Cost control strategy

COST CONTROL STRATEGY:
Proactive identification of desalination pumps failur..

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Cost control strategy

Annual maintenance cost has increased (28%) due to desalination water pumps failing. Attempt to control cost and prevent untimely asset failure requires either reduced production or proactive maintenance strategies.

- **Increased water production have caused degradation of desalination pumps:**

Production of water has increased by 1.5x in an attempt to meet continual market demand and reduce cost to produce.

- **Pumps failure has contributed to increased maintenance costs:**

Desalination pumps failure is responsible for the 28% increase in maintenance costs, with current operating procedures forecast to increase cost by 5-10%

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Cost pressures can be alleviated through the proactive identification of desalination pumps failures, with expected reductions of between 15-25% over the 2014-2015 calendar year.

Issues to explore:

1 What percentage of desalination pumps have failed due to purely production related issues as opposed to other failures?

2 Can we identify a particular trend or sequence of variables that correlate to pumps failure?

3 Provided that there does exist a subset of variables that correlate with respect to pumps failure, can we create an equation to represents this for a single desalination pumps?

4 Provided that a function can be created for a single desalination pump, can we scale this out for multiple desalination pumps?

Why do we do this?

1 We have been provided with information that indicates the majority of costs are because of pumps failure. Does the data support that pumps failure are actually the problem?

2 We analyze the data with the assumption that pumps failure can be prevented. Provided that we cannot prove this, we can conclude this failure cannot be understood with the data available.

3 If we can model this failure for 1 desalination, we may be able to scale this for others.

4 If we can scale this out for multiple pumps, we may be able to minimize pumps failures in the future in its entirety. ..

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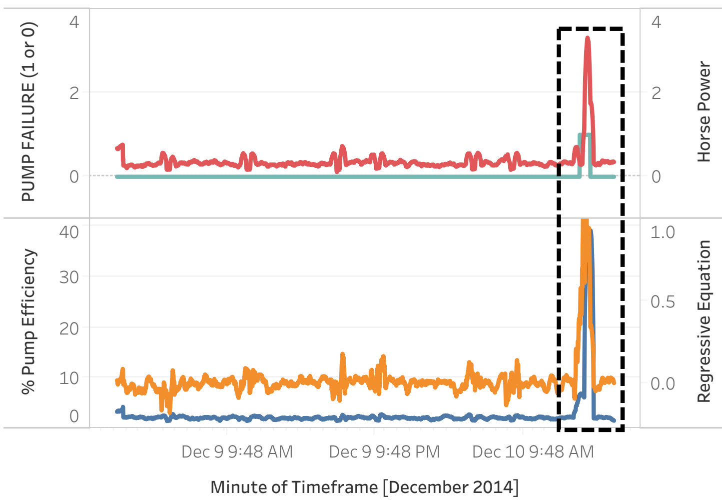
EXECUTIVE SUMMARY

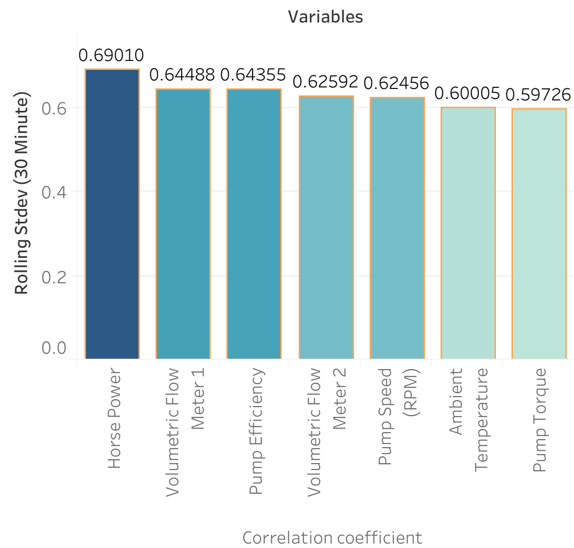
Descriptive and inferential statistical methodologies have enabled development of a proactive 'alarm', accurately identifying pump failures with Horse Power and Pump efficiency emerging as key variables of interest.

Measure Names

- Horse Power
- PUMP FAILURE (1 or 0)
- Pump Efficiency
- Regressive Equation

Statistical Alarm Plot





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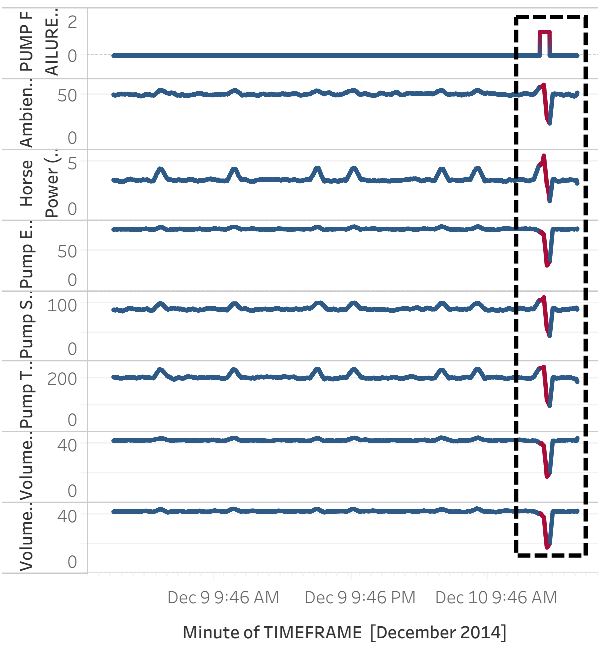
DESCRIPTIVE STATISTICS

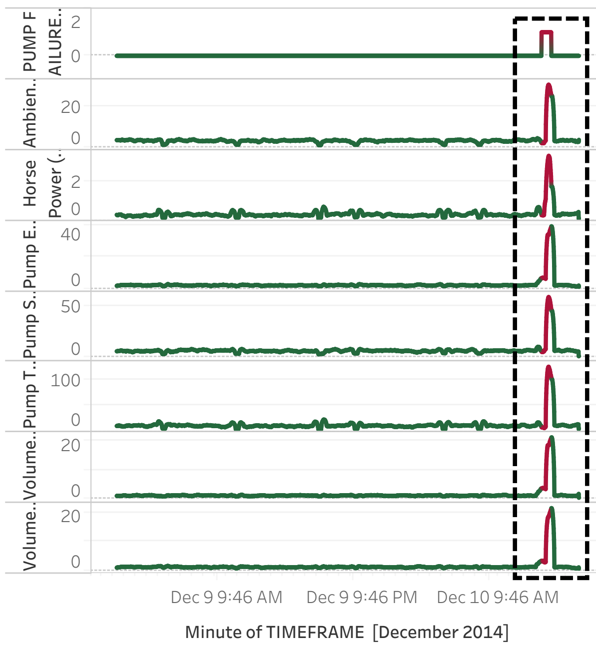
We can observe particular signature abnormalies showing obvious changes in both Rolling Mean and Rolling Standard Deviation Datasets when observed over the respective failure period of interest.

Notes: The variables were transformed from a 'raw' time series to a rolling 24h Standard Deviation and mean to smooth out the peakiness in the signal.

Rolling mean (30min)



Rolling Stdev (30min)



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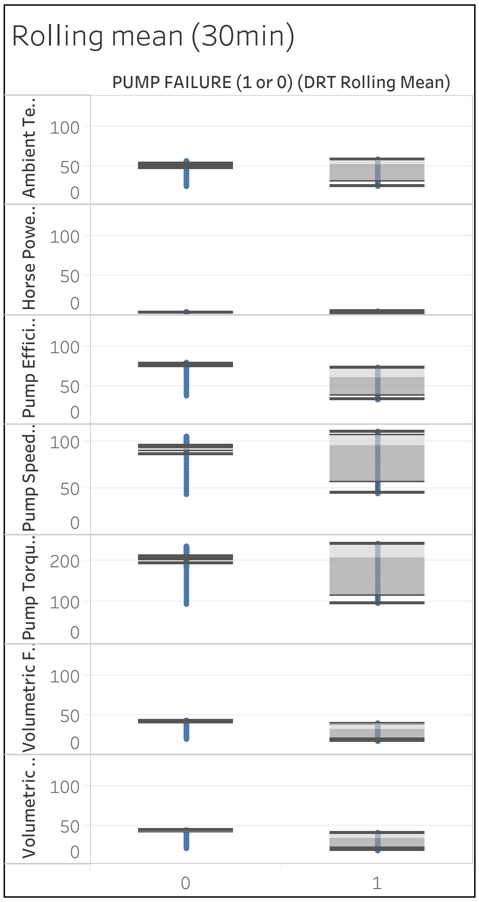
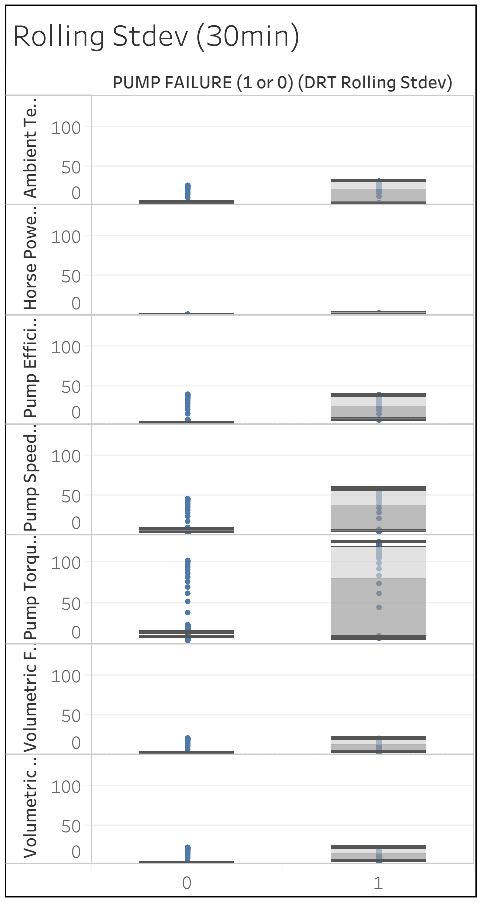
Further segmentation of the data via binary means (Pump failure = 0 or 1) illustrated through Rolling Standard deviation, show a clear difference between that of normal behaviour and that of Failure with Pump Torque, Pump Speed and Ambient Temperature showing the three (3) largest variances

DESCRIPTIVE ANALYSIS





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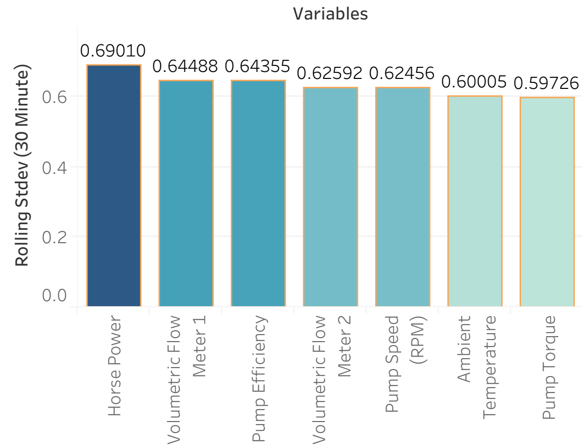
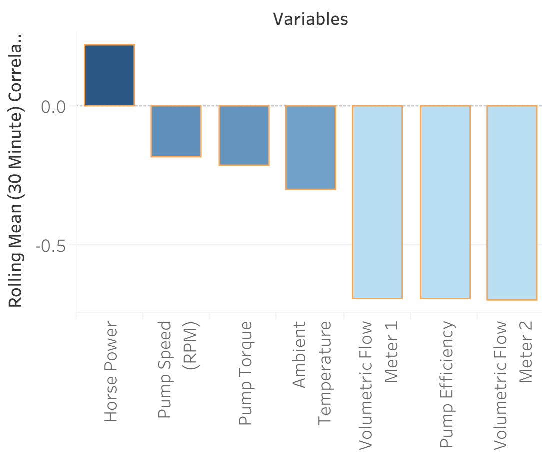
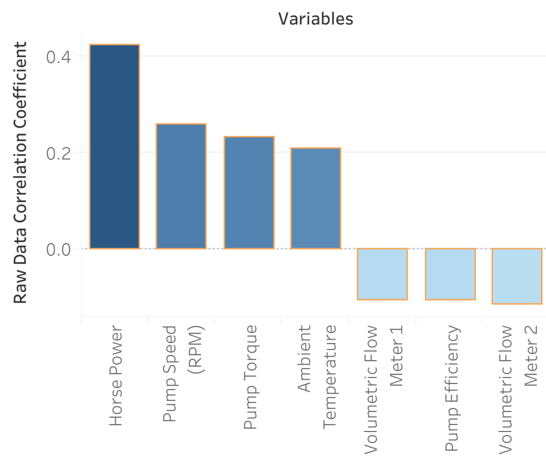
INFERENTIAL STATISTICS (Pearson Correlation)

Correlation analyses across datasets yield interesting insights with Pump efficiency and Volumetric Flow meter 2 negatively correlated with Pump failure in the Rolling Mean Dataset, whilst Horse Power, Volumetric Flow meter 1 and Pump Effiency show a strong positive correlation in the Rolling Standard Deviation dataset.

Notes: It is apparent that one of our datasets happens to show variables which are closely correlated to Pump Failure (The rolling Standard Deviation Dataset)..







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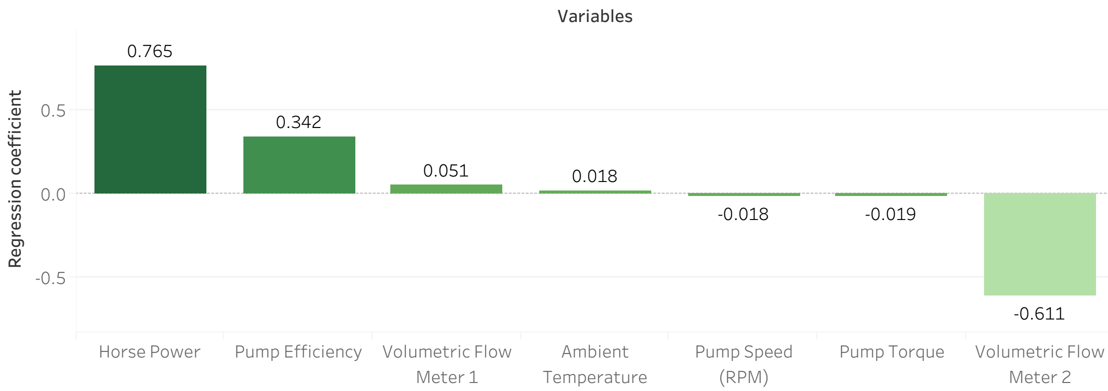
INFERENTIAL STATISTICS (Regression coefficient)

Analysis of the model fit reveals that with R-squared of 78%, a linear model is a good fit for the data with variables Horse Power, Pump efficiency having the largest coefficients (>0.5), indicative that these variables have the most immediate relationship with respect to Pump failure behaviour.

Note: We are not saying pump failures are directly attributed to these signals - Preliminary analysis have indicated that these are variables we should keep an eye on.



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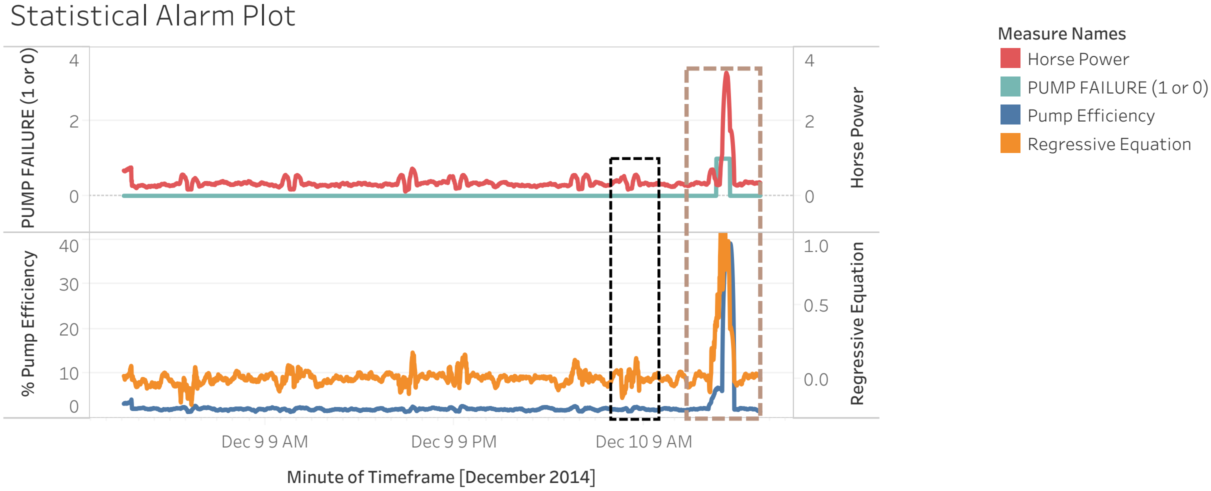
MULTIVARIATE EQUATION

Leveraging the two (2) key signals from our correlation analysis and using these as input variables in our regressive equation enabled us to create a unique failure signature for an individual pump.

Statistical Alarm Plot



Insights:

1 Using Pump Efficiency and Horse Power, our regressive function was able to effectively 'trace' the failure as well as provide a potential indication of pre failure signals. The variables were transformed from a 'raw' time series to a rolling 24h Standard Deviation to smooth out the peakiness in the signal.

2 Further analysis of the failure signal is required to ensure that the statistical analysis that was completed is scalable for pumps operating under different conditions. If it isn't performed, it is unlikely that our engineers will be willing to trust our equation due to lack of testing.

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COST CONTROL STRATEGY - Recap

➊Cost pressures can alleviated through the proactive identification of desalination pumps failures, with expected reductions of between 15/25% over the 2014-2015 calendar year.

▪Provided we cannot reduce production, only alternative is to improve maintenance strategies.

➋Descriptive and inferential statistical methodologies have enabled development of a proactive alarm, accurately identifying pump failures with Horse Power (HP) and pump efficiency (PE) emerging as key variables of interest.

▪HP and PE have the most immediate relationshop with respect to pump failure behavior.

▪Improve maintenance strategies using the failure data that exists for the pump which have failed. Data clearly exists because the asset has failed.

Southern Water Corp.