Clearwater Controls DERAGGER Trial

Final Report

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September 2018

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Clearwater Controls DERAGGER Trial - Final Report

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Executive Summary

i Introduction

Blocked pumps account for an estimated 80-90% of all unplanned work carried out on the sewer system and there is evidence to show that blockages and the build-up of rags prior to blockages increases pumping energy costs and will be having a detrimental impact to asset life. Running a pump partially ragged, with unstable current and an unbalanced impeller is likely to cause significant additional pump wear.

The UK water companies are keen to find solutions to this challenge, which has the potential to deliver great efficiency to the UK water sector through more proactive use of staff time, reduced energy consumption and improved asset life.

The Clearwater Controls Limited's DERAGGER is designed to reduce the problem of pump blockages and the associated increased pumping costs resulting from running partly ragged pumps. This technology is relatively new and has been installed widely in Scotland but to a much lesser extent in England and Wales. Water companies would like to know on which assets and under which conditions the DERAGGER technology is most beneficial. In order to answer these questions and provide independent analysis, accepted by UK water companies, an independent trial was run by WRc.

ii Aims and objectives

The aim of this work is to run a robust trial of the DERAGGER technology to evaluate the performance under real conditions and answer the following questions:

- What performance can be achieved in blockage prevention?
- What efficiency / energy saving can the technology achieve?

The work will also assess the installation process, establish on what assets and under what conditions can these benefits be achieved and establish if there are any adverse impacts on existing assets.

iii Methodology

The trial was managed by WRc with the support of Clearwater Controls and employees of United Utilities and Wessex Water.

Five pumping station sites were included in the trial, provided by Untied Utilities and Wessex Water. Four of the sites were wet wells and one a dry well and included sites where

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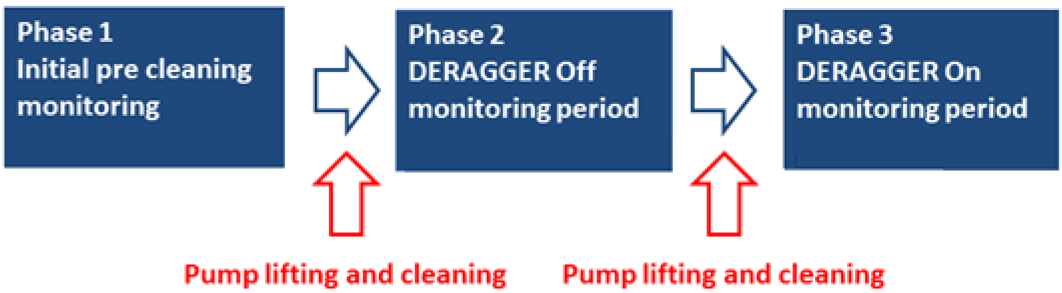
blockages were a significant problem and where energy reduction was a key objective. The Deragger was installed by Clearwater Controls on either one or two pumps in each pumping station. WRc witnessed the installations.

The trial consisted of three phases with a full pump lift and clean between Phases 1 and 2, and between Phase 2 and Phase 3.

Figure 1 Phases of the DERAGGER trial



iv Conclusions

1. The DERAGGER has been proven to deliver blockage reduction, and reduce the need for manual lifting and cleaning of pumps.

   - Reductions in maintenance were observed across all sites. The most significant benefit, where data was available, showed a reduction from 7 manuals cleans over a 10 week period to no manual cleans over 6 week period.
   - The exact reasons for the maintenance visits were not made available for three of the sites. Therefore calculating the actual reductions in manual blockage removal was not possible.
   - Feedback from users of the DERAGGER over a longer period has indicated that 100% reduction in the need to manually clear blockages has been achieved in some circumstances.

2. The DERAGGER has been proven to deliver energy savings.

   - This is true when comparing the DERAGGER to 'unclean' periods of pump operation where savings up to 80% have been demonstrated.
   - It is also true when comparing the DERAGGER to periods where pumps have been recently manually lifted and cleaned, where savings of between 5-20.6% have been demonstrated.

3. Substantial inefficiencies exist in the waste water network as a result of pumps running in a ragged condition which the DERAGGER could resolve.

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- These pumps do not always trip or raise an alarm; the result is that these inefficiencies are not being addressed. If installed, the DERAGGER can achieve energy savings in these instances.

4. It is highly likely that extensions in asset life will be achieved in proportion to the efficiencies gained in pump run times and energy consumption.

    - On the three trial sites where frequent blockages were not reported, energy efficiency improvements were detected as a result of the DERAGGER implementation. By addressing the inefficiencies that exist due to ragging, it is highly likely that extensions in asset life will be achieved in proportion to the efficiencies gained in pump run times and energy consumption.

5. There is no evidence from this trial that the DERAGGER reversal process damages pumps.

1. Introduction

1.1 The problem of pump ragging

Sewage pumping stations are at the centre of improvements to the operation of wastewater networks to reduce risk of failure and manage operating costs. The UK's sewage pumping stations cost an estimated £50 million annually in pumping energy costs and £160 million in maintenance costs to operate. On top of this the size of potential fines, when things go wrong and pollution events occur, has dramatically increased in recent years.

Blocked pumps account for an estimated 80-90% of all unplanned work carried out on the sewer system and there is evidence to show that blockages and the build-up of rags prior to blockages increases pumping energy costs and will be having a detrimental impact to asset life. Running a pump partially ragged, with unstable current and an unbalanced impeller is likely to cause significant additional pump wear.

The UK water companies are keen to find solutions to this challenge, which has the potential to deliver great efficiency to the UK water sector through more proactive use of staff time, reduced energy consumption and improved asset life.

1.2 Context to the trial

The Clearwater Controls Limited's DERAGGER is designed to reduce the problem of pump blockages and the associated increased pumping costs resulting from running partly ragged pumps. This technology is relatively new and has been installed widely in Scotland but to a much lesser extent in England and Wales. Water companies would like to know on which assets and under which conditions the DERAGGER technology is most beneficial. In order to answer these questions and provide independent analysis, accepted by UK water companies, an independent trial was proposed to Clearwater by WRc.

1.3 The collaboration and the roles of different parties

The trial was delivered as a collaboration between Clearwater Controls, WRc and a group of UK water companies. It was partially funded with support from Scottish Enterprise.

WRc's role

WRc is an independent and trusted consultant to the water industry. WRc's Sewer Operations team have been at the forefront of sewer operation and specifically blockage reduction. This work has included developing good practice on the management of sewer blockages, sewer infiltration, sewage pumping stations, street ironworks failures, and sewer inspection methods. WRc also has extensive experience running technology trials providing robust and industry wide accepted data on the performance of technologies.

WRc's role was to run the trial and provide the required coordination, independence and scientific rigour to the work to ensure the work is focused on delivering to the identified aims and objectives (see section 2.4)

Clearwater Controls role

The role of Clearwater Control was carefully defined in planning the work to ensure the trial remained independent. Clearwater Controls have however been an integral part of the work with the following role:

- Provision of the equipment for test.
- Installation of the equipment (with WRc's attendance).
- Collection and provision of raw data to WRc from the equipment under test.

Water company roles

Water companies have participated in this work on two levels:

- **Provision of trial sites -** United Utilities and Wessex Water both provided sites for the trial. As part of this, they have provided detail on the sites and information on the operational activities. We acknowledge and thank both organisations for their support in making the trial happen.
- **Participation in the steering group -** In setting up and planning the trials a group of interested water companies was formed. This wider group provided advice and guidance and have been kept up to date on the progress of the trial.

As part of the agreement between the group members this report will be made available to those companies in advance of any broader circulation.

1.4 Aims and objectives

The aim of this work is to run a trial of the DERAGGER technology to evaluate the performance under real conditions.

The work will provide sufficient robust information to answer the following questions:

- What performance can be achieved in blockage prevention?
- What efficiency / energy saving can the technology achieve?

- On which assets and under what conditions can these benefits be achieved?
- Is the installation process simple and easy to perform?
- Does the DERAGGER have any adverse impacts on existing assets?
- Can the DERAGGER meet a defined success criteria (parameters of which are to be discussed with participating water companies)?

1.5 WRc Approved™ certification

Alongside the trials Clearwater Controls have submitted the DERAGGER (and the sister DERAGGER Pro full station controller) technologies for WRc Approved certification. The WRc approval has run alongside the trial and used both historic data and new data from the trial. Both products have now received full WRc accreditation, certificates of accreditation can be found in Section 7.

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2. Clearwater Controls Ltd and the DERAGGER technology

2.1 Clearwater Controls

Clearwater Controls launched in 2009 as the research and development division of ID Systems (UK). Since then the company has conceived, developed and now delivers a suite of intelligent pump-monitoring and anti-ragging solutions, built around unique technology.

Clearwater Controls provides intelligent ways to maximise efficiency in the waste water sector. The DERAGGER anti-ragging technology monitors pumps in real time to identify and eliminate blockages before they form, meaning pumps no longer need to be lifted and cleaned.

2.2 DERAGGER Technology as described by Clearwater Controls

The DERAGGER anti-ragging device aims to answer the age-old problem of wet-wipe type ragging of waste water pumps.

Existing solutions only detect/address the blockage once it has already started to form, by which time it is too late. Reversing a pump once a blockage has already formed leads to rags being knitted together and thrown back into the well.

The DERAGGER aims to deliver a solution with a unique technology that monitors in real-time the wave form of the power to the pump. This wave form analysis allows the device to immediately detect the instant that even a single wet-wipe starts to impede the pump impellor. By facilitating this real-time detection, the DERAGGER is able to slow and stop the pump the instant that an impediment forms, then briefly reversing the pump to dislodge the impediment and allowing it to be passed in suspended flow through the system, preventing the creation or build-up of rag-balls.

Utilising the unique way the DERAGGER monitors motor behaviour, Clearwater Controls also manufactures the POWER MONITOR which combines power monitoring, sensing and logging in one compact device. With the ability to display full power information on its display and sensing when the power goes out of limits, it incorporates a built in removable SD card that logs 20 years of power information.

The DERAGGER PRO represents a new generation of station controllers. Based on an intelligent modular concept, it provides a complete interface for the DERAGGER and other supported accessories required in pumping operations. The sophisticated technology ensures the most energy-efficient pumps are used. Additionally, by spreading intelligence between multiple devices, it creates redundancy should one part of the system fail.

3. Trial methodology

The detailed methodology is set out in the test protocol document (UC12465v2.0) May 2017. This section summarises the process and approach.

3.1 Site Selection

Selecting the most appropriate pumping stations for the trial was based on an agreed list of selection criteria which would ensure that the chosen sites were both representative and showed the potential for benefits from installation of the DERAGGER technology.

Key criteria were:

- To cover both wet and dry well configurations,
- Size of pumps – to cover two size ranges,
- Power and flow measurement available,
- Blockage and maintenance history,
- Condition of pumps,

Further details on site selection including full list of criteria is available in Section 4 of Appendix A.

In practice, as with almost all trials, there was a compromise between the selection criteria and the availability of sites. The sites selected were not exactly as originally set out however were sufficient to give an indication of DERAGGER performance in a variety of conditions. The Sewage Pumping Station sites included in the trial were:

United Utilities

- Navigation Way and Dutton Forshaw both located on the same sewer in Preston.
- Thorn Park also located in Preston but on a separate sewer.
- Marsh Farm located in Blackpool.

Wessex Water

- West Quay located in Bridgewater.

Details of the selected sites are provided in Section 4.

3.2 Installation

Installation of the DERAGGER systems was undertaken by Clearwater Controls, which is standard procedure, using their trained staff and following an established procedure. Each installation took around half a day to complete from confirmation of authorised isolation through to re-instating the panel supply and informing the client that the panel was back in operation. This is typical, although installation may take an hour or two longer for large Star Delta or Soft Start installations as the size of contactors and wires are much larger and more complex to handle.

The DERAGGER unit itself is rail mounted and measures 35 mm wide x 110 mm tall x 100 mm deep so in many cases can be installed directly into the existing panel. Where there is not sufficient space an additional box can be added to hold the DERAGGER. However this is rare; based on all of Clearwater Controls installations this is required around 5% of the time. Both types of installation were implemented for the trial. None of the installations interfered with any of the existing equipment and no additional pre-commissioning work was required.

Photograph 3.1 shows the installation at Wessex Water where the DERAGGER was installed within the existing control panel. Photograph 3.2 shows the installation at Thorn Park where two separate boxes were installed to house the DERAGGER units, one for each pump.

Photograph 3.1 Typical installation of the DERAGGER at Bridgewater West Quay, centre of middle rail

Photograph 3.2 Thorn Park installation of the DERAGGER

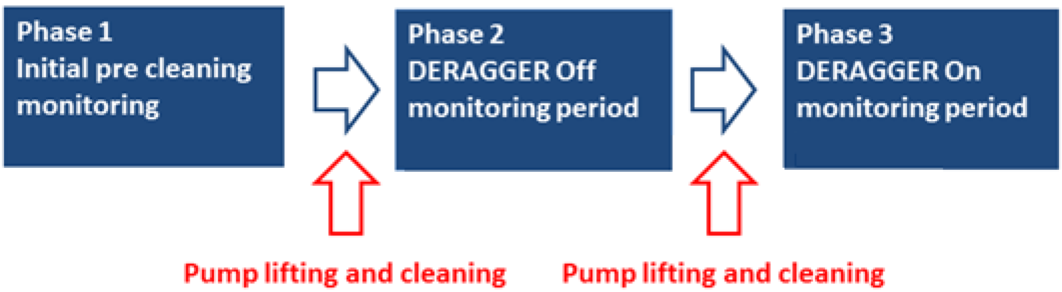
On-site checks were undertaken following installation and the work was signed off by both the Clearwater Controls engineer and the on-site operative to confirm it was acceptable to both parties. WRc attended site to witness the installations. All were judged to be conducted as would be expected for an M&E contractor working on a Water Utility site. The installation process was considered to be straight forward.

In addition to the DERAGGER installation, WRc installed an electromagnetic flow meter at Thorn Park pumping station to provide an accurate flow measurement.

3.3 Operation

The trial was run in three phases for each site with a full pump lift and clean between Phases 1 and 2, and between Phase 2 and Phase 3.

Figure 3.1 Phases of the DERAGGER trial



Phase 1 - Initial pre-cleaning monitoring

Following the installation of the DERAGGER, the pumps were monitored for at least 1 week in its existing condition prior to any cleaning. During this period the anti-ragging functionality was disabled. The data collected in this phase was used to understand the pre-existing performance of the pumping station. This included a review of the pumps operating condition to ensure that the pumps were not in imminent danger of failure.

Pump lifting and cleaning

The pumps were then lifted and cleaned by the water company maintenance operatives, this was done using the existing site method. A photographic record was taken of the pre and post-cleaning states to include any fouling and the condition of the impeller. Clearwater Controls always recommends vactoring the well before DERAGGER activation; however this was not carried out at all of the trial sites.

Phase 2 - DERAGGER Off monitoring period

Following the lift and cleaning of the pump, the DERAGGER continued logging with the anti-ragging functionality disabled for a period of at least 4 weeks. The data collected in this phase was used to understand how a pump would operate in ideal conditions (i.e. manually cleaned of all rags), and to also ascertain the rate at which the “clean” status of the pump deteriorated over time. The data was also analysed to ensure there were no critical faults in the pumps’ operating condition that would indicate likelihood of imminent pump failure.

Pump lifting and cleaning

Before the anti-ragging functionality on the DERAGGER was enabled (‘DERAGGER On’), the pumps were lifted and cleaned again. Lifting and cleaning is important, as the DERAGGER must start operation with a clean pump, partly because the reversal process should not be activated when an impeller is already heavily ragged. It is also necessary to ensure that an impeller is correctly torqued and properly secured as per manufacturer guidelines. For wells suffering from extreme ragging, it is recommended that a vactor of the well takes place before the DERAGGER anti-ragging is activated, however due to operational restrictions at the water companies this did not happen at all sites in this trial.

Phase 3 – DERAGGER On monitoring period

Once the anti-ragging functionality on the DERAGGER was enabled (‘DERAGGER On’), the pumps were then monitored for a period of at least 6 weeks. The data collected in this phase was used to understand the impact of the DERAGGER has on the performance of the pumping station. The main comparison used here is phase 3 versus phase 2**.** This means that the pumped performance is compared against the period after the pumps had been manually lifted and cleaned (Phase 2), allowing a fair comparison where the DERAGGER is the only new variable. If pump cleaning is carried out infrequently, then actual performance gains may be greater than this comparison would suggest.

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3.3.1 Trial phase comparison

- Phase 1 is designed as a proxy for normal operational conditions.
- Phase 2 shows the performance of the pump after a manual clean has taken place.
- Comparison between phase 1 and phase 2 provides information on how quickly the pump returns to 'normal' conditions after the manual clean, i.e. the pump's propensity to block.
- Phase 3 monitors the performance of the pump with the DERAGGER enabled.
- Comparison between Phase 2 and Phase 3 shows the impact of the DERAGGER on a pump that has been manually lifted and cleaned.

3.4 Data Collected

In order to achieve robust and trusted trial outcomes there is a need for good reference data. A number of parameters are recorded by the DERAGGER unit. The key pieces of information that were gathered during the trial are as follows:

Pump operating regime

The pumping regime was supplied for each pumping station. The regime was not changed for the purpose of the trial, and generally duty standby was used, with occasional changes, most notably at Navigation Way.

Maintenance activity

A record of the maintenance activity (planned and reactive) was provided by both water companies for the trial sites, however for three sites (Navigation Way, Dutton Foreshaw, Marsh Farm) this data has been summarised, and detailed records have not been made available.

Flow measurement

Three of the United Utilities sites, Dutton Forshaw, Marsh Farm and Navigation Way, do not have a flowmeter installed. For these sites average run time was used as a surrogate for this; The actual flow could be inferred from this if the size of the well is known and it is assumed that on run results in the entire well being pumped.

At the Wessex Water site, Bridgewater West Quay, the flow has been calculated using the 15 minute sampled Dry Weather Flow pump flow data to provide the average daily flow

(m^3/day). However for the purposes of this trial it has been deemed unsuitable as it is not possible to allocate the flow to individual pumps, of which only one is included in the trial.

For Thorn Park an electromagnetic flow meter was installed and was used to calculate the volume of water pumped per unit of energy consumed.

Energy use

Energy use for all of the sites was calculated from the DERAGGER data for individual pumps. This prevented any ambiguity around how often each pump was used, which would have arisen from any site level electricity meters, which are commonly installed.

DERAGGER data

The DERAGGER measures and saves a range of parameters. The following were logged at each trial site. A longer list of all the parameters is provided in the trial protocol document:

- Number of cleans and starts,
- Number of thermal overload trips,
- Motor run hours and total daily run time,
- Energy Consumption in kWh
- Average daily current consumptions.

The pumped flow is also not available for the majority of sites because there was no flow meter installed. The number of cleans is only recorded in Phase 3, since cleans cannot be performed prior to this phase, and cleans that would have been performed cannot be recorded.

3.5 Data analysis

Raw data was provided as output from the DERAGGER in the form of .DAT files available for each pump at each site involved in the trial. The data harvesting software provided by Clearwater was used to produce several Excel files including hourly and daily statistics and high resolution files containing data at intervals of five seconds.

Clearwater Controls also provided WRc with a basic overview of the site and how they believed the DERAGGER performed during the trial at each site. Further processing of these Excel files was then carried out using R statistical computing software.

3.5.1 Energy analysis

The ideal approach for calculating energy saving is based on m^3/kWh using data from an energy sub-meter (measuring specific pump power consumption) and a flow meter. The DERAGGER includes energy sub-metering capabilities; however the majority of trial sites did not have a flow meter. Therefore, energy usage was calculated with the kWh energy consumption column provided in the high resolution Excel files produced by the DERAGGER. Any changes in this value were used to calculate the energy use in a given period, which allowed for the case of when a DERAGGER reset was performed. Run times and the number of pump starts were calculated using the DailyStats Excel files. This is different from the proposed approach due to an absence of flow data. As above, these DailyStats excel files are outputted by the data harvester tool from the raw .DAT files.

The average current was calculated per week by filtering out all high resolution entries with Running = 0. This was the average value while the pump was in operation. To calculate potential efficiencies made (where a flowmeter was not present), a calculation was made of pump run time achieved per kWh of electricity. Such a measure would provide an indication of any efficiency gains and would be independent of the flow observed by assuming that each run indicates the pumping of the entire well.

Weeks are defined from the first day that each phase of the trial began, with the exception of the boundary between Phase 1 and Phase 2, the pre and post-clean monitoring periods. The exact date of this pump clean is unknown, so the weeks used in Phase 2 are defined as a continuation of those in Phase 1. This results in one to two days being excluded in the weekly tables at the end of Phase 2.

The above data was analysed with the pump start / stop data for all the sites with the exception of Thorn Park where there were also flow measurements.

Blockage analysis

The number of maintenance activities performed, relating to the number of blockages requiring manual intervention were recorded based on the paper records made at each pumping station, where made available.

In addition to this data the high resolution .csv files from the DERAGGER provide information on the number of DERAGGER initiated cleans.

West Quay

Due to differences in the trial at West Quay, the analysis was carried out slightly differently. Detailed maintenance and blockage data was available, enabling an improved analysis of blockages. West Quay experienced a very large number of blockages, resulting in very frequent manual cleaning being carried out. As a result, it was difficult to properly identify a pre-clean period. The data is presented in terms of the DERAGGER off period and the DERAGGER on period. On this site, when evaluating the impact of the DERAGGER it must be taken into account that it is being compared to a base line of a pump that is being repeatedly manually cleaned.

Thorn Park

There is no data available for Phase 1 for Thorn Park as the DERAGGER was not calibrated upon installation. Thorn Park featured a flow meter and detailed maintenance record. This allowed an improved analysis to be conducted. Data was provided by Clearwater in the form of a daily summary, including flow information. This was aggregated to produce the tables presented. Maintenance data was included to inform this analysis and identify any changes in manual maintenance required during the trial.

Due to the dates the flow meter was installed, and the lack of a pre-clean period due to normal cleaning, the time periods for each of the Phases are different to those with other sites. The flow meter was installed at this site on 14/02/2018; however the DERAGGER was not calibrated until 14/04/2018, where the trial begins.

4. Results

4.1 Thorn Park

4.1.1 Introduction

Thorn Park contains is a dry well with two Flygt 3153 7.5 kW pumps operated in duty standby. Pump blockages were reported by United Utilities as occurring at this site but not frequently. The DERAGGER was installed on both pumps. A flow meter was installed at the site to provide accurate flow measurement from both pumps.

Photograph 4.1 Flow meter installation at Thorn Park

Reason for site selection – Thorn Park was included to investigate if the DERAGGER could reduce power consumption at the site, as well as being a dry well application.

Pumps were lifted during initial DERAGGER install (off period) and inspected by United Utilities at this point. A site survey was undertaken in 2016 and the result of pump tests then reported a total efficiency at 41% for pump 1 and 45% for pump 2 compared to an as new value of 59%.

4.1.2 Results

The results of the trial at Thorn Park are displayed in the tables below, detailing the two phases of the trial (Phase 1 data unavailable). Unlike the other sites, a flowmeter was fitted at Thorn Park, and this data is also included in the tables below, allowing a calculation of the volume of pumped water per unit of energy consumed (This flow data was only available after phase 1). Some graphs of the key variables are also provided.

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Table 4.1 Summary of Phase 2 Thorn Park

Variable	Week 1		Week 2		Week 3	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	13.3	13.4	14.7	13.5	18.1	13.4
Unblock/ Cleans	0	0	0	0	0	0
Energy use (kWh)	58	74	58	54	104	66
Run time (minutes)	612	700	480	505	617	627
Average Power (kW)	6.03	6.80	7.37	6.83	10.43	6.77
Runtime (minutes) per kWh	10.55	9.46	8.28	9.35	5.93	9.5
Flow (m^3)	46.8	46.6	35.6	33.1	43.6	40.8
m^3 / kWh	0.81	0.63	0.61	0.61	0.42	0.62

Variable	Week 4		Week 5		Week 6	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	15.0	13.4	13.2	13.5	13.2	13.4
Unblock/ Cleans	1	0	0	0	0	0
Energy use (kWh)	48	59	45	55	39	45
Run time (minutes)	438	569	481	517	434	446
Average Power (kW)	7.43	6.76	6.01	6.80	5.96	6.71
Runtime (minutes) per kWh	9.13	9.64	10.69	9.4	11.13	9.91
Flow (m^3)	32.8	37.1	35.6	33.5	30.7	28.6
m^3 / kWh	0.68	0.63	0.79	0.61	0.79	0.64

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Table 4.2 Summary of Phase 3 Thorn Park

Variable	Week 7		Week 8		Week 9	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	9.46	13.1	13.7	13.3	13.7	13.2
Unblock/ Cleans	0	0	0	0	1	0
DERAGGER Cleans	44	24	40	20	39	4
Energy use (kWh)	22	66	34	49	35	44
Run time (minutes)	268	646	353	493	365	447
Average Power (kW)	6.00	6.51	6.46	6.56	6.41	6.50
Runtime (minutes) per kWh	12.18	9.79	10.38	10.06	10.43	10.16
Flow (m^3)	19.9	41.3	30.7	33.0	32.1	30.7
m^3 / kWh	0.90	0.63	0.90	0.68	0.92	0.70

Variable	Week 10		Week 11		Week 12	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	13.7	13.1	13.6	13.0	13.6	13.0
Unblock/ Cleans	1	0	0	0	0	0
DERAGGER cleans	16	7	9	7	4	8
Energy use (kWh)	35	42	50	65	35	43
Run time (minutes)	361	417	498	646	363	434
Average Power (kW)	6.47	6.37	6.39	6.36	6.37	6.34
Runtime (minutes) per kWh	10.31	9.93	9.96	9.94	10.37	10.09
Flow (m^3)	31.6	28.4	42.9	43.8	31.4	29.4
m^3 / kWh	0.90	0.68	0.85	0.68	0.90	0.68

Variable	Week 13		Week 14	
	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	13.7	13.1	13.6	13.0
Unblock/ Cleans	0	0	0	0
DERAGGER Cleans	11	12	4	4
Energy use (kWh)	37	44	15	17
Run time (minutes)	387	455	155	179
Average Power (kW)	6.40	6.31	6.40	6.30

Variable	Week 13		Week 14	
Runtime (minutes) per kWh	10.46	10.34	10.33	10.53
Flow (m^3)	33.2	30.4	13.4	12.0
m^3 / kWh	0.89	0.69	0.89	0.71

Figure 4.1 Pump Efficiency (m^3/kWh) Thorn Park

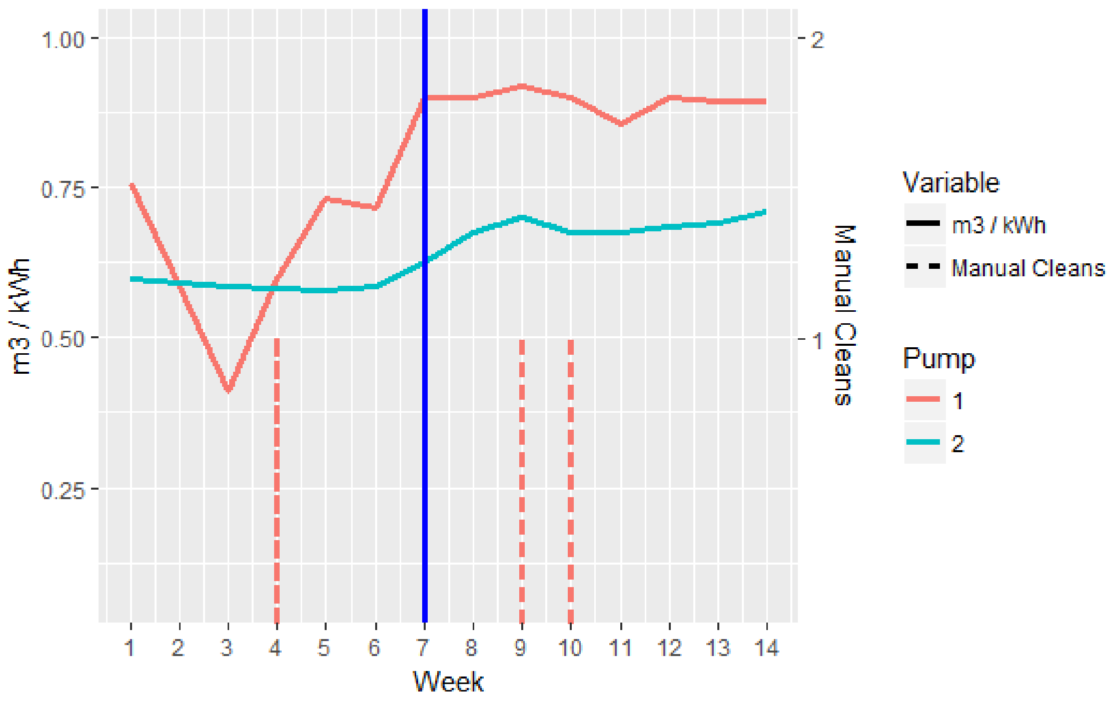


Figure 4.1 above displays the m^3/kWh for both pumps during Phase 1 and Phase 2 of the trial period. The number of manual clean events is recorded as bars (three cleans on three different days). The vertical blue line denotes the separation of the phases.

4.1.3 Key observations

- Pump efficiency increases after the DERAGGER is switched on. This is evident for both pumps.

- The volume of water pumped per kWh was calculated for both phases of the trial, with the DERAGGER on period demonstrating a 20.6% improvement in pumping efficiency, these figures are summarised in Table 4.3.

Table 4.3 Pump efficiency at Thorn Park (both pumps)

Phase	Average m^3/kWh	% Improvement
DERAGGER off (Phase 2):	0.63	
DERAGGER on (Phase 3):	0.76	20.6%

- The number of manual clean events increases after the DERAGGER is switched on. One of cleans performed in Phase 3 was undertaken as additional work when the pump was lifted for an unrelated issue. The total number of DERAGGER initiated automatic cleans are shown in Table 4.4.

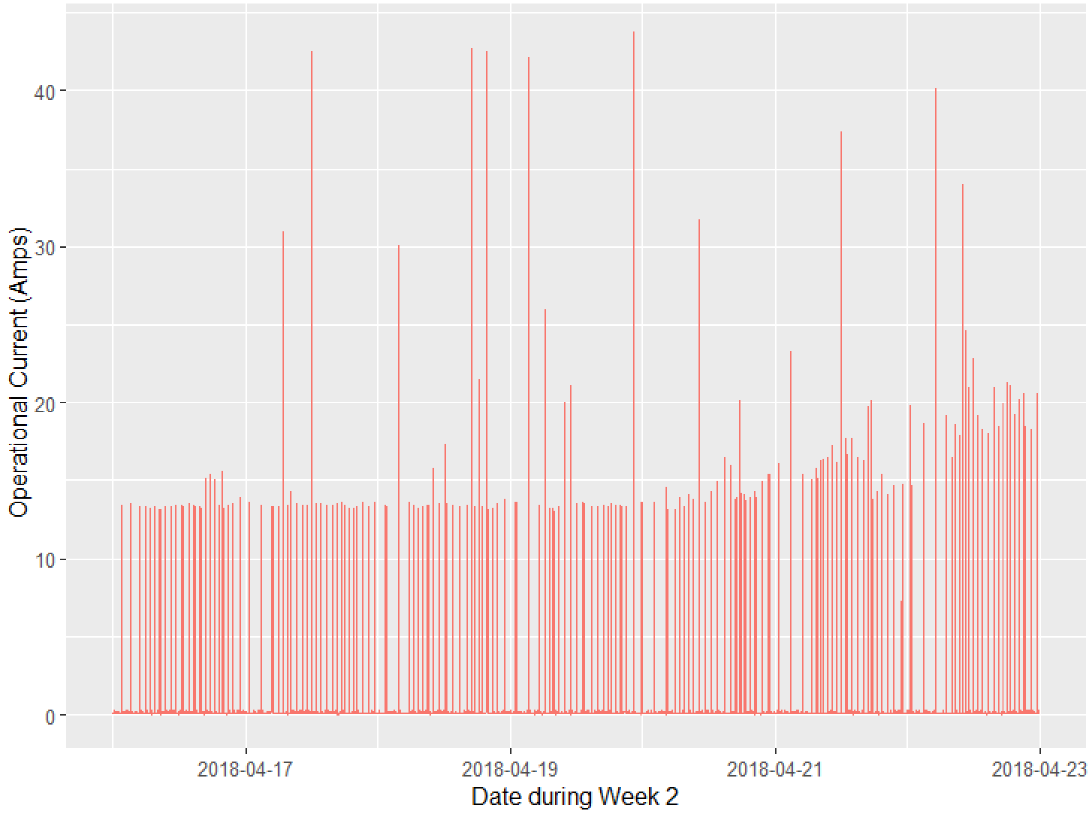
Table 4.4 Number of automatic cleans in Phase 3

Phase 3	Pump 1	Pump 2
Automatic cleans	173	115
Run time (minutes)	2747	3717

- Average runtimes, power and energy consumption per volume of water are comparatively stable after DERAGGER activation. This suggests that the DERAGGER is successfully maintaining the clean state of both pumps.

- The drop in the performance of pump 1 during the first half of Phase 2 is demonstrated in Figure 4.2 where there is a steady increase in the current drawn by the pump as the pump becomes fouled.

Figure 4.2 Build-up of current at Thorn Park on Pump 1



4.2 Marsh Farm

4.2.1 Introduction

Marsh Farm is a wet well with two small 1.3 kW Flygt 3085 pumps with 463 impellors run as duty standby. The site requires a large amount of reactive maintenance due to frequent blockage events. The DERAGGER was installed on both pumps. Clearwater reported that the pumps were in good condition when visiting the site.

Reason for site selection – Marsh Farm was selected as a trial site in order to observe the improvement which could be achieved through using the DERAGGER on a site with a large number of blockages. United Utilities hoped that the DERAGGER could reduce reactive maintenance required to clean the pump while delivering some additional energy savings.

4.2.2 Results

The result of the trial at Marsh Farm are summarised in the following tables and graphs. The exact end date of this period is not known, however it was during the week commencing 25/12/2017, with the total period being approximately three weeks. Cells shaded in blank indicate that there was insufficient data available to calculate that value, this is usually due to the pump not being in use.

Table 4.5 Summary of Phase 1 Marsh Farm

Variable	Week 1		Week 2		Week 3	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	4.16	2.52	4.36	2.32	2.72	2.30
Energy use (kWh)	7	5	12	56	7	18
Run time (minutes)	175	237	247	3030	287	1081
Average Power (kW)	2.40	1.27	2.91	1.11	1.46	1.00
Runtime (minutes) per kWh	25.00	47.40	20.58	54.11	41.00	60.06
Number of Runs	93	92	108	17	114	112
Average Runtime (minutes)	1.88	2.58	2.29	178	2.52	9.65

Table 4.6 Summary of Phase 2 Marsh Farm

Variable	Week 4		Week 5		Week 6	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	4.16	2.46	4.21	2.43	2.41	2.59
Energy use (kWh)	11	7	10	8	18	4
Run time (minutes)	251	354	238	403	999	156
Average Power (kW)	2.63	1.19	2.12	1.19	1.08	1.54
Runtime (minutes) per kWh	22.82	50.57	23.8	50.38	55.50	39.00
Number of Runs	135	134	125	149	73	117
Average Runtime (minutes)	1.85	2.64	1.90	2.70	13.68	1.33

Variable	Week 7		Week 8		Week 9	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	2.43	2.41	2.44	NA	2.48	NA
Energy use (kWh)	8	9	8	7	6	7
Run time (minutes)	440	5.16	405	NA	328	NA
Average Power (kW)	1.09	1.05	1.19	NA	1.10	NA
Runtime (minutes) per kWh	55.00	57.33	50.63	NA	54.67	NA
Number of Runs	162	25	141	NA	126	NA
Average Runtime (minutes)	2.70	20.64	2.87	NA	2.60	NA

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Table 4.7 Summary of Phase 3 Marsh Farm

Variable	Week 10		Week 11		Week 12	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	2.44	2.35	2.48	2.31	2.44	2.39
Energy use (kWh)	13	2	12	1	4	4
Run time (minutes)	659	101	614	26	223	234
Average Power (kW)	1.18	1.19	1.17	2.31	1.08	1.03
Runtime (minutes) per kWh	50.69	50.50	51.17	26.00	55.75	58.50
Number of Runs	206	36	192	11	87	88
Average Runtime (minutes)	3.20	2.81	3.20	2.36	2.56	2.66

Variable	Week 13		Week 14		Week 15	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	2.34	2.42	2.43	2.53	2.40	2.52
Energy use (kWh)	4	4	5	5	4	5
Run time (minutes)	205	201	255	243	245	241
Average Power (kW)	1.17	1.19	1.18	1.23	0.98	1.24
Runtime (minutes) per kWh	51.25	50.25	51	48.6	61.25	48.2
Number of Runs	78	78	99	97	95	97
Average Runtime (minutes)	2.63	2.58	2.58	2.51	2.58	2.48

Variable	Week 16		Week 17		Week 18 (six days)	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	2.40	2.55	2.47	2.55	2.44	2.48
Energy use (kWh)	4	4	5	6	5	6
Run time (minutes)	184	180	261	245	283	283
Average Power (kW)	1.30	1.33	1.15	1.47	1.06	1.27
Runtime (minutes) per kWh	46.00	45.00	52.20	40.83	56.60	47.17
Number of Runs	73	73	100	100	112	112

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Variable	Week 16		Week 17		Week 18 (six days)	
Average Runtime (minutes)	2.52	2.47	2.61	1.45	2.53	2.53

Figure 4.3 Average Efficiency Mash Farm

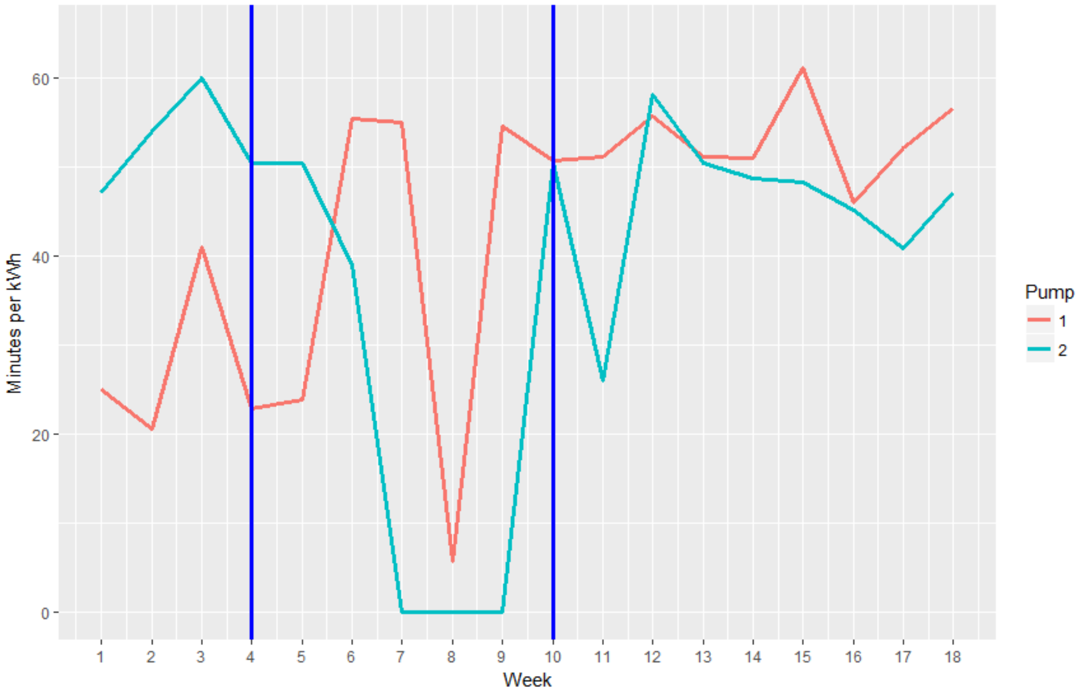

Figure 4.3 shows the average minutes of pump operation per kWh consumed for each week. This is shown separately for each pump, while the blue vertical lines denote the three phases of the trial.

Figure 4.4 Average runtime Mash Farm

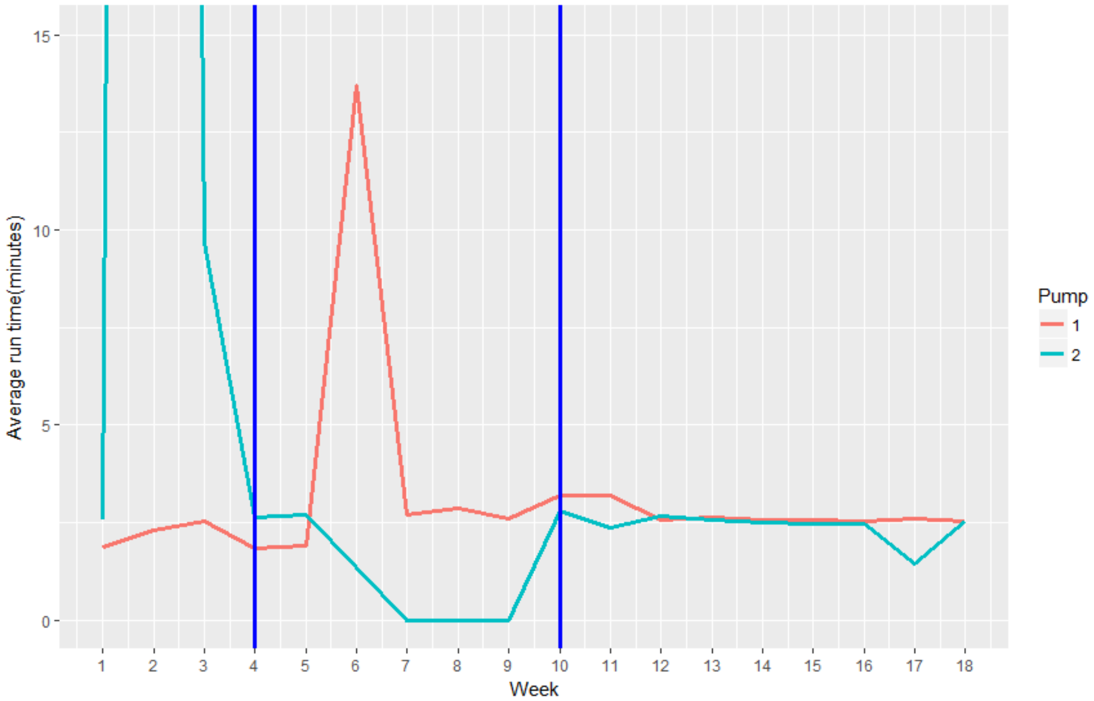

Figure 4.4 shows average run time (total runtime/number of calls to run) for each week. For a wet well site such as this, the average run time represents the time needed to fully empty the well under dry weather conditions and is a good surrogate for pumping station performance.

4.2.3 Key observations

- During Phase 1 there is evidence to show the pumping station is operating poorly, specifically pump 2 which is operating for extended periods, if not continuously as shown in Figure 4.4.

- A short term improvement is seen in Phase two after the manual clean. However both pumps return to an erratic state.

- Both pumps performed very well after the DERAGGER was turned on, with no sustained ragging issues. This indicates that the DERAGGER was successfully preventing potential blockages.

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- The average minutes of operation per kWh consumed increases and stabilises in Phase 3 as shown in Figure 4.3. A 20% efficiency improvement was calculated for pump 1, which has data for the whole trial period, between Phase 2 and 3, as shown in Table 4.8.

Table 4.8 Pump 1 Runtime per kWh

Phase	Runtime / kWh	% Efficiency Improvement
Pre-Clean (Phase 1):	27.3 minutes	
DERAGGER off (Phase 2):	43.6 minutes	60%
DERAGGER on (Phase 3):	52.3 minutes	20%

- The average run time (time required to empty the well) decreases and becomes more consistent in Phase 3, as shown in Figure 4.4.

- The average number of jobs raised per month for the pumping station decreased significantly after the DERAGGER was enabled, as shown in Table 4.9. The exact nature of these jobs is not known and they may or may not relate to blockages.

Table 4.9 Number of jobs raised

	Phase 1	Phase 2	Phase 3
Number of jobs raised	9	9	1

- The total number of Deragger initiated automatic cleans are shown in Table 4.10.

Table 4.10 Number of automatic cleans in Phase 3

Phase 3	Pump 1	Pump 2
Automatic cleans	17	7
Run time (minutes)	2929	1754

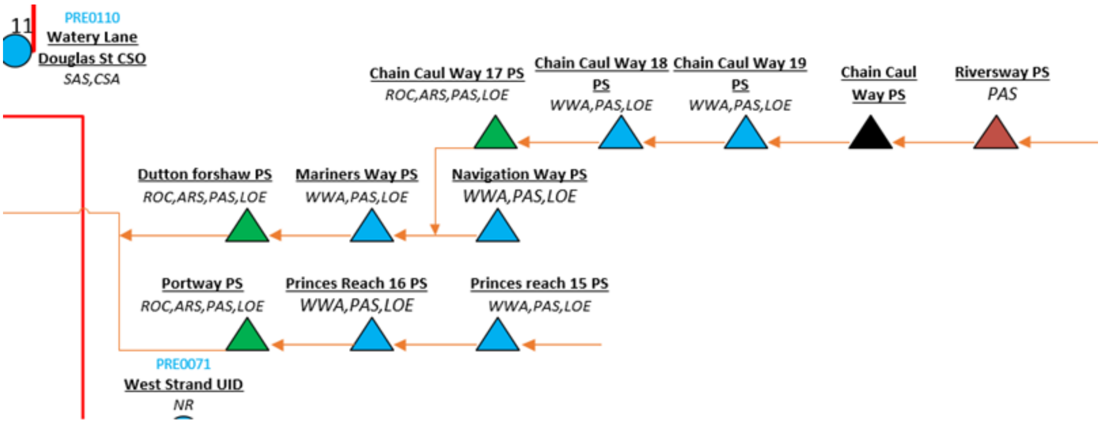
4.3 Dutton Forshaw

4.3.1 Introduction

Navigation Way and Dutton Forshaw are located within the same sewer system, as shown in Figure 4.5. Navigation Way feeds Dutton Forshaw via Mariners Way, another pumping station. There is also additional flow input from the chain of Caul Way pumping stations.

Within this network only Navigation Way and Dutton Forshaw are included within the trial due to a number of operational challenges (temporary pumps and pump failures).

Figure 4.5 Pumping station network



Dutton Forshaw is a wet well with two 9 kW Flygt N-pumps operated as duty rotate. Pump blockages were reported by United Utilities as rare at this site. The DERAGGER was installed on both pumps.

Reason for site selection – Dutton Forshaw was included as part of a chain of pumping stations with Navigation Way. The focus for Dutton Forshaw was to investigate if the DERAGGER could reduce power consumption at the site.

When inspected as part of the trial both pumps showed clear signs of wear due to the large volume of waste and rags they pump. Pump 1 was 0.8 mm outside the clearance tolerance between the impellor and volute, and Pump 2 was 0.5 mm outside of the tolerance. The galvanised steel chains for Pump 2 were replaced with stainless steel chains during cleaning. Pump 1 and Pump 2 were built up with rags on the top of the pump when lifted, however nothing that onsite operators felt would affect pumping capability. Both pumps were cleaned of a small build-up of fat in the volute.

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Photograph 4.2 Pump condition Dutton Forshaw, pre-cleaning

4.3.2 Results

The result of the trial at Dutton Forshaw are summarised in the following tables and graphs.

Generally both pumps were online and both were used throughout the first two periods. After the DERAGGER is switched on, Pump 2 is used almost exclusively after the first two weeks. This is believed to be because Pump 1 was removed for maintenance due to an issue with the pump guide rails.

It should be noted that the exact date of cleaning is unknown; the date of 25/12/2017 used is only the first day of the week in which cleaning took place. As a result of this, the number of high current events and the energy consumption are only estimates for the first two periods.

Table 4.11 Summary of Phase 1 pre-clean Dutton Forshaw

Variable	Week 1		Week 2		Week 3	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	17	17.5	17	17.4	16.8	16.7
Energy use (kWh)	19	39	34	36	31	32
Run time (minutes)	124	233	216	218	195	205
Average Power (kW)	9.19	10.04	9.44	9.91	9.54	9.37
Runtime (minutes) per kWh	6.53	5.97	6.35	6.06	6.29	6.41
Number of Runs	102	170	178	177	155	147
Average Runtime (minutes)	1.22	1.37	1.21	1.23	1.26	1.39

Table 4.12 Summary of Phase 2 Post-clean DERAGGER off Dutton Forshaw

Variable	Week 4		Week 5		Week 6	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	16.7	16.9	16.6	16.8	17	17.4
Energy use (kWh)	33	36	36	37	30	30
Run time (minutes)	214	225	208	248	189	186
Average Power (kW)	9.25	9.6	10.38	8.95	9.52	9.68
Runtime (minutes) per kWh	6.48	6.25	5.78	6.70	6.30	6.2
Number of Runs	180	179	217	219	177	175
Average Runtime (minutes)	1.19	1.26	0.96	1.13	1.07	1.06

Variable	Week 7		Week 8		Week 9	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	17	17.4	17	17.5	17	17.4
Energy use (kWh)	37	38	37	38	35	35
Run time (minutes)	232	229	236	234	218	216
Average Power (kW)	9.57	9.96	9.41	9.74	9.63	9.72
Runtime (minutes) per kWh	6.27	6.03	6.38	6.16	6.23	6.17
Number of Runs	218	217	218	218	205	206
Average Runtime (minutes)	1.06	1.06	1.08	1.07	1.06	1.05

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Table 4.13 Summary of Phase 3 – DERAGGER on Dutton Forshaw

Variable	Week 10		Week 11		Week 12
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 2
Average Current (A)	17	17.1	17	17.6	17.4
Energy use (kWh)	66	4	56	4	51
Run time (minutes)	392	25	349	20	316
Average Power (kW)	10.10	9.6	9.63	12	9.68
Runtime (minutes) per kWh	5.94	6.25	6.23	5	6.20
Number of Runs	295	25	262	15	246
Average Runtime (minutes)	1.33	1	1.33	1.33	1.28

Variable	Week 13	Week 14	Week 15
	Pump 2	Pump 2	Pump 2
Average Current (A)	17.4	17.5	17.5
Energy use (kWh)	52	60	46
Run time (minutes)	317	364	280
Average Power (kW)	9.84	9.89	9.86
Runtime (minutes) per kWh	6.10	6.07	6.09
Number of Runs	244	274	224
Average Runtime (minutes)	1.30	1.33	1.25

Variable	Week 16	Week 17	Week 18 (Five days)
	Pump 2	Pump 2	Pump 2
Average Current (A)	17.6	17.5	17.4
Energy use (kWh)	49	56	37
Run time (minutes)	300	341	231
Average Power (kW)	9.8	9.9	9.61
Runtime (minutes) per kWh	6.12	6.09	6.24
Number of Runs	222	262	170

Variable	Week 16	Week 17	Week 18 (Five days)
Average Runtime (minutes)	1.35	1.30	1.36

Figure 4.6 Average efficiency Dutton Forshaw

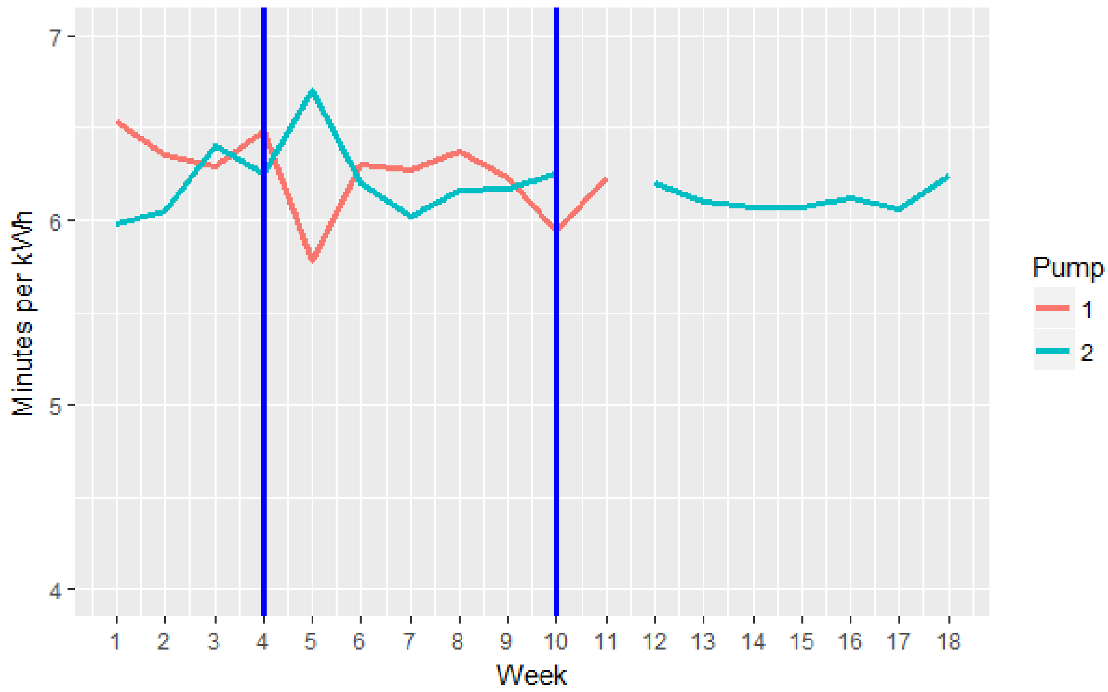

Figure 4.6 shows the average minutes of pump operation per kWh consumed for each week. This is shown separately for each pump; the blue vertical lines denote the three phases of the trial. Pump 1 was not run after week 11.

Figure 4.7 Average runtime Dutton Forshaw

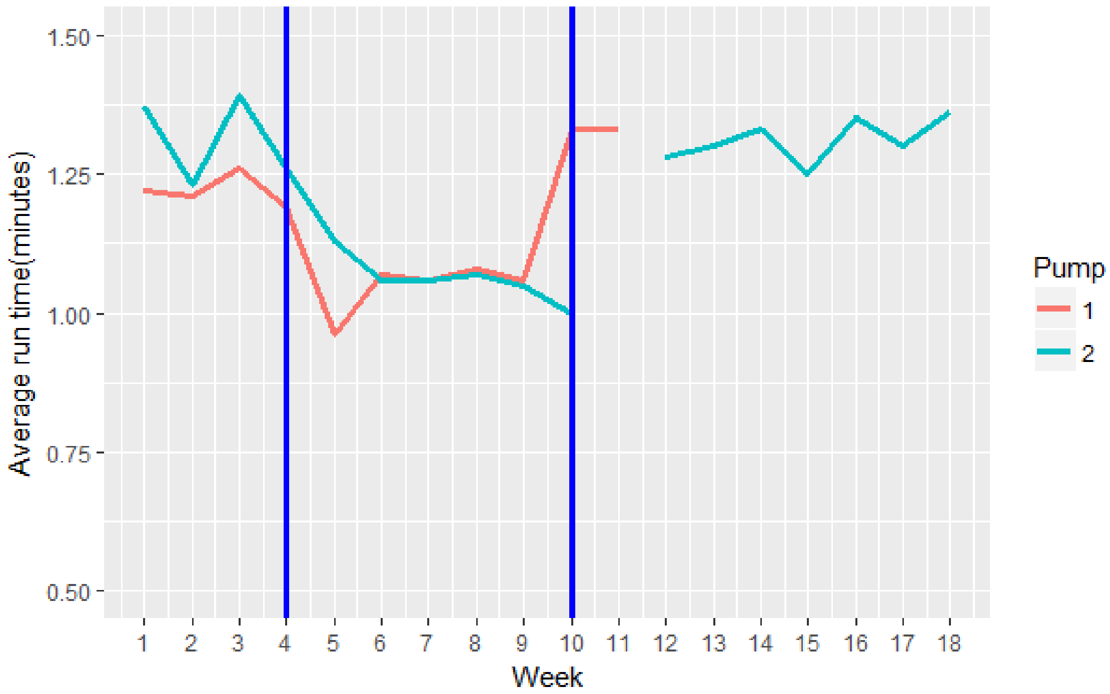

Figure 4.7 shows average runtime (total runtime/number of calls to run) for each week. For a wet well site such as this, the average run time represents the time needed to fully empty the well under dry weather conditions and is a good surrogate for pumping station performance. Pump 1 was not run after week 11.

4.3.3 Key observations

- After the manual clean at the start of phase 2, a small increase in performance of the pumps can be inferred. The average runtime decreases indicating that ragging impediments to the pump (in Phase 1) may have been affecting pump efficiency.
- Performance of pump 1 improves after the DERAGGER was turned on, with no sustained ragging issues. This indicates that the DERAGGER was successfully preventing potential blockages.
- The average minutes of operation per kWh consumed stabilises in Phase 3 as shown in Figure 4.6. A 15% efficiency improvement was calculated for pump 1, which has data for the whole trial period, between Phase 2 and 3, as shown in Table 4.14.

Table 4.14 Pump 1 runtimes per kWh

Phase	Runtime / kWh	% Efficiency Improvement
Pre-Clean (Phase 1):	6.24 minutes	
DERAGGER off (Phase 2):	6.24 minutes	0%
DERAGGER on (Phase 3):	7.19 minutes	15%

- Average run time increases after the DERAGGER is switched on. This phase coincided with an increase in rainfall across England of 30% higher than the average for this time of year, so it is difficult to infer the significance of this result in the absence of a flow meter.

- The average number of jobs raised per month for the pumping station decreased slightly after the DERAGGER was enabled, as shown in Table 4.15. The exact nature of these jobs is not known, however an unrelated issue with an ultrasonic level sensor is noted after DERAGGER installation.

Table 4.15 Number of jobs raised

	Phase 1	Phase 2	Phase 3
Number of jobs raised	8	4	3

- The total number of DERAGGER initiated automatic cleans are shown in Table 4.16.

Table 4.16 Number of automatic cleans in Phase 3

Phase 3	Pump 1	Pump 2
Automatic cleans	37	62
Run time (minutes)	741	2194

*A high number of cleans (41) are performed by the DERAGGER in the first 48 hours of the anti-ragging being switched on. This can be seen as normal behaviour as the remaining debris in the well is pulled through the pump. A small number of additional DERAGGER cleans are carried out during the remainder of phase 3, these appear to prevent issues without any manual intervention.

4.4 Navigation Way

4.4.1 Introduction

Navigation Way and Dutton Forshaw are located within the same sewer system, as shown in Figure 4.5.

Navigation Way is a wet well with two Sykes 2 kW vortex pumps operated as duty standby. Pump blockages were reported by United Utilities as rare at this site. The DERAGGER was installed on both pumps.

Reason for site selection – Navigation Way was included as part of a chain of pumping stations with Dutton Forshaw. The focus for Navigation Way was to investigate if the DERAGGER could reduce power consumption at the site.

The Pumps were inspected as part of the trial and were in very poor condition. A photograph of Pump 1 is shown below. The vortex impellors were found to be at a poor standard in both pumps, which United Utilities described as being the main reason why the pumps were performing poorly and why the pumps are not pumping down the level in the well to its full capability. Both pumps had excessive wear and scoring marks, and the claw was worn on one side of Pump 2, resulting in the pump not being seated correctly. WRc raised concerns over the efficiency of the pumps and questioned the ability to adequately demonstrate effective power savings.

Photograph 4.3 Pump condition Navigation Way, pre-cleaning

4.4.2 Results

The result of the trial at Navigation Way are summarised in the following tables and graphs.

No data is available after 31/12/2017 for Pump 2. Site visits made by Clearwater confirm that the pump was isolated at one time. It may be the case that Pump 2 was removed due to poor performance, which was raised as an earlier concern. No data is available for either pump between 14/01/2018 and 27/01/2018, affecting weeks 7, 8 and 9; there is no indication of why this is the case.

Table 4.17 Summary of Phase 1 pre-clean Navigation Way

Variable	Week 1		Week 2		Week 3	
	Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Average Current (A)	3.22	3.17	3.23	3.16	3.20	3.21
Energy use (kWh)	12	143	45	74	1	133
Run time (minutes)	615	7894	2327	3981	78	7066
Average Power (kW)	1.17	0.22	1.16	1.12	0.77	1.13
Runtime per kWh	51.25	55.20	51.71	53.80	78	53.13
Number of Runs	1	1	5	5	5	2
Average Runtime	615	7894	465	796	16	3533

Variable	Week 4	
	Pump 1	Pump 2
Average Current (A)	3.21	3.20
Energy use (kWh)	14	106
Run time (minutes)	679	12879
Average Power (kW)	1.24	0.49
Runtime per kWh	48.5	18.97
Number of Runs	4	7
Average Runtime	170	1840

Table 4.18 Summary of Phase 2 Post-clean DERAGGER on Navigation Way

Variable	Week 5	Week 6	Week 10
	Pump 1	Pump 1	Pump 1
Average Current (A)	3.25	3.23	3.28
Energy use (kWh)	7	2	6
Run time (minutes)	357	85	241
Average Power (kW)	1.18	1.41	1.49
Runtime per kWh	51.00	42.50	40.17
Number of Runs	28	5	23
Average Runtime	13	17	10.48

Table 4.19 Summary of Phase 3 - DERAGGER on Navigation Way

Variable	Week 11	Week 12	Week 13
	Pump 1	Pump 1	Pump 1
Average Current (A)	3.29	3.30	3.31
Energy use (kWh)	6	5	4
Run time (minutes)	279	242	183
Average Power (kW)	1.29	1.24	1.31
Runtime per kWh	46.50	48.40	45.75
Number of Runs	50	43	30
Average Runtime	5.58	5.63	6.1

Variable	Week 14	Week 15	Week 16
	Pump 1	Pump 1	Pump 1
Average Current (A)	3.29	3.32	3.25
Energy use (kWh)	2	3	4
Run time (minutes)	100	151	184
Average Power (kW)	1.2	1.19	1.30
Runtime per kWh	50.00	50.33	46
Number of Runs	19	24	15
Average Runtime	5.26	6.29	12.27

Variable	Week 17	Week 18	Week 19 (six days)
	Pump 1	Pump 1	Pump 1
Average Current (A)	3.28	3.31	3.30
Energy use (kWh)	2	3	2
Run time (minutes)	115	134	115
Average Power (kW)	1.04	1.34	1.04
Runtime per kWh	57.5	44.67	57.5
Number of Runs	16	19	17
Average Runtime	7.19	7.05	6.76

Figure 4.8 Average efficiency Navigation Way

Figure 4.8 shows the average minutes of pump operation per kWh consumed for each week. This is shown separately for each pump; the blue vertical lines denote the three phases of the trial. Pump 2 was only in operation up to week 5.

Figure 4.9 Average runtime Navigation Way

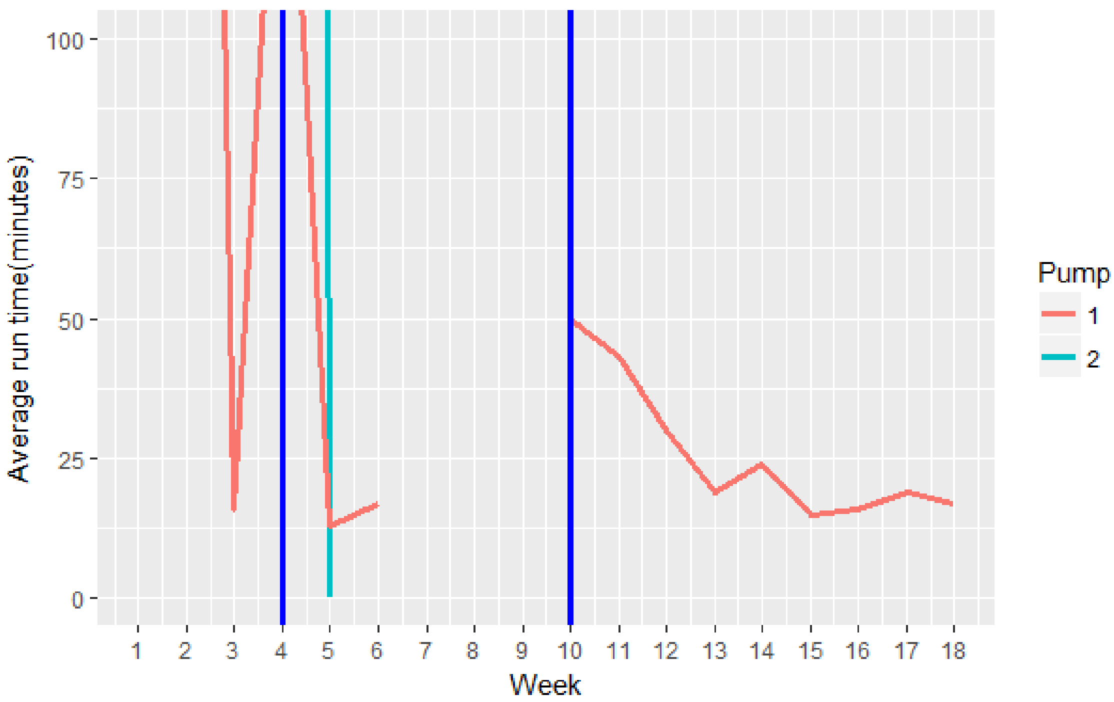

Figure 4.9 shows average runtime (total runtime/number of calls to run) for each week. For a wet well site such as this, the average run time represents the time needed to fully empty the well under dry weather conditions and is a good surrogate for pumping station performance. Pump 2 was only in operation up to week 5.

4.4.3 Key observations

- Both pumps were running for very long periods, almost continuously in Phase 1. This is likely a reflection of the poor condition of the pumps with severely worn vortex impellors.

- The average minutes of operation per kWh consumed varies with a slight increase over the period of Phase 2 and 3 as shown in Figure 4.8. The efficiency improvement was calculated for pump 1 which has data for the whole trial period and is shown in Table 4.20.

Table 4.20 Runtime per kWh for pump 1

	Runtime / kWh	% Efficiency Improvement
Pre-Clean (Phase 1):	51.4	
DERAGGER off (Phase 2):	45.5	- 11%
DERAGGER on (Phase 3):	48.5	7%

- The run times, measured as minutes, reduced by 75% in Phase 2 compared to Phase 1 suggesting ragging of the worn impellors was a problem in Phase 1. The experience of Clearwater Controls is that vortex pumps experience drastically longer run times when ragged. The reduced run times were maintained for several weeks after manual cleaning. After which there is then a steady increase in the run times up to week 10, suggesting that the pump is slowly becoming ragged.

- After DERAGGER activation and second manual clean the run times are further reduced by 26% and stabilise; indicating that the DERGGER maintains a clean pump.

- The average number of jobs raised per month for the pumping station decreased slightly after the DERAGGER was enabled, as shown in Table 4.21. The exact nature of these jobs is unknown, and may or may not relate to blockages.

Table 4.21 Number of jobs raised

	Phase 1	Phase 2	Phase 3
Number of jobs raised	7	7	5

- The total number of DERAGGER initiated automatic cleans is shown in Table 4.22 and is comparatively low compared to the other sites.

Table 4.22 Number of automatic cleans in Phase 3

Phase 3	Pump 1
Automatic cleans	3
Run time (minutes)	1503

4.5 West Quay

4.5.1 Introduction

West Quay features three dry weather flow dry well pumps. There are additionally another two storm water pumps present at the site. The trial was focussed on Pump 3, one of the dry weather flow pumps. This pump was particularly prone to blockages, and required frequent maintenance.

There was also an existing flow meter fitted at West Quay, and daily readings of this were provided by Wessex Water. However this flow meter is fitted to measure the flow across all three dry weather pumps at the site. Without any operational details about the other pumps, it was very difficult to match this flow with pump three. Energy consumption information was also provided, however this was provided at site level. This included the power supplied to all three dry weather flow pumps and two additional storm pumps. The site level energy consumption was checked against the DERAGGER's energy consumption to check if there were days when only pump 3 was operational. However the site level energy consumption was at least 200% more than Pump 3 energy consumption throughout the trial, suggesting pumps 1 and 2 were used extensively throughout the trial. This meant that it was not possible to use the flow data to verify the energy savings of the DERAGGER.

Reason for site selection – West Quay was selected as a trial site in order to observe the improvement which could be achieved through using the DERAGGER on a site with a large number of blockages. Wessex Water hoped that the DERAGGER could reduce reactive maintenance performed to clean the pump while delivering some additional energy savings.

4.5.2 Results

Maintenance records and recorded blockages were provided for West Quay. This allows individual events to be matched to known blockages, and also for the impact of the DERAGGER on the system.

Table 4.23 Blockages and associated maintenance on Pump 3

Week	Maintenance to Unblock Pump 3	Blockage Recorded
1	Yes	Yes
2	Yes	No
2	Yes	No
.3	Yes	Yes
5	Yes	Yes
6	Yes	Yes
10	Yes	Yes

Table 4.23 shows that blockages on Pump 3 were highly frequent, with blockages occurring once or twice per week during April and June. No blockages were recorded and no maintenance performed to unblock Pump 3 for the following 6 weeks after the DERAGGER is activated on 05/06/2018.The DERAGGER greatly reduces the amount of maintenance required.

The pre-clean period was too short to be presented for this site. Due to the frequency of blockages, the pump is lifted and unblocked on a regular basis, with the first of these events occurring only three days after the DERAGGER started data logging.

Table 4.24 Summary of Phase 2 West Quay

Variable	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Average Current (A)	26.6	26.7	26.6	26.5	26.7	26.9
Maintenance to Unblock	1	2	1	0	1	1
Energy Use (kWh)	1801	910	736	563	551	434
Run time (minutes)	7708	3908	3215	2478	2395	1870
Average Power (kW)	14.0	14.0	13.7	13.6	13.8	13.9
Runtime (minutes) per kWh	4.28	4.29	4.37	4.40	4.35	4.31
Number of Runs	86	127	256	342	320	281
Average Runtime (minutes)	89.6	30.8	12.6	7.2	7.5	6.7

Variable	Week 7	Week 8	Week 9	Week 10
Average Current (A)	26.6	26.5	26.8	26.3
Maintenance to Unblock	0	0	0	1
Energy Use (kWh)	433	408	647	271
Run time (minutes)	1904	1813	2761	1177
Average Power (kW)	13.6	13.5	14.1	13.8
Runtime (minutes) per kWh	4.40	4.44	4.27	4.34
Number of Runs	316	328	250	176
Average Runtime (minutes)	6.0	5.5	11.0	6.7

Table 4.25 Summary of Phase 3 West Quay

Variable	Week 11	Week 12	Week1 13	Week1 14	Week 15	Week 16
Average Current (A)	26.4	26.3	26.3	26.3	26.2	26.2
Maintenance to Unblock	0	0	0	0	0	0
Energy Use (kWh)	426	402	379	381	389	121
Run time (minutes)	1877	1807	1706	1707	1747	544
Average Power (kW)	13.6	13.4	13.3	13.4	13.4	13.3
Runtime (minutes) per kWh	4.41	4.50	4.50	4.48	4.49	4.50
Number of Runs	367	342	326	326	321	99
Average Runtime (minutes)	5.1	5.3	5.2	5.2	5.4	5.5

Figure 4.10 Average efficiency West Quay

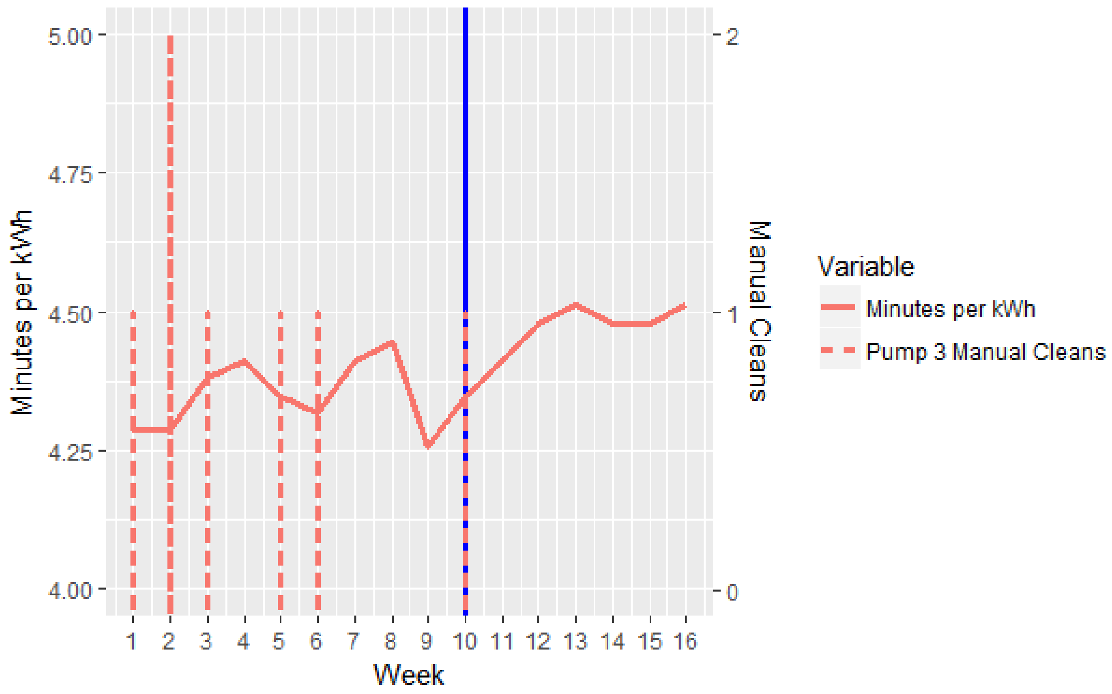

Figure 4.10 shows the efficiency measured in minutes of pump runtime per kWh of energy consumed. The manual cleans are shown alongside this as dashed lines, and the vertical blue lines show the different phases of the trial.

Figure 4.11 Average runtime – West Quay

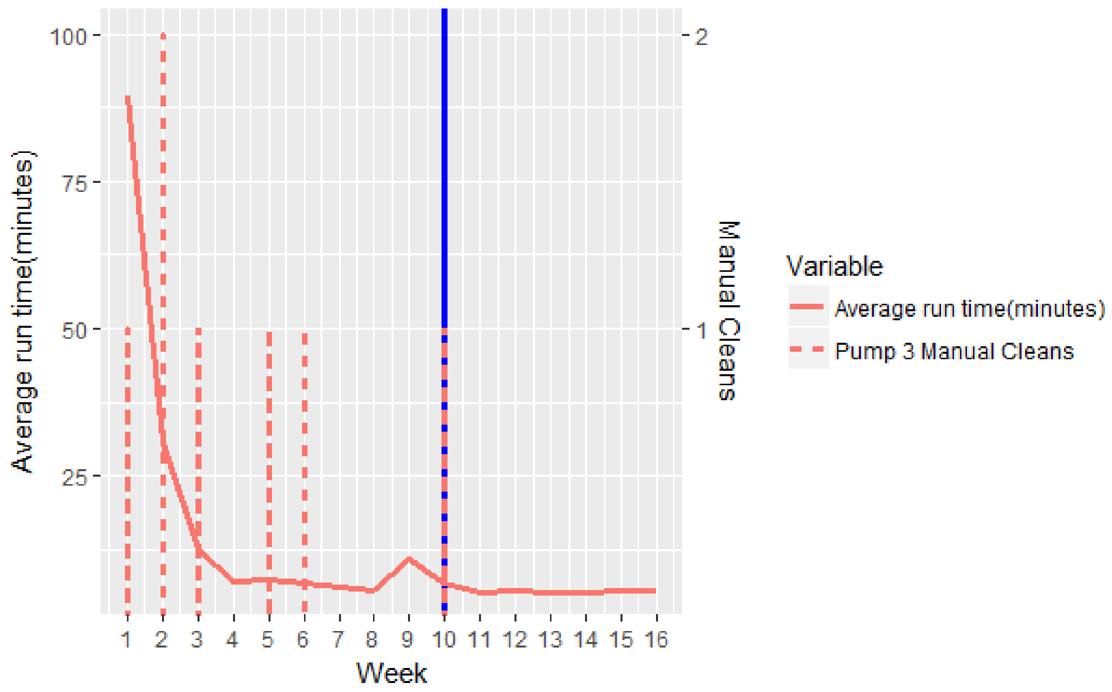

Figure 4.11 shows the average run time in minutes per week. The manual cleans are shown alongside this as a dotted line, and the vertical blue lines show the different phases of the trial.

4.5.3 Key Observations

- The pumping station was performing poorly in Phase 1 with very long run times and frequent blockages requiring manual cleaning.
- Run times were managed during phase 2 by a total of seven cleans, including four cleans in three weeks. After DERAGGER activation, improved run times are maintained, without the need for manual cleans.
- The average minutes of operation per kWh consumed is variable in phase 1 and 2 with short term improvements following frequent manual cleaning, indicated a high propensity for pump blocking. After DERAGGER activation, efficiency increases and stabilises. The efficiency improvement was calculated and is shown in Table 4.26.

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Table 4.26 Runtime per kWh

Phase	Runtime / kWh	% Efficiency Improvement
DERAGGER off (Phase 2):	4.3	
DERAGGER on (Phase 3):	4.5	5%

- With the DERAGGER active there are no manual cleans, indicating that the DERAGGER has successfully prevented further blockages and levelled out energy consumption. The total number of DERAGGER initiated automatic cleans is shown in Table 4.27.

Table 4.27 Number of automatic cleans in Phase 3

Phase 3	Pump 1
Automatic cleans	75
Run time (minutes)	9388

- The poor performance of the pump in Phase 2 is demonstrated in Figure 4.12 which shows several periods where the current is reduced to zero, demonstrating that the pump is actually offline for large periods of time due to blockages.

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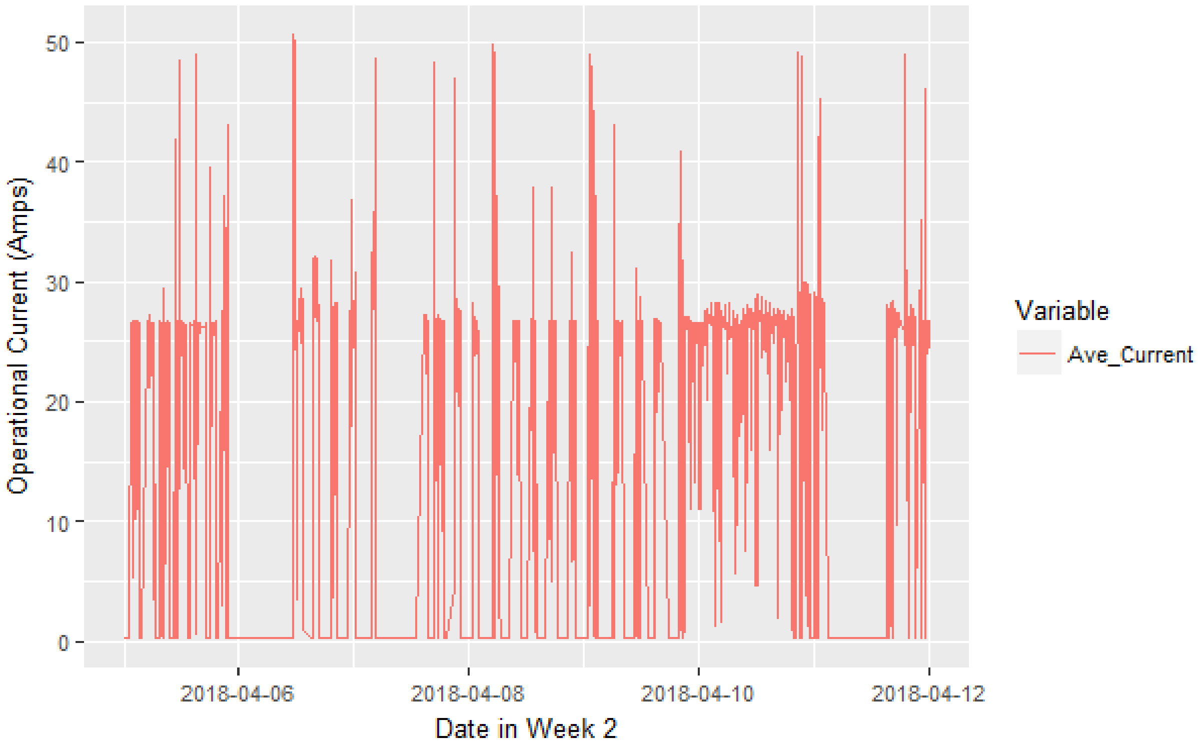
Figure 4.12 Pump 3 Current



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5. Summary of Results and Feedback

5.1 Summary of Results

Site	Objective and result
Thorn Park	Thorn Park was included to investigate if the DERAGGER could reduce power consumption at the site, as well as being a dry well application. • The DERAGGER maintained the clean state of the pumps over the period of the trial. • A 20.6% improvement in pumping efficiency was achieved after the DERAGGER was turned on.
Marsh Farm	Marsh Farm was selected as a trial site in order to observe the improvement which could be achieved through using the DERAGGER on a site with a large number of blockages. United Utilities hoped that the DERAGGER could reduce reactive maintenance performed to clean the Pump while delivering some additional energy savings. • At the start of the trial the pumping station was operating poorly, specifically pump 2 operating for extended periods. Manual cleaning resulted in only short term improvements. • The DERAGGER maintained the clean state of the pumps and the total number of maintenance jobs raised per month dropped from 9 to 1, however the reason for these jobs is not known and may not relate to blockages. • A 20% efficiency improvement was achieved, measured as runtime/kWh after the DERAGGER was turned on.
Dutton Forshaw	Dutton Forshaw was included as part of a chain of pumping stations with Navigation Way. The focus for Dutton Forshaw was to investigate if the DERAGGER could reduce power consumption at the site. • A 15% efficiency improvement was achieved, measured as runtime/kWh after the DERAGGER was turned on. • The total number of maintenance jobs raised per month decreased slightly, however the reason for these jobs is not known and may not relate to blockages. An unrelated ultrasonic level sensor problem was specifically noted.

Navigation Way	Navigation Way was included as part of a chain of pumping stations with Dutton Forshaw. The focus for Navigation Way was to investigate if the DERAGGER could reduce power consumption at the site. • The pumps are in poor condition which is likely to have an impact on the benefits which can be achieved at this site. • The DERAGGER maintained the clean state of the pumps over the period of the trial. • A 7% increase in pump efficiency, measured as runtime/kWh, was achieved after the DERAGGER was turned on. • Run times dramatically reduced by 75% with manual cleaning and a further 26% with the DERAGGER enabled. • The total number of maintenance jobs raised per month decreased slightly after DERAGGER activation, however the reason for these jobs is not known and may not relate to blockages.
West Quay	West Quay was selected as a trial site in order to observe the improvement which could be achieved through using the DERAGGER on a site with a large number of blockages. Wessex Water hoped that the DERAGGER could reduce reactive maintenance performed to clean the pump while delivering some additional energy savings. • The pumping station was performing poorly in Phase 1 with very long run times. Frequent manual cleaning results in short term improvement in pump performance. • The DERAGGER maintained the clean state of the pumps over the period of the trial with no manual cleans required over a 6 week period. • A 5% increase in pump efficiency, measured as runtime/kWh, was achieved after the DERAGGER was turned on. This is an improvement over phase despite the need for manual cleaning. • A greater energy efficiency may be seen if we were able to compare the DERAGGER On (Phase 3) period with a pre-clean (Phase 1) situation.

5.2 Feedback

Feedback was sought from a range of users of the DERAGGER technology. This was gathered as part of the WRc Approved process, using a structured approach to gather views from real customers with direct experience of the technology and working with Clearwater Controls in the UK and US.

The feedback received was all positive on both the DERAGGER and working with Clearwater Controls. Specific comments received included:

US based user of 20 DERAGGERS since 2015

"100% reduction in blockages and approx. 10% to 15% energy reduction".

"We first encountered De-Ragger in November, 2014 in Los Angeles, CA (LACSD) on another manufacturer's pump. LACSD was very happy with the product and we had an immediate need at two very large and important master lift stations. One of the stations is in Lincoln Park, NJ and the other is in Lake Worth, FL. When the pumps were initially installed, there were no real clogging issues, but over time, flushable wipes started clogging the pumps to the point that they had to be manually cleaned at least once a week which was unacceptable. In 2015 we installed De-Raggers at both locations and have had no clogging issues since".

"We are using De-Raggers in various locations to ensure clog-free pump operation. We will offer a non-clog guaranty, but in all cases require the use of a De-Ragger in the control system".

"This is a very good product and we highly recommend it. Excellent service as well".

UK based user of over 200 DERAGGERs since 2011

"I was employed at the time of introduction of the Deragger technology around 2011 when I had over 35 years' experience of pumping station design, operation, maintenance and procurement and the concept of deliberately and regularly running a pump in reverse rotation seemed more likely to cause damage to the point of eventual destruction than to have any beneficial effect. Reversing could cause failure from impeller securing bolts loosening off and flying through the volute casing or creating extra friction between impeller and wear surfaces, by opening the faces of the mechanical seals allowing water into the oil chamber and motor, and by hammering the keyway slack leading to friction failure as the impeller loosens and misaligns.

Keeping an open mind on the outcome, trials of this reversing technology showed that utilizing the inbuilt programming facility to set up the frequency and timing of reverse cleaning cycles on a site by site basis prevented any of the expected detrimental effects. This may be due in part to the improvements in pumpset manufacturing through the use of multi-spring mechanical seals, CNC machining tolerances and impeller screw retaining compounds.

The predicted benefits, however, were soon realized with dramatic reductions in pump chokes and reduced energy consumption being recorded in a number of field trials. This led to a wider implementation of this technology as part of a pumping station intervention Capital

Maintenance Program, and the alteration of the Standards and Specifications to incorporate this technology where the risk of blockage was high for all new wastewater pumping stations.

The main benefits of adopting this technology are threefold: -

1. *reduced Opex through choke frequency reduction*
2. *reduced energy costs through operating efficiently for longer*
3. *increased operational life through reduced wear caused by rag friction*

In the event of a choke occurring suddenly as a result of a ball of rags forming in the infrastructure and entering the eye of the impeller but not being passed through the Deragger can detect this using torque comparison technology which would trigger a reverse cycle. This can also be attempted a programmable number of times until either the choke clears or the pump is switched off and a maintenance visit is scheduled.

At the time of my retirement the Deragger controllers had been installed on over 200 pumping stations where blockage issues were having an Opex impact. These sites are now mainly blockage free with only occasional trips, many of which can be reset by remote telemetry to restore operation.

Generally, it was found that the use of reversing technology allowed pumps to maintain a higher operating efficiency through operating rag free, which also reduced the number of maintenance visits required, without any detrimental effect to the impeller securing arrangement.

My initial scepticism appeared to be unfounded, and I would therefore encourage keeping an open mind on the adoption of technologies that challenge old established beliefs, and which have the potential to return benefits, as in this case."

US based distributor of over 50 DERAGGERS since 2014

Benefits seen by your customers; *"Varies by customer but at least 90% reduction in blockages and in many instances there have been no clogs since installation".*

6. Conclusions

1. The DERAGGER has been proven to deliver blockage reduction, and reduce the need for manual lifting and cleaning of pumps.

    - Reductions in maintenance were observed across all sites. The most significant benefit, where data was available, showed a reduction from 7 manuals cleans over a 10 week period to no manual cleans over 6 week period.
    - The exact reasons for the maintenance visits were not made available for three of the sites. Therefore calculating the actual reductions in manual blockage removal was not possible.
    - Feedback from users of the DERAGGER over a longer period has indicated that 100% reduction in the need to manually clear blockages has been achieved in some circumstances.

2. The DERAGGER has been proven to deliver energy savings.

    - This is true when comparing the DERAGGER to ‘unclean’ periods of pump operation where savings up to 80% have been demonstrated.
    - It is also true when comparing the DERAGGER to periods where pumps have been recently manually lifted and cleaned, where savings of between 5-20.6% have been demonstrated.

3. Substantial inefficiencies exist in the waste water network as a result of pumps running in a ragged condition which the DERAGGER could resolve.

    - These pumps do not always trip or raise an alarm; the result is that these inefficiencies are not being addressed. If installed, the DERAGGER can achieve energy savings in these instances.

4. It is highly likely that extensions in asset life will be achieved in proportion to the efficiencies gained in pump run times and energy consumption.

    - On the three trial sites where frequent blockages were not reported, energy efficiency improvements were detected as a result of the DERAGGER implementation. By addressing the inefficiencies that exist due to ragging, it is highly likely that extensions in asset life will be achieved in proportion to the efficiencies gained in pump run times and energy consumption.

5. There is no evidence from this trial that the DERAGGER reversal process damages pumps.

Appendix A CLEARWATER DERAGGER II AND DERAGGER PRO TEST PROTOCOL

A1 Background

Blocked pumps account for an estimated 80-90% of all unplanned work carried out at pumping stations and there is evidence to show that blockages and the build-up of rags prior to blockages increases pumping energy costs. The UK water companies are keen to find solutions to this challenge.

The Clearwater Controls Deragger II and Deragger Pro are technologies designed to reduce the problem of pump blockages and the associated increased pumping costs. This technology is relatively new and has been installed widely in Scotland but to a much lesser extent in England and Wales.

Water companies would like to know on which assets and under what conditions the Deragger technology is most beneficial. In order to answer these questions and provide Clearwater Controls with independent data, that would be accepted by UK water companies, an independently managed trial is proposed. A number of water companies have expressed an interest in participating in the trials which will be carried out at pumping stations operated by those companies

A2 Purpose of this document

This document sets out the approach for the trial of the Deragger to ensure that the work addresses the identified objectives and all parties (Clearwater controls, the participating water companies and WRc) are all clear on the plan and how the work will be delivered.

This document covers four main areas:

- **Aim and objectives** – what are we trying to achieve from the trial.
- **Site selection** – what criteria will be used to select the trial sites
- **Reference data** – essential information needed for the trial.
- **Trial operation** – how will the trial be run and who is responsible for what.

This document will be used as the primary reference document against which decisions can be referenced.

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A3 Aims and objectives

The aim of this work is to run a trial of the Clearwater Deragger technology to evaluate the performance under real conditions.

The work will provide sufficient robust information to answer the following questions:

- What performance can be achieved in blockage prevention?
- What energy saving can the technology achieve?
- On which assets and under what conditions can these benefits be achieved?
- Can the Deragger meet a defined success criteria (parameters of which are to be discussed with participating water companies)

Based on the above, the following sections detail the proposed trial and evaluation approach.

A4 Site Selection

Selecting the most appropriate pumping stations for the trial is an important decision which needs to be considered alongside the objectives of the trial and the availability of sites operated by the participating water companies.

The project is looking to trial the Deragger technology on up to four pumping station sites. These could be provided by 1, 2, 3 or 4 different water companies. Selection of the sites will be made through discussion within the project group (Clearwater controls, the participating water companies and WRc) based on the selection criteria and the sites which are made available by the water companies.

A4.1 Selection criteria

The following criteria have been identified for consideration in identifying suitable sites. Those which are considered of greatest importance in the identification of trial sites are listed.

Criteria	Why included
Wet well or dry well	Potential to include both
Starter/Drive type	Need to know but not critical
Pumping station – number of pumps	Ideally a 2 pump station. Aim to keep it simple.

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Criteria	Why included
Age and condition of pumps	Age less important than condition. Needs to be representative of a typical Deragger installation.
Type/make of pump and impeller	Need to document but not critical so long as compatible with Deragger
Size of pumps	See 4.2, plan to test on two size ranges.
Scheduling of duty / standby / assist	Useful data in understanding the site
Power measurement on each pump	Needed to establish energy savings
Flow measurement (referenced to each pump)	Needed to calculate savings. This must be measured rather than inferred. Could be installed if not already in place. Clamp on meters to be used only if sufficient length of exposed straight pipe is available.
Blockage history	Frequency of blockages is important to know. Is this once a week or once a month?
Maintenance history and work undertaken	Historic information on planned and reactive maintenance is essential
Hours run	Useful data in understanding the site
Notification of any planned works	Either on the SPS or within the network which could impact on the trial

A4.2 Potential test site characteristics

The following are current thoughts on what the four sites could look like. This is based on a split between small and large pumping stations. The pumps grouping which have been selected are:

- <3 kW
- **3-7 kW – Selected to represent small pumps**
- 7-22 kW
- 22-30 kW
- **>30 kW – Selected to represent large pumps**

Wet well and dry well pumps will be monitored to demonstrate the potential energy savings at the different pumping stations.

This approach is proposed for discussion at the initial meeting of the group.

Small pumping stations with historic blockage problems
Focus is on establishing the performance of the Deragger in blockage prevention at these known problem sites.

Site 1 - Small dry well	**Site 2 – small wet well**
• Pump size 3-7kW • Two pumps • High blockage frequency – once a week	• Pump size 3-7kW • Two pumps • High blockage frequency – once a week
Likely challenges: • Availably of good historic data • Flow measurement	

Larger pumping stations with historic blockage problems and significant energy use Focus is on establishing the performance of the Deragger in blockage prevention at these larger sites and also the energy saving which can be achieved.	
Site 3- large dry well • Pump size >30kW • Blockage frequency – once a month	**Site 4 – large wet well** • Pump size >30kW • Blockage frequency – once a month
Likely challenges: • Availability of good historic data • Flow measurement • Large PS likely to operate more than 2 pumps • Can we identify these and will they be made available for the trial under the proposed trial conditions.	

A5 Reference data

In order to achieve robust and trusted trial outcomes there is a need for good reference data. A number of these parameters will be recorded by the Deragger unit, the calibration of which will be independently checked prior to the trial. The key pieces of information that will be gathered during the trial are as follows:

A5.1 Maintenance activity

A record of all activity (planned or reactive) undertaken on the pumping station during the trial period.

A5.2 Flow measurement at the trial sites

A record of the flow delivered by the pump(s) with the Deragger installed. For the trial this data should be from a flowmeter, not inferred flow based on time or level.

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A5.3 Pump operating regime

The Deragger will operate with the existing pump regime.

A5.4 Operational Parameters

The Deragger's own diagnostic counters will include number of cleans, number of starts, number of trips, under/over current tips, under/over voltage trips, phase loss trips, motor run hours, kW hours, av. Daily kW/hrs, av. daily run time, av. daily current consumptions, av. Daily kW/pumped flow, etc. A full list of the parameters recorded by the Deragger is included in the appendix of this document. All of this data can be recorded with the reverse function both enabled and disabled.

A6 Trial Operation

The process of trialling the Deragger technology needs to ensure that robust data can be collected which allows the benefits to be established. This requires careful consideration of how a 'no Deragger' vs 'Deragger' conditions are established and compared. This is important because there are many variables which will impact on the performance of the pumping station and potentially the assessment of the Deragger. This section outlines an approach to provide a structured and carefully managed trial to produce robust and trusted data on the performance of the Deragger.

In order to best reflect normal operating conditions, where multiple pumps are used in a duty/standby procedure, each will be fitted with a Deragger II unit.

A6.1 Test duration

A period of 13 week period is proposed for the trial, with the option of extending this by an extra 4 weeks to collect further data if this is deemed necessary, dependent on the number of reverse events observed in comparison to the number of blockage events. A detailed breakdown of how this time will be used to test the Deragger is presented in 6.5.

The duration of the trial will depend on the blockage frequency at a particular site.

Proposed Timescale:

	Week																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Deragger Installed	*																
'Pre clean' monitoring																	
Pump cleaning		*															
'Deragger Off' monitoring																	
Pump cleaning						*											
'Deragger On' monitoring																	
Data analyses																	
Additional monitoring Period																	

A6.2 Pre-installation

The installation and commissioning of the sites will be undertaken by Clearwater Controls in collaboration with the participating water companies. WRc's involvement will only be to ensure that the installations meet the requirements set out in the protocol documents.

Clearwater Controls will liaise with the water companies to ensure the correct procedures and health and safety requirements are followed. A pre-installation meeting will take place between the Clearwater Controls representative and the on-site operational staff to ensure procedures are understood and for site operatives to learn about the Deragger operation and maintenance.

Contractual agreements between Clearwater Controls, WRc and the water companies will set out the responsibilities for commission of the trials. To be agreed following selection of trial sites.

A6.3 Installation and commissioning

Installation is estimated to take 6hrs per pump, the method statement and risk assessment for which, will be agreed and signed off in advance. The work will be carried out by the Clearwater Controls engineer. On site checks will take place following installation and be signed off by both the Clearwater Controls engineer and the on-site operative to confirm it is acceptable to both parties.

A6.4 Pre-cleaning monitoring

Following the commissioning of the Deragger, the pump will be monitored for 1 week in its existing condition prior to any cleaning. The data collected will be used to plot the rate of deterioration once the Deragger is enabled. It is important that the site maintenance records show when the pump was last cleaned and how frequently. The trial should start when the time from the last clean is at its greatest, as far as this is possible.

A6.5 Pump lifting and cleaning

The pump will be lifted and cleaned by the water company maintenance operatives, this will be done using the existing site method. A photographic record should be kept of the pre and post cleaning states and a record should be taken of any fouling and the condition of the impeller.

A6.6 'Deragger Off' monitoring period

The Deragger will be installed with the anti-ragging functionality disabled for a period of 4 weeks (following the initial pump cleaning) to capture the pumps energy consumption, operating parameters and provide a short period of detailed information on the pumping station, how it operates and any problems.

Any problems which could impact on the trial (such as upstream sewer cleaning, planned pump replacements, planned wet well cleaning or other periodic maintenance) will be identified following this stage to enable solutions to be found prior to the trial commencing.

A6.7 'Deragger On' monitoring period

The anti-ragging functionality on the Deragger will be enabled ('Deragger On') and monitored for a period of 4 weeks (following the second pump cleaning).

A6.8 Additional monitoring period

An optional extension of the 'Deragger On' period will be made available if necessary. This will be decided based on the number of reverse action events by comparison to the history of blockage frequency for the site. An initial look at the data will take place in order to determine normal frequencies.

A6.9 Site visits and monitoring during the trial

All site visits will be organised and made with the water company representatives. Additional site visits may be necessary, and can be agreed on a ad-hoc basis

Data will be manually uploaded from the Deragger SD card by the water company operatives and sent to WRc, having previously been shown how by the Deragger engineer. The raw data will be made available to view for all of the parties involved in the trial. The data will be extracted after each of the monitoring phases detailed above.

Water companies are also expected to provide data through-out the trial and provide photographic evidence of any blockage/other maintenance events that occur.

A6.10 Data analysis

WRc will independently review and analyse all the data from the trials, Clearwater's in-house data processing tools will be reviewed by WRc and outputs audited. It is expected that it will take one month to analyse the data and report the initial findings.

Sources of data would include:

- Asset information.
- Historic site data.
- Flow and power measurement.
- Deragger operation data.
- Operational activity, i.e. pump sequencing and run times.
- Maintenance records, both proactive and reactive.

A6.11 Performance measured

The aim of the trial is to capture sufficient robust data to enable the performance of the Deragger to be assessed against a number of measures. The following performance measures are proposed:

Blockage prevention
Reduction in number of blockages based on identified blockages requiring manual intervention with the Deragger enabled. Measured as the percentage reduction, over a 1 month period before and after the Deragger is enabled.

Energy savings
Energy saving achieved based on kWh/m3 using data from the energy monitor and the flow meter with the Deragger enabled. Measured as percentage reduction, over a 1 month period before and after the Deragger is enabled.

Both the above will be referenced to the pumping station characteristics i.e. pump type and size.

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A6.12 Meetings and reporting

Three meetings are planned with the group of Clearwater Controls and the water companies. One at the beginning (16th May) to align expectations, one in the middle to review progress and one at the end to review the outputs. These will be held at WRc in Swindon at dates to be confirmed.

WRc will produce a single report fully documenting the trials. This report will be made available to all the participating water companies. Clearwater controls will be able to use the report for marketing and discussions with water companies outside of the group of companies involved in the trial. If required, the test sites will be anonymised in the report.

Clearwater Controls and the water companies involved in the trials will be given the opportunity to comment on the draft final report. All comments and feedback will be documented.

A7 Deragger monitoring parameters

Counters:

- Starts
- Anti Ragging Cleans
- Anti Ragging Trips
- Current Imbalance Trips
- Over Current Trips
- Under Current Trips
- Overload Trips
- Motor Run time
- Over voltage Trips
- Under voltage Trips
- Phase Loss Trips
- Frequency Trips
- Dry Well detection Trips
- Dry Well detection
- Energy (kW/Hrs)
- Last pump run time (Draw Down Time)

Live Data:

L1:

- Current
- Voltage
- Active Power
- Reactive Power

- Apparent Power

L2:

- Current
- Voltage
- Active Power
- Reactive Power
- Apparent Power

L3:

- Current
- Voltage
- Active Power
- Reactive Power
- Apparent Power

- Total active power
- Total apparent power
- Power factor
- % full load current
- Average current
- Average voltage
- Frequency
- Analogue input 1
- Analogue input 2

Daily Averages:

- Daily average Current
- Daily run time
- Daily kWHrs
- Daily average kW
- Total Flow pumped

Other:

- Running
- Tripped
- Cleaning
- Alarm
- Alarm code
- Digital input and output status