

Survival Analysis for Steering Committee of the Center for Risk Management

Blue team 12

Sophee Li, Chris Nobblitt, John Pamplin, Jerry Liao

Executive Summary

This report analyzes the operation of the pump stations during 48 hours when hurricane Katrina struck the Gulf Coast for the Steering Committee of the Center for Risk Management. During the hurricane, 41% out of 770 pump stations survived. Half of the pump stations failed after 45 hours. Being jammed by trash or landslide material was the most likely cause of pump stations failure (15.1%), followed by being flooded (14.9%), mechanical failure (14.5%), and structural damage (14.4%). We noticed that most of the jammed pump stations occurred between 22 and 27 hours. Therefore, we recommend the Committee to evaluate why pump station survival rates plummet so drastically during that time period. Such analysis may provide insight into delaying or preventing failure during future hurricanes.

Results

The cause of the pump station failure was a significant indicator of time to failure. Half of the pumps that suffered mechanical failure survived beyond 45 hours. The pumps that were taken out by storm surge lasted a similar amount of time, with half of said stations surviving beyond 42 hours. Pump stations that were flooded or were jammed by debris had much lower median survival times, with only half surviving beyond 26 and 25 hours respectively. Figure 1 below shows the survival probabilities of the failed pump stations over the 48-hour period, broken down by the cause of failure.

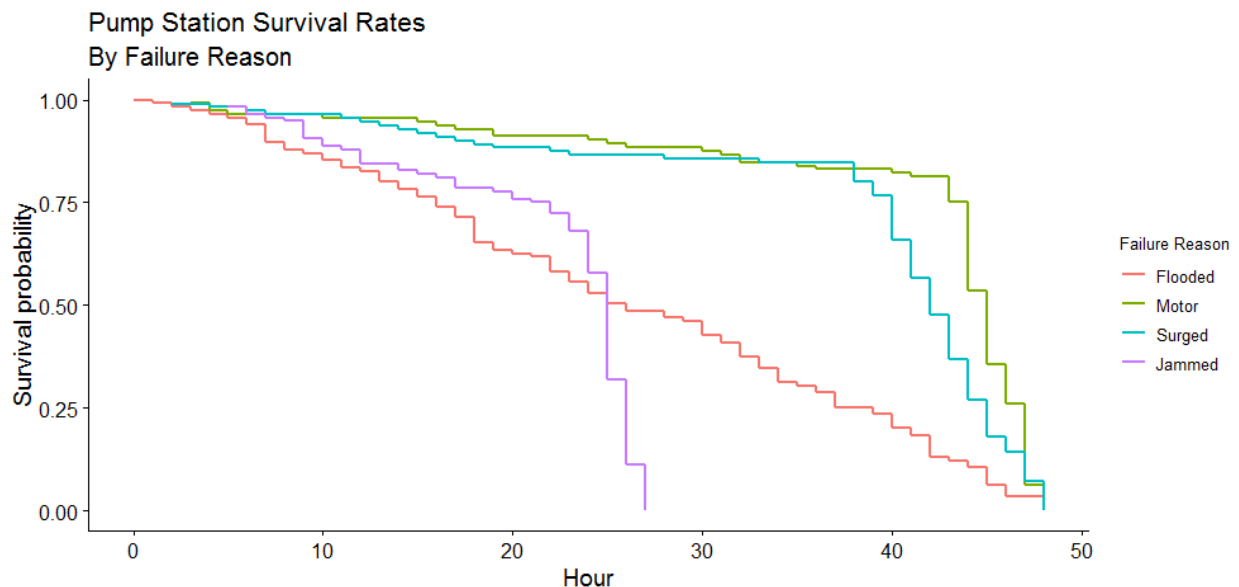


Figure 1.

In the figure above, we see that pumps which failed mechanically or sustained structural damage were nearly all operational until around 40 hours. Survival rates plummet in the late 48-hour period, around 38 hours for storm surge failures and 43 hours for mechanical failures. Jammed pump stations show a similar, drastic drop in survival rates, albeit much earlier in the critical period, at approximately 23 hours. Unlike the three other causes of failure, flooding made pumps

fail at a constant rate without any significant accelerations. Examining log-rank test, all the groups had statistically significant different survival rates over time. These types of failures should not be aggregated into coarser groups because they have unique survival characteristics.

To supplement the above survival curves, the associated hazard plots are shown below in Figure 2.

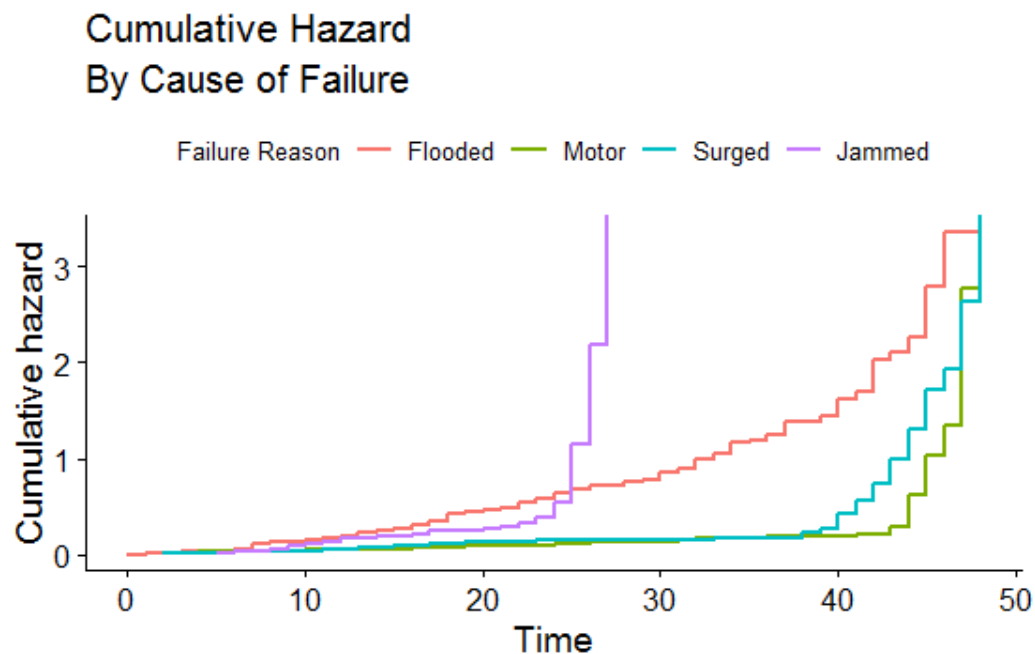


Figure 2.

Spikes in failure acceleration are visible for jammed, surged, and mechanically failed pump stations in that order. It should be noted that no more pumps failed from debris blockage after the acceleration around 23 hours into the critical period. This may indicate that only certain pumps in the catchment area are susceptible to this type of failure. The hazard plot for flooded pumps confirms that the failure rate remained steady for most of the 48 hour period, with a slight acceleration at the end.

Conclusion

Based on our research, the Steering Committee of the Center for Risk Management can understand how different reasons caused the pump stations to fail over the 48-hour critical period. We recommend our client to primarily focus on the pump stations jammed by trash or landslide materials because they accounted for the largest portion of the failures and they all occurred roughly at the same time. Moving forward, we can keep tracking if the failure rate of the pump stations over time is similar across prior and future hurricanes, and get a better understanding of what infrastructure needs to be improved.