(Water in the GCC … Towards Efficient Management)

Risk Assessment of Tropical Cyclone on Water Supply Systems

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Presentation Outlines

- Introduction
- Main Objective
- Gonu Tropical Cyclone
- Method of Risk Assessment
- Analysis of Risks
- Conclusions

Introduction

- Drinking water utilities are exposed to both natural and manmade hazards that are common in Oman.
- Oman is subjected to tropical cyclone zone that can cause major damage to structures and infrastructure such as water utilities.
- In June, 2007, a severe ‘Gonu’, hit the coastal area of Oman, with 213-232 km/h winds and heavy rainfall causing extensive flooding and substantial damage to critical infrastructure.
- Particularly severe damage was caused to the water systems. The hurricane left thousands without water service or low water pressure for almost a month.
- PAEW) in cooperation with the Ministry of Defense (MOD) and the Royal Oman Police made their best efforts to restore water supply to the needy areas affected by the cyclone.

Introduction

- A holistic risk assessment and management approach, including the entire drinking water system, from source to tap, is the most effective way to ensure a safe drinking water supply.

- Risk assessment plays an important role in disaster mitigation as it provides the essential information for adopting optimum disaster prevention measures, and for developing effective warning system as well as evacuation and emergency plans.

- Risk assessment involves the separate assessment of hazard and vulnerability.

- This paper focuses on the risk assessment of tropical cyclone to drinking water facilities.

Main Objective

The main objective of the present research is to analysis and assesses the risks caused by tropical cyclone to water supply systems in Oman. The work focuses on the hazard (risk) assessment of Gonu cyclone to drinking water facilities and the emergency responses to repair and reconstruct damaged systems.

Gonu Tropical Cyclone

- The most severe and disastrous of tropical cyclone that effected Oman coast.
- It developed to TC on 4th of June 2007 with a surface wind speed of (213-232 km/h) that classified to its highest severity “Category 4” according to the criteria of storm severity
- The rainfall associated with Guno TC on the 05th-06th of June was the extreme in history of records in Oman (1032 mm).
- TC Gonu caused havoc to the infrastructures, building and to other properties and several lives in the areas of Muscat, Sur and Quriyat near the coast.
- The economic loss was to be in the range of 1.5billion Omani Riyal.

Gonu Tropical Cyclone

Figure (1): Satellite Image for Gonu Cyclone on 4th June, 2007

Gonu Tropical Cyclone

The Height of Water in Al Qurm Area of Muscat

Flooded Roads in Muscat

Road Destruction in Muscat

Human Responses

Method of Risk Assessment

- Risk assessments can be carried out with a range of methods that can be broadly classified into quantitative and qualitative approach.

- Due to lack of adequate information and the numerical data and resources necessary for a statistically significant quantitative approach, qualitative analysis is conducted.

- The most common form of qualitative risk assessment is a “risk matrix”, which assesses individual incidents in terms of categories, e.g. low, medium and high, according to their expected consequence and likelihood.

- Risk and Vulnerability Analysis (RVA) method is used to analyze the risk of tropical cyclone to the water utility systems in Oman.

Risk = Hazard x Vulnerability

Analysis of Risk

Water Infrastructure Facilities Effected by Gonu

- To Total disruption of Barka desalination plant due to interruption of electric power necessary to run the pumps for pumping water to the districts reservoirs.
- Total disruption of Al-Ghubra desalination plant due to interruption of gas pipe lines necessary to run the plant.
- Collapse and total loss of the Wadi Adai wells due to settling of soil around the well, resulting severe damage.
- Loss of water transmission lines from the well field.
- Damage in voltage lines for Al-Khoudh well field due to erosion at the base of the poles causing damage to lines, switchboards, and substations.
- Damage in transmission pipes between the main reservoirs in desalination plants and districts reservoirs resulting in a loss of water.
- Ruptures in pipelines in exposed crossings streams (wadi) as a result of strong currents.
- Breaks and uncoupling of pipes in mountainous topography as a result of landslides and water currents.
- Damage to pipelines appurtenances (such as different types of chambers and valves)
- Damage to pumping equipments and electrical installations in some of the pump stations due to the flood.

Risk Estimation

The risks were estimated using Risk and Vulnerability Analysis (RVA).

Risk = Hazard x Vulnerability

The Criteria Regarding the Hazard Probability for Risk Matrix

Hazard	Description	Score
Rare	The event may occur only in exceptional circumstances (Frequency: <10%).	1
Unlikely	The event could occur at sometime (Frequency: 10- 30%)	2
Possible	The event should occur at sometime (Frequency: > 30 -70%).	3
Likely	The event will probably occur in most circumstances (Frequency: > 70-90%).	4
Almost Certain	The event expected to occur in most circumstances (Frequency: > 90%)	5

Risk Estimation

Vulnerability of Water Utility for Tropical Cyclone Risk

Vulnerability	Description	Score
Negligible	Minimal disruption to water utility	1
Minor	Minor failure to water utility	2
Moderate	Failure of the water utility	3
Major	Substantial failure of the water utility	4
Severe	Total failure of the water utility	5

Risk Estimation (Risk Table)

Vulnerability and Hazard Categories to Generate Risk Scores

Hazard	Vulnerability					
	Score	Negligible	Minor	Moderate	Major	Severe
		(1)	(2)	(3)	(4)	(5)
Rare	(1)	1	2	3	4	5
Unlikely	(2)	2	4	6	8	10
Possible	(3)	3	6	9	12	15
Likely	(4)	4	8	12	16	20
Almost Certain	(5)	5	10	15	20	25

The risk scores have been assigned a color code to easily represent relative risks as:

- Green scores represent low risks that may not need any mitigation measures.
- Yellow score represent medium risk that may need mitigation measures
- Amber scores represent high risks need mitigation measures.
- Red scores represent extreme risks that will almost certainly need immediate action.

Risk Estimation

- The damages to water utilities caused by tropical cyclone are depend on cyclone force (category) and strong wind, heavy rain and storm surge associated with the tropical cyclone.

- The hazard risks generated by tropical cyclone to the water facilities have been analyzed and assessed initially without any controls and then allowing for existing mitigating measures.

- Some of mitigation measures identified for high risks include development of an efficient tropical cyclone warning system and adequate emergency plans design the water utilities to appropriate engineering standards, sediment and erosion control measures, construction of coastal defense structures and stronger tanks and buildings, and trained staff to respond during emergencies.

Risk Estimation

Risk of Tropical Cyclone to Water Supply Systems (Utilities)

Risks to Water Systems		Before Mitigation Measures			After Mitigation Measures		
Hazard	Vulnerability	P	V	Risk	P	V	Risk
Transmission and Distribution Pipelines							
Complete Damage in transmission pipes	Failure of the water utility	2	3	**6**	2	3	**6**
Burst in main transmission lines	Failure of the water utility	4	3	**12**	4	3	**12**
Failures in the distribution pipes	Substantial Failure of the water utility	4	4	**16**	4	3	**12**
Break in distribution pipelines	Total failure of the water utility	5	5	**25**	5	4	**20**
Ruptures in pipelines	Total failure of the water utility	5	5	**25**	5	4	**20**
Damage to pipelines appurtenances such as chambers valves and fittings	Total failure of the water utility	4	5	**20**	4	2	**8**
Pumping Stations							
Breakdowns of pumps and motors	Substantial Failure of the water utility	4	4	**16**	2	4	**8**
Loss of incoming power supply	Total failure of the water utility	5	5	**25**	2	5	**10**
Failures of control systems	Total failure of the water utility	4	5	**20**	2	5	**10**
Failure of individual pump sets	Total failure of the water utility	5	4	**20**	2	4	**8**

Risk Estimation

Risk of Tropical Cyclone to Water Supply Systems (Utilities)

Desalination Plant							
Failure of sea intake structures	Failure of the water utility	3	3	**9**	2	3	**6**
Excessive suspended solids at the sea intakes	Total failure of the water utility	5	5	**25**	5	5	**25**
Failure at desalination Plant	Substantial Failure of the water utility	4	4	**16**	3	4	**12**
Major Failure at Desalination Plant	Substantial Failure of the water utility	3	4	**12**	2	4	**8**
Mechanical or electrical failure within the desalination plant	Total failure of the water utility	5	5	**25**	4	5	**20**
Interruption of gas pipe lines	Total failure of the water utility	5	5	**25**	3	5	**15**
Well field and Service Reservoir							
Pollution of water in the reservoir	Total failure of the water utility	3	5	**15**	1	5	**5**
Structural failures of the reservoir	Substantial Failure of the water utility	2	4	**8**	1	4	**4**
Cracks in the reservoir	Substantial Failure of the water utility	5	4	**20**	2	4	**8**
Collapse and total loss of the well field	Total failure of the water utility	2	5	**10**	1	5	**5**
Damage in voltage lines for well field	Total failure of the water utility	5	5	**25**	4	5	**20**

Conclusions

- Guno was severe tropical storm that Sultanate of Oman has ever experienced so far. The impact of the cyclone on Muscat's water system was particularly severe.

- The most valuable lesson learned from Guno was that; all water systems are required to develop emergency response plans based on vulnerability assessments conducted for their individual systems.

- Developing an effective emergency response plan for drinking water has become a top priority for the PAEW after the Guno cyclone.

- The PAEW is planning ahead to provide alternate safe water during an emergency ahead of time to ensure the water is safe and the supply is available for it customers.

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Thank you for attention

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