Case Study: Smart sewer analytics set to prevent spills, save environment

Matt Jordan, Manager Network Asset Performance @ TasWater

Andrew May, Senior Consultant @ Nukon (OSIsoft partner)

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Conference Theme & Keywords

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Smart sewer analytics pilot

TasWater commenced operations on 1 July, 2013 and was formed through the amalgamation of the three Tasmanian Water and Sewerage Corporations.

TasWater's vision is to be a trusted and respected provider of essential services that is making a positive difference to Tasmania.

CHALLENGE

How to receive advanced warning of and prevent potential sewage spills given limited field sensor data and varying operating conditions?

- Midway Point Tasmania
- Sensitive shellfish growing area
- Proactive monitoring for “difficult” to monitor assets and scenarios

SOLUTION

The PI Data Infrastructure, Asset Framework, Asset Analytics, Event Frames, PI Notifications, Seeq and real-time insights developed by Nukon.

- AF Asset hierarchy synchronized with ClearSCADA system using Nukon CS2PI Integration toolkit.
- AF Analytics for SPS Operation (pump starts and run times)
- Seeq Analytics for machine learning and PI Event Frame generation
- PI Notifications for OCC alerts

RESULTS

New detection methods better than current methods. Proactive field call out to other abnormal behaviors ahead of spill conditions.

- 13 hours ahead of current methods
- Successfully detected multiple anomalies with the network
- Future expansion to other failure modes and regions
- Rapid adoption

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Case Study: Smart sewer analytics set to prevent spills, save environment

Matt Jordan

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Manager Network Asset Performance

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Senior Consultant

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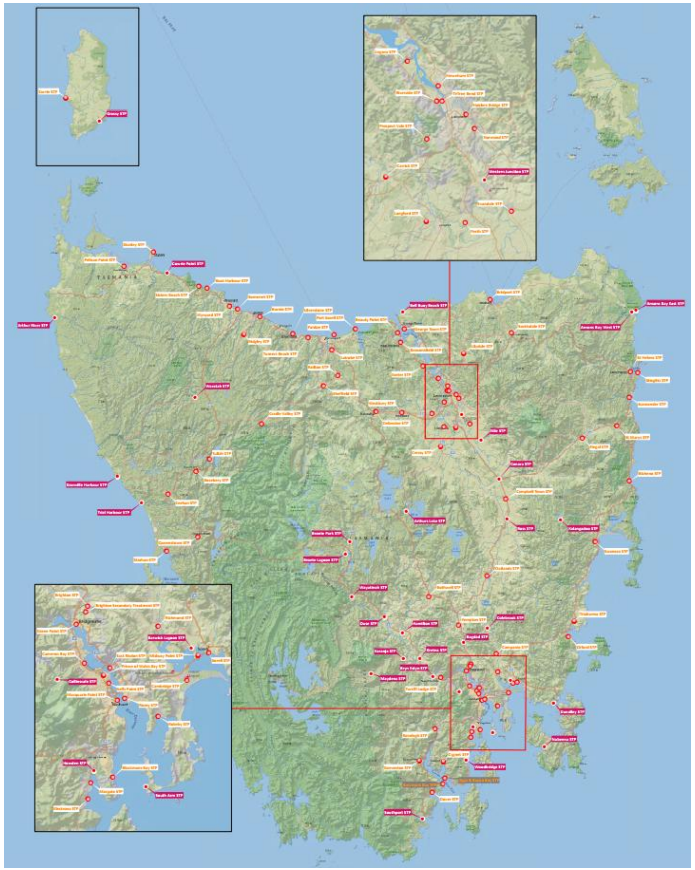
About TasWater

TasWater is Tasmania's primary water and sewerage service provider.

Created from three regional water and sewerage companies in 2013.



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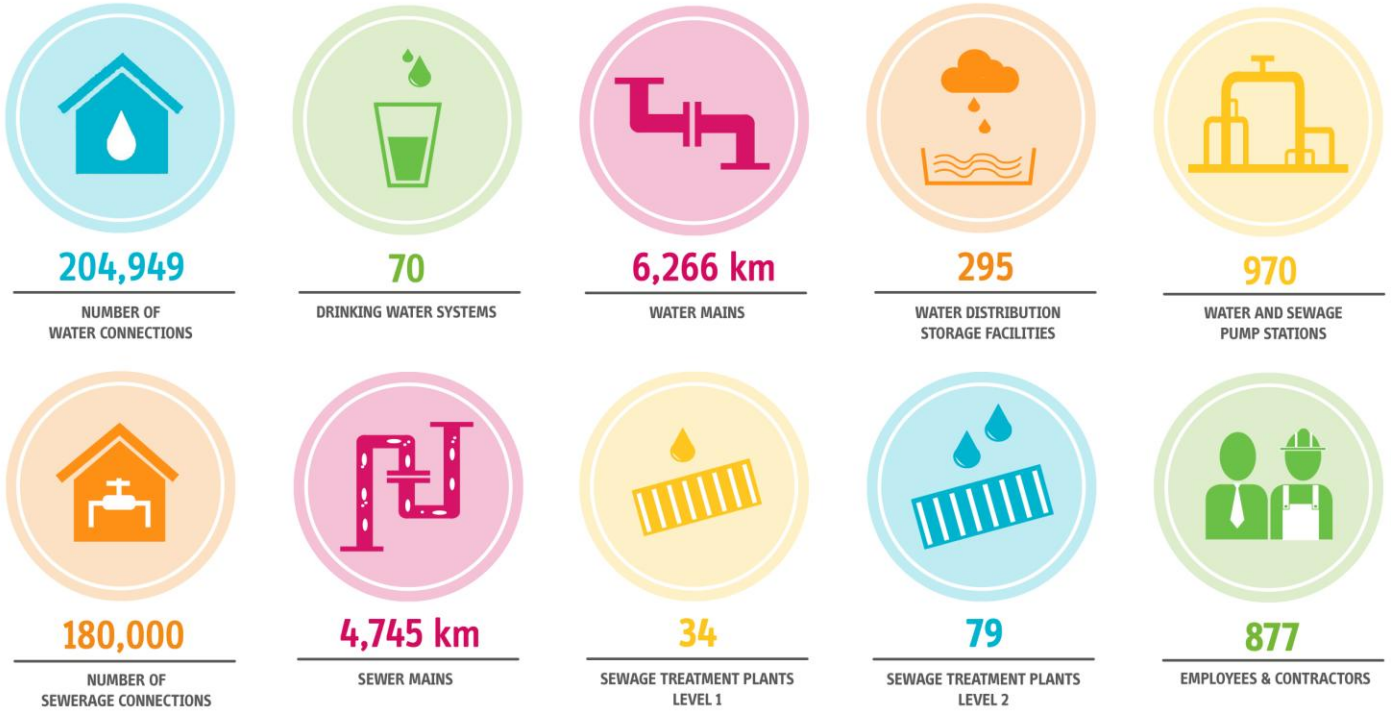
TasWater Snapshot



Information as of March 2018

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Who is Nukon?

- We began in 2013 and have grown rapidly from a 1 person company to our current team of 26 staff covering Australia and NZ. Nukon was acquired by SAGE Group in 2016. This group includes Nukon, SAGE Automation and NSAG.
- Key Customers
  - Coles
  - Murray Goulburn Co-Operative
  - Melbourne Airport
  - Fonterra
  - Treasury Wine Estates
  - TasWater
  - City West Water
  - South East Water
  - George Weston Foods
  - Simplot
  - GrainCorp
  - Chemring
  - CCA

Certified PI System Infrastructure Specialist

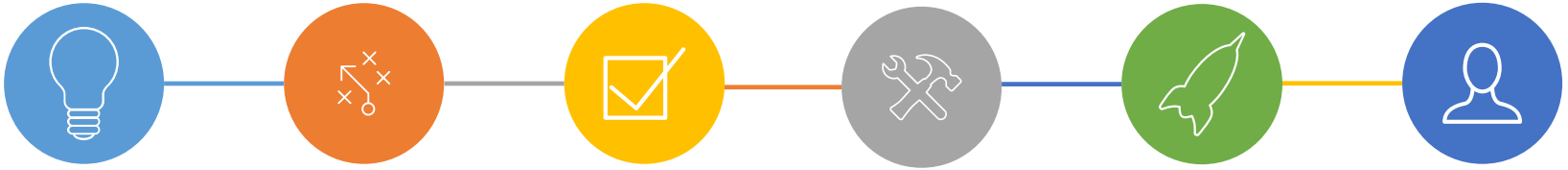
Seeq®

Seeq VAR Partner

Fonterra · City West Water™ · Murray Goulburn · coles · GrainCorp · Melbourne Airport · Treasury Wine Estates · TasWater

NUKON

What we do



R&D

Consulting

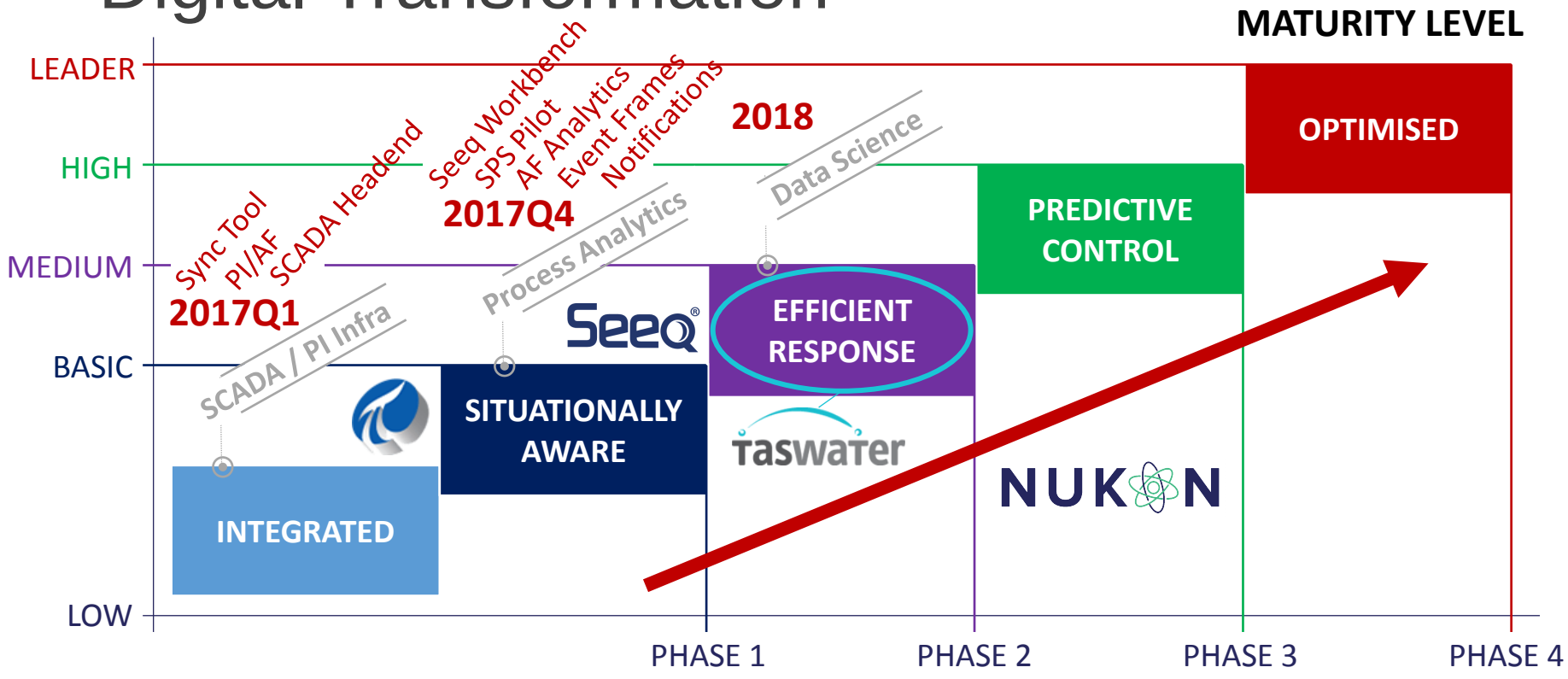
Design

Implementation

Change Management

Support

Digital Transformation



Some Stats

- Nukon SPS Monitoring Solution
- Seeq Workbench
- Nukon ClearSCADA to PI Configuration Management Tool
- OSIsoft PI Data Infrastructure
- Schneider Electric ClearSCADA Systems

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Spills from the Sewerage Pipe Network

- Spills are an unavoidable reality of managing a sewerage network
- TasWater has approximately 2,000 sewer mains breaks and spills per year – 43 breaks / 100km sewer main
- Predominantly, these are ‘run to fail’ or ‘prevent fail’ assets
- High critical mains the strategy is ‘avoid fail’
- Proactive and Reactive Maintenance Practices
- Relining / Renewal – Only when cost effective

Goulbourn Valley Water

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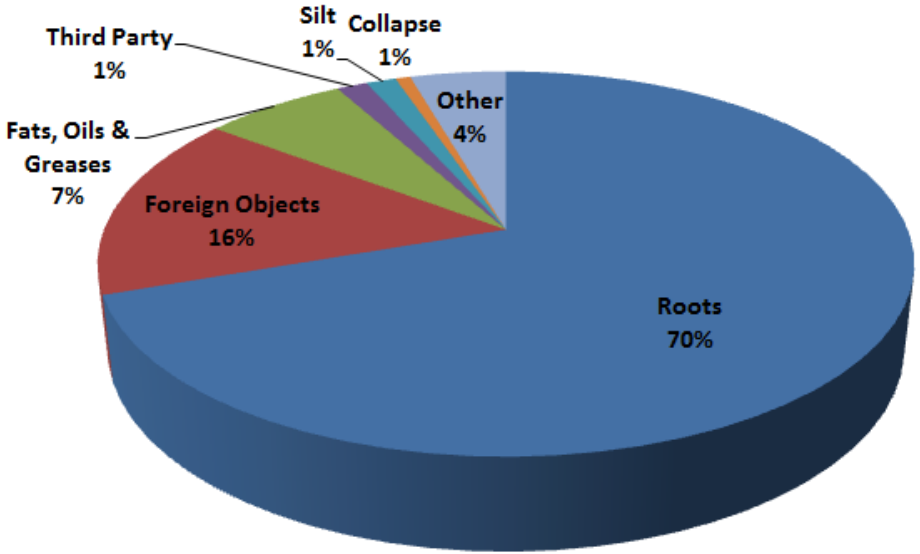
Spills from the Sewerage Pipe Network

- Maintenance Strategies are generally only effective on some types of blockages
- Sewerage system mangers are always looking for ways to identify blockages as soon as possible to the event occurring, minimising or even preventing the consequences being realised



Blockage Causes

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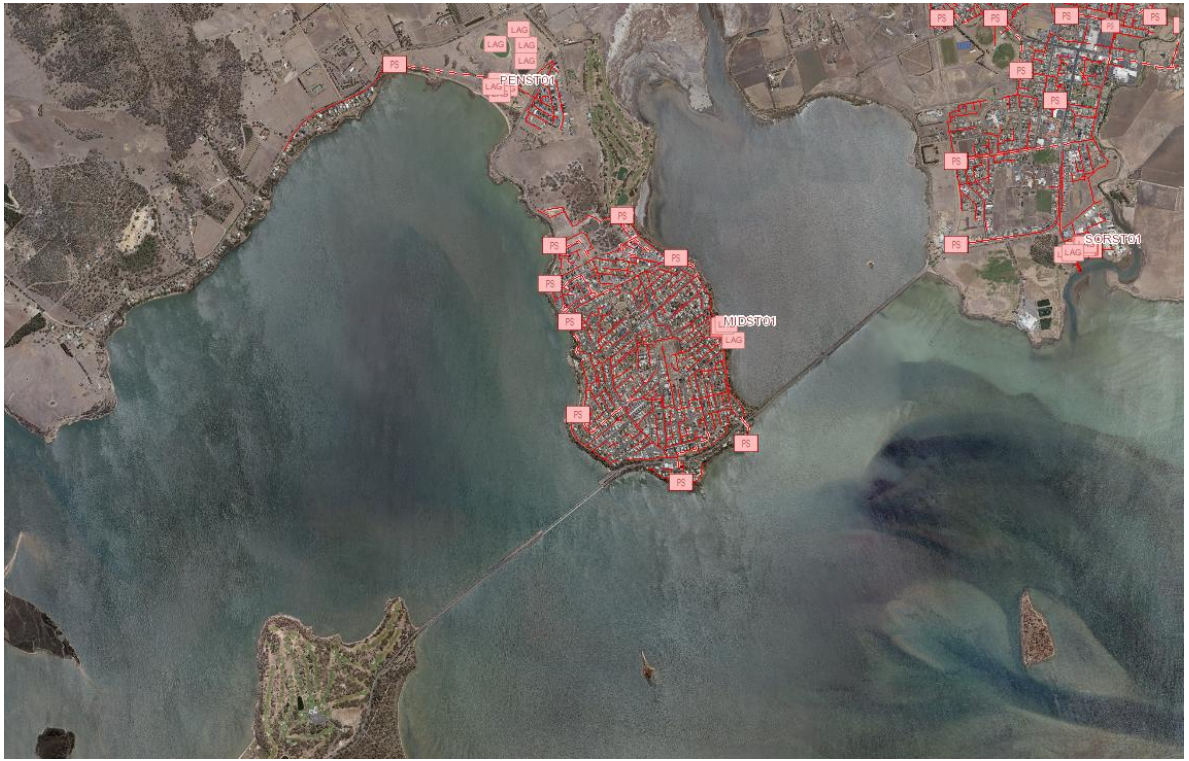
Midway Point Sewerage System

- 1 Sewage Treatment Plant
- 7 Sewage Pump Station
- 27 km of gravity sewer mains
- 1200 customer connections
- Surrounded by sensitive receiving waters



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The Challenge - Sewage Spills to Sensitive Waters

Pitt Water

- Largest oyster lease area in Tasmania
- 14 hectares of inter-tidal leases

Rae Allen

asioysters.com.au

Ramsar Wetland

- **Internationally important wetland** - registered on a list of the Convention on Wetlands (Ramsar, Iran 1971)
- Australian Government passed the ***Environment Protection and Biodiversity Conservation Act 1999*** (EPBC).

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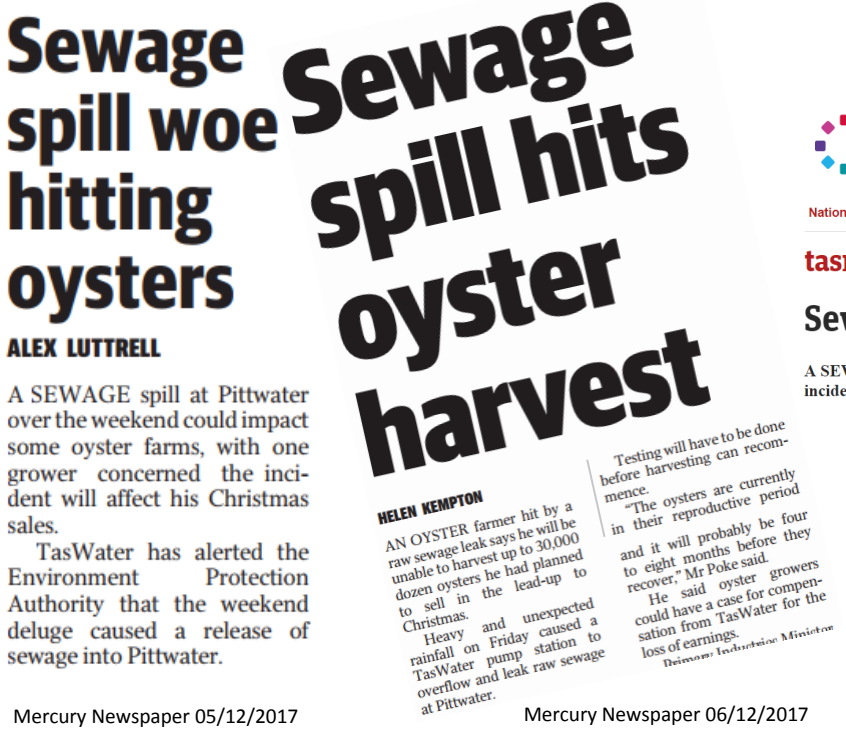
Sewer Spills to Sensitive Waters



Sewage spill woe hitting oysters

ALEX LUTTRELL

A SEWAGE spill at Pittwater over the weekend could impact some oyster farms, with one grower concerned the incident will affect his Christmas sales.

TasWater has alerted the Environment Protection Authority that the weekend deluge caused a release of sewage into Pittwater.

Mercury Newspaper 05/12/2017

Sewage spill hits oyster harvest

HELEN KEMPTON

AN OYSTER farmer hit by a raw sewage leak says he will be unable to harvest up to 30,000 dozen oysters he had planned to sell in the lead-up to Christmas.

Heavy and unexpected rainfall on Friday caused a TasWater pump station to overflow and leak raw sewage at Pittwater.

Testing will have to be done before harvesting can recommence.

"The oysters are currently in their reproductive period and it will probably be four to eight months before they recover," Mr Poke said.

He said oyster growers could have a case for compensation from TasWater for the loss of earnings.

Primary Industries Minister

Mercury Newspaper 06/12/2017

news.com.au

National | World | Lifestyle | Travel | Entertainment | Technology | Finance | Sport

tasmania

Sewage spill major blow for Pittwater oyster growers

A SEWAGE spill at Pittwater over the weekend could impact on some oyster farms, with one grower concerned the incident will impact on his Christmas sales.

http://www.news.com.au/national/tasmania/sewage-spill-major-blow-for-pittwater-oyster-growers/news-story/df1233bc0582276bf1646fbde2fcb4ed

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How the Project Evolved

Blockage occurred 24 August 2017, spilling approximately 6,000 L into Pittwater

Problem: When a sewer main blocks and ultimately spills, the first notification TasWater has is from a member of the public hours and sometimes days after it first spills.

Question: What processes and monitoring techniques could we implement to detect sewer main failures as soon as practicable after the blockage has occurred, minimising the impact or preventing a spill occurring.

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The Challenge

- Limited visibility into upstream and downstream network segments
- Notifications of blockages are ‘reactive’
- Practically impossible (cost prohibitive) to instrument the entire network
- How to gain better visibility, without large capital investment?
- Existing monitoring at Sewage Pumping Stations via SCADA

  Can this be utilised to infer an upstream blockage?

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Project Value Drivers

TasWater's Vision: be a trusted and respected provider of essential services that is **making a positive difference to Tasmania**

- Community Safety
- Environmental Impact
- Impact on Local Economy
- Reputational Damage;
  TasWater and Tasmania's 'Clean Green' image
- Incident management

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Approach

- Highly Collaborative
- Agile
- Make the best possible use of existing telemetry
- Augment time-series data with data science

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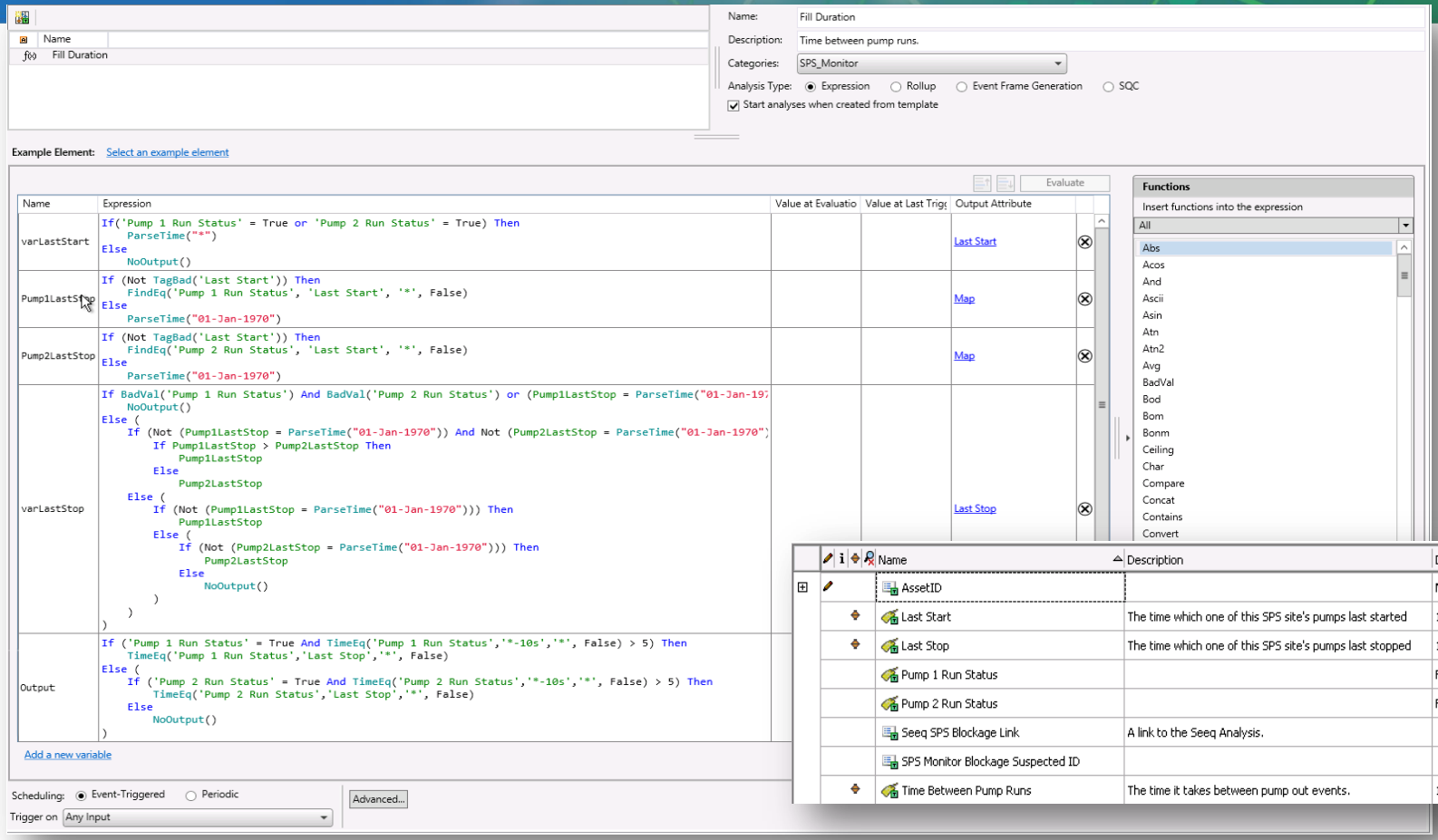
Benefits

TasWater realised these benefits:

- Fast deployment & low cost of implementation
- Helps to protect the environment by reducing the number of significant incidents through early detection
- Improved insights into network and asset behaviour through event correlation
- Sophisticated analytical toolset which can be used for historical and real-time process data analytics
- Does not require additional monitoring at sites (deferred capital investment)
- Increases responsiveness to ‘abnormal’ operating conditions
- Active alerts for ‘out-of-bounds’ conditions, configurable based on unique behaviour of the asset


Name
Fill Duration
Name: Fill Duration
Description: Time between pump runs.
Categories: SPS_Monitor
Analysis Type: Expression Rollup Event Frame Generation SQC
Start analyses when created from template
Example Element: Select an example element
Evaluate
Name
Expression
Value at Evaluatio
Value at Last Trig
Output Attribute
varLastStart
If('Pump 1 Run Status' = True or 'Pump 2 Run Status' = True) Then
ParseTime("*")
Else
NoOutput()
Last Start
Pump1LastStop
If (Not TagBad('Last Start')) Then
FindEq('Pump 1 Run Status', 'Last Start', '*', False)
Else
ParseTime("01-Jan-1970")
Map
Pump2LastStop
If (Not TagBad('Last Start')) Then
FindEq('Pump 2 Run Status', 'Last Start', '*', False)
Else
ParseTime("01-Jan-1970")
Map
varLastStop
If BadVal('Pump 1 Run Status') And BadVal('Pump 2 Run Status') or (Pump1LastStop = ParseTime("01-Jan-197
NoOutput()
Else (
If (Not (Pump1LastStop = ParseTime("01-Jan-1970")) And Not (Pump2LastStop = ParseTime("01-Jan-1970"
If Pump1LastStop > Pump2LastStop Then
Pump1LastStop
Else
Pump2LastStop
Else (
If (Not (Pump1LastStop = ParseTime("01-Jan-1970"))) Then
Pump1LastStop
Else (
If (Not (Pump2LastStop = ParseTime("01-Jan-1970"))) Then
Pump2LastStop
Else
NoOutput()
)
)
)
Last Stop
Output
If ('Pump 1 Run Status' = True And TimeEq('Pump 1 Run Status','*-10s','*', False) > 5) Then
TimeEq('Pump 1 Run Status','Last Stop','*', False)
Else (
If ('Pump 2 Run Status' = True And TimeEq('Pump 2 Run Status','*-10s','*', False) > 5) Then
TimeEq('Pump 2 Run Status','Last Stop','*', False)
Else
NoOutput()
)
Add a new variable
Functions
Insert functions into the expression
All
Abs
Acos
And
Ascii
Asin
Atn
Atn2
Avg
BadVal
Bod
Bom
Bonm
Ceiling
Char
Compare
Concat
Contains
Convert
Name
Description
Default Value
AssetID
Not Defined
Last Start
The time which one of this SPS site's pumps last started
1/01/1970 12:00:00 AM
Last Stop
The time which one of this SPS site's pumps last stopped
1/01/1970 12:00:00 AM
Pump 1 Run Status
False
Pump 2 Run Status
False
Seeq SPS Blockage Link
A link to the Seeq Analysis.
SPS Monitor Blockage Suspected ID
Time Between Pump Runs
The time it takes between pump out events.
1.50694925E+09
Scheduling: Event-Triggered Periodic
Advanced...
Trigger on Any Input

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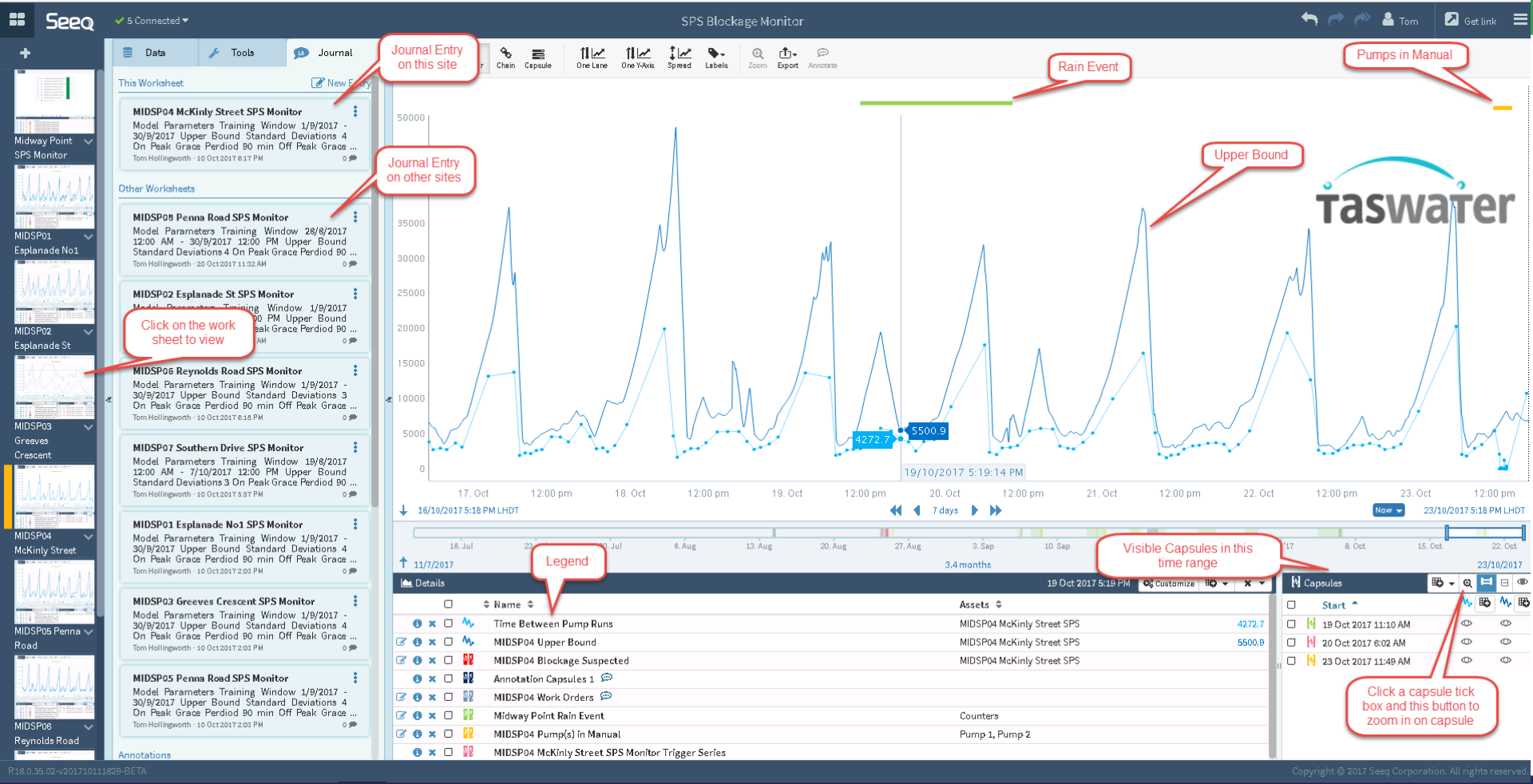
Seeq
5 Connected
SPS Blockage Monitor
Tom
Get link
Data
Tools
Journal
Journal Entry on this site
Journal Entry on other sites
Click on the work sheet to view
This Worksheet
New Entry
MIDSP04 McKinly Street SPS Monitor
Model Parameters Training Window 1/9/2017 - 30/9/2017 Upper Bound Standard Deviations 4 On Peak Grace Perdiod 90 min Off Peak Grace ...
Tom Hollingworth · 10 Oct 2017 6:17 PM
Other Worksheets
MIDSP08 Penna Road SPS Monitor
Model Parameters Training Window 28/8/2017 12:00 AM - 30/9/2017 12:00 PM Upper Bound Standard Deviations 4 On Peak Grace Perdiod 90 ...
Tom Hollingworth · 20 Oct 2017 11:32 AM
MIDSP02 Esplanade St SPS Monitor
MIDSP06 Reynolds Road SPS Monitor
Model Parameters Training Window 1/9/2017 - 30/9/2017 Upper Bound Standard Deviations 3 On Peak Grace Perdiod 90 min Off Peak Grace ...
Tom Hollingworth · 10 Oct 2017 6:18 PM
MIDSP07 Southern Drive SPS Monitor
Model Parameters Training Window 19/8/2017 12:00 AM - 7/10/2017 12:00 PM Upper Bound Standard Deviations 3 On Peak Grace Perdiod 90 ...
Tom Hollingworth · 10 Oct 2017 5:57 PM
MIDSP01 Esplanade No1 SPS Monitor
Model Parameters Training Window 1/9/2017 - 30/9/2017 Upper Bound Standard Deviations 4 On Peak Grace Perdiod 90 min Off Peak Grace ...
Tom Hollingworth · 10 Oct 2017 2:03 PM
MIDSP03 Greeves Crescent SPS Monitor
Model Parameters Training Window 1/9/2017 - 30/9/2017 Upper Bound Standard Deviations 4 On Peak Grace Perdiod 90 min Off Peak Grace ...
Tom Hollingworth · 10 Oct 2017 2:03 PM
MIDSP05 Penna Road SPS Monitor
Model Parameters Training Window 1/9/2017 - 30/9/2017 Upper Bound Standard Deviations 4 On Peak Grace Perdiod 90 min Off Peak Grace ...
Tom Hollingworth · 10 Oct 2017 2:03 PM
Annotations
Chain
Capsule
One Lane
One Y-Axis
Spread
Labels
Zoom
Export
Annotate
Rain Event
Pumps in Manual
Upper Bound
Taswater
50000
35000
30000
25000
20000
15000
10000
5000
0
4272.7
5500.9
19/10/2017 5:19:14 PM
17. Oct
12:00 pm
18. Oct
19. Oct
20. Oct
21. Oct
22. Oct
23. Oct
16/10/2017 5:18 PM LHDT
7 days
Now
23/10/2017 5:18 PM LHDT
16. Jul
6. Aug
13. Aug
20. Aug
27. Aug
3. Sep
10. Sep
8. Oct
15. Oct
22. Oct
11/7/2017
3.4 months
23/10/2017
Legend
Visible Capsules in this time range
Details
19 Oct 2017 5:19 PM
Customize
Name
Assets
Time Between Pump Runs
MIDSP04 McKinly Street SPS
4272.7
MIDSP04 Upper Bound
5500.9
MIDSP04 Blockage Suspected
Annotation Capsules 1
MIDSP04 Work Orders
Midway Point Rain Event
Counters
MIDSP04 Pump(s) in Manual
Pump 1, Pump 2
MIDSP04 McKinly Street SPS Monitor Trigger Series
Capsules
Start
19 Oct 2017 11:10 AM
20 Oct 2017 6:02 AM
23 Oct 2017 11:49 AM
Click a capsule tick box and this button to zoom in on capsule
R18.0.35.02-v201710111829-BETA
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Capsules?... What the hell are capsules?

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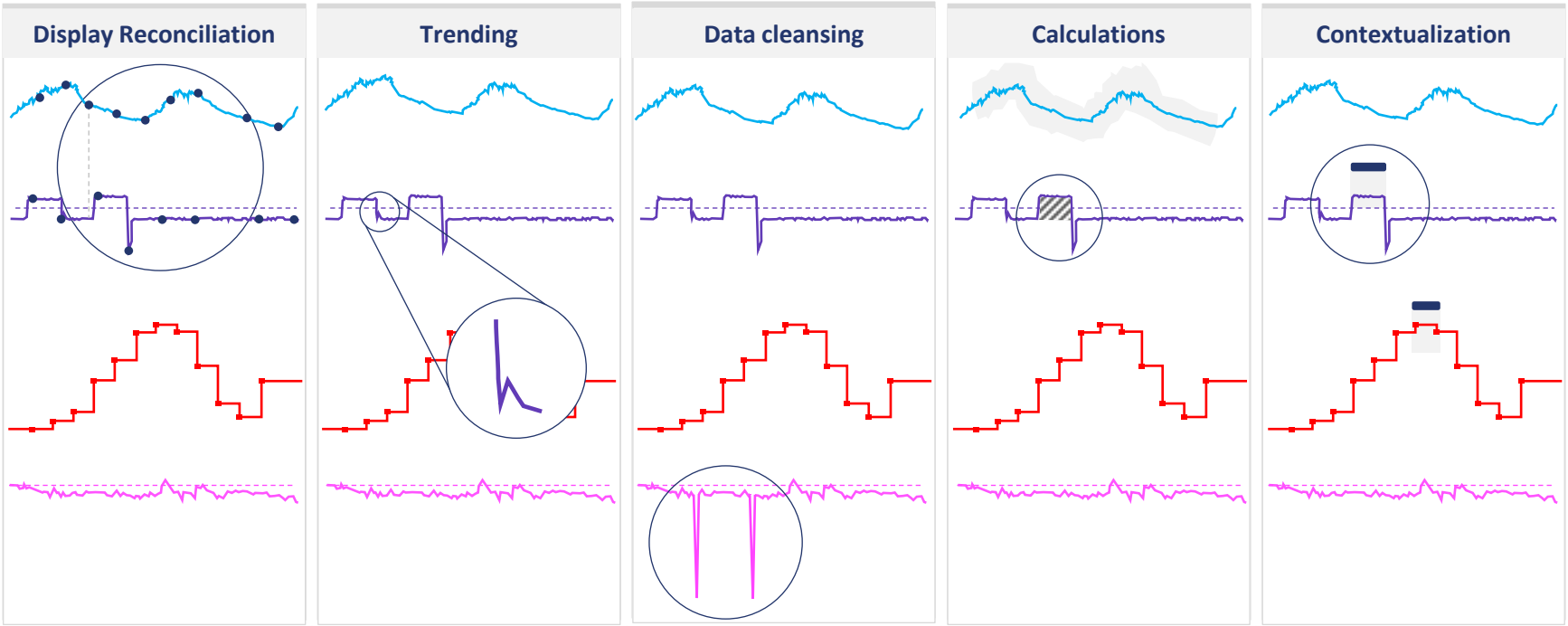
Process Data Challenges



Data alignment
Interpolation models
Units of measure

Just in time downsampling
Pan & Zoom across time
Axis and trend line options

Drop outs and flyers
Noisy signals
Gaps in data

Time-weighted statistics
Area under a curve
Derivatives

Context within signals
Context from SQL sources
EAM, MES, Batch systems

Courtesy of Seeq. Reproduced with permission.

Time Series Data

Time

Continuous analog signals (time, value)

Temperature

Years of history, **thousands** of sensors

Asset Operation

But lacking **context** (what was going on?)

Seeq

Courtesy of Seeq. Reproduced with permission.

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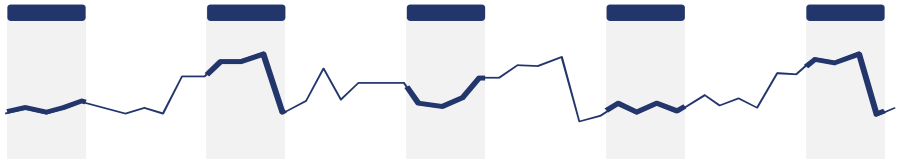
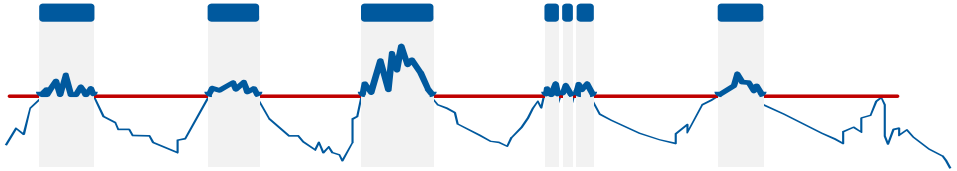
Condition Definition

“Conditions” define when a state is true, and each instance of the condition is called a **capsule**

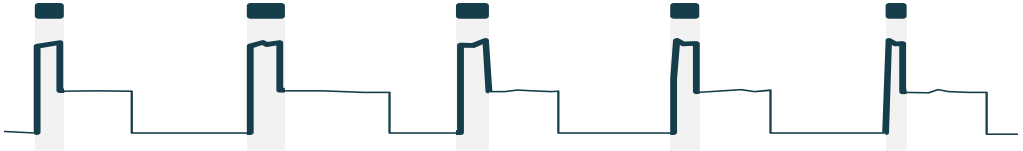
Define by **Time**



Define by **Limit**



Define by **Pattern**



Seeq

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Capsules Definition

“Capsules” are time periods of interest, defined by the user that add context to time series data

Define by **Time**

Define by **Limit**

Define by **Pattern**

Courtesy of Seeq. Reproduced with permission.

Working with Multiple Conditions

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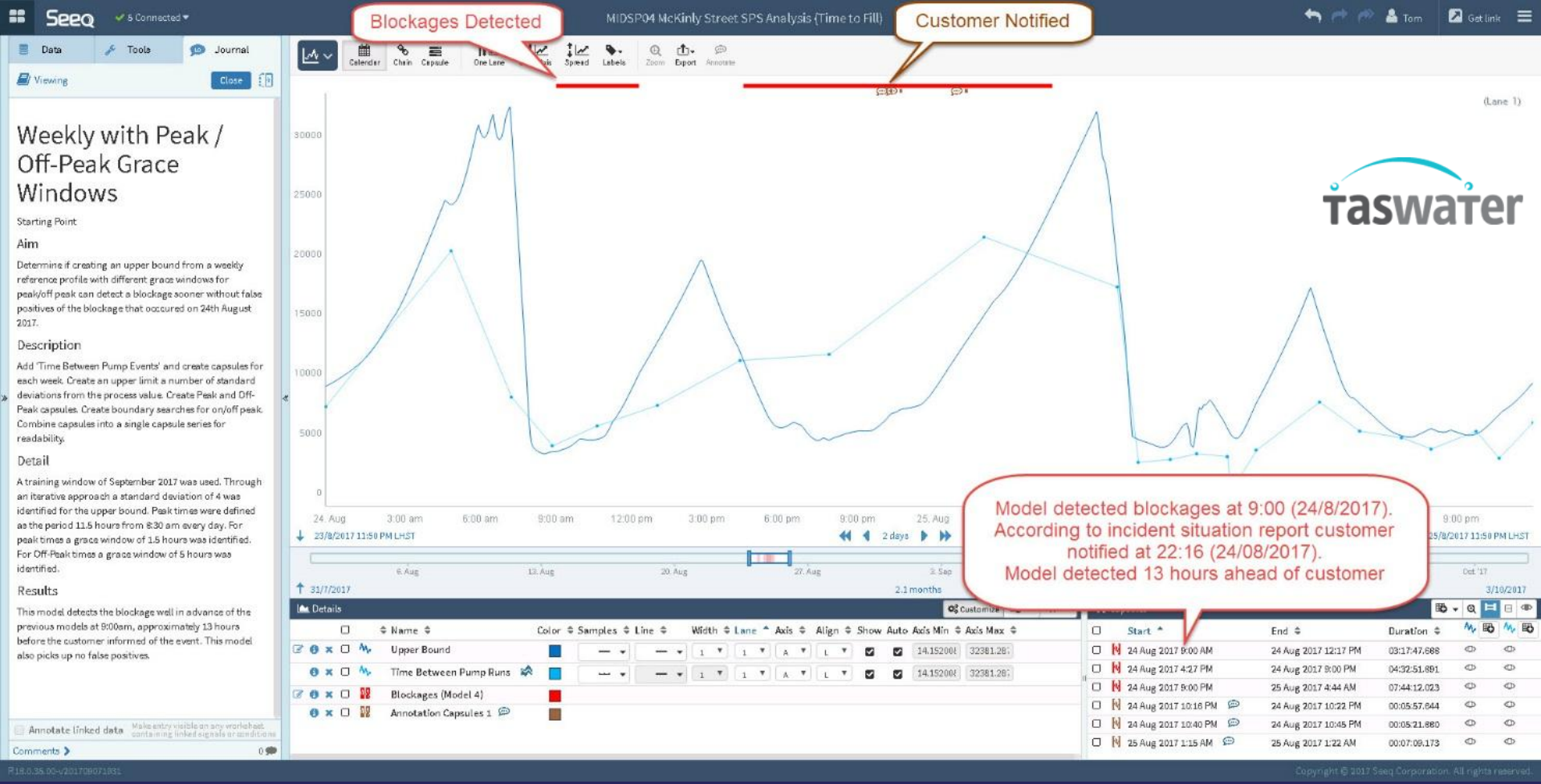
Seeq
5 Connected
Blockages Detected
MIDSP04 McKinly Street SPS Analysis (Time to Fill)
Customer Notified
Tom
Get link
Data
Tools
Journal
Viewing
Close
Weekly with Peak / Off-Peak Grace Windows
Starting Point
Aim
Determine if creating an upper bound from a weekly reference profile with different grace windows for peak/off peak can detect a blockage sooner without false positives of the blockage that occured on 24th August 2017.
Description
Add 'Time Between Pump Events' and create capsules for each week. Create an upper limit a number of standard deviations from the process value. Create Peak and Off-Peak capsules. Create boundary searches for on/off peak. Combine capsules into a single capsule series for readability.
Detail
A training window of September 2017 was used. Through an iterative approach a standard deviation of 4 was identified for the upper bound. Peak times were defined as the period 11.5 hours from 8:30 am every day. For peak times a grace window of 1.5 hours was identified. For Off-Peak times a grace window of 5 hours was identified.
Results
This model detects the blockage well in advance of the previous models at 9:00am, approximately 13 hours before the customer informed of the event. This model also picks up no false positives.
Annotate linked data
Comments
Calendar
Chain
Capsule
Spread
Labels
Zoom
Export
Annotate
(Lane 1)
30000
25000
20000
15000
10000
5000
0
24. Aug
3:00 am
6:00 am
9:00 am
12:00 pm
3:00 pm
6:00 pm
9:00 pm
25. Aug
9:00 pm
23/8/2017 11:50 PM LHST
25/8/2017 11:50 PM LHST
2 days
6. Aug
13. Aug
20. Aug
27. Aug
3. Sep
Oct '17
31/7/2017
2.1 months
3/10/2017
Taswater
Model detected blockages at 9:00 (24/8/2017).
According to incident situation report customer notified at 22:16 (24/08/2017).
Model detected 13 hours ahead of customer
Details
Customize
Name
Color
Samples
Line
Width
Lane
Axis
Align
Show
Auto
Axis Min
Axis Max
Upper Bound
Time Between Pump Runs
Blockages (Model 4)
Annotation Capsules 1
Start
End
Duration
24 Aug 2017 9:00 AM
24 Aug 2017 12:17 PM
03:17:47.688
24 Aug 2017 4:27 PM
24 Aug 2017 8:00 PM
04:32:51.891
24 Aug 2017 9:00 PM
25 Aug 2017 4:44 AM
07:44:12.023
24 Aug 2017 10:16 PM
24 Aug 2017 10:22 PM
00:05:57.644
24 Aug 2017 10:40 PM
24 Aug 2017 10:45 PM
00:05:21.880
25 Aug 2017 1:15 AM
25 Aug 2017 1:22 AM
00:07:09.173
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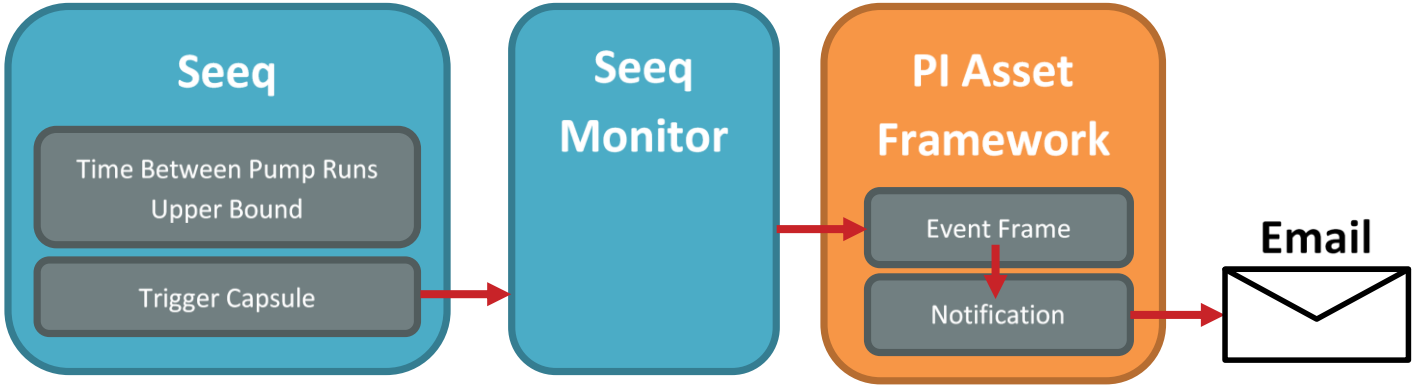
Write-back Event Frames & Notifications



Case Study: Smart sewer analytics set to prevent spills, save environment

- Video (3 mins)

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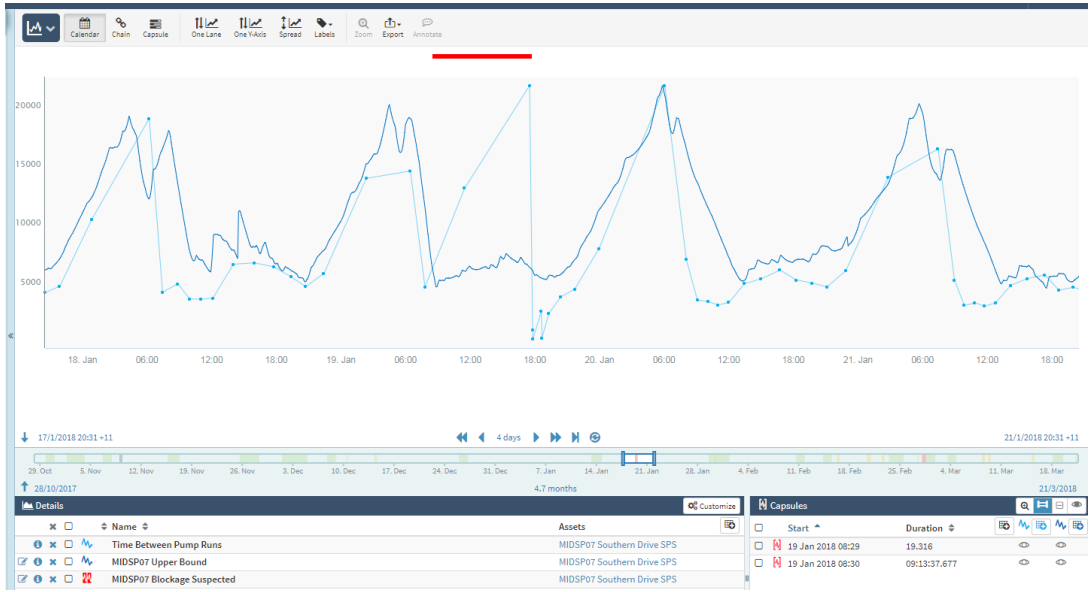
Current Application

- Yet to capture a blockage event – no dry weather blockages to date
- Successfully detected unusual flows



- Work Order: New SPS Softstarter
- Date of Work:

  19/01/2018
- Pumps disabled during works

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Outcomes

The new system will be trialled the over 12 months and will be initially constrained to the Midway Point sites to allow for model tuning.

- Solution has already detected abnormal behaviour
- Successful adoption by Operations Control Centre, Asset Management and Service Delivery groups
- Continuing to refine calculations to minimise false positives
- Planned future expansion for other use cases and plant analytics
- Provided insight into operation of the system

TasWater and Nukon will continue to work collaboratively with Seeq on further model improvements and wider deployment to all high risk SPS sites.

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Innovation

"This is the **first time this data has been used this way** in Tasmania and we are **excited** to be running this trial at the moment just east of Hobart at Midway Point"

"TasWater is **investing** significantly in the upgrade of sewage infrastructure around the state as part of the 10-year capital works plan. …we're hopeful this program can be used **wherever our assets are in high risk areas and significantly reduce the impact of spills and help TasWater work more responsively** with shellfish growers for better outcomes"

- Alexander Jovcic, Department Manager of Service Optimisation at TasWater

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Questions

Please wait for the **microphone** before asking your questions

State your **name & company**

Please remember to…

Complete the Online Survey for this session

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Merci

谢谢

Danke

Спасибо

Gracias

Thank You

감사합니다

ありがとう

Grazie

Obrigado

Integrate and enhance your time series data
to be more responsive and realize more value

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