MANGAKINO WASTEWATER RENEWALS – AN EVIDENCE DRIVEN APPROACH

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ABSTRACT

The township of Mangakino was developed during the 1950s for workers constructing power stations on the Waikato River.

The 19 km of wastewater reticulation for the 660 homes is all around 60 years old and mostly earthenware.

Taupo District Council is aware that the pipes are coming to the end of their useful working lives and approximately $7million would be required for a complete renewal. This is a significant financial hurdle for the Council.

Evidence indicating the poor condition of the network included a 2006 CCTV survey of 50% of the network, high levels of inflow and/or infiltration (I/I) during rain events and the 2012 smoke testing of most of the town. However, much of this information was incomplete and of variable quality.

Taupo District Council faced a dilemma. It did not have enough information to justify the replacement of the entire network, it could not identify all the specific lines requiring urgent replacement and it could not properly plan for a staged renewal of the network.

To remove the uncertainty, and allow the development of a logical and fully justifiable solution, the council worked with ProjectMax to develop a decision-making strategy. This included undertaking a complete CCTV survey of the network and then applying a structured set of Pass / Fail Criteria to determine if a particular line could continue, required repair, or required rehabilitation / renewal.

The process illustrates the clear benefit of obtaining robust and reliable information to inform decision making. Taupo District Council can now proceed with confidence to plan the works and make appropriate budgetary provisions. The approach highlights the importance of quality control of CCTV inspections and also demonstrates the clear budgetary benefit of only renewing pipes that require this action versus undertaking potentially premature renewals based on age and perceived condition.

KEYWORDS

Renewal Strategy, CCTV, Pass/Fail Criteria

PRESENTER PROFILES

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Renewals' and has significant experience and expertise in the use of CCTV, condition assessment, asset management and project delivery.

1 INTRODUCTION

The township of Mangakino is at the northern end of the Taupo District and lies on the edge of Lake Maraetai on the Waikato River.

The town was constructed over a short period of time in the 1950s by the Ministry of Works to house workers employed on the various dam construction projects on the Waikato River.

While never intended to be a permanent settlement it has survived and is now a mix of owner-occupied and rental residences, baches and vacant lots. It currently has some 660 houses on individual sites.

The wastewater system comprises a conventional gravity collection system utilising mainly earthenware pipes. The original four community septic tanks remain in service as settlement units. The settled effluent is treated in a SAF plant before discharge to seepage trenches on the edge of the lake.

A number of factors led the Taupo District Council (TDC) to believe that the wastewater reticulation system was nearing the end of its useful working life. The prospect of renewal expenditure of some $7 million (m) for a small community was somewhat daunting.

ProjectMax was engaged by TDC to review the available information and determine if there was an alternative path forward that would be more affordable while still addressing the issues.

2 THE ADOPTED APPROACH

2.1 THE EVIDENCE

TDC's concerns about the state of the Mangakino reticulation were driven by several considerations. These included:

- The pipework was known to be predominantly earthenware with most of it around 60 years old. This would align with the expected life of such pipes

- Many of the pipes were laid beneath the houses, presumably to minimise the overall extent of the pipework required. This gave rise to concerns about the potential for foundation problems if a pipe structurally failed

- The system retained the original community septic tanks and these are now utilised as settling chambers for the SAF wastewater treatment system. In storm events wash-through of solids occurs and the treatment plant is not equipped to fully manage this. It is suspected that infiltration and inflow within the system is excessive and this could be largely attributed to the condition of the pipes

- Smoke testing was undertaken across most of the network in 2012. This revealed some stormwater inter-connections and also some evidence of broken wastewater pipes. While there was a scattering of faults across the community it was not particularly indicative of the pipes being in poor condition

- The most damning evidence was a CCTV survey undertaken in 2006 of almost 50% of the 19km of pipework. The inspections were separately assessed and the outcome indicated that many of the pipes were in condition '4' or '5' although it was not known exactly what grading system this was based on. Given that this assessment was now 10 years old it seemed reasonable to assume that the condition of the pipes could only be worse, that widespread failure of the network was imminent and that significant expenditure would be required in the near future.

2.2 THE REVIEW

TDC believed that a major refurbishment of the network was inevitable, and would be required in the near future.

ProjectMax had previously worked with TDC and has extensive experience in CCTV inspections, condition assessment, the use of trenchless technology for pipeline rehabilitation and the development of smart strategies to '*Optimise Pipeline Renewals*'. ProjectMax was engaged to review the situation and determine if there were any alternative approaches that might be considered.

The 2006 CCTV survey was the most conclusive evidence that the pipework was on its last legs and the first step of the review was to take a sample of the surveys, and the associated assessments, to confirm that the information was valid and robust. It quickly emerged that the quality of the inspections, and associated log-sheets, was highly variable. It was also apparent that the assessment that followed was variable in its consistency and generally very pessimistic about the condition, and likely life expectancy, of the pipes.

The review determined that the 2006 survey and assessment could not be relied upon to provide robust evidence that would support the level of expenditure required to renew the entire network.

2.3 THE DILEMMA

TDC was now in a somewhat difficult situation. There was no debate that the network was old and extensive work would be required in the foreseeable future. However, the assessments of the 2006 survey could not be reliably used to identify pipes that needed urgent renewal. Reviewing the original CCTV video files (where they could be located) might have generated a more reliable assessment outcome but the information would be 10 years old and only covered half of the community. There was no reliable means of knowing which pipes might need renewal now, and which could be deferred for at least a few years to spread the cost of the project.

The most critical aspect of this uncertainty was the inability of staff to be able to present a robust, evidence based, justification to the council and the community that works of this magnitude were required, and required now.

2.4 THE ADOPTED RESPONSE

Given the uncertainties that had been revealed, and the potential magnitude of the decisions that would have to be made, TDC worked with ProjectMax to develop an overall strategy that would provide the information and analysis necessary to make well informed decisions about how to manage the renewal of the Mangakino wastewater reticulation.

The first step was to CCTV survey the entire network of 19 km of pipe to remove any doubt about the current condition of the pipes and to provide the best possible information on which to base a renewal strategy.

It was recognised that the survey might reveal that the entire network was on its last legs but the evidence of that would then be clear and complete for the council and the community. It was however hoped that at least a portion of the network would have some useful life remaining and this would provide the opportunity to spread the cost of the renewals over a more affordable period, perhaps 10 years or more.

A CCTV contractor was engaged by TDC with the New Zealand Pipe Inspection Manual (NZPIM) used as the methodology and coding standard. ProjectMax was engaged to undertake auditing of the initial inspections. Once an acceptable standard of inspection had been achieved ongoing random audits of around 5% of the inspections were undertaken by ProjectMax to ensure that quality was maintained.

The key outcome required of the inspections was to determine whether any of the pipes had a useful remaining life and TDC and ProjectMax developed a Pass/Fail Criteria that could be consistently applied to the CCTV outputs as they were generated.

At the time of writing the survey has covered 10.6 km of the 19 km of pipework and 34% of the network has achieved a 'Pass' grade. This effectively means that TDC can be confident that these pipes will continue to provide an acceptable level of service for the next 10 years. However, 64% of the network has received a 'Fail' grade and requires a relatively urgent intervention.

The intent is that at the end of the CCTV survey, and the application of the Pass/Fail Criteria, the overall picture will be assessed and recommendations made about how best to proceed with the rehabilitation of the network. This will include recommendations about the staging and timing of the works and how procurement can be managed to optimise the outcome for TDC. It is clear, even at this stage, that substantial financial benefits will arise compared to simply renewing the entire network as originally contemplated.

2.5 THE PASS/FAIL CRITERIA: IIMM SCORING

At the heart of the adopted response is the Pass/Fail Criteria. This is a documented logic to determine whether an intervention is required, and the nature of that intervention.

The criteria was jointly developed by TDC and ProjectMax. It has been tuned to reflect the issues considered to be important by TDC and can be modified for different communities and different situations. The version used for TDC is included as Figure 1 in the Appendices.

A fundamental starting point is the recognition that the gradings generated by the NZPIM (i.e. a score of 1 to 5.8 based on service faults, structural defects, peak scores and/or mean scores) cannot be directly translated to the '1-5' condition grades described in the International Infrastructure Management Manual (IIMM) as included in Table 1 of the Appendices. Over many years of pipeline reviews ProjectMax has concluded that directly translating NZPIM scores to IIMM scores will consistently overstate the extent of deterioration of a pipe network

The IIMM 'Rank' is expressed in terms of 'condition'. This is not directly usable as an expression of 'Likelihood of Failure' or 'Life Expectancy' even though the concepts are clearly closely related. The Pass / Fail Criteria uses a translation that is included in Table

1 in the Appendices. A Rank of '1' can now be broadly interpreted as *'An asset in near new condition, with a very low likelihood of failure, and a life expectancy in excess of 20 years'* and a '5' as *'An asset with serious defects, a high risk of failure, and a useful life expectancy of less than 2 years'*.

While the NZPIM peak score has severe limitations as a predictor of the likelihood of failure it can be used as an initial filter and the criteria divides the incoming CCTV inspections into three review groups, nominally named Type 1, 2 and 3. It should be noted that this step uses the NZPIM peak score. This is much more reliable as an indicator of the worst defects in the pipe than the mean score. The various Reviews are structured as follows:

1. If the NZPIM peak score for a pipe is less than 10 very little deterioration has occurred and the pipe is most unlikely to be a candidate for rehabilitation. These pipes can be awarded an automatic 'Pass' grade without further investigation. This step does however require the assessor to have confidence in the pipe inspector and that serious defects are not being missed.

2. If the NZPIM peak score is between 10 and 30 the log-sheets are reviewed to see if certain defects are present such as Large : Circumferential Cracking (Defect code CC). If such faults are present it indicates the need for a more detailed review of the pipe and it transfers to a Type 3 Review. If such faults are not present then the condition is likely to end up as an IIMM 2 or 3, i.e. signs of deterioration and a reduction in life expectancy, but low likelihood of imminent failure.

3. If specific faults were identified in the log-sheet in the previous step, or the NZPIM peak score is greater than 30, the CCTV recording is reviewed together with the log-sheet. This review will assess the various defects and features that are present in relation to their likelihood to generate a failure of the pipe from either a structural or service perspective and assign the appropriate IIMM ranking. The current NZPIM does not contain detailed guidance on this translation and it is important that the reviewer has considerable experience in CCTV assessment to ensure that accurate and consistent outcomes are generated.

At the end of this stage ProjectMax has translated the CCTV inspection of each pipe into an IIMM rank and also has a good appreciation of the specific faults that are present, the overall condition of the pipe, its location in the network and its proximity to buildings.

2.6 THE PASS/FAIL CRITERIA: APPLICATION

All of the pipes with a IIMM / LOF rank of greater than 1 (i.e. those not automatically diverted due to the NZPIM peak score being less than 10) are now assessed against a range of criteria to determine if an intervention is required (= Fail) or the pipe is able to continue to provide service, albeit with some minor maintenance (= Pass).

For the Mangakino assessment up to five tests are applied to determine if a Fail outcome is warranted. In priority order (highest to lowest) the tests used are as follows :

Consideration	Reason to Fail
Structural condition	LOF > 3
Criticality	The combination of elevated criticality (e.g. under a building) and high LOF is unacceptable

Consideration	Reason to Fail
Infiltration and Inflow	The observed defects and evidence of infiltration are unacceptable from an I/I perspective
Serviceability	The features and defects observed are likely to result in an unacceptable level of maintenance being required
Capacity	Irrespective of its condition the pipe has insufficient capacity for its intended purpose

A pipe must successfully pass all of these tests to be considered a 'Pass'. Failure to pass any test results in a 'Fail' outcome. As noted the considerations can be varied for each circumstance as can the trigger level for determining failure. This will reflect the asset owner's Level of Service objectives, their risk appetite and the availability of funding for interventions. As such it largely also mirrors a prioritisation process.

2.7 PASS / FAIL CRITERIA: DETERMINING THE INTERVENTION REQUIRED

The process described above will determine which pipes are deemed to Pass and which will Fail.

The next step in the process is to determine what the optimal intervention will be for a specific pipe that has failed.

Essentially there are 3 options that need to be considered:

Intervention	When Most Likely to be Used
Localised Repair	• There are specific defects and the remainder of the pipe would be able to provide acceptable service after the defects are repaired • The cost of multiple repairs is less than the cost of relining, or renewing, while having due regard to the remaining life that would be achieved
Relining (Spiral, slip or CIPP)	• Multiple defects and/or overall condition of pipe is poor • Any dips that are present are acceptable • No structural obstructions to lining process
Relay	• Existing position of pipe is unacceptable • Pipe cannot be relined • Pipe needs to be bigger • Logical to align with adjacent renewal works

2.8 PASS/FAIL CRITERIA : ASSEMBLING THE SOLUTION

From the above process a list of pipes requiring repair, suitable for relining and requiring renewal will emerge.

The optimal overall solution for how these interventions are pursued will depend on several factors including the mix and extent of the interventions that are indicated. Typically, the council's maintenance contractor will be able to undertake many of the localised repairs and this will be the approach pursued by TDC. The extent of reline Vs renew, and the relative priority of individual pipe interventions, will influence the nature of the rehabilitation contract and the time that it can logically be extended over. These elements have yet to be determined for Mangakino but all the information required to determine a logical procurement and delivery strategy will be available.

Just as critically, all the information necessary to justify the works that are required for senior management, council and the community will be available.

2.9 THE RESULTS TO DATE

To date the process outlined above has been applied to three different systems within the TDC area.

For Mangakino, with approximately half of the 19km network surveyed, 66% (by length) of the pipes have failed with 25% of the fails being suitable for localised repair.

For the smaller 1.5km Whakamaru network, 60% failed with 19% of these suitable for localised repair.

For the Taupo CBD area, comprising 5.5km of pipe, just 13% failed with 64% of these suitable for localised repair.

In each case, there was concern about the state of the network but uncertainty about the actual extent of any deterioration and the extent and nature of works that may be required. The survey and the application of the Pass/Fail Criteria has effectively removed this doubt and allowed the development of a detailed path forward.

While this discussion has focused on the inspection and assessment of the wastewater pipes the process also facilitates inspection and assessment of the manholes. These can also be a significant source of I/I and can make up a major portion of the overall cost of rehabilitation. The TDC CCTV inspections also include a reporting process for the condition of the manholes and this will form part of the overall strategy development for Mangakino.

3 WIDER APPLICATION OF APPROACH

The approach that is described in this paper was developed for Mangakino which is a relatively unusual community given that the entire town was largely constructed within a very short time period. However, there are many communities in New Zealand that converted from septic tanks to community schemes as specific projects in the 1960s and 1970s and will have a large group of pipes that are now all reaching retirement age. Similarly, within larger networks there will be groups of pipes of a specific type, or age, spread across the network, or in specific areas, that are causing concern and the process is equally applicable to them.

4 COSTS AND BENEFITS

4.1 COST OF SURVEY VS BENEFITS OF DEFERRAL

This project was not driven by a specific need, or expectation, that the costs of the CCTV survey, and the following detailed assessment, would be directly off-set by the deferral or avoidance of the renewals that were otherwise being considered. It was always possible that the survey would confirm that all the pipes did need to be replaced in the near future. It is useful however to have an understanding of the costs involved to ensure that the overall spend is optimised.

The CCTV survey work is likely to cost between $7 and $15/m depending on local market rates, the extent of heavy cleaning required and the effort required to locate and gain entry to manholes. Auditing of the CCTV contract is relatively cheap as only a small proportion of the surveys are actually checked but the increase in confidence in the overall process is significant. Detailed assessment of the CCTV inspections is approximately $2/m for the lines that require detailed assessment. If a lot of lines have NZPIM peak scores of less than 10 some of this assessment cost can be avoided. Alternatively, if it is apparent that virtually all of the pipes assessed are failing it may be appropriate to curtail the inspection and assessment process at some point and take the risk that some uninspected pipes with useful remaining life are renewed as part of an overall programme.

For the 19km pipelines in Mangakino the survey and assessment costs are likely to be of the order of $320,000 against a projected renewal budget of $7m i.e. approximately 4.5%. This is well within the range that would be considered acceptable for investigations, optioneering and business case justification for any other project of this magnitude.

Compared to the $300 (or more) /m cost for renewal or relining of the pipelines the inspection costs are relatively small compared to the certainty that they generate. You would need to engage with your accountants to confirm that it is better to spend $10/m on a survey to gain the possibility of deferring at least some of the renewals for perhaps 10 years. This assessment lends itself to Net Present Value (NPV) analysis and would require the modelling of various scenarios to assess where ‘break-even’ points might be. However, if you also mention that you are not entirely convinced of the need for renewal the accountants will almost always go for the ‘get more and better information’ option.

A relatively simple financial analysis for Mangakino would allow for 34% of the renewals being deferred for 10 years. If this $2.4m of deferred works is valued at an annual financial benefit (opportunity cost) of 5% then the 10 years of deferral has a value of $1.2m. This is well clear of the $320,000 spent and does not include the additional benefits arising from only doing repairs where appropriate on the failed pipes rather than renewals.

Also potentially entering the overall funding equation will be the different funding paths that will apply for repairs (operational expenditure), surveys (operational or capital expenditure depending on what you find and how it influences future actions) and rehabilitation / renewal (capital expenditure). However, rules regarding the allocation of expenditure to Operational Vs Capital should not be an obstacle to optimising the expenditure of the community’s financial resources.

4.2 PROCUREMENT AND PLANNING BENEFITS

Other benefits of having complete and comprehensive information about the condition and life expectancy of the pipes comes into project planning and procurement.

A review of the assessment information will reveal which pipes require an immediate intervention, which can be deferred, the location of those pipes and whether the preferred intervention is a repair, a rehabilitation or a renewal. The information will also indicate the relative priority of the renewals if there are pipes with different criticalities. A procurement model can then be constructed that aligns with the preferred option for different types of works and whether contracts are offered for multiple years or a one-off project.

Having complete information also removes much of the uncertainty that can arise in rehabilitation contracts where the ability to reline the main has not been confirmed prior to the letting of the contract and this is managed through variations and provisional quantities. This can create considerable uncertainty for the contractor and the asset owner in relation to the actual extent and nature of the works that will actually be required, the associated programme management issues and the final cost.

The availability of complete information at the time of tender removes risk and uncertainty for the potential contractors and this should ensure that the asset owner receives the most competitive pricing and realistic programming.

5 CONCLUSIONS

TDC was in a dilemma in relation to how to manage the old and deteriorating wastewater pipelines in Mangakino. All the anecdotal evidence, and some hard survey evidence, pointed to the pipes being in poor condition and requiring a $7m fix.

However, the evidence was old and incomplete. Staff could neither justify the replacement of the entire system or determine which pipes did need renewal now and which could be deferred. The location of pipes beneath houses elevated their criticality and added a further complication to the situation.

The adopted solution developed by TDC and ProjectMax was to replace perception and uncertainty with high quality information and a structured decision making process that provided complete coverage of the system. While there was no guarantee that this would provide an opportunity for deferral of works it would provide the council with the certainty it required to commit the necessary funding and/or understand the risk involved in deferring part, or all, of the works.

At this time it would appear that over 6km of the 19km in Mangakino can be safely deferred, 3km requires only localised repairs and the rehabilitation / renewal of the remaining 10km can be prioritised and staged with confidence to align with an optimised procurement strategy and council’s funding capacity. None of this would have been possible without the survey and assessment work being done. It is also apparent that, in this case, the cost of surveying and assessment is much less than the financial benefits achieved by deferring the renewal of pipes that have useful remaining life.

Two aspects are critical to the success of this strategy :

- High quality CCTV inspections
- The application of a robust and consistent Pass/Fail Criteria that is tailored to the needs of the asset owner

While the system has been trialed and proven on networks with specific issues it can be readily applied to any group of assets within a network that are being considered for renewal, but have incomplete information regarding their condition and Likelihood of Failure.

It is apparent that the approach adopted for Mangakino aligns closely with the water industry's desire to adopt process that are evidence driven and improve the economic efficiency of managing network renewals.

In the immortal words of W Edwards Deming "*Without data, you're just another person with an opinion*". An opinion was never going to be a robust justification for spending $7 million in Mangakino.

ACKNOWLEDGEMENTS

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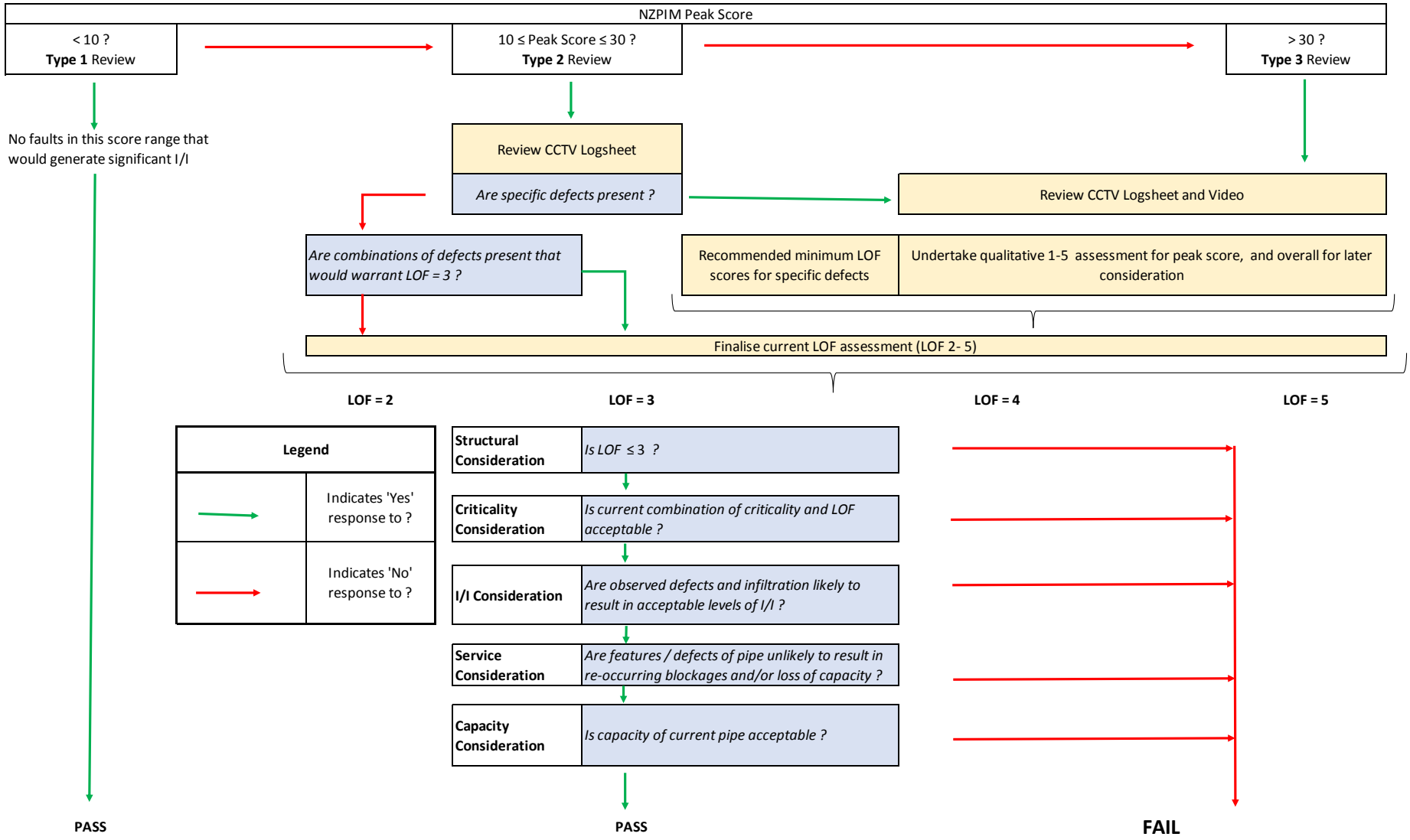
APPENDICES

Table 1 : Translation of IIMM 'Ranks' to Likelihood of Failure (LOF)

Rank	IIMM Description	Taupo District Council / ProjectMax Definitions	
		Likelihood of Failure	**Indicative Life Expectancy** (@ Low Criticality)
1	Very good condition	A sound modern pipe, well maintained, with either no signs of damage or superficial signs of "wear & tear"	> 20 years
2	Good condition – Minor defects only	A functionally sound pipe but with some "wear & tear" and possibly joint/connection failures	10-20 years
3	Fair to moderate condition – Maintenance required to return to acceptable Level of Service	A functionally sound pipe but with heavy wear & tear and deterioration is beginning to affect structural integrity & performance	5-10 years
4	Poor condition – Consider renewal	A questionable pipe showing significant failures that is likely to caused marked deterioration in structural integrity and performance in the medium term	2-5 years
5	Very poor condition – Approaching unserviceable	An unacceptable pipe with no reliable lifespan, likely to fail in the near/short term	< 2 years

Figure 1 : Pass Fail Criteria Used for Taupo District Council



Pass / Fail Criteria for Assessment of CCTV Inspections : Part 2