RISK-BASED ASSET INSPECTION PRIORITISATION PROGRAMME

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ABSTRACT

Wanganui District Council (WDC) has been undertaking a master planning exercise for its wastewater and stormwater networks. This includes prioritising its condition assessments and renewals programmes.

In order to make sure condition assessment investments were cost effective, WDC primarily wanted to prioritise proactive CCTV inspections based on the criticality, or consequence of failure while also taking into account the age/material index of the asset. The total business risk as a product of criticality and the likelihood of failure was identified as a secondary mechanism of prioritisation. A very broad range of criteria were considered in the identification of critical assets.

The prioritised results will be used to direct condition assessments going forward in the required 30 year asset management plan.

This paper explores the methodology adopted in this project, how it differs from more routine risk based assessments and how the results were able to then be used to programme the condition assessments and subsequent renewals. It will be of interest to readers who manage network assets and wish to be able to prove they are doing so in an efficient and cost effective manner.

KEYWORDS

Criticality, risk-based, prioritisation, assessment

1 INTRODUCTION

Wanganui’s wastewater system was originally designed and built as a combined wastewater system, serving the drainage needs of both wastewater and stormwater in a single collection system with the oldest parts of the system built towards the latter part of the 1800s.

A programme of sewer separation works commenced in the 1970s to collect all wastewater flows separately from stormwater. The wastewater is conveyed to the treatment plant while stormwater is discharged directly to the Whanganui River.

The sewer separation project involved the construction of an extensive amount of new pipelines, some of these being designed as wastewater pipes and some being designed as stormwater pipes.

While asset inspection programmes have been carried by WDC, the Council were interested in developing a proactive CCTV inspection programme. This will be run concurrently with a reactive CCTV programme which will use maintenance records and results from investigations such as Inflow and Infiltration analysis to select the pipes to be CCTV’d.

This paper focuses on the development of the proactive CCTV inspection programme.

The proactive CCTV inspection programme is structured around the associated risk, targeting condition inspections and subsequent preventative maintenance and renewals to where these are most needed.

This work involved three clear phases: -

- Defining the criticality of WDC’s gravity wastewater and stormwater infrastructure.

- Defining the likelihood of failure of the gravity pipelines.
- Using the combination of criticality and likelihood to prioritise proactive CCTV inspection of gravity pipelines.

2 PHASE ONE – DEFINING THE CRITICALITY

2.1 CRITICAL ASSET DEFINITION

The term "critical assets" can be defined as ***"those assets with a high consequence of failure"*** (National Asset Management Steering Group, 2006).

Failure of such assets can cause considerable disruption to the general public (for instance a large diameter trunk main break under a major road) or a negative impact on the environment or public health (for example a wastewater pipe that bursts over a waterway).

Risk, on the other hand, is a combined measure of the consequences of failure and the likelihood or probability that such a failure will occur. Thus, it is likely that if an asset has high consequences of failure but is relatively new then it should have a low probability of failure. Such assets will only have a moderate risk of failure (due to the low probability of failure).

Similarly it is possible for an old asset in poor condition (high probability of failure) that serves only a few customers (low consequences of failure) to also present only a moderate risk of failure.

From an ideal service delivery perspective, critical assets should never fail. However, since there is always some likelihood of failure, the asset owner must be prepared to tolerate some degree of risk with respect to the failure of these assets, provided that risk is As Low As Reasonably Practicable (ALARP).

Critical assets are collectively managed to achieve an ALARP risk profile across the wastewater and stormwater networks as a whole.

2.2 CRITERIA

A range of criticality criteria were considered. These were work-shopped with WDC to determine which were most applicable to WDC and their networks and what data was available which could be used to assess the network in relation to these criteria.

The following criteria were considered: -

- **The size of the upstream Catchment.**

  Usually the diameter of a pipe is a very good indicator of the expected flow of a pipe (and hence the upstream catchment). The larger a pipeline the greater the flow that it will potentially carry. The failure of a large pipeline will potentially have greater consequences associated with flooding, cost of repair or renewal and cost related to loss of service to the upstream catchment.

  Due to the wastewater and stormwater separation works undertaken the diameter of the pipe may not always be the best indication of the potential flow in the pipe (i.e. a combined pipe that now services wastewater only will be larger than required). Wastewater and stormwater network models can be used to verify this criterion.

- **The depth of pipes**

  Deeper pipes are generally more expensive to repair or renew and are more likely to be below the water table.

- **Pipelines Under Buildings**

Failure of pipelines under buildings can: -

  - Pose a health and safety risk
  - Cause significant disruption to the building occupants.

  In addition renewal and repair costs can be very high.

- **Pipelines Along or Adjacent to Slopes**

Slips resulting from a wastewater or stormwater failure can cause significant damage to adjacent property. The repair or replacement of these assets as well as the rectification of the damage caused by a slip can be very difficult and expensive.

- **Soil Type**

The consequence of a failure can vary depending on the soil type. Where pumice and sands are present even a very small leak can create a very large void under the ground creating a significant safety risk. After some consideration in respect to the critical definition it was decided that this criteria relates more closely to the likelihood of the risk.

- **Pipelines Under Heavy Trafficked Areas**

Failure of pipelines under roads with high traffic volumes can cause significant disruption to the community.

- **Pipelines Crossing Under Railway Tracks**

Failure of assets within the railway reserve can cause significant disruption to rail operations. These assets can also be more difficult to repair. There are two rail lines in Wangnaui, a local line and the main trunk line. Works in these areas require co-ordination with OnTrack.

- **Pipelines Crossing Natural Gas Pipelines**

Failure of pipes under or adjacent to a natural gas pipeline serving significant numbers of customers can cause significant disruption to the community. There are two high pressure gas lines in Wanganui, working near these gas lines requires co-ordination with Vector and specific Health and Safety protocols.

- **Pipelines in High Pedestrian Area**

Failure of pipes under footpaths or pedestrian malls with high pedestrian volumes can cause significant disruption to the community.

- **Pipelines Near Water Courses**

Failure of a wastewater pipe located near a watercourse could cause untreated wastewater to flow into the watercourse. Likewise, depending on location repairs or renewal could be very expensive.

- **Critical Customers**

Failure of pipes serving critical customers can lead to significant disruption to entities providing important social, cultural or economic benefits to the community and may also pose a significant public health risk because of the nature of the wastewater being conveyed (e.g. a hospital)

2.3 CRITICALITY GRADES

As mentioned earlier, application of the criteria above simply identifies those assets that are considered to be critical based on those particular criteria. However, some assets within a broad asset type will have greater consequences of failure than other assets of the same type. A large wastewater pumping station serving large numbers of properties will naturally have higher consequences of failure than a small pump station serving only a few houses. Likewise, trunk mains generally serve a large number of customers so should have a higher criticality grading than other smaller mains serving fewer customers. Thus, it is appropriate to implement a grading system for asset criticality.

The number of grades used for criticality assessments is dependent on the quality of the input data available and the purpose of the criticality assessment. If too many grades are selected, the differential between each grade becomes blurred. If too few grades are selected the criticality resolution becomes low which results in insufficient information to make informed prioritisations.

Through consultation with WDC, four grades of criticality were selected for this assessment. The selected criticality grades or rankings are set out in Table 1.

Table 1: Asset criticality grades

Grade	Criticality Description
A	High Criticality
B	Medium Criticality
C	Low Criticality
D	Very Low

The grading system (represented by colour coding) shown in Table 1 was used in depicting the various asset criticality grades on the GIS maps.

A benefit of ranking asset criticality by grade is that different renewal triggers or thresholds can be applied to assets of differing criticality grading. This leads to improved investment decisions where maintenance and renewal funds are expended as a matter of priority on those assets with the highest degree of criticality.

2.4 CRITICALITY ASSESSMENT

Each of the criteria were assessed and mapped individually. These maps were used in workshops to review the assessment, adjusting the scoring system which was used and to define the preliminary basis of what weightings should be applied to each asset. Using this scoring system and weightings an overall criticality was determined for each asset (multi-criteria analysis).

While some pipes may have been determined as high criticality based on the depth criteria, overall once taking into account all criteria deeper pipes would only be considered high criticality if also considered critical based on a second criteria.

Table 2 below shows a breakdown of the grades within each criteria (which were given a score), these scores were multiplied by the weighting determined for each criteria and added together to give an overall criticality. The overall criticality was mapped and different ranges were determined for each of the overall criticality grades.

Table 2: Criteria Scoring and Weighing

Criteria	**Scoring**			
	Very Low Criticality	**Low Criticality**	**Medium Criticality**	**High Criticality**
Pipe Diameter	<300mm	>=300 and <=375	>375 and <600	>600
Pipe Bridges or Tunnels	All Others			Pipe Bridges or Tunnels
Pipelines under buildings	All Others			Under Building
Pipelines crossing natural gas pipeline	All Others			Near HPGL
Pipelines crossing railway tracks	All Others	Wanganui Line		Main Trunk
Assets serving critical customers	All Others		Schools and other Civic Buildings	Hospitals, and Top Trade Waste Industries
Pipelines in high pedestrian usage areas	All Others			Central Commercial Zone
Pipelines under heavily trafficked areas	All Others	Collector	Secondary	National
Watercourses	All Others	Near River	Near Minor Waterways	Near Virginia Lake, Crossing or under River or Waterway
Pipelines along or adjacent to steep slopes	All Others			Pipes in or along the top of slopes with 20% grade or greater.
Pipe depth	All Others			>3m Deep

The resultant overall criticalities were reviewed at a workshop with WDC to ensure that the results of the assessment: -

- concurred with anecdotal information and historical knowledge provided by staff
- accurately reflected relative criticality while

- provided a practical spread.

While the level of criticality of an asset is of greatest importance, the number of pipes in each category is also essential. Having a very large proportion of high and medium criticality pipes would provide very little advantage in the subsequent CCTV prioritisation.

2.4.1 HIGH AND MEDIUM CRITICALITY ASSETS

From an ideal service delivery perspective, these are the most critical assets and should never fail. However, since there is some likelihood of failure, some degree of risk with respect to the failure of these assets must be tolerated, provided that risk is As Low As Reasonably Practicable (ALARP).

These assets have been divided into the two subsets (high and medium) to allow for a higher resolution of prioritisation for inspections, maintenance and renewals (i.e. high criticality are higher priority than medium).

2.4.2 LOW CRITICALITY ASSETS

These are assets where failure has a greater impact than those assets given a very low criticality score.

Some failure of these assets may be acceptable but measures should be in place to reduce the likelihood / frequency of failure of these assets.

2.4.3 VERY LOW CRITICALITY ASSETS

It is not worth preventing the failure of very low criticality assets unless there is a compelling economic reason to do so, or the frequency of failure is causing unacceptable customer or operational nuisance. This means that very low criticality assets are:

- Not preventively maintained.
- Only reactively repaired to return the asset to service following failure.
- Only renewed or replaced when it is economically optimal to do so, or when warranted by repeated failures causing intolerable nuisance to customers or network operations.

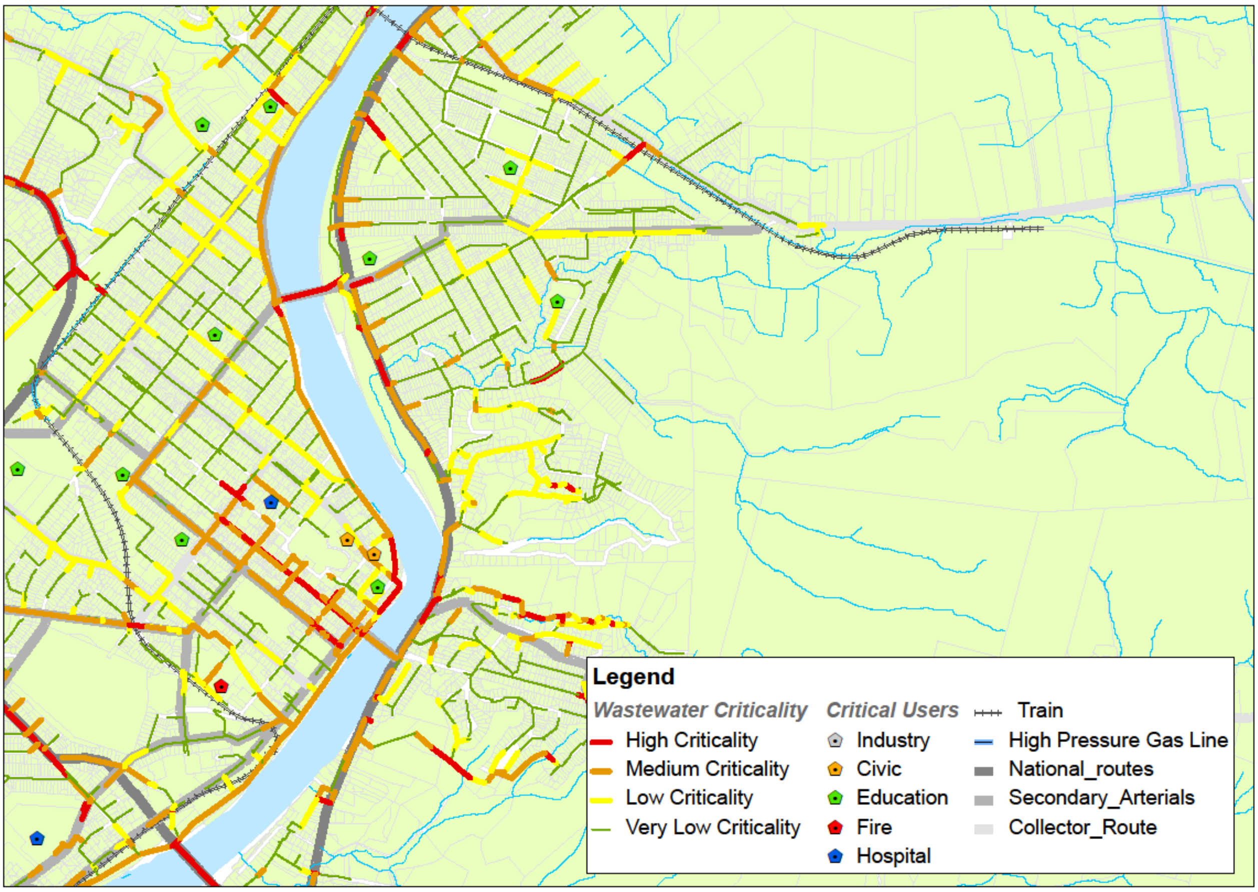
Table 3 below summarises the percentage of pipes of each criticality rating .

Table 3: Summary of Gravity Pipe Criticality

Criticality Rating	Approximate Percentage of Wastewater Pipes	Approximate Percentage of Stormwater Pipes
High Criticality	4%	5%
Medium Criticality	16%	14%
Low Criticality	14%	13%
Very Low Criticality	66%	67%

Figure 1 below gives a visual representation of an area of the Wastewater Systems overall criticality.

Figure 1: Wastewater System Criticality



3 PHASE TWO – DETERMINING THE LIKELIHOOD OF FAILURE

In this work the likelihood of failure has been determined based on an assets proximity to the end of its useful life (or if the useful life of the pipe has been passed).

3.1.1 ACTUAL USEFUL LIFE

There is a range of important asset, condition and performance information that helps to accurately determine the actual useful life of pipes. This includes:

1. Pipe asset condition and performance information like the rate of leaks and bursts.

2. Other related information such as the construction material of the pipes, their size and the surrounding geology and environment.

In the absence of pipe asset condition and performance information the pipe material has been used as an indicator for the average life of the pipe asset. The WDC Asset Management team provided a list of all pipe materials and the average life of each asset adopted by WDC. The values provided fall within the range given in the New Zealand Infrastructure Asset Valuation and Depreciation Guidelines, 2006 (NZIAVDG) and were comparable to those adopted by other authorities.

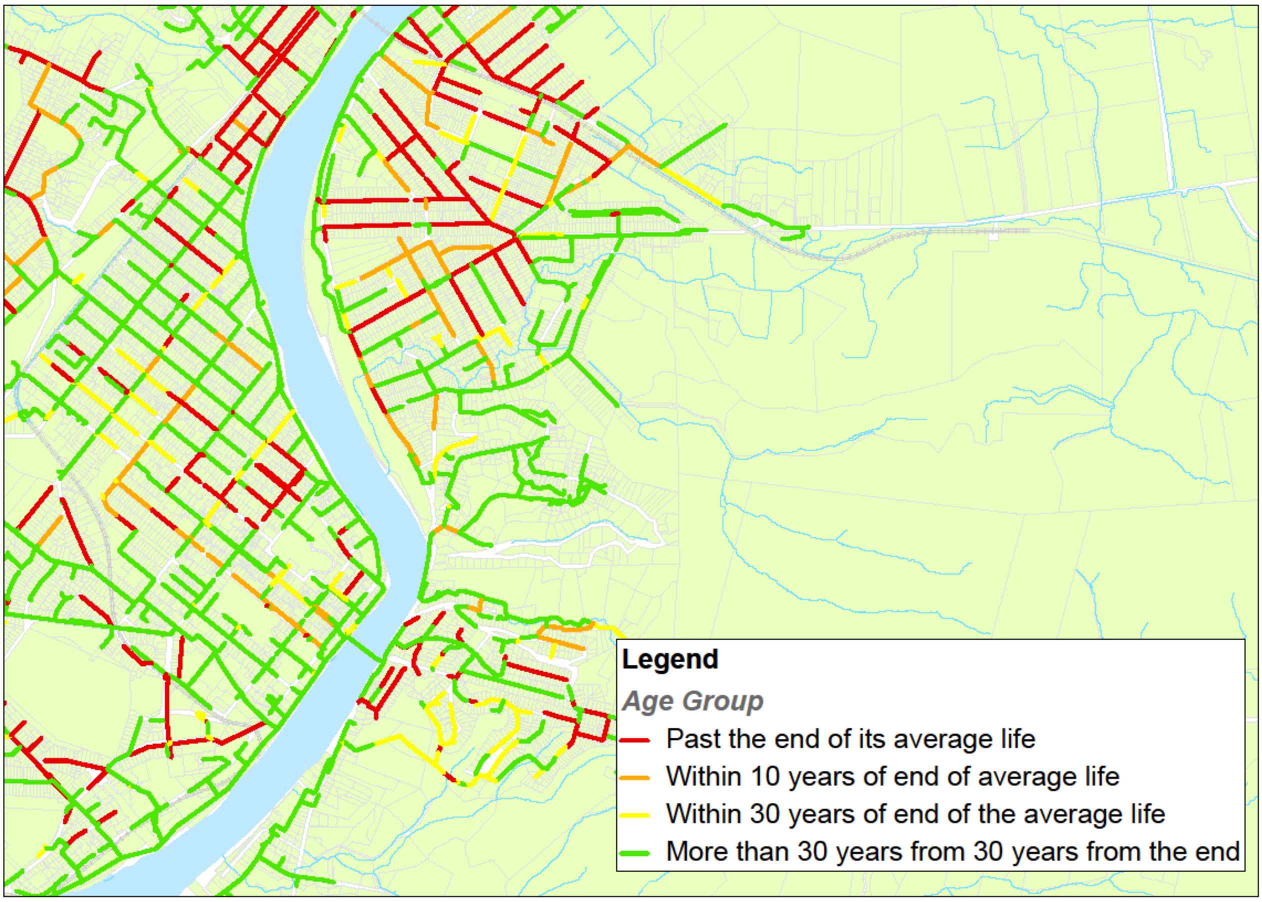
3.2 ASSIGNING LIKELIHOOD OF FAILURE

The likelihood of failure of each pipe was assessed based on an assets proximity to the end of its useful life using the following divisions:

- Pipes age exceeds the Average Life expected (based on the Material Type using WDC Expected Average Life)
- Pipe age within 10 years of the Average Life Expected
- Pipe age within 30 years of the Average Life Expected
- All other pipes

Figure 2 below provides a visual representation of the likelihood of failure assessment (for Wastewater).

Figure 2: Wastewater System – Likelihood of Failure



4 MANAGEMENT STRATEGIES FOR CRITICAL ASSETS

Strategies for managing critical assets fall into two categories (see Table 4 below):

- Strategies which reduce the consequences of asset failure
- Strategies which reduce the likelihood of asset failure.

Table 4: Strategies for Managing Critical Assets

Strategies to Reduce Consequences of Failure	• Increasing system resilience
	• Developing failure mitigation plans
	• Developing policies and management strategies for critical customers and receiving environments
Strategies to Reduce Likelihood of Failure	• Preventive Maintenance
	• Predictive Maintenance
	• Renewal

The consequences of failure of critical assets are sufficiently serious that it is desirable to prevent the failure of critical assets. The management objective is to ensure that the likelihood of failure is As Low As Reasonably Practicable (ALARP). Both strategies to reduce consequences of failure (i.e introducing asset redundancy) and strategies to reduce likelihood of failure are necessary for the effective management of critical assets.

5 PHASE THREE – DETERMINING CCTV INSPECTION PRIORITISATION

Proactive CCTV inspection will allow WDC to manage critical assets by

1. Determining where preventive maintenance and/or renewal is required.

2. Refining the likelihood of failure score for each asset which will reprioritise the frequency of future CCTV inspections.

The proactive CCTV prioritization was determined using a matrix combining the assets likelihood of failure and criticality. The matrix is summarised in Table 5 below.

Table 5: CCTV Prioritisation Matrix

		Criticality			
		Very Low (0)	Low (1)	Medium (2)	High (3)
Likelihood of Failure	Exceeds average age for material (1)	Non Priority	Priority 2	Priority 1	Priority 1
	Within 10 years of average for material (2)	Non Priority	Priority 3	Priority 2	Priority 1
	Within 30 years of average for material (3)	Non Priority	Priority 4	Priority 3	Priority 2
	More than 30 years from the end of average life for material (4)	Non Priority	Priority 5	Priority 4	Priority 3

A definition of each priority level is given below:

- Priority 1-3: Initially all of these pipes are to be CCTVd as soon as budgets allow (in order of prioritisation, it is likely to be more cost effective to carry out CCTV inspections in geographical clusters. Therefore some lower priority pipes may be CCTVd prior to the completion of CCTV inspections of all of the higher priority pipes). Subsequently priority 1 pipes are to be re-CCTVed at the highest frequency, priority 2 at the second highest frequency and so on.

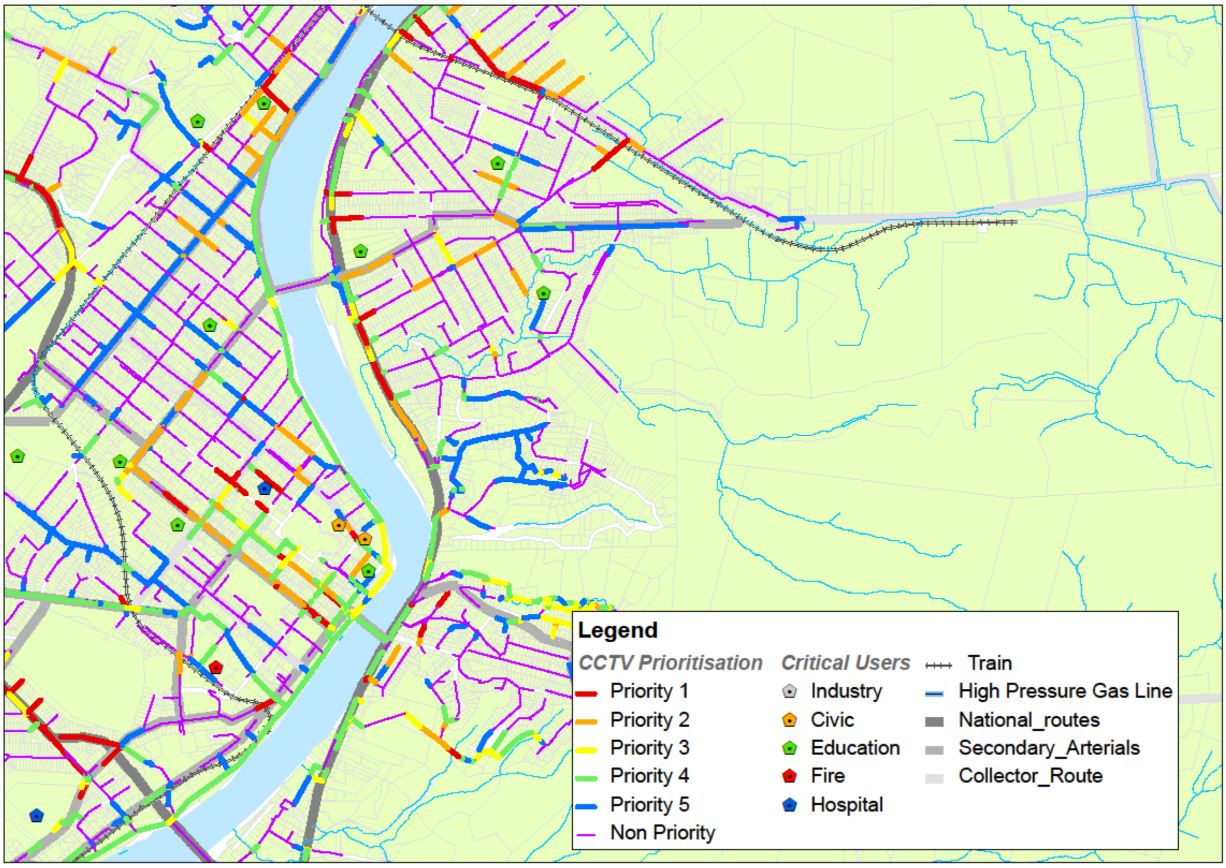
- Priority 4: Initially these pipes are to be CCTVd as soon as budgets allow and once the CCTV inspections of the higher priority pipes have been completed. If budgets are limited, it is recommended that only a representative portion of these pipes be CCTVd. Subsequently they are to be re-CCTVd at the fourth highest frequency.

- Priority 5: Initially these pipes are to be CCTVd only if budgets allow and once the CCTV inspections of the higher priority pipes have been completed. Subsequently they are to be re-CCTVd at the lowest frequency.

- Non Priority: These pipes have a very low criticality and therefore it is recommended that CCTV inspections are not carried out on these pipes unless other drives dictate (e.g. high I&I in a particular catchment).

Figure 3 below gives a visual representation of the final CCTV prioritisations determined for an area of the Wastewater System.

Figure 3: Wastewater System Proactive CCTV Prioritisation



It should be noted that the prioritisation has been determined on an individual pipe basis. As such it is possible to have multiple priority weightings in a single street/area. It may prove to be cost effective to package CCTV inspections geographically, in which case areas with clusters of medium to very high priority pipes should be prioritised first.

6 CONCLUSIONS

While the general methodology carried out in this project is consistent with asset management principals what differs is the way that this methodology was applied, with a consultative approach facilitated by the use of GIS providing outputs which can be used by WDC for a specific purpose.

A wide range of criteria were assessed in a visual manner (using GIS) and reviewed ensuring that the assessment considered detail in a balanced way giving an accurate big picture of where the consequence of asset failure is expected to be greatest.

By using this methodology all assets were assessed in a consistent manner which can be audited and updated in future should better information become available.

Proactive CCTV inspection will allow WDC to manage critical assets by

1. Determining where preventive maintenance and/or renewal is required.

2. Refining the likelihood of failure score for each asset which will reprioritise the frequency of future CCTV inspections.

While the criticality assessment has been used initially for prioritisation of CCTV inspection this assessment can be used to implement other management strategies reducing the risk associated with failure within WDC's wastewater and stormwater systems.

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