WHEN THE PROBLEM IS SO BIG, WHERE DO YOU START? RENEWALS TO MEET YOUR BUDGET

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ABSTRACT

Many engineers would consider pipe renewal boring and simple; it is hard to get people excited about a typical 150mm wastewater or watermain that is to be buried under the ground for 100-years and hopefully never seen again. It is no wonder that we have such a massive infrastructure deficit when there are so many other, more exciting projects that are crying out for money from local councils.

There is a consensus that a change in how we approach renewals is needed. However, with such a massive deficit of asset renewals to date, limited funding, and no significant change of approach in the last 10 years, it is hard to see a way forward. Two things come to mind when I think of renewals, the first is a Bart Simpson quote, "Let me get this straight: we're behind the rest of our class and we're going to catch up to them by going slower than they are? Coo Coo!" and the second is a simple proposition from a work colleague who said to me "at the current investment level in renewals we will complete the current replacement of all assets that last 100 years in approximately 1000 years". These might be an exaggeration but have truth at the heart of them.

At Stantec we help clients around the world with the "bread and butter" work of pipe renewals. In many cases, we come on board when trying to determine where best to spend the money when the list of pipes requiring renewal (pipes recorded as in poor condition or simply pipes known to require constant repair) significantly exceeds the budgets available. Clients come to us asking "when the problem is so big, where do we start, how do I get the most bang for my buck?".

This paper will outline some recent approaches Stantec has carried out to help scope renewals to meet the available budget. The first is an example from Wainuiomata, Wellington, where the condition has been predicted but performance a little less known. The second is from the United Kingdom, where pipe performance history is known but the condition is not. In both cases, we identified and designed a renewal programme of selected pipelines that could be carried out efficiently to achieve an immediate reduction of pipe breakages and customer outages while matching the available limited budgets.

For the work in Wellington, we trialled a selection process that has been automated using open-source data to enable repeated application for future use in other areas to create a "Long List" ready for review and refinement with client and contractor to help maximise renewal impact to meet the available budgets. These approaches allow clients to have an 'on-the-shelf' ready design they can refine to suit their budgets while maximising renewal length to achieve the best bang for their buck.

KEYWORDS

Renewals, Asset Management, Programme Delivery

PRESENTER PROFILE

Nicola is a Civil Engineer with three years' experience in geotechnical and the civil aspects of water engineering. She has worked on a range of projects, predominantly related to three waters infrastructure. Nicola has worked on pipeline renewals projects for Christchurch City Council and Wellington Water.

Rico Parkinson has over 14 years' experience in the water engineering industry. Rico is Chartered with Engineering New Zealand and the Team Lead for Stantec's Christchurch Water Civil Team. With extensive experience in renewal design throughout New Zealand and overseas he is known as a go to person for pipeline renewals within Stantec.

1 INTRODUCTION

A typical wastewater or watermain pipe gets buried in the ground for 100-years and hopefully never seen again. It's no wonder that we have such a massive infrastructure deficit when there are many other, more exciting, visible projects that are competing for funding from local councils. The New Zealand government has acknowledged this problem by starting to implement reform of the water sector. The United Kingdom faces a similar problem, although the reason typically is caused by privatised water suppliers trying to maximise the useful life in pipelines.

Many New Zealand councils have completed investigations and studies to understand the state of their networks and estimate when they need to theoretically replace assets. In many cases looking at these plans, graphs, and maps the reader is faced with a sea of red indicating assets overdue for renewal, like the graph in Figure 1 below. This data highlights the reality of the infrastructure deficit our communities are facing, and decision makers are left with the question of "when the problem is so big, where do we start, how do we get the most bang for our buck?"

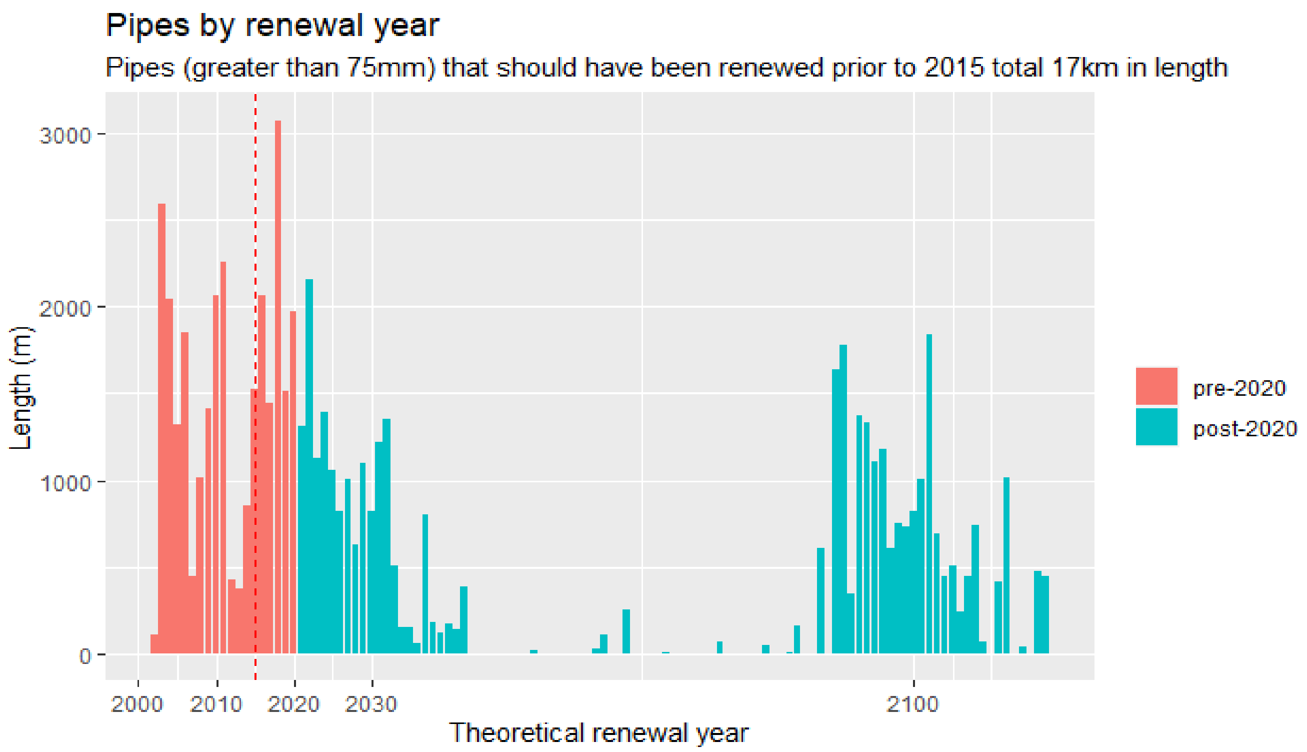

Figure 1: Graph of Water Pipes Renewal Dates in Wainuiomata, Wellington. (Stantec)

This paper outlines how Stantec has been helping clients around the world with the "bread and butter" work of pipeline renewals. Working with clients, Wellington Water (WWL) and Southern Water in the UK, to create renewal programmes to best meet their budgets and targets. This paper discusses two different approaches taken both with the desired outcome of maximising the reductions of bursts and outages.

2 WELLINGTON WATER RENEWALS

2.1 BACKGROUND

New Zealand government provided post-COVID Stimulus Funding to WWL, of which $15.4M was allocated to region-wide renewals. Stantec was engaged through the WWL Consultancy Panel to undertake the delivery for a portion of this with early contractor involvement alongside two panel contractors Construction Contracts Limited (CCL) and E.N. Ramsbottom (ENR). The combined consultant and contractor team was allocated a work package with a budget of $4.1M for Hutt City Council (HCC) in the Wainuiomata catchment. Figure 2 below shows the location of the project as circled in orange. The purpose of this project was to deliver a pipeline renewals programme that would reduce water supply outages to customers and reduce wastewater overflows from the network.

Figure 2: Location of Project, Wainuiomata, Wellington.

Stantec worked with WWL at the start of the project, preparing a proposal, reviewing the content and format of the delivery plan and the tender assessment process. This was to ensure efficiency and a fast-tracked approach to renewals.

The team undertook the delivery of the renewals package in three phases:

1. Asset assessment and prioritisation of renewals to match the budget. This is the focus of this paper. This phase is broken into the following sub-phases:
   - Data Collection
   - Long List Assessment
   - Short List Refining
2. Design and procurement, which was executed in a streamlined approach.
3. Construction and Construction monitoring and contract administration.

2.2 DATA COLLECTION AND REVIEW

To answer the "where do I start?", Stantec had to review existing information on the assets. Stantec received reference information from WWL and utilised open-source data which was collated using ARCGIS. The asset assessment involved bringing all the relevant data into GIS. The following information was provided by WWL for review:

- Asset condition
- Network fault data – burst history (water), overflow and blockage history (wastewater)
- Population projection
- Existing Capital Programme – theoretical renewal year
- Critical mains
- Water Supply Pipe Risk Assessment procedure
- HCC Water Pipes Risk Assessment Database
- Wainuiomata Zone Management Plan – water supply network hydraulic model, recommending storage options.
- Wainuiomata and Rossiter Ave Long term Flow and Overflow Monitoring Annual Report and I&I Assessment
- Wainuiomata Wastewater Options Report Final – a modelling analysis of the existing and future
- Predicted performance of the Wainuiomata wastewater network, recommending pump station and storage improvement options.
- Wainuiomata Wastewater Options Maps.

ARCGIS provided a platform to quickly create, visualise, and analyse asset properties assets for renewal prioritisation. Once the data was collated, Stantec was ready to create a long list to then discuss with WWL stakeholders.

2.3 LONG LIST ASSESSMENT

Using the data available Stantec created an asset selection process made from several simple logic scenarios based on the data. The selection process was then automated in GIS using the source data to enable a repeatable application for future use in other areas. If required for further use within WWL it created an "off the shelf" process for determining a long list for renewals. This initial selection process answered the question of "where do I start?", and the wave of red shown in Figure 1 reduced to a smaller list. This process is discussed in greater detail below.

2.3.1 WATER

The agreed activity brief set out two goals: to reduce leakage and to address the number of water outages impacting customers. Leakage was addressed by a selection criterion of sizing, master planning, condition grade, and pressure.

The selection criteria considered pipes greater than 75mm and less than 525mm in diameter, with a condition grade of 5 (pipe were given a 1-5 grade with 5 being the worse condition), and which should have been renewed prior to the current date according to the theoretical renewal year. Pipes that met these criteria are labelled "overdue". Targeting pipes with high repair frequency based on data for historic breaks did not suggest any single obvious area of Wainuiomata to target works in, because there was no single obvious area, several areas were then taken forward for further consideration in the long list.

Analysis of water outages impacting customers was also considered in the assessment by completing a criticality grading on the network. This grading considered the number of customers losing pressure or customers and/or key customers to completely lose supply if a particular pipe was out of service.

Four potential areas were identified in Figure 3 for further investigation as the long list, where there was a high correlation between water main age, material, and number of repairs. The majority of the water supply pipes identified for renewal were constructed from Asbestos Cement in the 1960s.

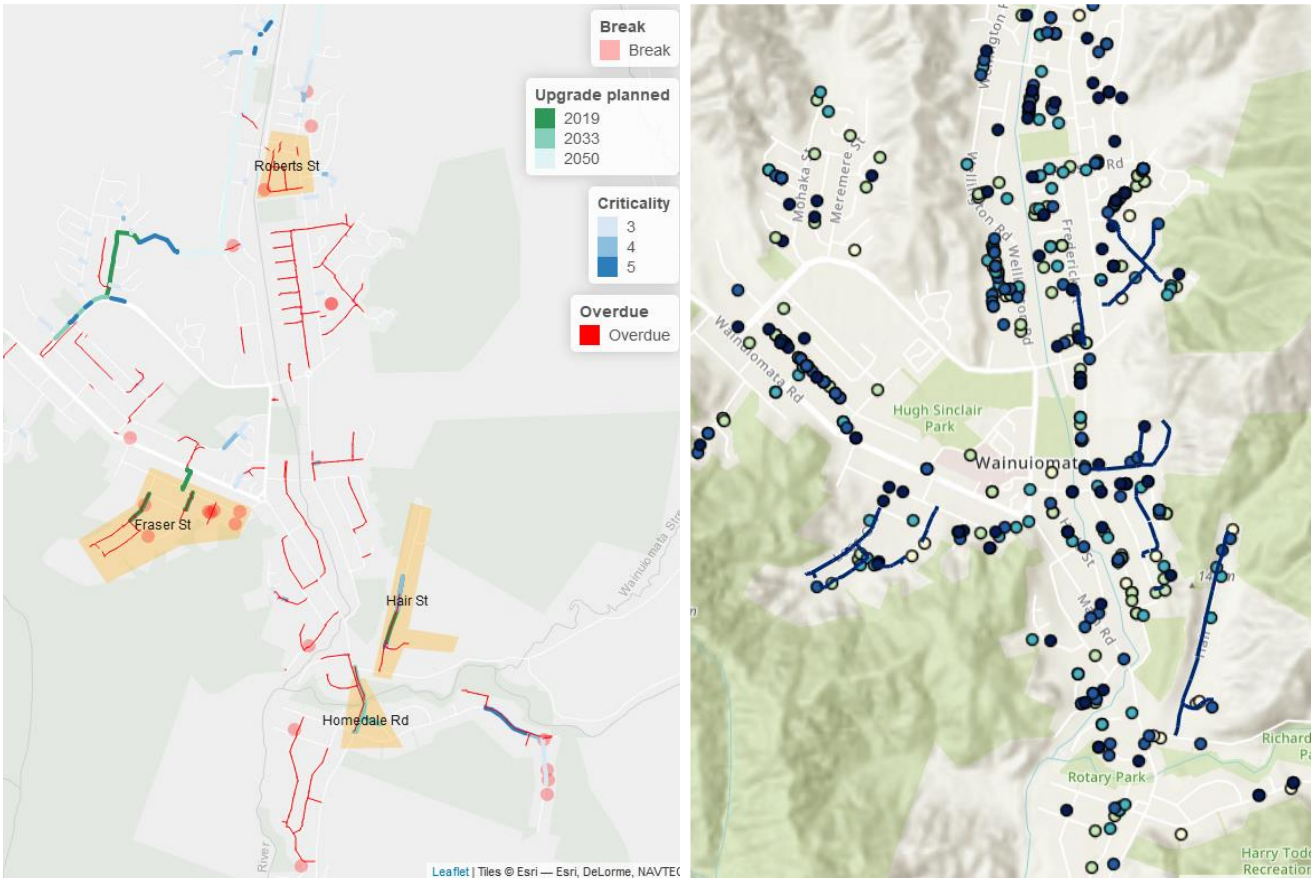

Figure 3: Water Supply Pipes "Overdue" mapped (left) and Repair map (right)

2.3.2 WASTEWATER

The overall objective for wastewater was to reduce wastewater overflows from the network. This was to be achieved by renewing pipes in areas with high inflow and infiltration (I&I). Priority was given to Moohan Street sub-catchment followed by Fraser Street sub-catchment as the areas were identified in the Wainuiomata options modelling report and maps as areas with high I&I.

In these sub-catchments, the selection criteria considered pipes of structural condition grades of four or above, pipes exceeding their useful life or having a remaining asset life of less than five percent and with a poor service condition grade. A map of wastewater pipes is shown in Figure 4.

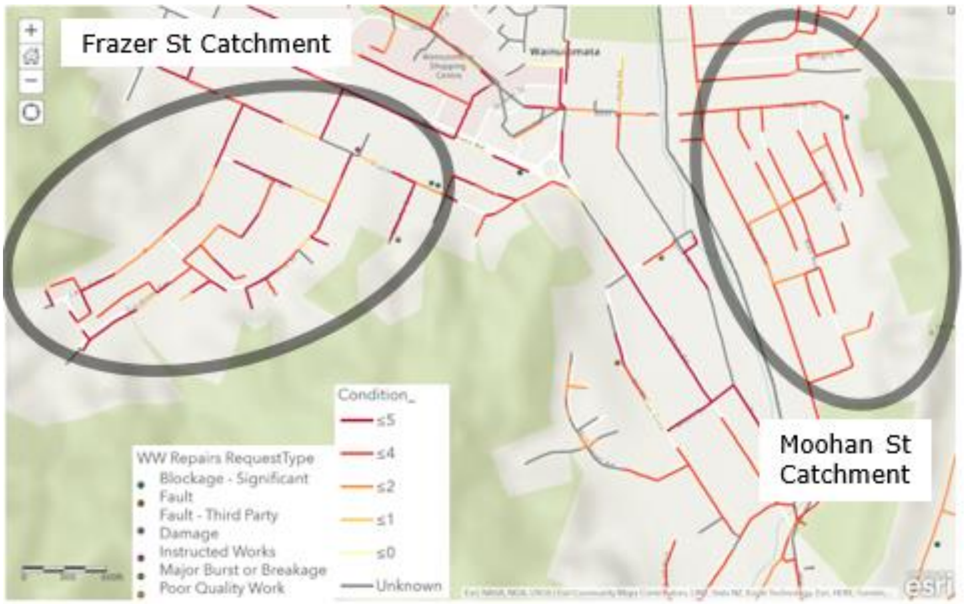

Figure 4: Wastewater Pipes Condition and Repairs mapped

2.4 SHORT LIST REFINING

Stantec issued a set of GIS maps with a recommended "long list" of renewals identified for further discussion with stakeholders. The key outcome of this phase was to refine the list to get the most "bang for our buck". The assets identified at long list stage are illustrated in Figures 5 and 6.

Figure 5: Moohan Street sub–Catchment Renewal Long List

Figure 6: Fraser Street Catchment Renewal Long List

Stantec worked directly with the contractors from an early stage in this project, utilising their experience from previous renewal works carried out in the area. Contractors undertook an assessment of their preferences of renewals to undertake at the long list stage and completed site visits to confirm the preferred method of renewal. Four methods of renewal were used: horizontal directional drilling, pipe bursting, PVC spiral wound lining and open trenching. All water supply mains were renewed using directional drilling. Wastewater mains were renewed with pipe bursting as the preferred method, when appropriate other methods were used, lining when existing material was AC and open trenching when depth of existing pipe was shallow. WWL had targeted to align water supply renewal locations with proposed wastewater renewals to increase efficiency working in one area and minimise customer disturbance. However, this approach was not able to be implemented as when discussed with the Contractors, there was reduced benefit in aligning them because using different contractors, at different time, using different methods removed any efficiencies that might have been achieved. Customer disturbance was minimised by using trenchless technologies where possible.

Continuous lengths were identified within the selected areas to consolidate efforts. Renewals targeted roads with lower traffic volumes and excluded pipes in private properties, growth areas where upsizing may have been required and trunk mains. In particular, for wastewater renewals due to the unknown location of I&I issues in the sub-catchments, avoiding these assets helped to maximise the length renewed.

There were several internal stakeholders from WWL with interest in this project that participated in a series of workshops to review the long list. Internal stakeholder parties included WWL's Network Engineering Team, Service Planning and Customer Operation Group. All parties wanted to maximise renewal impact to meet the available budgets.

To confirm the shortlist, additional design related activities were progressed encompassing all long list assets, including a capacity check, geotechnical, contaminated land, and archaeological desktop review and survey investigations (manhole level, CCTV and geotechnical site investigations for global dewatering consent). The water supply and wastewater assets identified at shortlist stage and progressed to detailed design are illustrated in Figure 7 on the following page.

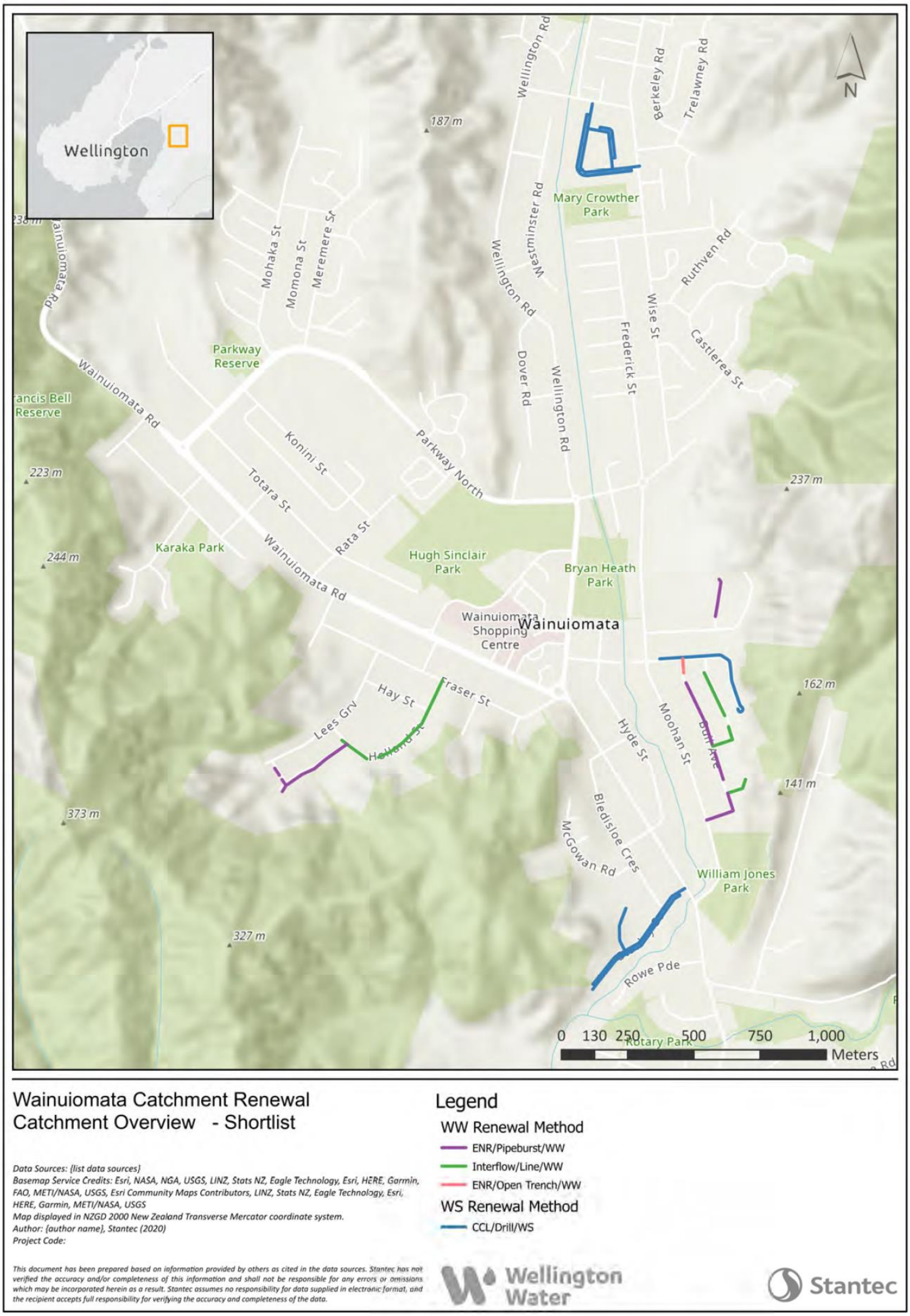

Figure 7: Water Supply and Wastewater Short List

2.5 KEY RISKS AND MITIGATIONS

This method of asset assessment and prioritisation helped to mitigate several key risks associated with delivering a project in this manner. Two key risks were late project delivery and not selecting the highest priority pipes for renewal.

The risk of the project being delivered late was addressed by the development of a collaborative approach working with contractors and the project team to align with WWL objectives. The delivery method addressed normal project bottlenecks with stakeholder input. Working through the shortlist period quickly and hosting a workshop where all stakeholders were invited to provide their insight in the same room. WWL's Internal stakeholders were involved with a series of workshops from kick off through to the long and shortlist selection, safety in design and delivery plan workshops.

The second key risk posed by this method of asset assessment and prioritisation is that the renewals selected were not the highest priority pipes. The team agreed not to deliberate over the highest priority pipe, to prioritise renewals using the data assessment tool and only consider assets that the contractor could move quickly on, using trenchless renewal methods wherever possible. This was done to avoid any renewals that required landowner approval, or resource consent or further intrusive investigations. While GIS tools were used to undertake the largest proportion of scaling the scope to meet the construction scope, stakeholders familiar with the networks were engaged with before finalising the renewals plan. The design team worked to seek approval from the network engineering team before issuing a scope to the contractors for construction. There was also an element of acknowledging that it was ok if the pipes being renewed were not the highest priority. This process was about balancing a reasonable amount of assessment and design effort, applying consistent, sensible rationale and overall achieve the desired project outcomes.

3 UNITED KINGDOM RENEWALS

3.1 BACKGROUND

The water industry in the United Kingdom is privatised, and renewals of pipelines typically is a last resort in managing customer outages. Due to the high cost of installation and funding targets not being directly related to the replacement of old assets, an infrastructure deficit is present. Where funding is on a five- year Asset Management Plan (AMP), long term renewal programmes can be reprioritised to operational needs if short term solutions can enable the targets to be met, when this happens the deficit continues to get worse.

Water suppliers set their own targets in agreement with the regulators and are based on needs and performance of the last AMP. Southern Water had a target or promise in the AMP six cycle (2015-2020) to "provide a constant supply of high-quality drinking water", which had a sub goal of "no increase in the average time you are without water, for example because of a burst water main". This meant that as the average age of water pipes increase and the failures increase, they had to carry out a range of work to find a balance in maintaining the overall outages that occurred. This could be from pressure management, increase in operation responses and repair efficiency or by replacing assets with a high burst rate.

3.2 DATA COLLECTION AND REVIEW

Southern Water was given a level of funding based on their past performance. The more they reduce outages and achieved their goal the more funding they received in way of rewards. In turn, if they were unable to achieve their target and the level of outages increased, they faced potential penalties.

An effective way to reduce outages is to reduce the number of old assets that are failing by renewing them. However, Southern Water had to assess if they could achieve the reductions within the budget constraints. This assessment had to consider not only the burst rates of ageing assets, but the impact of these assets on customer. They had to balance up if replacing a large length of pipe that affected a large number of customers was as beneficial as a shorter length with only few customers. With Southern Water supplying water to a very large area, as shown in Figure 8, this assessment needed to cover many possible scenarios.

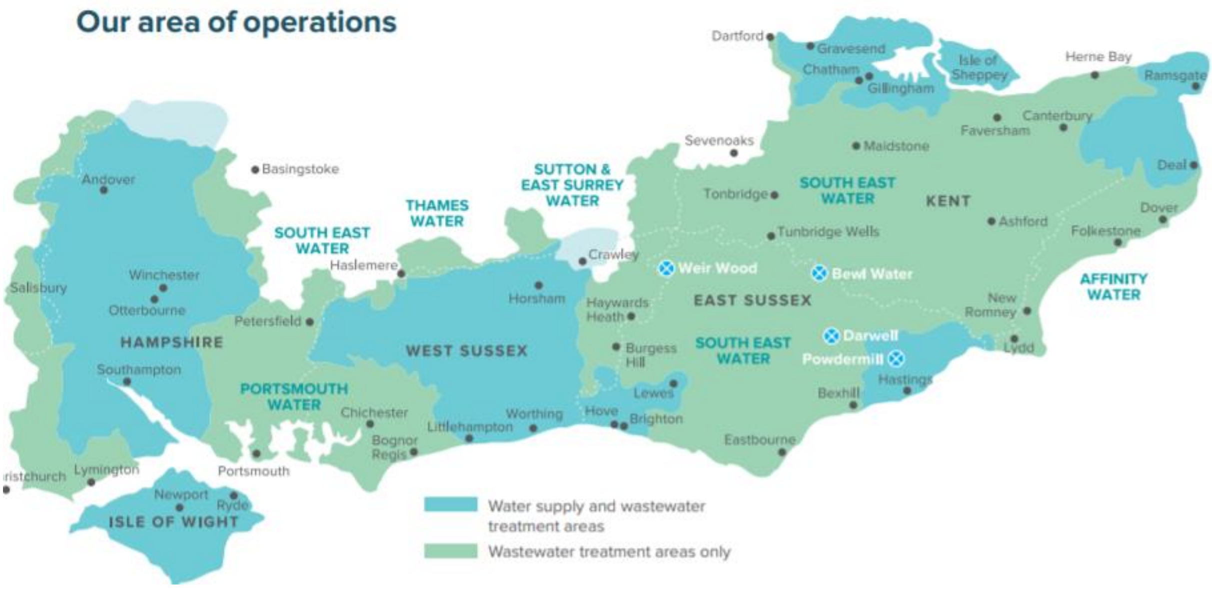

Figure 8: Southern Water's Area of Operation

To help determine if reductions were achievable, Southern Water was able to draw on their extensive data and resulting analysis, which they have collected for more than 15 years in a consistent manner. Data was available to look at any burst that had occurred, see which asset was affected, the type of failure, the outage duration and the number affected. This was readily available, along with the failed asset's basic parameters of material, age, and size.

Southern Water had extensive historic data but had not carried out condition assessments on many assets and utilised the performance history to indicate its condition. Southern water also had records of local legacy issues, such as older PVC being far more prone to failure. This information was able to be used to help better target renewals.

3.3 INITIAL LIST CREATION

Area boundaries that already existed were utilised in creating a long list of potential projects. These were the existing District Meter Areas (DMA's) which were the smallest catchments that have a catchment meter, which were used to help monitor water use and identify potential leakage prior to catastrophic failures. This broke the entire supply area consisting of more than 13,870km of watermains into more than 1350 areas. We considered each area as a possible renewal project and assessed if a possible reduction to the overall burst rate could be achieved efficiently.

To reduce to potential projects that were taken for detailed assessment, we used a simple check. Assuming an average cost per meter installation rate of ~£250/m and multiplying it by the defined areas total length of pipe and dividing it by the areas average burst rate over the last 15 years. Any area that had a £/burst less than £1,500,000 was used. This reduced the list to 435 possible schemes.

These 435 areas were then further reduced to 120 possible projects based on some simple logic statements, combined with a review of a burst map for each scheme, theses were:

- Was the five-year average burst rate higher than the ten-year average burst rate, this indicated that the area was getting worse?
- Was the total length greater than 250m (less than that can be resolved by the operations team)?
- Was there a high level of PE pipe, indicating renewals were likely to have been recently carried out.
- Have the burst rates stopped, if so, repairs or changes have likely been made?
- A review of the burst map to identify if the area had no apparent clusters, $/burst rate was unlikely to be reduced be redefining boundary.

These 120 schemes were then added to the list of 172 Asset Risk Management (ARM) boundaries. These were potential schemes identified by the operation teams where pipe replacements could be beneficial. These were identified over time and passed onto the engineering teams to assess as the solutions typically were far greater and in-depth than an operational solution could afford. They were also checked to ensure over lapping area were compared and duplicated removed. A long list of 292 possible projects had then been created.

3.4 LONG LIST CREATION

We then had a base to start to create a long list of viable and defined projects. This involved redefining the boundaries to include only the pipes of concern (ones of similar age and material) that are bursting within a DMA.

We also now needed to sort a prioritisation based on not only burst reduction but by also considering the reduction of minutes of outages to customers (calculated from outage duration and number of customers affected). A spreadsheet was created to search through the different data sources and to display this data based on the area boundaries defined. An example of this is located below.

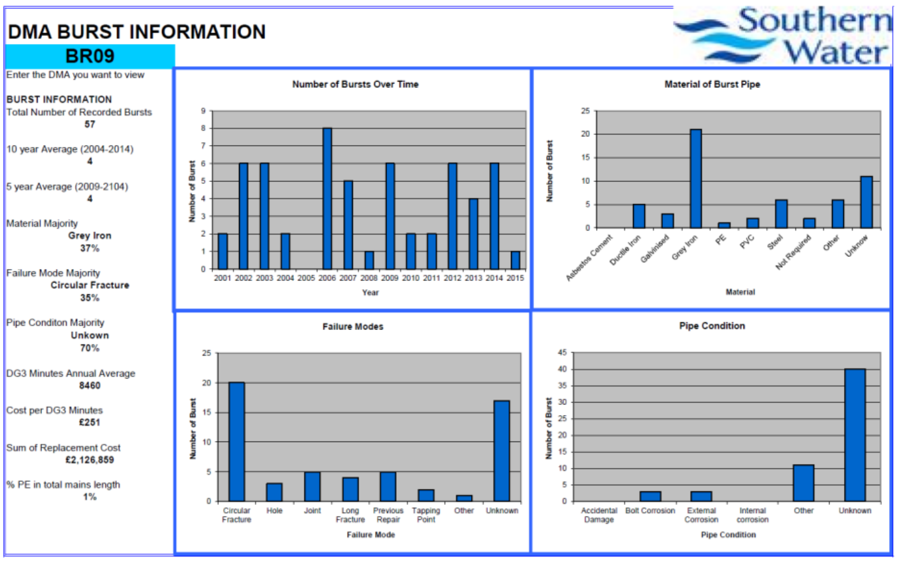

Figure 9: Spreadsheet to Summarise Areas for Review

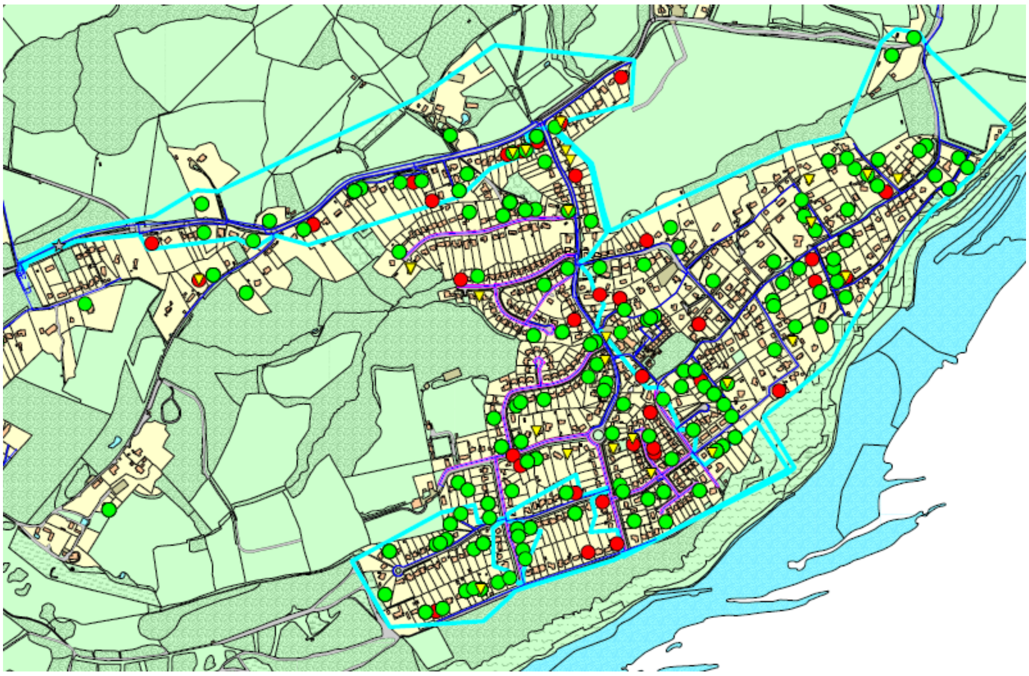

Figure 10: Renewal Scheme Concept Plan Example for Fairlight

As part of the creation of a long list of well-defined projects, the boundaries of the areas were all reviewed and refined. A concept map is shown above. This outlines the boundary (in cyan), and the burst locations were plotted to try to capture pipes that were problematic and causing bursts in the area. (The green indicates a burst up to 15 years old and the red indicates bursts less than 5 years old). This area was one of the larger schemes and was a result of the DMA catchment analysis. The area excluded in the centre was identified as being recently renewed with PE pipe.

All refined 292 possible schemes were then plotted on to a graph showing the area's £/ burst and £/customer outage minute. This enabled us to understand the potential benefit that could be achieved depending on the funding available.

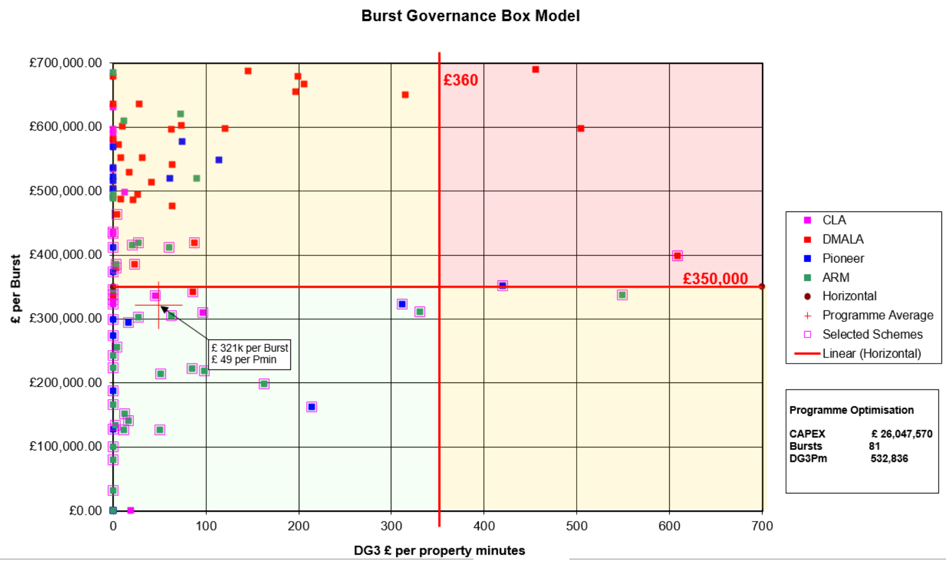

Figure 11: Burst Governance Box Model

The top 50 schemes were then selected as the long list. With a focus on the achieving the best “bang for our buck”. This was done by selecting schemes nearest to the origins of the graph. These 50 schemes were then developed further then used to create a select a list of projects to be designed.

3.5 SHORT LIST REFINING

A workshop was held with the relevant operational team to review the concept plans to determine accuracy. If there was any further information available to refine the schemes. This led to some boundaries being altered to reflect recent repairs and short length of renewals still be captured in GIS, along with changes in pressure management that may have could be shown to reducing the burst rates in the last few years.

We then produced three different scenarios of scheme grouping that were taken forward to the programme managers. These had a target budget of less than £8.1 Million to be invested in the remaining three years of the AMP cycle. These scenarios consisted of the following: focusing on burst reductions, focusing on customer outages and the lowest spent for maximum meters of pipe replaced. The maximum meters of pipe replaced was selected (i.e., closest projects to the graph origin). This consisted of 31 schemes that were then taken forward to preliminary design.

An overview and example of a preliminary design is shown below. Before carrying out detailed design these preliminary designs were reviewed with the Operational teams for each County in a workshop for each area. This ensures agreement on the extents and connection points for each project.

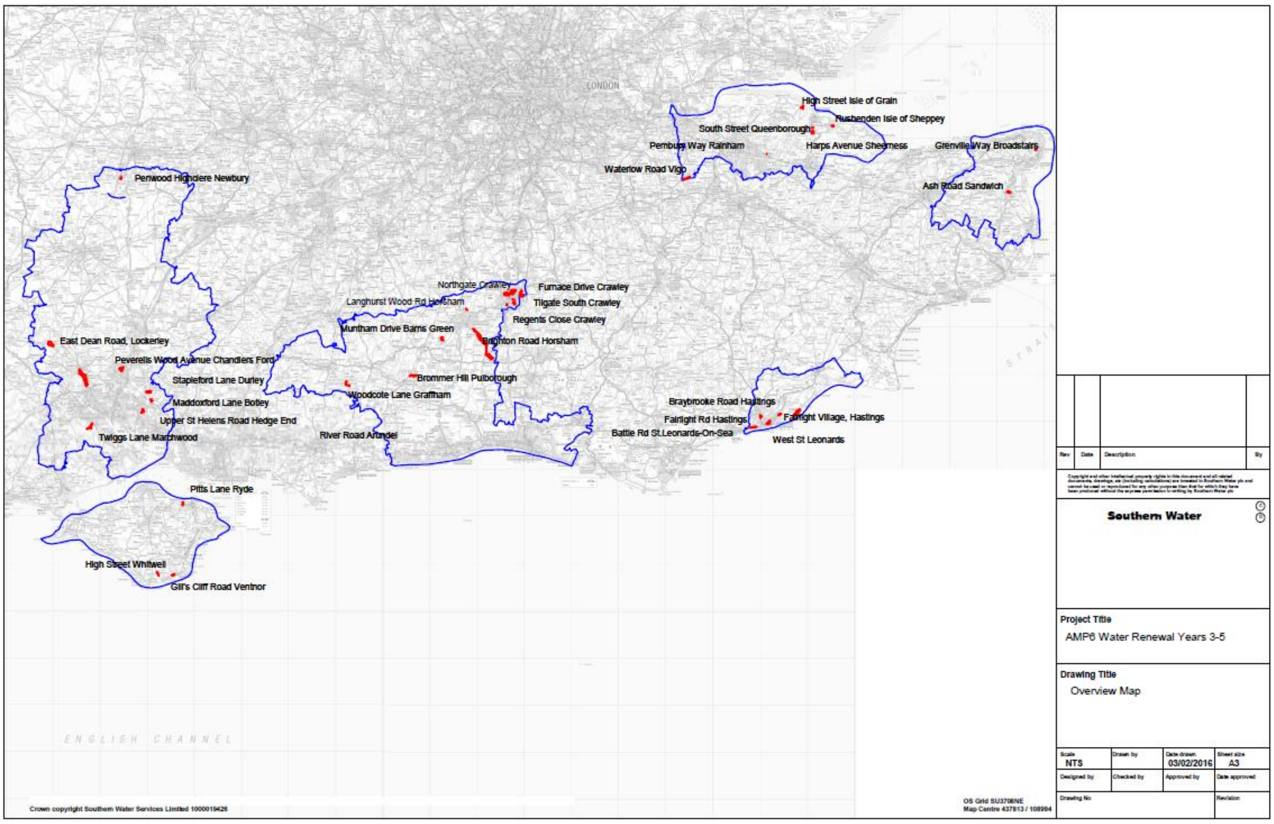

Figure 12: Overview of All Projects

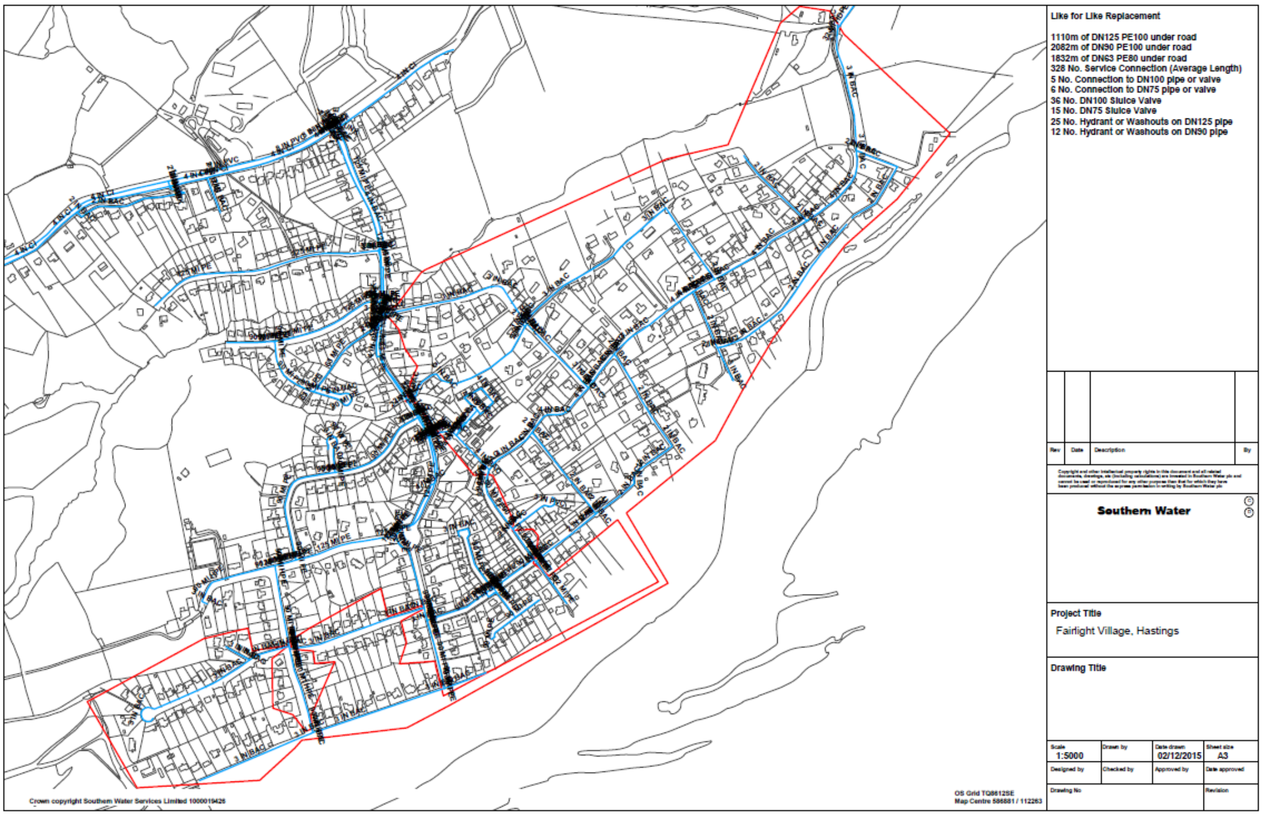

Figure 13: Preliminary Design for Fairlight

3.6 KEY RISKS AND MITIGATIONS

This method of asset assessment and prioritisation helped to mitigate several key risks for Southern Water. Two key risks discussed are how the comparison between different operational areas can cause poor funding distribution and the unknown benefits of carrying out renewals to their outage reduction target and burst reductions.

Southern Water operates in three County's, Kent, Sussex, and Hampshire. All counties had their own operational teams that prioritised their own risk and potential renewal projects. Risk prioritises changed within these different operational teams over time when staffing changed and knowledge of reasons for projects were lost. As an overall operator, Southern Water recorded projects all in the ARM register, but had no way to prioritise these between the different teams.

The prioritisation process carried out by Stantec enabled a comparison that was repeatable and took the ARM projects indicated from the different operational teams and created a prioritisation founded against tangible targets for Southern Water, this mitigated the risk of poor funding distribution between counties.

The second risk is being unable to quantify the benefit that may be achieved by renewals, this was especially problematic for Southern Water where targets, penalties and rewards were based on maintaining the number of outage minutes over the whole region. The prioritisation process Stantec created was able to indicate the benefits by averaging the past bursts and outages in the project schemes, while also ensuring there had been a positive increase of the last 5 years help to ensure the benefits of renewals would be achieved.

As part of the process, it was also considered beneficial to carry out the best value for money for burst reductions as well as customer outages, even though the tangible target was to maintain outage minutes. This was agreed on, with the understandings if the overall burst rates were reduced it would free up operational resources and funding to focus on responding to repairs causing that customer outages.

4 CONCLUSIONS

With infrastructure deficits, deciding which pipes that are recorded as poor condition or requiring constant repair, to renew can be streamlined by applying asset assessment and prioritisation tools. Clearly defining the selection criteria for condition and performance information will enable the prioritisation of pipe renewals to address the question, "where do I start". Stantec has worked through this process with clients in New Zealand and the UK to deliver successful renewal programmes.

The process taken for WWL involved targeting renewing pipes that were easy wins due to time constraints associated with the Government Stimulus funding, aiming to maximise metreage replaced, getting the most "bang for our buck". This was achievable with the work WWL had carried out on determining condition grades. Risks of programme slip were mitigated by ensuring collaboration and buy-in across the team. The risk of renewals not being of the highest priority asset was mitigated by acknowledging limitations of using GIS tools to undertake renewal prioritisation and engaging with stakeholders to confirm the scope.

The process taken for Southern Water involved targeting renewing pipes that brought the largest reduction of customer outages and achieving a reduction in bursts with the shortest length of renewals. This was achievable because of the extensive data that had been collected by Southern Water on repairs to the water network and the work in assigning them to the correct asset and quantifying the outage duration and effects of every event. The risk of being unable to quantify the benefits of the renewals has been minimised because of this historic performance data. The risk of uneven prioritisation between differing operational teams carrying out individual prioritisation was mitigated by the creation of a uniform assessment of potential projects.

These approaches can be summarised into three simple lessons, these are:

1) Data on pipe age and material can be used to help identify prioritisations.
2) Data on performance being assigned to assets, such as burst locations, outage duration and their effect help to quantify the benefits renewals may bring and enable prioritisation.
3) Prioritisation of renewals across different operational team or councils can be achieved when data is collected in a comparable way.

When we consider the original question of "when the problem is so big, where do we start, how do we get the most bang for our buck?" We can all acknowledge that the problem is big. We can start with understanding and using available data. We also need to consider further data that could be collected in the future to assist with this process. This data can be used to determine the "best bang for our buck", and the assessment and prioritisation process can be adjusted to suit the data that is available.

ACKNOWLEDGEMENTS

Dugall Wilson, Stantec Project Manager

Gareth Cowles, Stantec Project Technical Lead

Beth Parkin, Stantec / WWL Renewals Programme Lead