A JOURNEY FROM AGE BASED RENEWALS TOWARDS OPTIMISED LONG TERM CONDITION BASED RENEWALS

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ABSTRACT

Hastings District Council (HDC) has historically planned its wastewater renewals programme using an age based renewal methodology. Recent assessments of the asset age profiles, predicted backlogs and maintenance records highlighted discrepancies between the forecast age based renewals and actual asset condition and performance. The existing planning methodology predictions did not match the reality we were experiencing.

This paper discusses HDC's journey away from a purely age based renewals planning methodology towards a more robust condition and risk based renewals planning strategy enabling a responsible approach to "sweating" the asset.

The paper will discuss the steps taken in this journey towards a more advanced asset management approach including:

- Step 1: Age based asset data system analysis. This identified a substantial backlog that was in significant contrast to actual asset performance/condition/collapses/maintenance costs.
- Step 2: Collection of age based data condition. This involved range of investigation techniques including CCTV, laser and sonar profiling, core sampling and destructive testing.
- Step 3: Base asset life assessment. This resulted in an increase in the remaining life of three major asset types based on material.
- Step 4: Development of a condition and risk based renewals planning framework. Three key asset groups, based on criticality and risk, were identified and three very different intervention strategies were developed for each asset group.
- Step 5: Renewals programme development for the 2015 Long Term Plan (LTP) and 30 year infrastructure strategy.
- Step 6: Identification and implementation of improvement activities.

The adoption of this renewals planning strategy allows HDC to efficiently and responsibly "sweat" their waste water assets. It has smoothed funding requirements, enabled long term renewals forecasting in a manner that focuses risk, and ensures maximum value is achieved from the assets and renewal budgets.

KEYWORDS

Renewal planning, advanced asset management, infrastructure strategy, optimized planning

1 INTRODUCTION

This paper discusses Hasting District Council's (HDC's) journey from a predominantly age based renewals planning methodology towards a more advanced planning approach. Over the past three years HDC has developed a condition and risk based renewals planning framework that has moved renewal planning towards optimized decision making and is enabling a responsible approach to "sweating" the assets.

2 BACKGROUND

2.1 Wastewater System Overview

The wastewater system comprises a network of pipes (394km), manholes (5481), pump stations (46), control equipment, a treatment plant and long ocean outfall (2.75km). This system has been developed over many years and represents a significant community investment.

This paper focuses on the renewals methodology developed to plan the pipeline asset category renewals.

2.2 HISTORIC AGE BASED RENEWALS PLANNING APPROACH

HDC has historically planned its wastewater renewals programme using an age based renewal methodology. The age based wastewater renewal programmes were then reprioritised and adjusted to fit in with Council's road reconstruction programmes. By default this has historically seen Council's roading programme to an extent, also driving the wastewater renewals capital investment, as there was no robust evidence that investment in renewal of wastewater assets elsewhere was required. The key differentiating factor between assets such as roads and wastewater pipelines is the ease and cost associated with our ability to assess the performance and deterioration of each asset.

2.3 AGE BASED ASSET DATA SYSTEM ANALYSIS

Historically the wastewater renewal planning has been developed based on wastewater network asset information stored and managed in a Hansen Asset Data Management System (ADMS). The system records key asset information such as installation date, material type, pipe diameter, pipe length, depth, base life and assessed life.

The renewals programme planning for the Council's Long Term Plan (LTP) has historically involved the following:

- **Initial Draft Programme Development**: From the ADMS identification of assets reaching the end of the life within the planning period i.e. for the LTP 10 years.

- **Co-ordination:** Assessment of the draft age based wastewater renewals programme in relation to the roading renewal priorities and the realignment of wastewater renewals within the roading programme. In order to achieve a coordinated programme the write off of up to 15 years asset life has been permissible. The co-ordination process also identified information and data gaps which sometimes led to further condition investigations.

- **Finalisation:** Final review of the co-ordinated programme and inclusion in the LTP and annual plans.

This approach to renewals planning highlighted a number of shortcomings that led to the development of a more robust renewals planning approach. These shortcomings included:

- A lack of robust asset condition information

- A lack of pipe deterioration trends

- A roading renewal programme driving wastewater renewals prioritisation

- The assignment of asset lives based on general industry guidelines and other assumptions made without any robust evidence or documentation of basis and assumptions.

3 AGE BASED RENEWALS PLANNING INADEQUACIES

Recent assessment of the asset age profiles, predicted renewal backlogs and maintenance records highlighted discrepancies between the forecast age based renewals and actual asset performance and condition. Generally pipe condition and performance in the collection network was better than predicted by the ADMS with condition and performance of the pipe system exceeding age based predictions. This was confirmed by the relatively low levels of services faults and requests being experienced i.e. levels of services were generally being maintained in pipes beyond their base lives.

Analysis of the age based ADMS pipe information carried out in 2012 highlighted a significant potential renewals backlog in the following pipe materials; concrete, earthenware and PE liners. This gave rise to questions regarding the level of renewals investment - had HDC been underinvesting in wastewater reticulation renewals?

Further investigation and condition analysis was undertaken which indicated that the assets initially found to be in backlog were actually still in acceptable condition and their lives were appropriately adjusted. This experience contributed to the decision to review the renewals planning approach.

4 DEVELOPMENT OF A CRITICALITY AND RISK BASED RENEWALS PLANNING METHODOLOGY

As a consequence of the issues experienced with the predominantly age based renewals planning approach HDC undertook investigations into alternative renewals planning approaches. The outcome of these investigations was a recommendation to move towards a renewals planning methodology that considered asset criticality and risks/consequences of pipe failure. This recommendation was adopted and a renewals planning improvement programme was developed and implemented. The programme is discussed below.

4.1 IDENTIFICATION AND CATAGORISATION OF ASSET TYPE

A literature review was undertaken and the recommendation from the Sewer Rehabilitation Manual (SRM) to divide assets into groups based on criticality was implemented. HDC's wastewater assets have been divided into three categories;

- **Category A**; those high priority pipelines most critical to the HDC sewer network

- **Category B**; high priority pipelines but non critical assets

- **Category C**; low priority non critical assets.

The categorisation of pipelines has enabled HDC to develop and implement a variety of targeted renewals and maintenance responses dependent on asset category. The level of investigation, data gathering and analysis, intervention strategies and funding prioritisation for each category vary based on key risk factors.

4.2 ASSET CATEGORISATION METHODOLOGY

This section explains the methodology adopted for categorising the pipe assets.

4.2.1 CATEGORY A - HIGH PRIORITY CRITICAL ASSETS

The critical pipeline assets are defined as all trunk, interceptor and trunk rising main sewers within the wastewater network.

Typical features of pipelines in this category are:

- Large diameter (generally 375mm diameter or larger)
- Critical to the function of the wastewater network
- Surrounding connectivity within the network
- Service large catchments and convey significant flows
- Would cause significant disruption above and below ground in the event of structural failure
- Have a low number or no lateral connections
- Are high value assets within the network

4.2.2 CATEGORY B - PRIORITY NON CRITICAL ASSETS

Priority non critical assets are defined as non-critical pipelines in locations that require proactive renewal planning rather than a reactive run to fail approach. A set of criteria was developed to identify pipelines that fall into this category. The criteria for selection includes the following:

- All non critical pressure pipelines
- Deep (greater than 3m deep)
- Under buildings, and other structures such as railway lines
- In private property
- Servicing key community infrastructure such as the hospital
- Servicing areas of industry that are significant economic contributors to the community
- Or located in other difficult to access or renew areas.

Category B sewer assets are typically assets that are challenging to renew due to their depth and location. They are in higher risk locations or are not straight forward to renew and require specific consideration and design for renewal. These are sewers that are not trunk sewers, but in the event of structural or major service failure are considered to have a higher impact on the community and/or higher cost of renewal compared to those in Category C. These are pipelines that HDC would not want to renew reactively.

4.2.3 CATEGORY C - NON CRITICAL ASSETS

Non critical assets are defined as the general collection network in all areas except those identified as Category B. Typical features of pipelines in Category C are:

- Small diameter (generally smaller than 375mm diameter)
- General sewer reticulation serving residential, commercial and light industry
- In easy to access road, road reserve or public land

4.3 CONDITION ASSESSMENT AND INVESTIGATION

As sewer pipelines are generally below ground, condition and deterioration are not easily assessed and often require a significant investment. Inspecting all pipeline assets was not identified as best practice due to issues with the practicality, time required and cost. Therefore to assist HDC in determining the condition of its pipelines two different inspection methodologies were developed based on pipeline categorization:

1. Critical Asset Condition Assessment Methodology
2. Non critical Asset Condition Assessment Methodology

These inspection methodologies are discussed in the following sections:

4.3.1 CRITICAL ASSET CONDITION ASSESSMENT

Initially a desktop study and review of existing data including CCTV footage of critical assets was carried out. The results of this study identified that the pipe material for the vast majority of critical assets is reinforced concrete pipe and all pipes appear to have the same failure mechanism – loss of wall thicknesses due to the aggressive biological attack of hydrogen sulphide bacteria. The HDC sewer network is a very flat long network due to the topography of the area and the geographical location of the wastewater treatment plant near the coast. This results in long detention times and the creation of anaerobic wastewater by the time flows enter the critical pipelines i.e. trunk pipelines.

Due to this consistent failure mechanism, previous CCTV and condition rating scoring based on the New Zealand Pipe Inspection Manual (NZPIM) and its definition of failure was considered inappropriate data to base robust condition assessments from, therefore further investigations into the critical assets would be required.

This began an extensive CCTV, laser and sonar profiling to determine the internal profile of the critical pipelines. To determine total loss of wall thickness, laser profiling requires details of the original pipe profile including internal diameter, wall thickness and location of reinforcing cage. Unfortunately this information is not always readily available for older pipelines.

A desktop study based on the various concrete pipe manufacturing standards from 1910 onwards and consultation with the major concrete pipe manufactures in New Zealand was used as a baseline to determine profiles for various age pipes. To test the research results, pipe cores were completed at a number of sample locations to confirm actual remaining thickness along with testing in the laboratory to determine pH and remaining pipe strength. Pipe data and laser results were adjusted accordingly to correspond with core samples.

4.3.2 CRITICAL ASSET CONDITION SCORING SYSTEM

A unique scoring system has been developed for critical assets. This CCTV scoring method has been developed and used to sufficiently define, capture and quantify the internal surface condition of a pipe and provide an overall condition score for each pipe section.

The development of this scoring system has enabled HDC to better identify failure and the various stages of deterioration of the critical pipelines.

This scoring system and methodology is outlined below:

1. View CCTV Inspection footage for surface damage faults using the definitions/scoring outlined in the table and the reference photos below.

2. For surface damage faults that Score 3, 4 or 5, record the location, severity (score) and length of each surface damage fault (rounded to the nearest 0.5m).

3. Estimate background score for the remaining pipe using the scoring system set out in the table and reference photos below (note the condition of the remaining pipe is not rated under the New Zealand Pipe Inspection Manual CCTV report scoring system).

4. Summarise the data for each Section Length

5. Calculate the overall score for each section length of sewer by multiplying the fault scores and background scores by the length of pipe affected, and dividing by the total sewer length i.e.

$$\textit{Overall Score} = \frac{(D + B * (L - S))}{L}$$

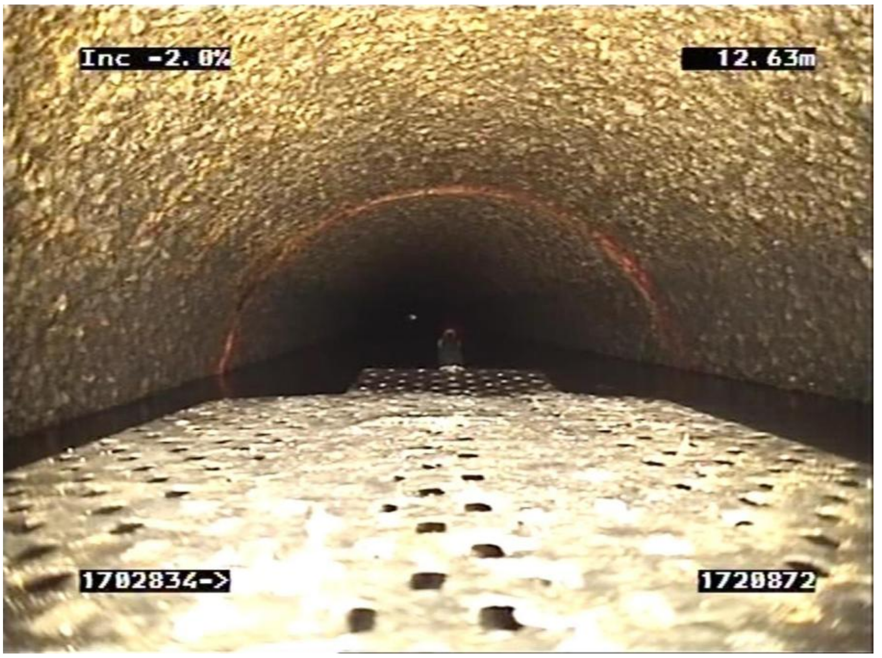
B = Background score
L = Section Length (length between manholes/ reference points)
S = Sum of surface damage length
D = Sum of the surface damage score * surface damage length

6. Group each section length into condition bands based on their Overall Score as follows:

- High – all pipe scores > 3
- Medium – all pipe scores > 2.05 < 3
- Low – all pipe scores < 2.05

Table 4-1 Critical Asset Condition Scoring

Score 1	no significant pipe wall deterioration visible	
Score 2	pipe material eroded and aggregate exposed	

Score 3	rebar staining visible but rebar not exposed and/or severe aggregate exposed	
Score 4	rebar just visible, generally less than 25% diameter	
Score 5	rebar significantly exposed, generally between 25-50% diameter	

Due to the critical nature of these pipelines HDC are systematically working through carrying out site investigations on all critical pipelines as they reach 50% of base asset life.

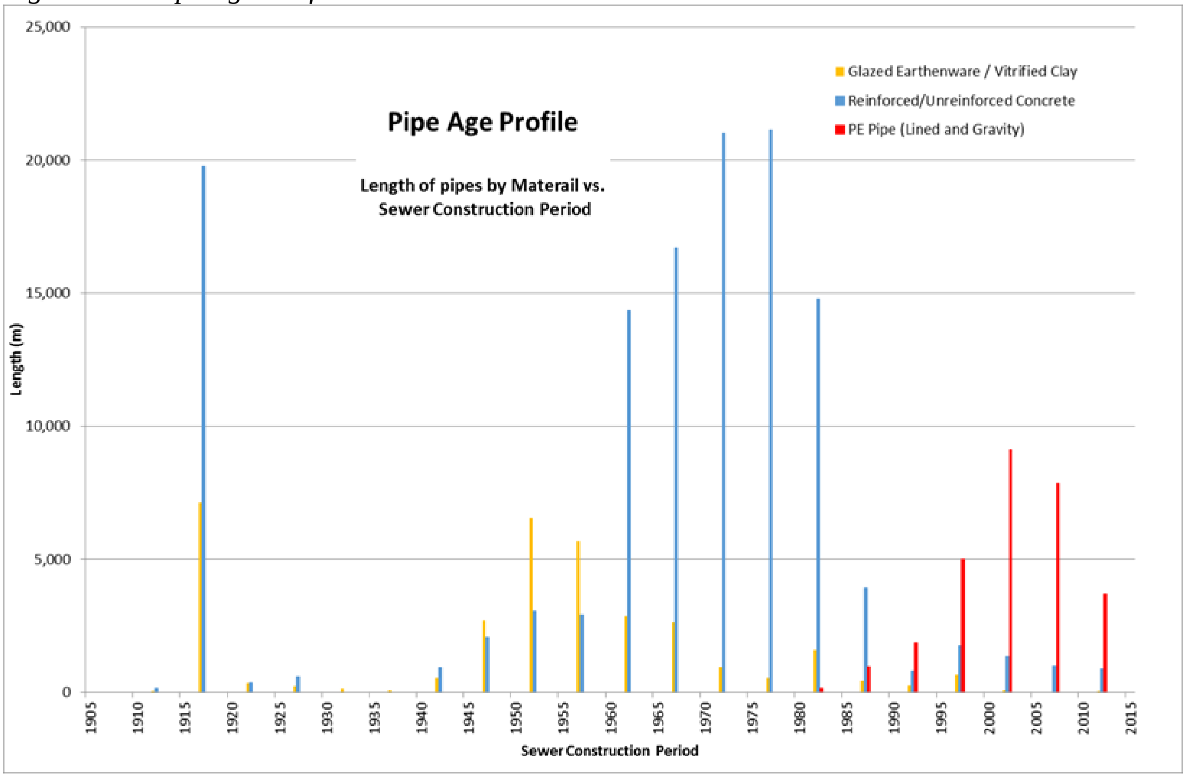
4.4 NON CRITICAL ASSET CONDITION ASSESSMENT

Following analysis of non-critical pipelines within HDCs asset data system, three materials were identified as making up a the majority of all pipelines within the renewal backlog or programmed within the next 30 years based on current assessed base asset lives. These materials, (concrete, earthenware, and PE liner) formed the basis of the data assessment and site investigations.

4.4.1 MATERIAL SUMMARY

HDC's current sewer assets were first constructed in 1910. A large proportion of the pipes are reinforced concrete, constructed between 1960 and 1985, with an initial unreinforced concrete peak around 1910 to 1915. The use of PE began after 1980 with a peak between 1995 and 2000. Earthenware has been used throughout this period, with an initial peak around 1910 and 1915, and later 1945 to 1960, but its use has tailed-off with very little if any use after 1960.

Figure 4-1: Pipe Age Profile



Note: The periods plotted are in 5 years intervals, with the data plotted in the centre of that period. Pipe data is limited to non-critical pipelines and excludes pressure pipes, pumping station pipework, vents and laterals.

PE lined, concrete and earthenware pipe materials were chosen for targeted sampling of condition using CCTV in conjunction with review and analysis of maintenance records. Although PVC pipe makes up a significant proportion of the total sewer network, PVC pipes are relatively new and are expected to have significant remaining life. The oldest PVC pipes have a remaining life beyond 30 years, a sample of these pipelines is planned over the next 10 years.

The three materials targeted for site investigation make up the following percentages of the total network:

- 9.6% PE lined sewers
- 42.7% concrete (reinforced and unreinforced)

- 11.2% earthenware

These three pipe materials cover the majority of the HDC sewer network, 63.5%.

4.4.2 INVESTIGATION METHODOLOGY

The investigation methodology to gather data on the three key materials identified within the non-critical asset group is discussed in each of the sections below.

MAINTENANCE RECORD REVIEW

Initially maintenance records were reviewed. This included review of the reactive and preventative maintenance records in an attempt to identify correlations between:

- pipe age and level of maintenance
- pipe age and type of maintenance
- pipe material and level of maintenance
- pipe material and type of maintenance

All correlations were either weak or could not be identified. Overall the total maintenance carried out was at low levels and only a small $/m.

CCTV Inspections

Existing Records

HDC had previously carried out quite an extensive CCTV investigation and pipe scoring between 2007 and 2012. These CCTV records coincidentally were primarily focused on our three key materials (as these materials are those reaching the end of the assumed base lives).

Results analysed for correlations between:

- pipe age and CCTV inspection scores
- maintenance and CCTV inspection scores

Both of these correlations were weak.

Samples of CCTV where then reviewed manually by viewing CCTV footage and inspection reports. The manual review focus was on those pipelines whose condition scored 3 or higher. That is those pipes classified as ‘moderate’, ‘poor’ or ‘fail’ under the NZPIM method.

An assessment was made on the likely remaining life of each pipeline in the sample to identify required treatments and associated timeframes. The following categories were developed to ensure consistency in approach.

Treatment

- Renew
- Repair (trenchless patch)
- Maintenance (i.e. root cutting, flushing)
- Re - inspect
- Do nothing

Timeframe

- Immediate
- 0-5 years
- 5-10 years
- 10-15 years
- 15+ years

Criteria established to classify the pipelines into the categories above which considered:

- Frequency and severity of faults
- Type and extent of cracking or break
- Condition of lateral connections onto the sewer pipeline
- Depth and extent of surface damage
- Impact of root infiltration

Results were collated, remaining life of sample pipes calculated and trends identified and applied to the non-critical pipe stock, using normal distribution (bell curves). Results of this assessment are discussed and shown in section 4.5 below.

PE Lined

It was quickly identified that HDC held no CCTV inspection records for the PE lined pipes throughout the network. This could be attributed to two key factors.

1. The PE lines are a relatively new pipe material installed approximately 20 years ago. A review of Council records indicated the aim of lining was to reduce infiltration issues and provide a short term measure to remedy structural defects of the host pipe.

2. The reduced pipe diameter associated with the lines made CCTV investigation very difficult (PE liners in 150mm diameter sewers are only 110mm internal diameter).

This meant we needed to commission a targeted site investigation for PE lined pipes. 10% of the total PE lined pipes within the network were inspected and 5% of results manually reviewed. This was considered a reasonable cost effective sample to gauge the general performance of this pipe material.

4.5 DATA ANALYSIS AND CONCLUSIONS

4.5.1 CCTV INSPECTIONS

CCTV inspection scores are not the best method for determining when a pipe is due for renewal. CCTV Inspections were undertaken in accordance with the NZPIM and scored accordingly. It was found that many of the pipelines categorised as ‘poor’ or ‘fail’ are not necessarily due for immediate renewal and often had 15 years or more of remaining life.

All reviews of data for correlations between condition scoring and what would be factors reasonably assumed to be associated with condition, such as pipe age and maintenance activities, were poor.

4.5.2 PE LINED

Assessments were made on structural performance of the PE lined pipe, based on visual CCTV inspection defect logs and likely construction method (following research on construction details and contracts).

CCTV inspection indicated the following:

- PE lined sewers were generally in sound structural condition
- Some issues with variable grade (dips), poor flow and associated debris accumulation
- Fat accumulations
- Poor connection of cut-in lateral connections with the sewer main
- Beading from pipe joints may be catching debris

The entire sample of PE lined pipes were considered structurally sound. The associated faults were limits to service issues such as lack of capacity or ragging at areas of poor jointing/interfacing with manholes, rather than a deterioration of pipe material. Any renewal requirement would be directly associated with the operational costs associated with maintenance activities outweighing the cost of capital investment over the life of the pipe.

4.5.3 EARTHENWARE PIPE

There are two clear peaks in the construction of earthenware sewers, 1910 to 1915 and 1945 to 1970. The proportion of maintenance events is slightly higher for sewers constructed prior to 1950 and may reflect the age of the sewers and associated defects over time. The average annual maintenance cost across all the earthenware sewers is $0.40/m; this is deemed an acceptable level of maintenance spend and does not support a significant theoretical backlog of pipe failure.

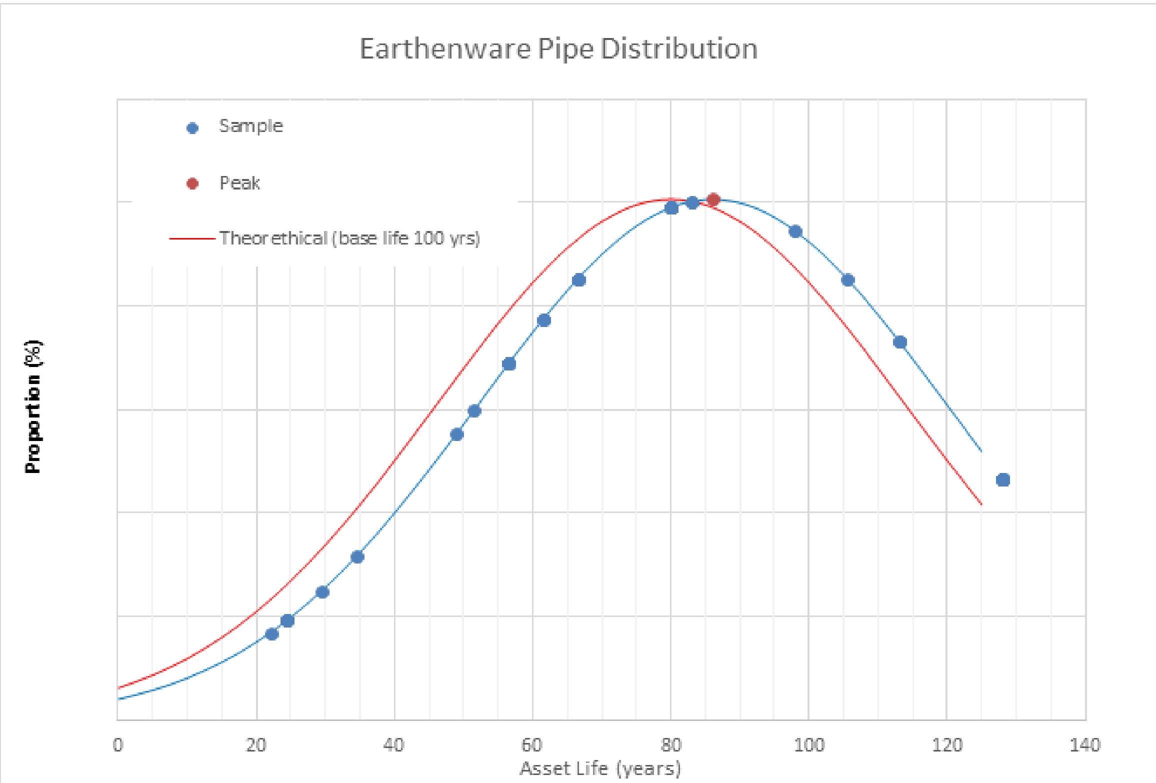
The CCTV inspection completed to provide analysis of the wider earthenware network provided a good coverage of the range of installation dates. 13.4% of the total earthenware pipes were manually reviewed and assessment made on remaining life.

Table 4-2 CCTV Review of Earthenware Pipe Remaining Life

Construction Date	1911-1920			1920's			1930's – 1950's		
Re-new in:	Sample count	Sample Proportion (%)	Smoothed Proposed Proportion (%)	Sample count	Sample Proportion (%)	Smoothed Proposed Proportion (%)	Sample count	Sample Proportion (%)	Smoothed Proposed Proportion (%)
Immediate	1	4.0	2	1	20.0	2	0	0.0	5
0-5 years	0	0.0	2	0	0.0	2	1	7.7	10
5-10 years	1	4.0	2	0	0.0	2	5	38.5	15
10-15 years	0	0.0	2	0	0.0	2	0	0.0	20
15 years+	23	92.0	92	4	80.0	92	7	53.8	50
Total	25	100	100	5	100	100	13	100	100

Construction Date	1960's			1970's Onwards		
Re-new in:	Sample count	Sample Proportion (%)	Smoothed Proposed Proportion (%)	Sample count	Sample Proportion (%)	Smoothed Proposed Proportion (%)
Immediate	1	5.6	5	1	7.1	5
0-5 years	1	5.6	10	5	35.7	10
5-10 years	8	44.4	15	1	7.1	15
10-15 years	2	11.1	20	1	7.1	20
15 years+	6	33.4	50	6	42.9	50
Total	18	100	100	14	100	100

Figure 4.2 Earthenware Pipe Sample Service Life Distributions



Following a desktop study it was determined that historically the manufacture, construction and jointing methods of earthenware pipe have been variable and it is not well understood when these methods may have changed. This may be evidenced in the results of the CCTV inspection assessment, where the older pipes appear to be in better condition than more recently constructed earthenware pipes. With this in mind a more conservative approach has been taken in the recommendation to adjust base lives.

It is suspected that many of the pipes with service lives much less than the base life have been affected by one-off site specific events, for example poor connection of a lateral or point failure due to trauma, rather than a long term pipe material deterioration.

Following review of CCTV to re inspect single point structural failures on earthenware pipes, it has been confirmed earthenware is highly susceptible to propagation of cracks, which has been observed to result in structural failure of the entire pipeline in a period as short as 3-5 years. Due to this susceptibility, approximately 27% of earthenware pipes have a service life less than their base life i.e., they should be replaced before the end of their base life.

The majority of earthenware pipes which are at the end of their theoretical economic life have at least 15 years or more service life remaining. The 1911-1929 banding appear to fit into this category.

The average service life of the earthenware pipe sample is 86 years.

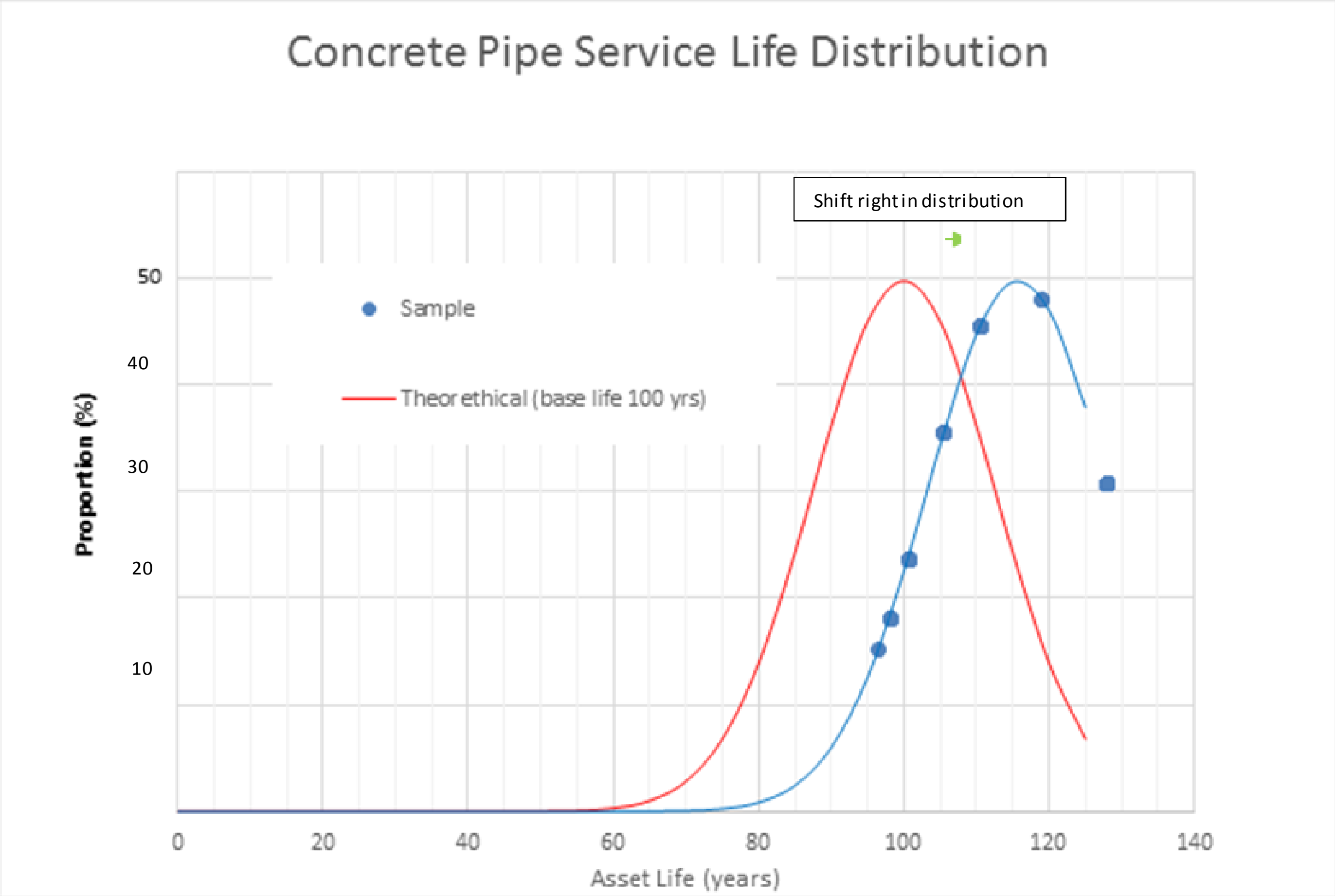
4.5.4 CONCRETE PIPE

The clear peak of unreinforced concrete pipe occurred between 1911 – 1922. The concrete pipe sample focused on inspecting these pipelines. A 7.5% sample of the total concrete pipes were manually reviewed and assessment made on their remaining life.

Table 4-3 CCTV Review of Concrete Pipe Remaining Life

Construction Date	1911-1922		
Re-new in:	Sample count	Sample Proportion (%)	Smoothed Proposed Proportion (%)
Immediate	9	8.0	10
0-5 years	20	17.9	15
5-10 years	13	11.6	15
10-15 years	14	12.5	10
15 years+	56	50	50
Total	112	100	100

Figure 4-3 Concrete Pipe Sample Service Life Distribution



It is suspected that many of the pipes with service lives much less than the base life have been affected by one-off site specific events, for example poor connection of laterals, rather a long term pipe material deterioration. Re-inspection of these pipes indicates isolated circumference and longitudinal cracking are not prone to significant crack propagation if left undisturbed.

The majority of concrete pipes which are at the end of their theoretical economic life have at least 15 years or more service life remaining. The average service life of 1911-1921 un reinforced concrete pipe sample is 115 years.

5 OUTCOMES FROM ANALYSIS AND INVESTIGATIONS

5.1 BASE LIFE ASSESSMENT AND ADJUSTMENT

Following review of the site investigation and data gathering discussed above, base asset lives were reassessed. This has resulted in an increase in the remaining life of non-critical assets of three major asset types from three material focused CCTV investigations coupled with analysis of historical maintenance data. Critical assets lives have only been adjusted where condition assessment has been carried out for that individual asset and any adjustment is specific to that individual asset.

The table below summarises the changes to the asset base lives. This work represents the beginning of the change from age based to condition based asset lives.

Table 5-1: Summary of Adjusted Base Asset Lives

Pipe Category	Pipe Material / Sewer Feature	Existing Asset Base Life	Recommended Asset Base Life	Reason for change
High – Category A	Various	Various	N/A	Condition assessed based on full CCTV inspection and investigation. The end life of individual pipe lengths will be adjusted on a case by case basis following assessment.
Medium - Category B Low – Category C	Pre 1921 Concrete (reinforced and unreinforced)	100 years	115 years	Condition assessed based on sample CCTV inspection and intervention strategy
Medium - Category B Low – Category C	All other Concrete (reinforced and unreinforced)	100 years	100 years	No change. Insufficient data collected to provide robust evidence for any change.
Medium - Category B Low – Category C	PE Lined Sewers	19 years	50 years	Condition assessed based on sample CCTV inspection and intervention strategy
Medium - Category B Low – Category C	Earthenware and Glazed Earthenware	80 years	86 years	Condition assessed based on sample CCTV inspection and intervention strategy
Medium - Category B Low – Category C	Lateral Connections	100 years	To match sewer main	Align renewal of lateral connections with sewer main.
Medium - Category B Low – Category C	Manholes	100 years	To match sewer main	Align renewal of manholes with sewer main.

The changes to the base asset lives as described in the table above are implemented in conjunction with an intervention strategy (see section 6.1 below) for each of the three pipe categories identified.

6 RENEWALS PROGRAMME IMPLEMENTATION FRAMEWORK

The implementation framework for the sewer renewals programme includes intervention strategies for each pipe category and provides a consistent approach for wastewater reactive renewals.

6.1 INTERVENTION STRATEGIES

Development of a condition and risk based renewals planning framework. Three key asset groups, based on criticality and risk, were identified and three very different intervention strategies were developed for each asset group. These are described in the sections below.

6.1.1 CATEGORY A - HIGH PRIORITY- CRITICAL ASSETS

The failure of critical pipelines to HDC is unacceptable. This provides HDC with two options

1. Significantly reduce the theoretical base life of all critical assets to minimize risk of failure or,

2. Regularly carry out proactive investigations into the condition of critical pipelines.

As these pipelines constitute a significant proportion of the total value of all pipe assets in the network they are very expensive to renew. In this instance the costs associated with proactive investigation equates to only a very small percentage of total capital costs vs. renewing prematurely.

On this basis the proactive investigation of those pipelines that have been identified as critical will be undertaken from 50% of the assigned base life. Investigation will include CCTV inspection, laser and sonar profiling, and core samples where suitable. The regularity of inspection will be determined on a case by case basis following the first inspection and assessment of condition and any other external risk factors i.e. located under State Highway.

6.1.2 CATEGORY B - PRIOIRTY NON-CRITICAL ASSETS

1. Regularly review reactive and preventative maintenance records to identify issues and inform the programme for CCTV inspection.
2. Prioritise sewers with the shortest theoretical remaining life for CCTV inspection, typically within the last 10 to 20 years of the pipes theoretical remaining life and those identified as potentially in failure mode from the maintenance records.
3. Develop a renewal programme from the CCTV findings.
4. Update asset valuations and base life accordingly.
5. On-going improvement in data quality and confidence in the data, with a focus on pipelines with the lowest level of data confidence.

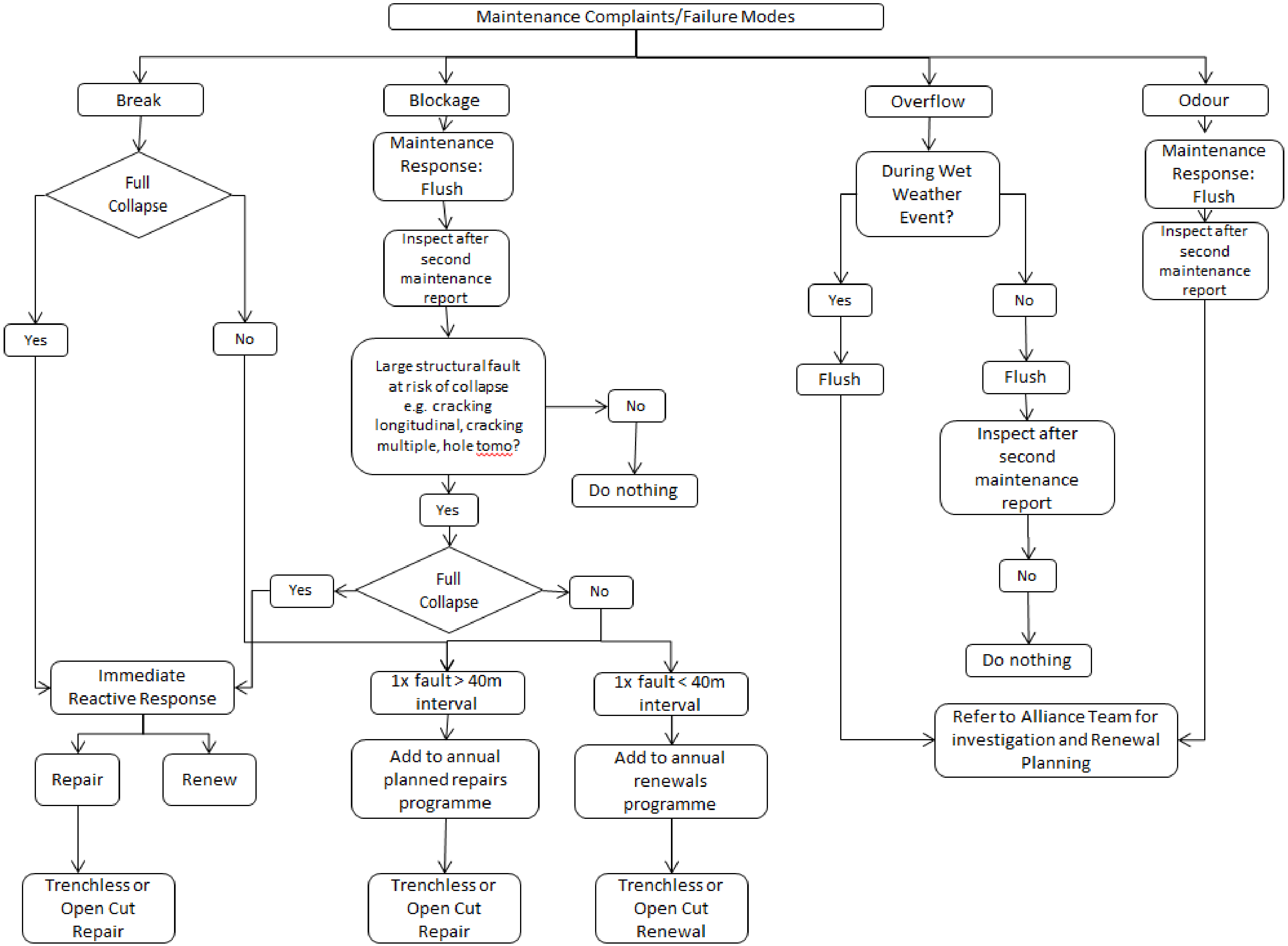
6.1.3 CATEGORY C - NON-CRITICAL ASSETS

1. Regularly review reactive and preventative maintenance records to identify issues and inform the programme for CCTV inspection.
2. CCTV Inspection of all sewers within 5 to 10 years of the end of the pipes' theoretical life (subject to funding and priority to Category B works).
3. Timed to coincide with other works such as road renewals if possible.
4. Develop a renewal programme from the above information.
5. Update asset valuations and base life accordingly.
6. On-going improvement in data quality and confidence in the data, with a focus on pipelines with the lowest level of data confidence.

6.2 REACTIVE RESPONSE TO FAILURE MODES

Category C pipe lines have been identified as appropriate to run to failure. To ascertain when renewal of these pipelines is required the definition of failure is required. A systematic approach was developed to ensure consistent decision-making to assist in determining the best course of action when a failure occurs requiring operational response. Figure 6-1 below summarises the response plan developed.

Figure 6-1 Reactive Renewal Decision Making Process



6.2.1 FAILURE MODES

Failure of a sewer asset will generally fall under:

- Service
- Structural
- Economic
- Capacity

These failure modes can be tied back to each of the operational occurrences specified in figure 6-1 above. There are many permutations on the ultimate cause of failure and how it is manifested. Some faults are specific to a particular pipe material or the nature of the installation.

SERVICE

Service faults, for example fat deposits, roots, gravel, debris, limit flow through the sewer and can lead to blockages and failure. They are generally temporary and are usually remedied relatively quickly and without excavation. There is an argument that these do not affect the life of an asset as they would not normally impact of the structural strength of the pipe. However they do attract a maintenance cost. Renewing the asset may reduce service failures, i.e. removing dips in a sewer. Service faults are not always identified in CCTV inspections as they can be reduced or removed by the pre-cleaning process.

STRUCTURAL

Pipe faults tend to be structurally related, for example pipe cracks, sewer collapse, or surface corrosion and will reduce the life of the asset. CCTV inspection tends to identify the early stages of structural failure, rather than service failures.

ECONOMIC

An economic failure of an asset could be when the cost to maintain the asset starts to exceed the net present value of its replacement cost.

CAPACITY

A capacity failure can occur when additional flows find their way into a sewer that had not originally allowed for them in the original design. These can include:

- infiltration of groundwater into the sewer through joints and cracks in the pipe
- stormwater cross-connections.

7 RENEWALS PROGRAMME

The wastewater renewals programme has been developed to include a longer term (30 year) planning horizon. Currently there is greater certainty regarding the timing, scope and budget of the renewals programme in the 10 year (LTP) planning horizon than in the 11-30 year horizon. The improvement activities discussed in the next section will help towards developing greater certainty and accuracy for the longer term renewals planning.

Historically the wastewater pipeline renewals were detailed individually by street name. The improved renewals programme divides the budgets into two key budgets (1) Planned Pipeline Renewals and (2) Reactive Pipeline Renewals.

Planned Pipeline Renewals
The Planned Pipeline Renewals comprise renewals from the Category A and B asset groups. These renewals are detailed by Name, Year and Budget in the LTP.

Reactive Renewals
The Reactive Renewals comprise a single budget line in the LTP for Category C asset group. The total budget is broken down into work packages based on reactive responses to pipe failure and the most recent condition information. The scale of the reactive renewals budget will be assessed and modified every three years based on the previous year's actual expenditure and the most recent condition analysis for this group of assets.

7.1 COMPARATIVE RENEWALS PROFILES

The figures below provide an overview of how the renewal profile has changed as a result of improved asset condition information and the modification of asset lives based on this information.

The following key points can be made about the 2012 vs.2015 renewals programme budgets:

- In the 2015 programme planned renewals is made up of Category B pipes identified in the analysis and investigation stage and includes collection pipelines and the Park Road Rising Main (previously further out in the 10 Year programme).
- The planned renewals aims to address any previously identified true backlog items in the first three years of the LTP.
- The critical asset renewal programme has addressed priority renewals over the past 2 years and includes the third phase of the Critical Trunk renewals comprising priority renewals of the three inland trunk sewers.
- The critical trunk programme has been revised in 2015 and structured around a three yearly cycle of investigation, analysis and renewal.
- This programme commenced in 2013/14. The reactive renewal budget in 2015 has been introduced as part of the new renewals strategy and is available to respond to reactive Category 3 collection network failure. The budget apportioned to non-critical assets aims to optimise asset life and service potential.
- These budgets will be revised at the next LTP cycle based on Category 3 asset performance and further condition assessment.

Figure 7-1 2015 10 Year Renewal Programme

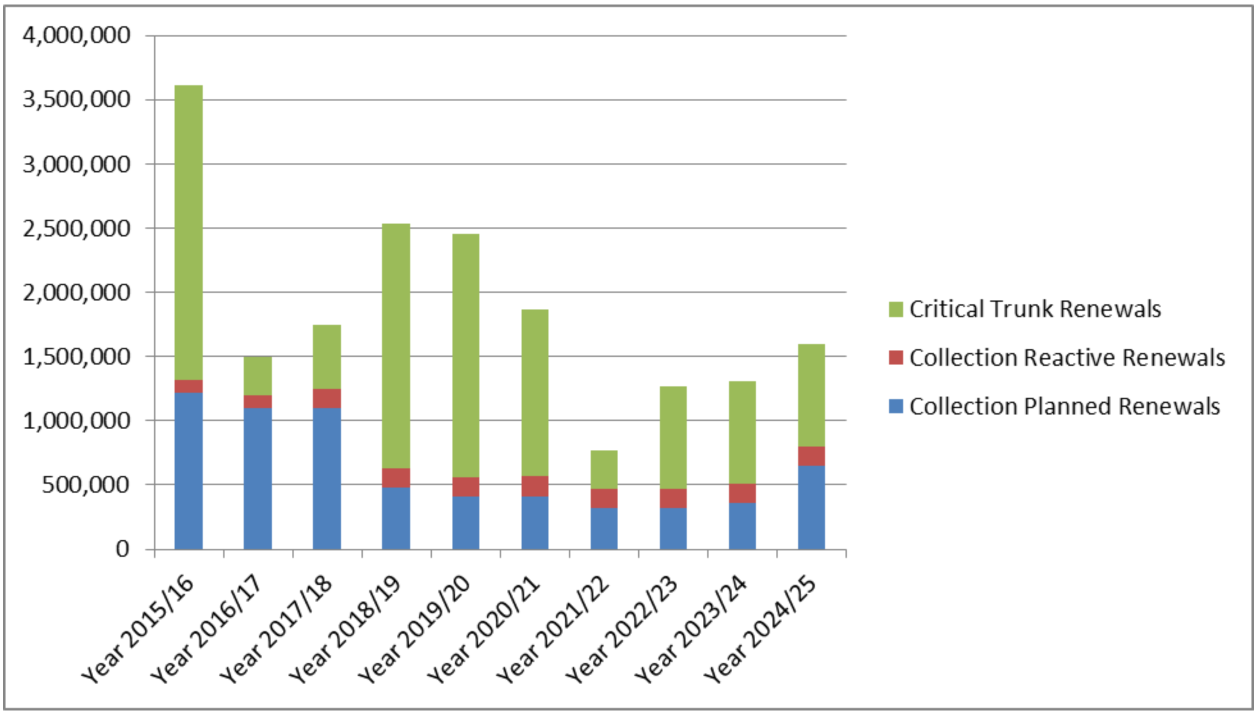


Figure 7-2 2012 10 Year Renewal Programme

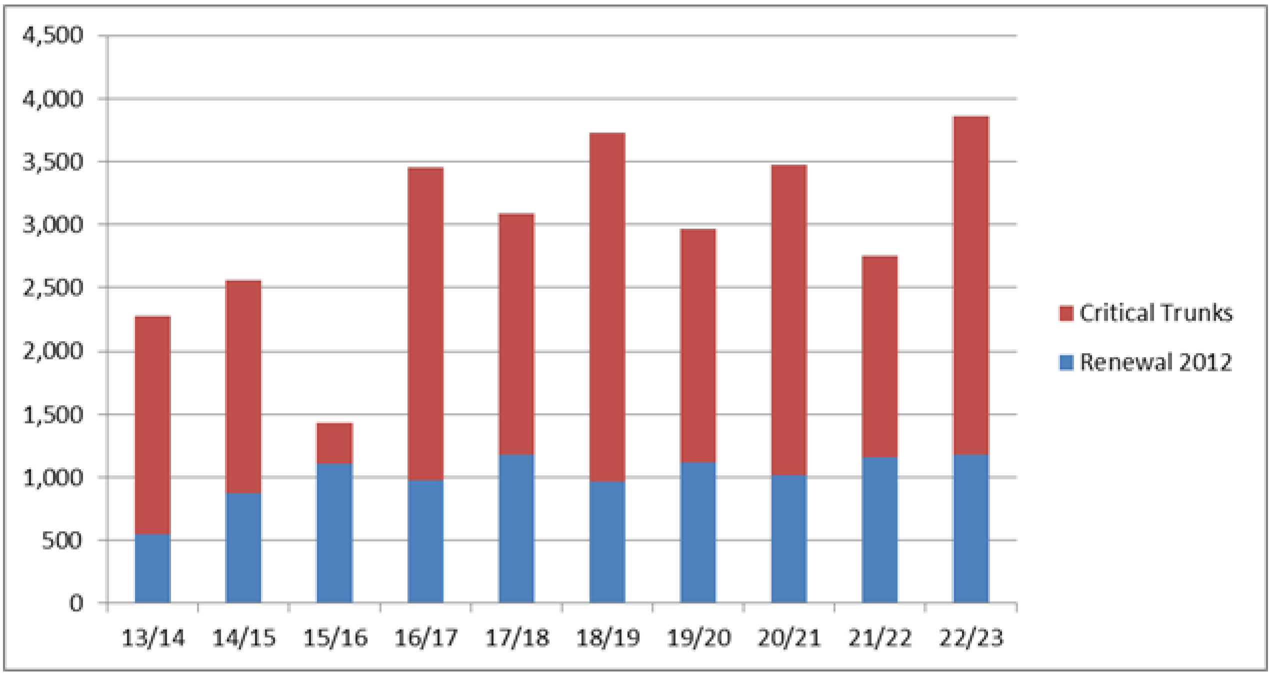
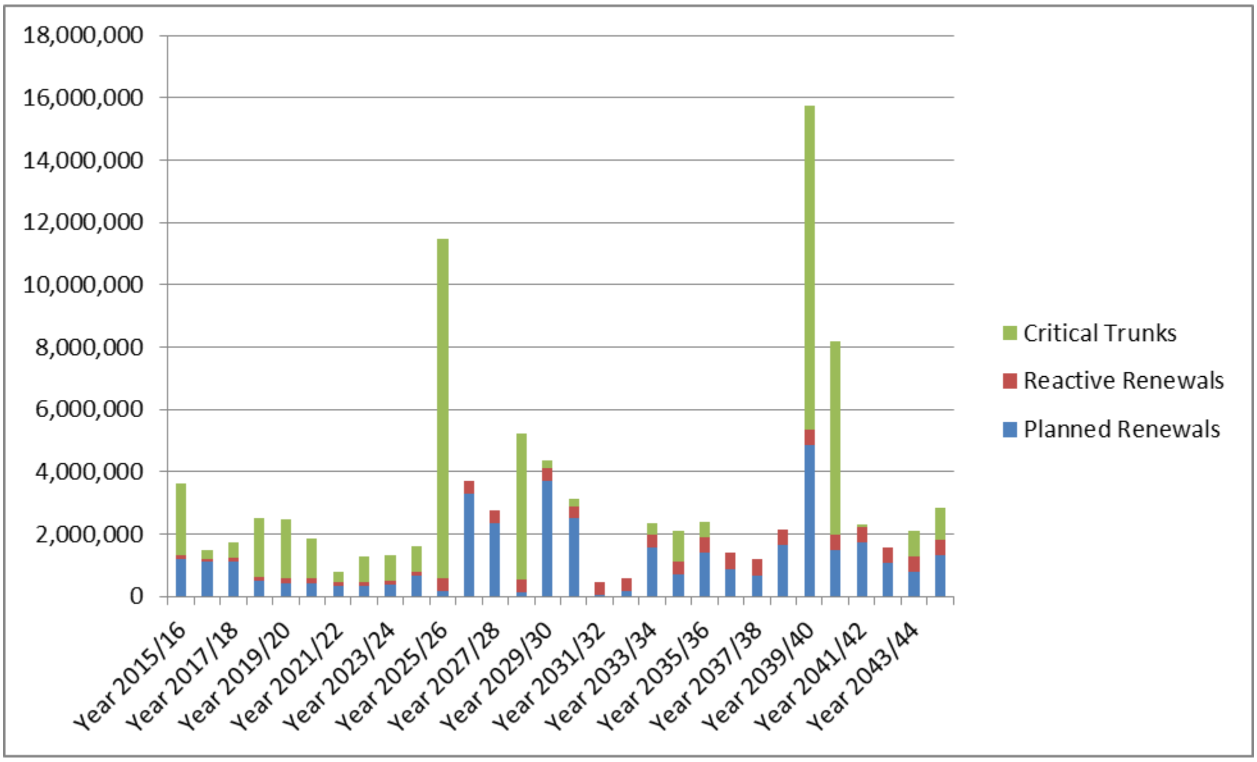


Figure 7-2 2015 30 Year Renewals Programme



The 30 year renewals budgets for the planned renewals category from years 11-30 are based on the ADMS age based date hence the significant change in profile. This will be modified based on future condition assessment and analysis.

8 IMPROVEMENT ACTIVITIES

As HDC have made the initial move from age based renewals towards optimised long term condition based renewals, a range of longer term areas for ongoing improvement and optimisation have been identified. These improvement activities are as follows:

- Improving data management and systems with the adoption of Infonet as a viewing platform for CCTV and other condition information.

- Improving field data capture through the maintenance contract i.e. faults, to enable more accurate analysis of the maintenance history through the pipelines' life.

- Align further investigations with HDC's Long Term Plan (LTP) cycle including three yearly CCTV investigations.

- Improved budget planning and optimised investment based on implementation history of reactive renewals

- Documentation of lessons learnt from consistent failure mode. For example there is a current focus on odour and septicity studies for critical pipelines and a step change in appropriate pipe materials for critical assets i.e. resistant to biological hydrogen sulphide attack.

- Ongoing improvements in operational responses to various failure modes.

9 CONCLUSION

The adoption of this renewals planning strategy allows HDC to efficiently and responsibly "sweat" their waste water assets. It has smoothed funding requirements, enabled long term renewals forecasting in a manner that focuses risk and ensures maximum value is achieved from renewal budgets.

Embarking on this journey has resulted in immediate improvements, and the identification of a range of longer term areas for ongoing improvement and optimisation throughout the wastewater system management. Our journey towards responsibly sweating our assets and optimising investment has just begun.

REFERENCES

1. International Infrastructure Management Manual

2. New Zealand Pipe Inspection Manual

3. Sewer Rehabilitation manual