Events: 100 year return period

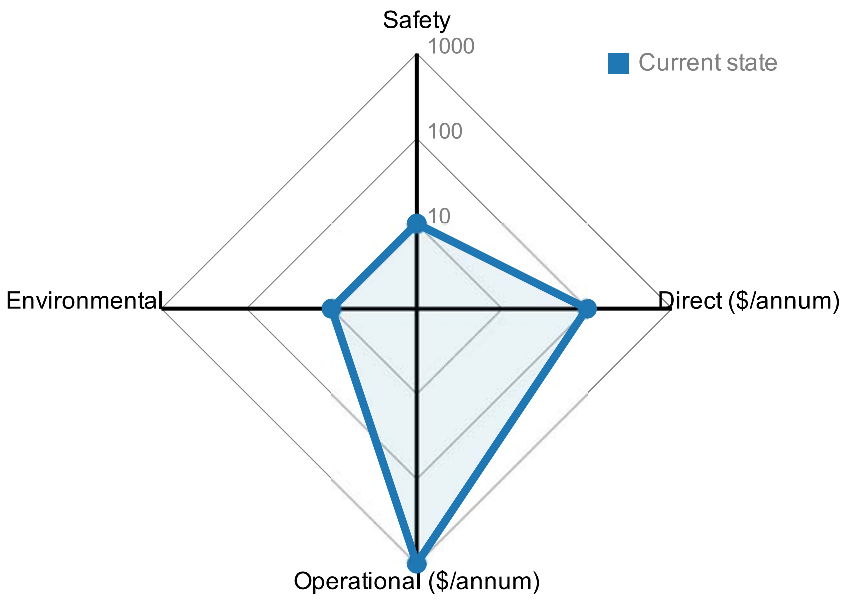
Comments	DPS I-10 would withstand a 100yr return period event. Pumps drain the drainage area
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Pump station would continue to operate
Direct ($/annum)	Water damage

Threat: Events: 500 year return period

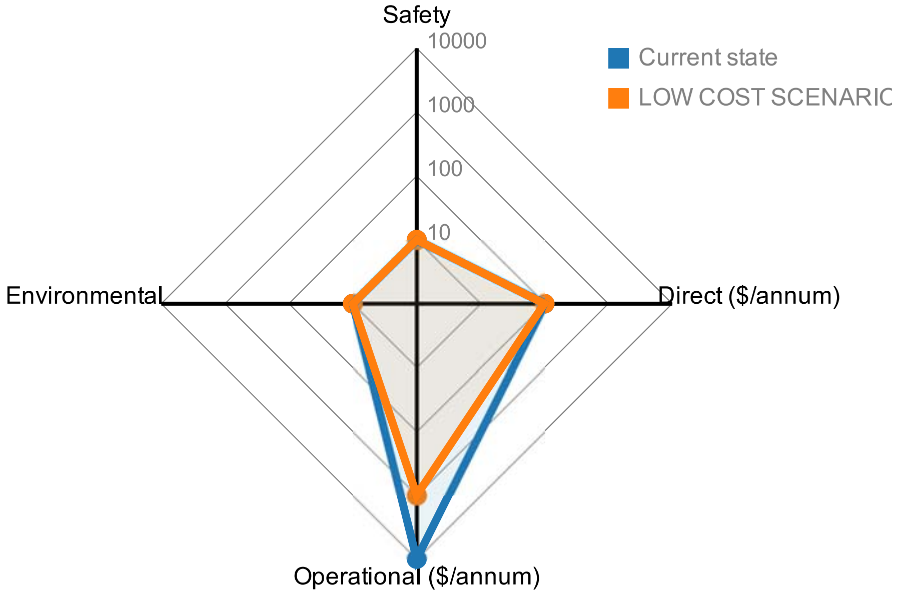
Comments	DPS I-10 would withstand a 500yr return period event. Pumps drain the drainage area
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental damage
Operational ($/annum)	Pumps operate normally during a storm event
Direct ($/annum)	Water and wind damage

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. Emergency generator would supply 60 Hz and 25 Hz would be supplied form Carrollton Power Plant.
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	Pump station has been storm proofed. There is always a risk of having personnel injured.
Environmental	No environmental damage
Operational ($/annum)	No secondary water source for cooling / priming the pumps, but it is considered very unlikely that the drinking water network would be shut down under the wind scenario
Direct ($/annum)	Wind damage repairs

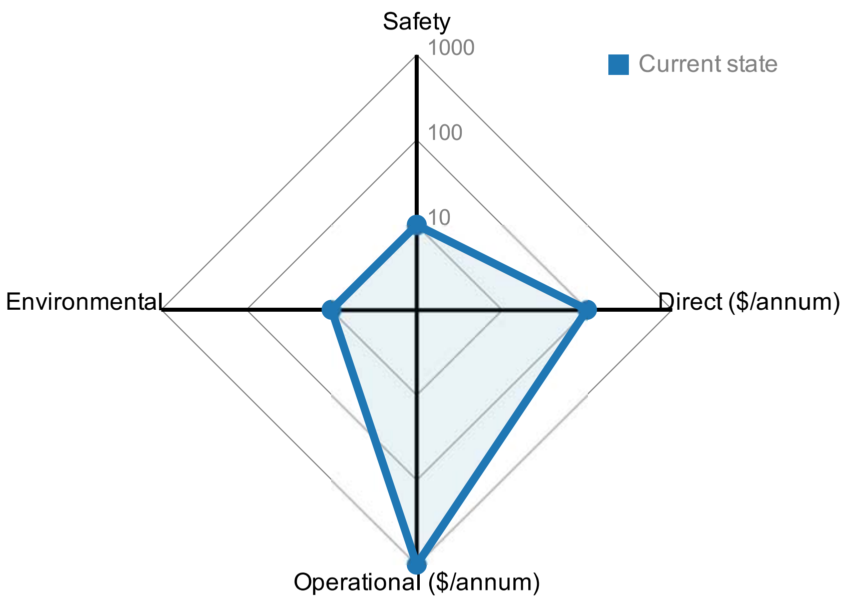
Measure LOW COST SCENARIO (Water)

Total One-Time Cost	$ 50000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 50
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Implement a secondary water source for pump cooling / vacuum pumps	One-time	50000			50000

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 10 and 12.5 ft. with peak wind gusts of 105 mph. Station would be flooded
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental consequences
Operational ($/annum)	All the equipment (including the transformer) would withstand Swiss-Re predicted water levels as they are located above 12.5 ft.
Direct ($/annum)	Water and wind damage

DPS Pritchard**: Short Resilience Report

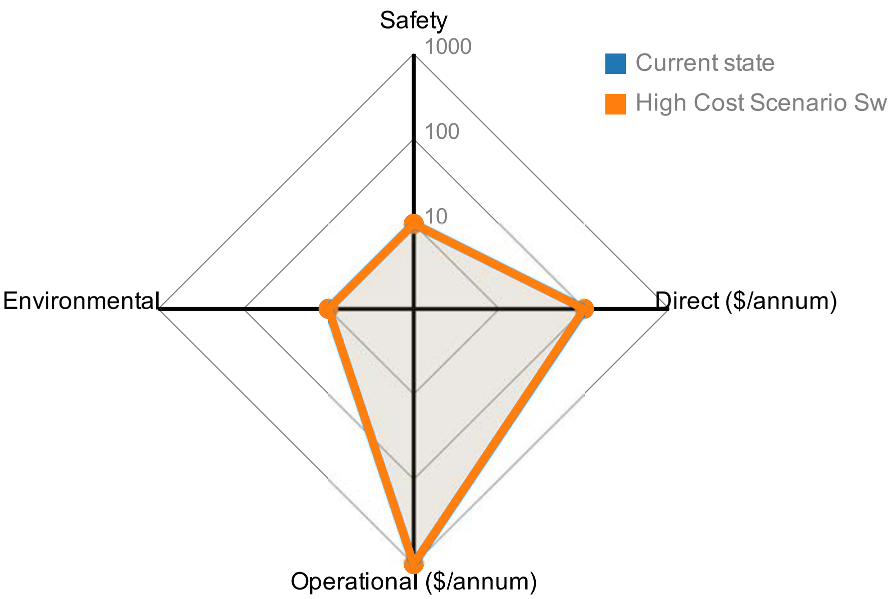
Location Description	2901 Monticello Avenue, New Orleans LA
Primary Function	This station pumps water from subsurface drainage to the Monticello Canal.
Context Information	DPS Pritchard is located adjacent to the Monticello Canal south of Airline Highway and north of Earhart Boulevard, at the termination of Pritchard Place (see Map). 3 Pumps, 3 vertical Station pumping capacity 253 cfs, or 113,554.64 GPM 60 Hz 253 cfs, or 113,554.64 GPM Building Value:$7,000,000.00 Contents Value: $50,000.00 This pump station is designed to be placed on automatic control without maintaining operator presence. The entire perimeter of the exterior wall would be coated with an approved waterproofing material at least to the DFL on the exterior surface. The wet well accesses for the constant duty pump and sluice gates would be sealed. The doors would be replaced with storm doors, and the rollup door would be replaced with a hurricane rated unit. The doorways would be modified to accept an approved flood barrier. The roof would be replaced, and all exhaust fans and intakes would be modified or replaced with roll type shutters. A new sump pump would be installed in the vertical pump drywell. Batteries, the generator fuel fill, and fuel vent lines would be raised above the DFL. The 4,160 volt outdoor switch/fuse enclosure would be elevated above the DFL, and all cable entrance conduit stub ups would be sealed inside the building. The low voltage service cabinet is below the DFL and would therefore require elevating. A pump station building generator is proposed to supply 60 HZ power for the proposed station leakage removal pumps. This generator would be located inside the existing facility.
Full Replacement Cost	$ 7050000

DPS Pritchard**: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	DPS 6 used to provide the only coverage of this station's catchment area, but both DPS Oleander and DPS Pritchard were added to improve drainage in their respective areas. Hence, there is redundancy both directly from DPS Oleander as well as DPS 6 to an extent. Station has a single 60Hz Entergy mains supply as well as a backup generator unit on-site capable of supplying the full station load. Three pumps in total, all in service.	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	M
Skills availability	Unmanned site, Few skilled workers deployed during hurricane events. Skill level was not evaluated, needs deeper dive.	L
Ease of access	Road access only. Multiple roads to access the facility - all low elevation.	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	Station is above ground level around 5ft which gives some protection to flooding 60Hz transformer is above ground level by 1 foot	M
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	Not assessed, needs deeper dive.	L
ARI		**0.554**

Threat: Events: 100 year return period

Comments	The 100yr scenario would have no impact on the facility according to FEMA / USACE 100 year maps
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental consequences
Operational ($/annum)	Station would operate when required
Direct ($/annum)	Minor water damage repairs

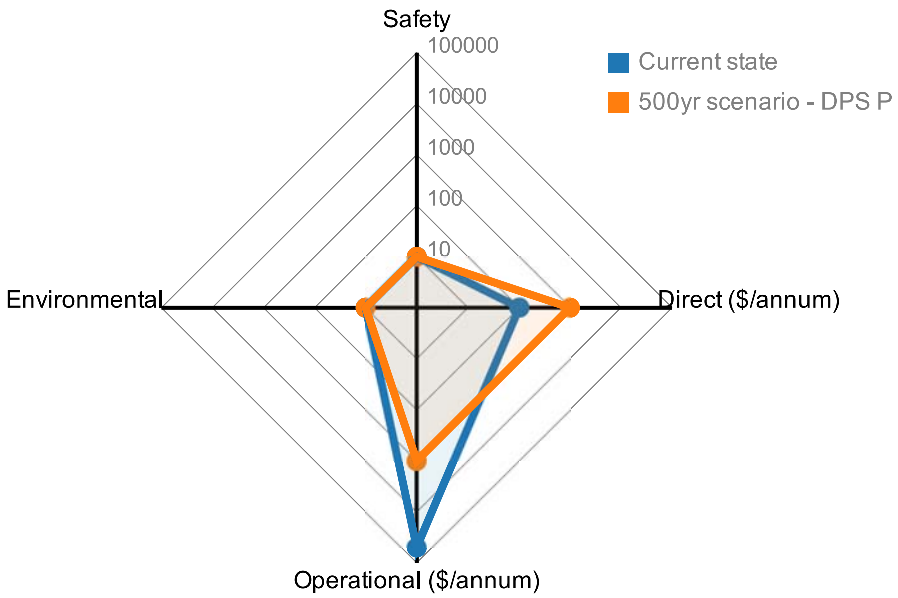
Measure High Cost Scenario Swiss Re-DPS Pritchard

Total One-Time Cost	$ 8700000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Raise the whole pump station above NOLA study level	One-time	8700000			8700000

Threat: Events: 500 year return period

Comments	The 500yr scenario would lead to 0 to 2ft of water in the surroundings of the facility according to FEMA / USACE
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	**Comments**
Safety	Pump station has been storm proofed minimizing the risk to personnel being injured during storms
Environmental	No environmental consequences
Operational ($/annum)	The transformer may be impacted by the water level - however the generator would supply power to the station
Direct ($/annum)	Minor water wind damage

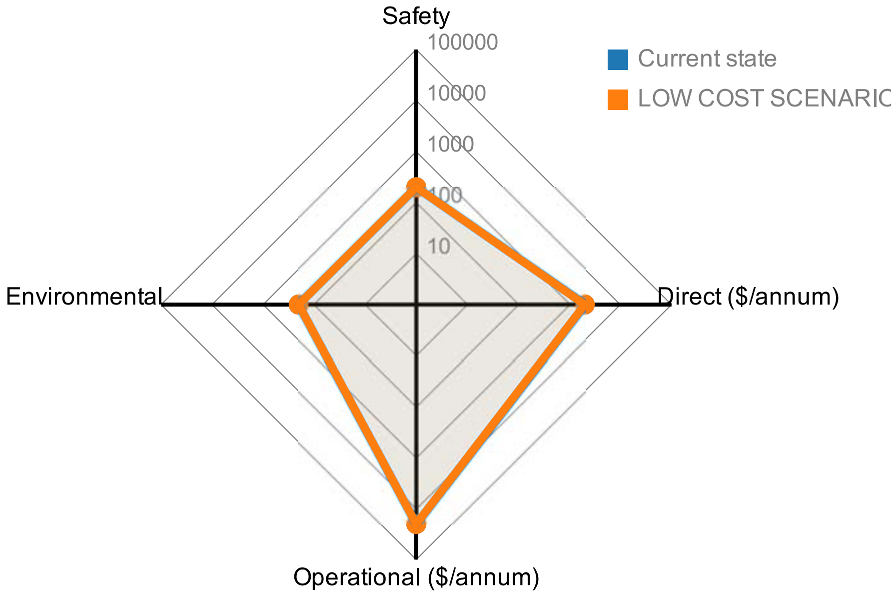
Measure 500yr scenario - DPS Pritchard **SELECTED**

Total One-Time Cost	$ 378453
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 1000
Earliest Recovery of Function	4 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the transformer platform by 5ft above ground - Add a new transformer	One-time	378453			378453

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds could reach 100 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Entergy power will more than likely be lost. Emergency generator would supply 60 Hz power
Earliest Recovery of Function	1 hours
Repair and recommissioning cost	$ 2000



Current Risk Type	Comments
Safety	
Environmental	
Operational ($/annum)	Entergy 60Hz would be down - however, the onsite generator would supply enough power for the pumps to run No secondary water source for cooling / priming the pumps, but it is considered very unlikely that the drinking water network would be shut down under the wind scenario
Direct ($/annum)	Wind damage

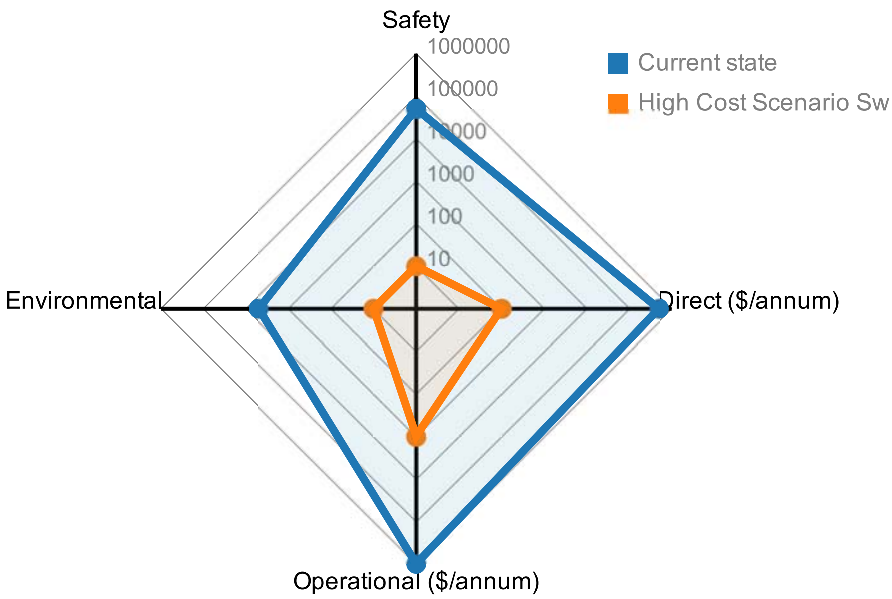
Measure LOW COST SCENARIO (Water)

Total One-Time Cost	$ 50000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0 days
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Implement a secondary water source for pump cooling / vacuum pumps	One-time	50000			50000

Threat: Scenario: SR 100 years

Comments	During a 100 year storm surge event Swiss RE predicts flood levels to rise between 7.5 and 10 ft. with peak wind gusts of 105 mph. Station would be flooded
Earliest Recovery of Function	2 months
Repair and recommissioning cost	$ 500000



Current Risk Type	Comments
Safety	Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damages to the environment could be important due to the fact that the whole area surrounding the station would be under water
Operational ($/annum)	The entire station would be under water
Direct ($/annum)	Repairs to station pumps, motors, switchgear, etc

Measure High Cost Scenario Swiss Re-DPS Pritchard **SELECTED**

Total One-Time Cost	$ 8700000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the whole pump station above NOLA study level	One-time	8700000			8700000

Carrolton Freq Changer: Short Resilience Report

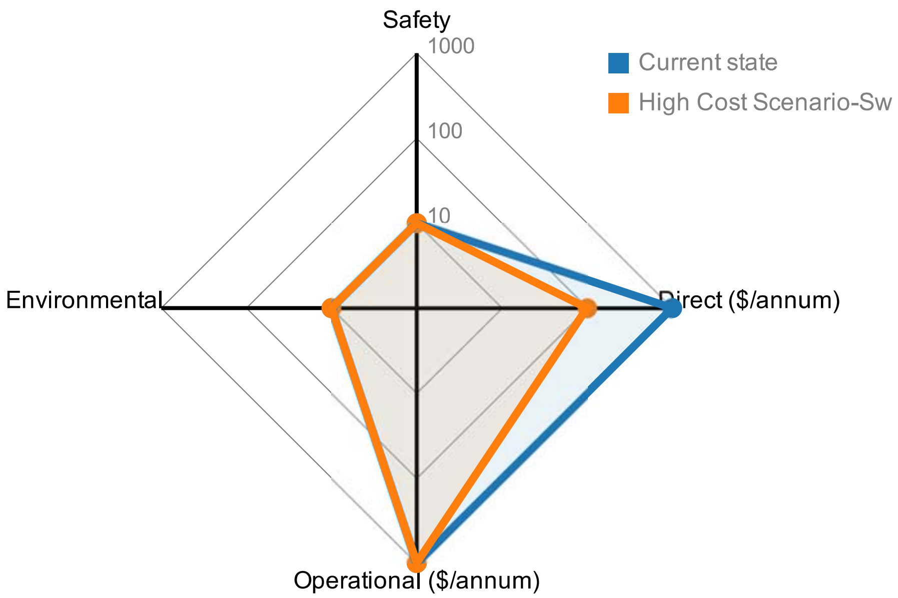
Location Description	8400 Earhart Blvd New Orleans LA 70118
Primary Function	To convert 4160 volt 60 Hz power via feeders 2016 and 2024 from Entergy to 24 Hz (25 Hz) to various facilities. Provides power to DPS 1 2 3 4 5 6 7.
Context Information	This station is part of SWBNO's 25Hz electrical distribution system. This station converts the 60Hz power from the Entergy grid to 25Hz frequency power. Station has a single 60Hz Entergy mains supply - no other electrical supply or on-site backup generation capacity exists for this station. Staff indicate that a plan has been adopted to connect this station to the 60Hz production capacity at the Carrollton WTP to provide redundancy for the station's 60Hz Entergy feed, but it is not clear when this will occur. Station has a single 6.5MW and a single 2MW frequency changer, both units are in service.
Full Replacement Cost	$ 20000000

Carrolton Freq Changer: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	This station is part of SWBNO's 25Hz electrical distribution system. This station converts the 60Hz power from the Entergy grid to 25Hz frequency power. Station has a single 60Hz Entergy mains supply - no other electrical supply or on-site backup generation capacity exists for this station. Staff indicate that a plan has been adopted to connect this station to the 60Hz production capacity at the Carrollton WTP to provide redundancy for the station's 60Hz Entergy feed, but it is not clear when this will occur. Station has a single 6.5MW and a single 2MW frequency changer, both units are in service.	M
Supply chain strength	Spare parts don't exist anymore for the majority of the pumping equipment. All the parts are machined by the highly skilled maintenance team. Generally major spares aren't kept on inventory so failures are addressed ad'hoc. Small / minor electrical spares on site. Supply chain strength associated with major repairs seems very weak because it would take time.	M
Skills availability	Not Manned, 2-4 persons during major storm events. Lack of staffing continues to be a major issue	L
Ease of access	Road access only. Multiple roads to access the facility - all low elevation. Prone to flooding	L
Documentation and procedures	Documentation is written into a log book at the station. There is very little to none predictive maintenance, ie vibration analysis, oil analysis, thermal imaging, etc. Hurricane plan in place that applies to all DPS.	M
Flood protection	Very little flood protection - main floor is elevated 4ft above ground but the 60 Hz transformers are outside and elevated 1ft above ground level	L
HAZMAT and Fire protection	Portable fire extinguishers only.	L
Building code compliance	It is presumed building meets building codes	M
ARI		**0.550**

Threat: Events: 100 year return period

Comments	Minor flooding could occur in certain low lying areas. Power supply from Entergy will be lost. Power plant would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	7 months
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	As the building has been storm proofed, personnel inside the building can be considered to be safe
Environmental	No damage to the environment
Operational ($/annum)	If commercial power is lost, Carrollton Frequency changer is shut down and the plant frequency changer takes over
Direct ($/annum)	Water and wind damage

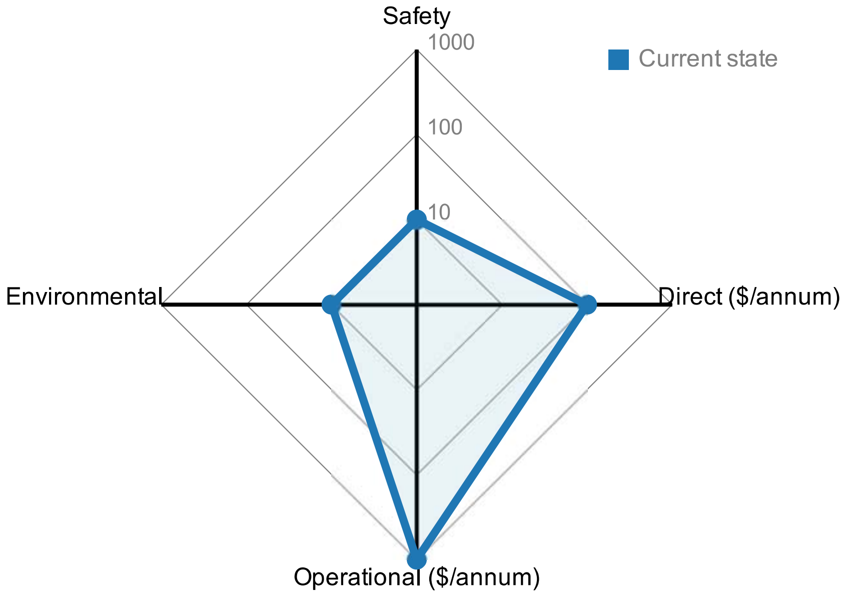
Measure High Cost Scenario-Swiss Re- Carrolton freq chgr

Total One-Time Cost	$ 24400000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the whole station above NOLA study level	One-time	24400000			24400000

Threat: Events: 500 year return period

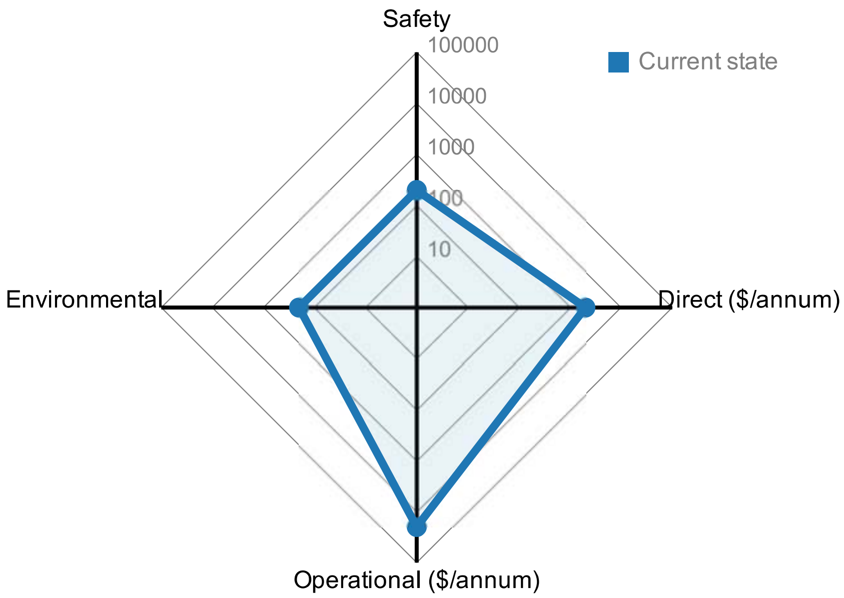
Comments	Winds could reach 130 mph. Flooding could occur in certain low lying areas specifically the streets but would not effect the Carrollton Frequency Converter building. Power supply from Entergy will be lost. Carrollton Frequency Converter would be out of operation requiring Plant Frequency Converter to take over. Power plant would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000



Current Risk Type	Comments
Safety	Plant frequency converter building is boarded up during hurricanes to avoid flying debris from breaking windows, etc. This building has been storm proofed
Environmental	No environmental damage
Operational ($/annum)	Entergy power shuts down. Plant frequency converter takes over
Direct ($/annum)	Wind and rain damage

Threat: Hurricane < 100 years - Wind

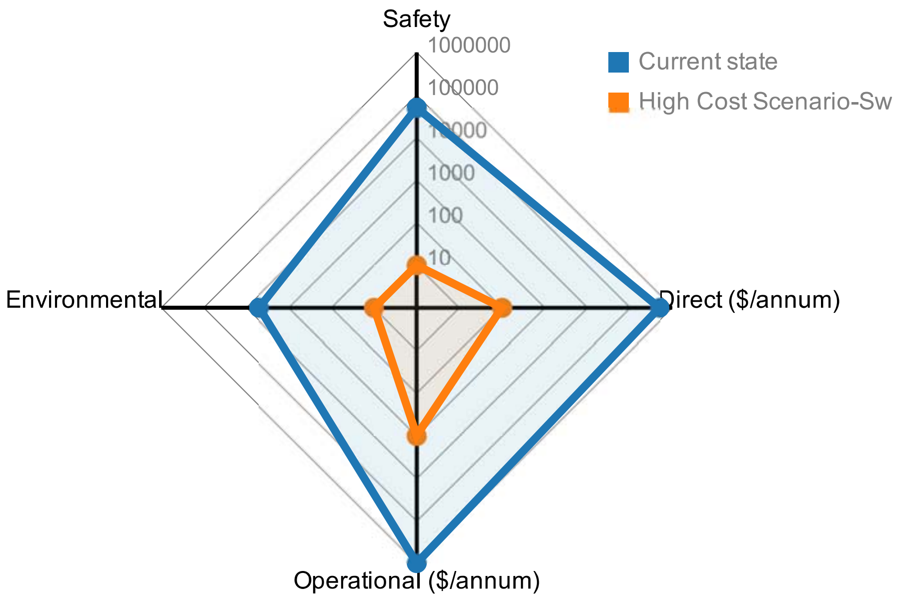
Comments	Wind speeds could reach 120 mph. causing minor damage to the building specifically roofs. Flooding could occur in certain low lying areas. Mobile structures could sustain major damage. Power supply from Entergy will be lost. Power plant would generate power for the entire WTP and some drainage stations.
Earliest Recovery of Function	48 hours
Repair and recommissioning cost	$ 2000



Current Risk Type	Comments
Safety	Building has been stormed proofed, risk to personnel small
Environmental	No environmental consequences
Operational ($/annum)	If the 60Hz goes down, the station is out of service, This station is not normally utilized for regular events. DPS 17 can supply power to the various DPS in case this station fails.
Direct ($/annum)	Wind damage

Threat: Scenario: SR 100 years

Comments	SwissRE predicts flood levels to rise between 7.5 and 10 ft. with peak wind gusts of 105 mph.
Earliest Recovery of Function	7 months
Repair and recommissioning cost	$ 500000



Current Risk Type	Comments
Safety	Given the levels of water reached under the Swiss-Re scenario, citizen fatalities would be expected.
Environmental	The damages to the environment could be important due to the fact that the whole area surrounding the station would be under water
Operational ($/annum)	The whole station would be under water. Plant frequency converter takes over
Direct ($/annum)	Wind and water damage

Measure High Cost Scenario-Swiss Re- Carrolton freq chgr **SELECTED**

Total One-Time Cost	$ 24400000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 2440
Earliest Recovery of Function	0 hours
Repair and recommissioning cost	$ 1000

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost
Raise the whole station above NOLA study level	One-time	24400000			24400000

Station A SPS: Short Resilience Report

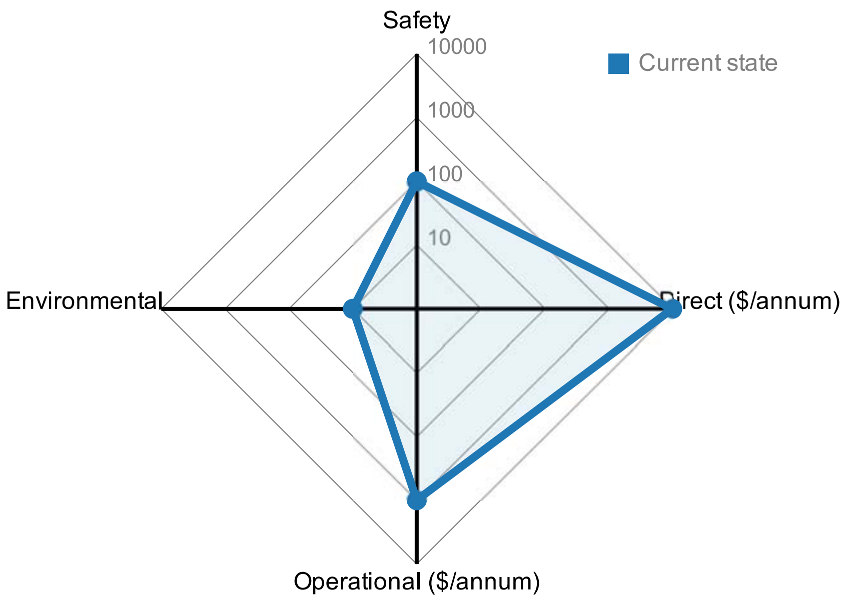
Location Description	1321 Orleans Avenue (entrance is off Essence Way and Basin St)
Primary Function	Sanitary Pump Station "A" (SPS-A) is the main sewage pump station for the SWBNO.
Context Information	Pump Station A is an Above Ground Suction Lift type station, located at 1321 Orleans Avenue. It discharges to the 72- inch force main that flows directly to the East Bank Wastewater Treatment Plant. In addition to pumping the wastewater collected from its large service area (Central Business District), Pump Station A repumps flow from Pump Stations 1, 3, 5, 6, 8, 9, 14, and 15. Pump Station A contains four (36-inch by 36-inch) horizontally-aligned pumps on 60 Hz and 2 pumps on 25 Hz. No major deficiencies were found. Slight to mild deterioration was observed on the piping, pumps and bolts. No pump names, VFD driven by 2300 hp, 4000 volt, 60 Hz, 358 amp General Electric motor. This facility is the only SPS that is manned by SPS personnel (SPS D is manned full time by DPS personnel). During Hurricane Katrina the flood level reached 1' below the first floor elevation. The facility has 6 pumps - 2 on 25hz and 4 on 60hz. Only two pumps typically run as running anymore overwhelms the wastewater treatment plant. Each pump is in an isolated concrete walled pit and during Katrina the pits flooded through the pipe wall penetrations. First floor, on which the electrical systems and pump motors reside, is elevated approximately 4 to 5 feet above surrounding parking lot. Building has exterior cracking in the brick walls. Currently SWBNO negotiating with FEMA to repair the building. The facility was shut off during Katrina after the East Bank Wastewater plant was lost. Ground elevation: - 1.6.7 feet Building elevation: -0.7 feet
Full Replacement Cost	$ 48150000

Station A SPS: Asset Resilience Indicator

Parameter	Comments	Score (L/M/H)
Redundancy/Excess capacity	SPS "A" has 6 pumps - two on 25hz and 4 on 60 hz. Under normal operations only 2 pumps are used. Has redundant power supply from DPS 02 and Westbank power control, however one of the under river feeders 226 from West Power has been compromised. External generator located on site, not connected - requires connection and throw switches.	M
Supply chain strength	Aging equipment in some cases obsolete, where no manufacturer spare parts are readily available, as a result highly specialized fabrication staff, fabrication and machining facilities / equipment manufacture spares when required. This leads to extended repair times of sometimes critical equipment. Where spare parts are able to be sourced, SWBNO maintains a large warehouse and dedicated staff to manage inventory.	L
Skills availability	Lack of staffing continues to be a major issue leading to maintenance repair delays in some cases.	L
Ease of access	Access available until street flooding occurs, then site is no longer accessible	M
Documentation and procedures	Hurricane Preparedness manual readily accessible. Maintenance strategies have not been reviewed in years	L
Flood protection	Electrical equipment and pumps elevated 4 to 5 feet above ground floor. Ground elevation is 2.3 ft. Facility not in any flood zone.	M
HAZMAT and Fire protection	Handheld fire extinguishers only	L
Building code compliance	Building has deteriorated over the years. External cracks have appeared.	L
ARI		**0.513**

Threat: Events: 100 year return period

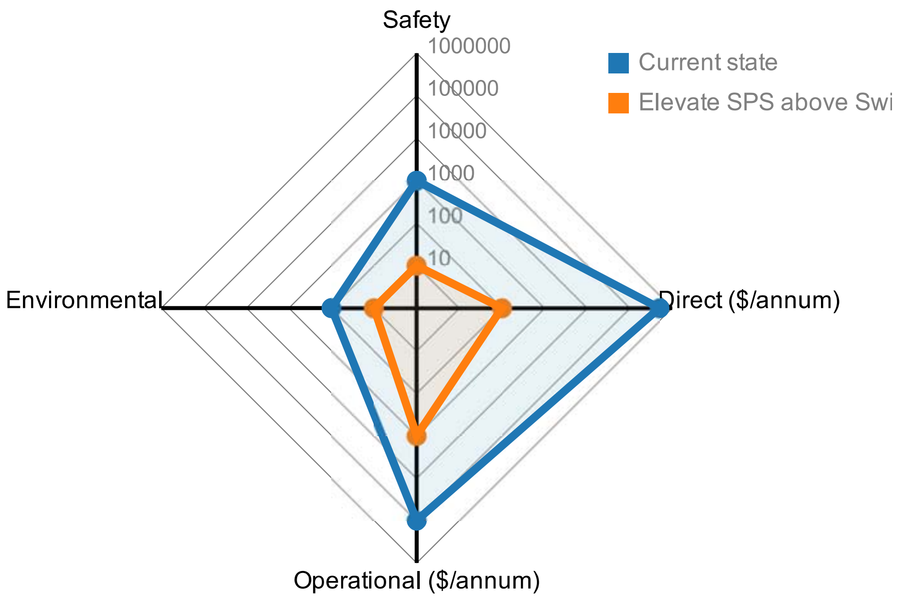
Comments	The first floor is 4 to 5 feet above surrounding ground level. According to FEMA's 100 y scenario there is no risk of flooding for this facility
Earliest Recovery of Function	1 days
Repair and recommissioning cost	



Current Risk Type	**Comments**
Safety	Minimal safety risk during a 100 y event according to FEMA's scenario but exterior wall cracking could create a safety risk during hurricane force winds. Further investigation required.
Environmental	The only hazardous chemicals at this site are lubrication oils with minimal risk.
Operational ($/annum)	The facility is on SCADA that can be controlled from the Control Center located at the St. Joseph main facility.
Direct ($/annum)	Exterior wall cracking. Further investigation required.

Threat: Events: 500 year return period

Comments	The first floor is only 4 to 5 feet above surrounding ground level. The entire first floor where the motors and electrical systems are located would require being raised 8 feet and pump pits would need the walls raised and waterproofed or sump pumps installed.
Earliest Recovery of Function	15 days
Repair and recommissioning cost	$ 6000000



Current Risk Type	**Comments**
Safety	Minimal safety risk during the SwissRE scenario beyond staff being trapped at the facility until flood water recedes. Exterior wall cracking could create a safety risk during hurricane force winds. Further investigation required. A failure of this station could create a health issue in the catchment
Environmental	The only hazardous chemicals at this site are lubrication oils with minimal risk.
Operational ($/annum)	The facility is on SCADA that can be controlled from the Control Center located at the St. Joseph main facility. If Station A had to fail for whatever reason no sewerage would be pumped from the Central Business District and from SPS 1, 3, 5, 6, 8, 9, 14, and 15. Sewerage would back up. Downtime to repair 2 weeks
Direct ($/annum)	With the exterior wall cracking and the facility age there is a remote risk that a hurricane force wind could trigger wall failure.

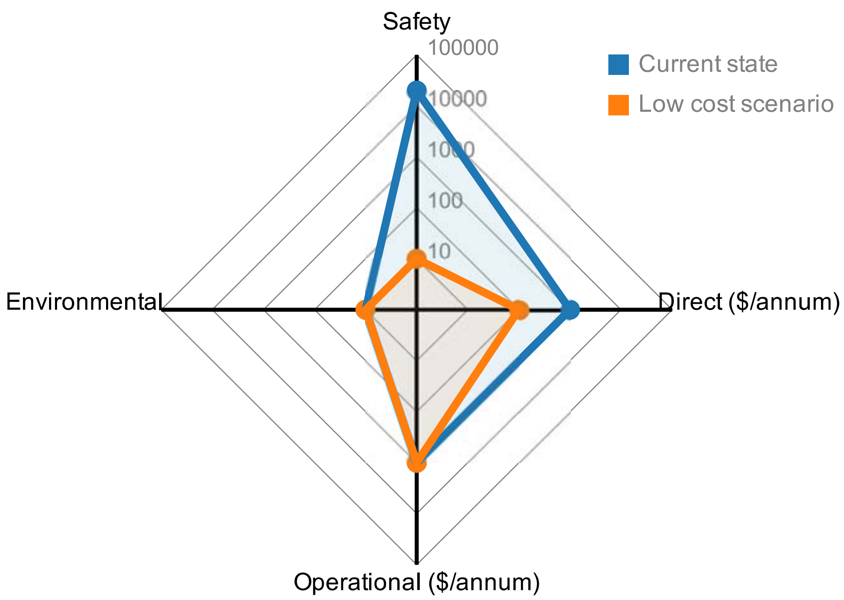
Measure Elevate SPS above SwissRE **SELECTED**

Total One-Time Cost	$ 7000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 10000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Raise the whole equipment	One-time	7000000			7000000

Threat: Hurricane < 100 years - Wind

Comments	Wind speeds up to 120 mph. cause damage to the building specifically roofs. Flooding occurs in certain low lying areas specifically the streets, may restrict access to the building. 60 Hz power supply from Entergy will be lost. Emergency generator would supply 60 Hz power to the facility. 25 Hz power supplied from SWBNO available.
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 10000



Current Risk Type	Comments
Safety	Exterior wall cracking could create a safety risk during hurricane force winds. Further investigation required.
Environmental	No environmental damage
Operational ($/annum)	Facility operates as normal
Direct ($/annum)	Hurricane

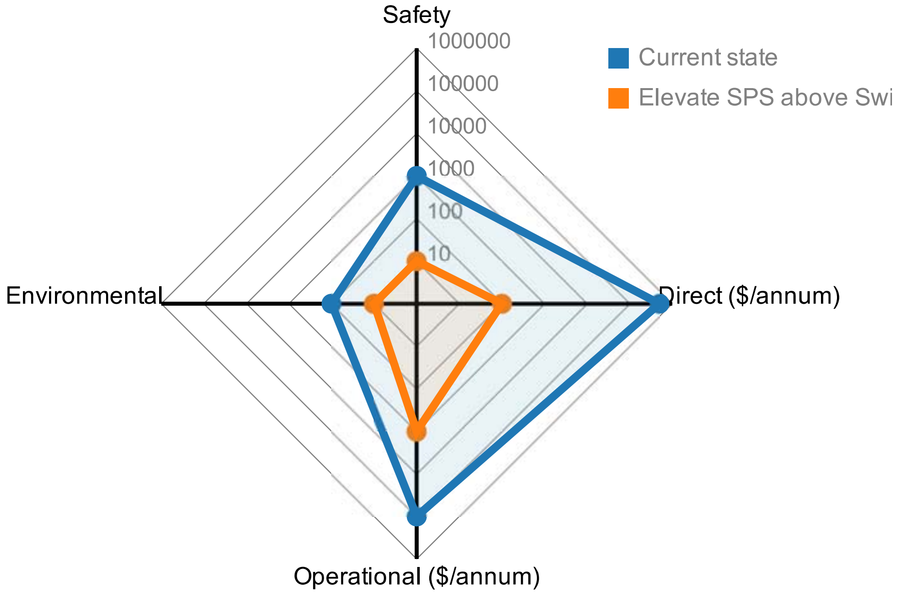
Measure Low cost scenario

Total One-Time Cost	$ 0
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	
Earliest Recovery of Function	
Repair and recommissioning cost	

Mitigating Action	Type	Cost	Interval	Annualized Cost	One-time Cost

Threat: Scenario: SR 100 years

Comments	The facility, at 10' flooding, would be a complete loss. The first floor is only 4 to 5 feet above surrounding ground level. The entire first floor where the motors and electrical systems are located would require being raised 8 feet and pump pits would need the walls raised and waterproofed or sump pumps installed.
Earliest Recovery of Function	15 days
Repair and recommissioning cost	$ 6000000



Current Risk Type	Comments
Safety	Minimal safety risk during the SwissRE scenario beyond staff being trapped at the facility until flood water recedes.
Environmental	The only hazardous chemicals at this site are lubrication oils with minimal risk.
Operational ($/annum)	The facility is on SCADA that can be controlled from the Control Center located at the St. Joseph main facility. If Station A had to fail for whatever reason no sewerage would be pumped from the Central Business District and from SPS 1, 3, 5, 6, 8, 9, 14, and 15. Sewerage would back up. Downtime to repair 2 weeks
Direct ($/annum)	From the SwissRE scenario the building and equipment inside would be a complete loss.

Measure Elevate SPS above SwissRE **SELECTED**

Total One-Time Cost	$ 7000000
Total Recurring Cost	$ 0
Annual Operating Cost Reduction	$ 0
Earliest Recovery of Function	0 days
Repair and recommissioning cost	$ 10000

Mitigating Action	**Type**	**Cost**	**Interval**	**Annualized Cost**	**One-time Cost**
Raise the whole equipment	One-time	7000000			7000000

Appendix A: Methodology for resilience analysis tool

Unit Resilience

Unit resilience data are entered for the top level of the asset management.

Unit resilience assessment is based on Operational Resilience Indicator and Financial Resilience Indicator information. Parameters and criteria comply with the AWWA J100-10 (R13) Risk and Resilience Management of Water and Wastewater Systems (RAMCAP)

Operational Indicator:

- Emergency Response Plan
- National Incident Management System (NIMS) Compliance
- Mutual Aid and Assistance
- Emergency power for critical operations
- Ability to meet minimum daily demand (water) or treatment (wastewater) when production or treatment plant is nonfunctional
- Critical parts and equipment
- Critical staff resilience

Operational Indicator:

- Business Continuity Plan (BCP

- Utility Bond Rating
- GASB (Governmental Accounting Standards Board (GASB) Statement No. 34) Assessment
- Unemployment
- Median Household Income

Asset Resilience

Asset resilience assessment is based on the following criteria:

- Redundancy/Excess capacity
- Supply chain strength
- Skills availability
- Ease of access
- Documentation and procedures
- Flood protection
- HAZMAT and Fire protection
- Building code compliance

For every item we have considered three levels:

- Low (for “None” / “Weak” / “Poor”)
- Medium (for “Some” or “Reasonable”)
- High (for “Fully” or “Very good”)

Threat Analysis

Threat analysis records the effects of individual threats on vulnerable assets.

4 parameters have been evaluated:

Safety (Impact on people)

Safety		Minor injury / Lost time < 10 days	Moderate injury /Lost time<30 days	Serious Injury /Disability	In-situ fatality	Citizen fatality
		Minimal	Moderate	Severe	Extreme	Catastrophic
Monthly	Frequent	Medium	High	Very high	Very high	Very high
Yearly	Likely	Low	Medium	High	Very High	Very high
Once every 5 year	Possible	Very low	Low	Medium	High	Very high
Once every 20 year	Remote	Very low	Very low	Low	Medium	High
Once every 100 year	Exceptionnal	Very low	Very low	Low	Low	Medium

Environmental (Impact on environment)

Environmental impact		Minor pollution	Temporary damage (<1 year)	Long term damage (<2 years)	Activity disruption <7 days	Suspension of operating permit
		Minimal	Moderate	Severe	Extreme	Catastrophic
Monthly	Frequent	Medium	High	Very high	Very high	Very high
Yearly	Likely	Low	Medium	High	Very high	Very high
Once every 5 year	Possible	Very low	Low	Medium	High	Very high
Once every 20 year	Remote	Very low	Very low	Low	Medium	High
Once every 100 year	Exceptionnal	Very low	Very low	Low	Low	Medium

Operational (impact on business → Business interruption)

Operational	Rebuilt cost & BI	<$100,000	<$1,000,000	<$5,000,000	<$10,000,000	>10,000,000
	Sensitive population affected	< 100 people	< 500 people	< 1000 people	< 5000 people	> 20000 people
	Customer days impact	< 5,000	< 50,000	< 100,000	< 500,000	> 500,000
	Image impact on Veolia	Few customer claims	Client claims	Local media cover	National media cover	Class Action
		Minimal	Moderate	Severe	Extreme	Catastrophic
Monthly	Frequent	Medium	High	Very high	Very high	Very high
Yearly	Likely	Low	Medium	High	Very high	Very high
Once every 5 year	Possible	Very low	Low	Medium	High	Very high
Once every 20 year	Remote	Very low	Very low	Low	Medium	High
Once every 100 year	Exceptionnal	Very low	Very low	Low	Low	Medium

Direct cost (Damage on the assets)

Direct costs (Repair or replacement cost)		< $10,000	<$100,000	<$1,000,000	<$5,000,000	>$5,000,000
		Minimal	Moderate	Severe	Extreme	Catastrophic
Monthly	Frequent	Medium	High	Very high	Very high	Very high
Yearly	Likely	Low	Medium	High	Very High	Very high
Once every 5 year	Possible	Very low	Low	Medium	High	Very high
Once every 20 year	Remote	Very low	Very low	Low	Medium	High
Once every 100 year	Exceptionnal	Very low	Very low	Low	Low	Medium

Appendix B: Detailed topics of review for interviews

Procurement

- Overview of procurement process
- Supplier management
- Supplier information
- Risk evaluation and management process
- HR management of staff involved

Chemicals

- Overview of procurement process and identify specificities for chemicals
- Procurement and stock management (storage autonomy, self-sufficiency and planning)
- Risk register (product register, risk analysis , and protection measures)
- Environmental and safety management of products and handlers
- Required products in the event of crisis or emergency
- HR management of staff involved

Client

- Revenue
- Client risks
- Key Client (per type) information
- Client connection
- Risk evaluation and management process
- HR management of staff involved

Network

- Network and connections
- Network planning
- Development strategy
- Capex and Opex requirements
- Network security
- HR management of staff involved

Asset management

- Asset register
- Asset portfolio – identification of critical assets and associated protection measures
- Security measures
- Asset maintenance
- Asset acquisition, construction and divestment
- Risk strategy (risk identification, mitigation measures incl. transfer i.e. insurance)
- Regulated risk register
- Emergency and crisis management (including business continuity planning)
- HR management of staff involved

Appendix C: Economic Figures

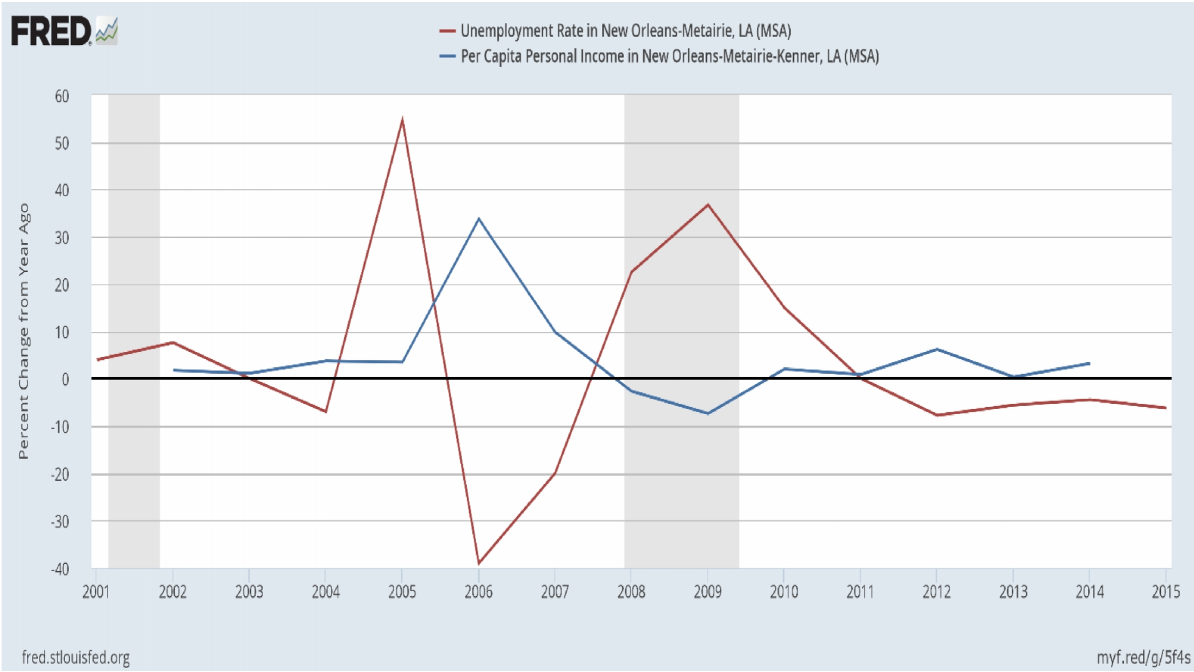


Figure 1 Unemployment vs Per Capita Income New Orleans 2001 – 2015

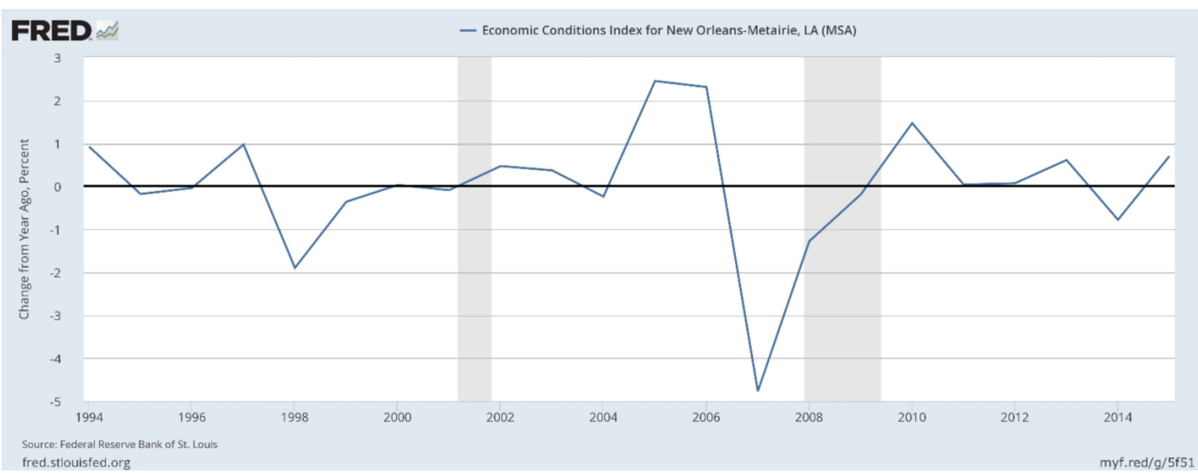


Figure 2 Economic Conditions New Orleans 1994 – 2015

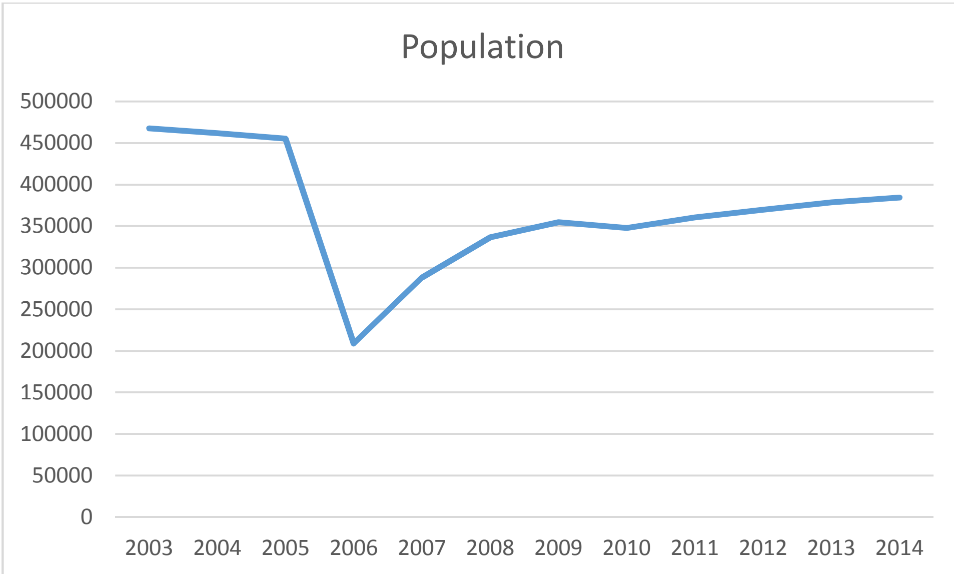


Figure 3 New Orleans Population 2003 – 2014

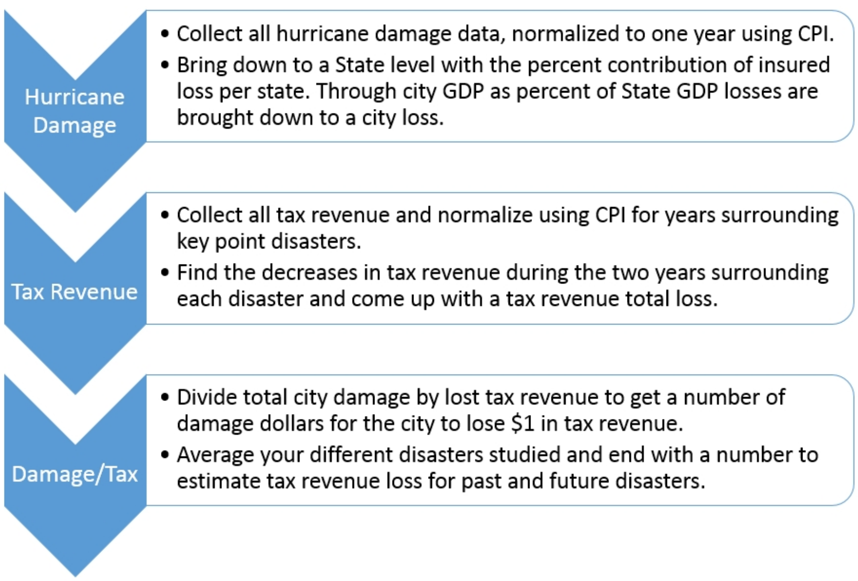
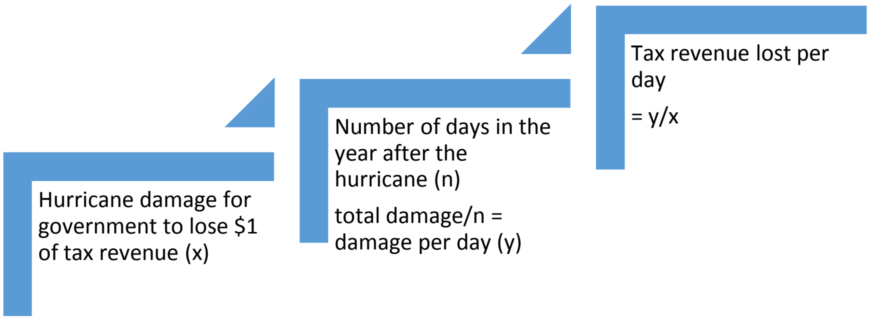


Figure 4 Tax revenue loss model



(Total Damage / Days in year after disaster)/Hurricane damage for government to lose $1 in tax revenue = Daily tax revenue loss

Figure 5 Daily tax revenue loss number model

Year	Total income (actual)	Total income trended with 4% increase (new baseline) in year of nat cat	Negative change compared to new trended baseline	Sum
2002	$ 460,955,140.08	$ 460,955,140		
2003	$ 478,963,888.48	$ 478,963,888		
2004	$ 495,864,000.00	$ 495,864,000		
2005	$ 393,295,200.00	$ 515,698,560	$122,403,360.00	
2006	$ 334,002,400.00	$ 536,326,502	$202,324,102.40	$ 324,727,462
2007	$ 342,565,200.00			
2008	$ 376,390,602.56	$ 356,267,808	$ -20,122,794.56	
2009	$ 410,216,005.13	$370,518,520.32		
2010	$ 433,481,357.03			
2011	$ 477,504,947.07			
2012	$ 475,380,751.89	$ 496,605,145	$ 21,224,393.06	
2013	$ 497,993,779.14	$516,469,350.75	$ 18,475,571.61	$ 39,699,965
2014	$ 510,984,219.42			
2015	$ 534,438,457.78			
2016	$ 549,236,338.55			

Figure 6 Trended Tax and Service Income

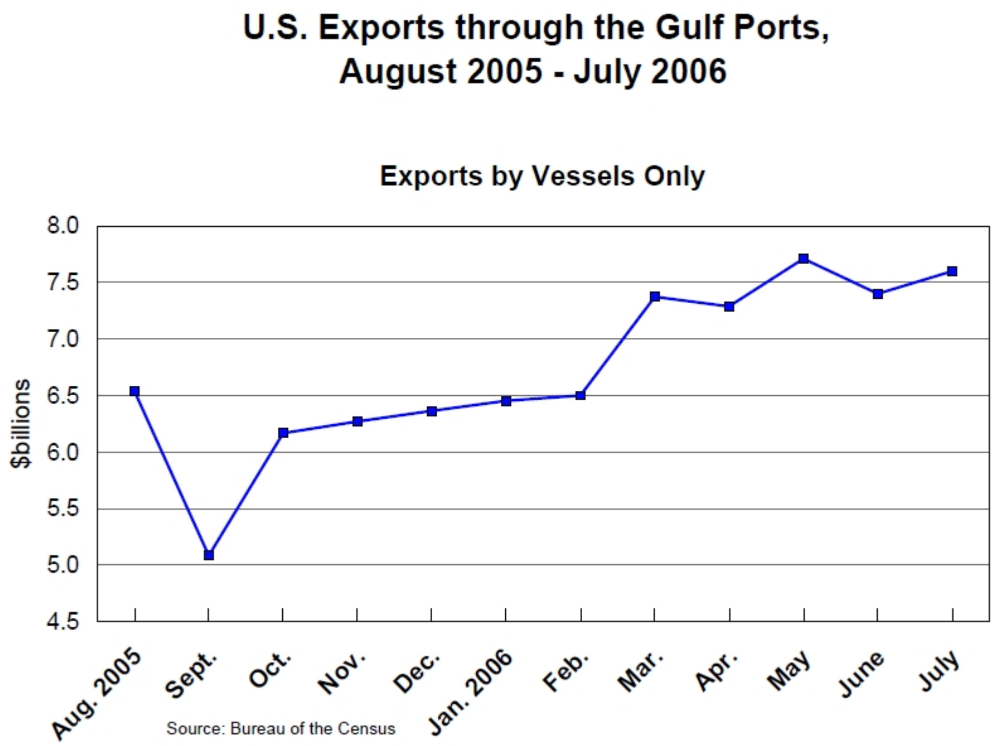
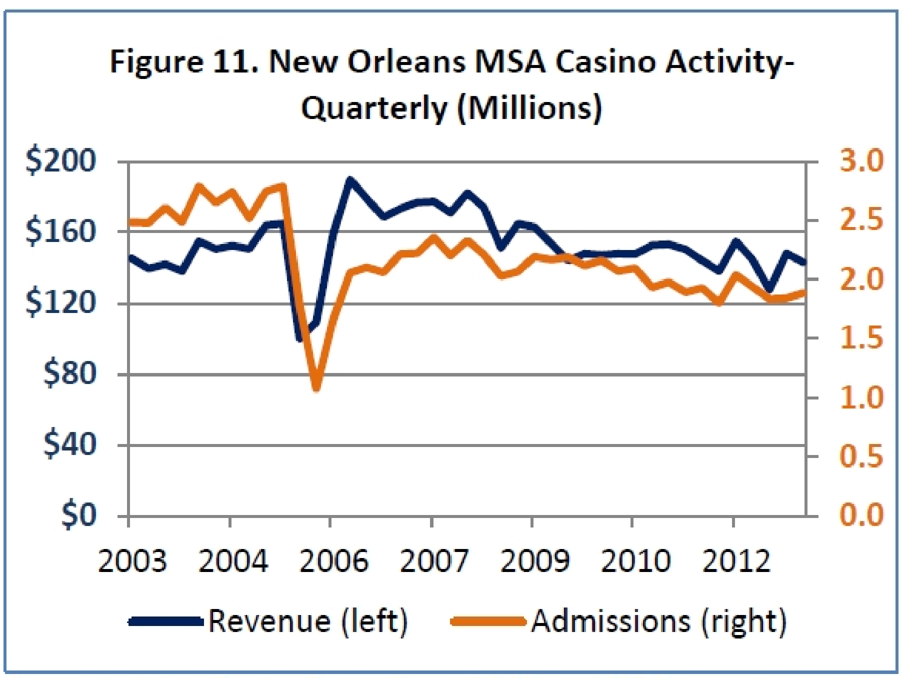


Figure 7 US Port Activity



Source: Louisiana Gaming Control Board (LGCB) and DBER

Figure 8 NOLA Casino Revenues

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