University of Southern Queensland

Faculty of Health, Engineering & Sciences

Development of Stormwater Asset Management Plan For Local Council

A dissertation submitted by

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Abstract

This research project aims to develop a stormwater asset management plan for local council and how predictive modelling can be utilised to develop a more strategic advanced system. Local council have endorsed a ‘Core’ asset plan as the framework for all assets. The Chief Executive Officer has implemented a 95-point plan to improve council services and one of these is to progress from a ‘Core’ Asset plan to an advanced plan for all assets.

Sunshine Coast Council Stormwater Unit has made a commitment to progress from the ‘Core’ plan and in doing so has now undertaken a proactive CCTV survey of all existing asset classes with a focus on critical assets. Predictive modelling of existing reinforced concrete pipe has been identified as a key driver and how council monitor the asset condition and determine the residual life of the asset. These outcomes in turn are calculating the useful life of the asset and providing some effective comparisons with more conventional models.

A study was undertaken on a variety of stormwater networks and upon completion of the condition assessment and predictive modelling it was ascertained that these networks are not meeting their useful life expectation. This shortfall in useful life means that local council need to review all areas of the asset management plan including risk and criticality, levels of service, maintenance and renewal programs and growth management.

IIMM (2015) clarifies that for any asset management plan to be effective it has to rely on good data, robust assessment of asset condition and to ensure the lifecycle costs of the assets will provide a sustainable future. The dissertation has provided a positive and proactive process for local councils to achieve a sustainable system that will enable the organisation and key stakeholders to deliver over the long term.

The project has provided a solid base for council to improve on these processes and to also provide an opportunity for further development in how other asset classes can be incorporated into this plan.

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Limitations of Use

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Certification of Dissertation

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

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Abbreviations and Acronyms

AM – Asset Management

AMC – Asset Management Council

AMP – Asset Management Plan

AMS – Asset Management systems

CCC – Caloundra City Council

CCTV – Closed-Circuit Television

EA – Engineers Australia

FRC– Fibre Reinforced Concrete Pipe

GDA– Geocentric Datum of Australia

HDPE – High Density Polypropylene Pipe

IIMM – International Infrastructure Management Manual

IPWEA – Institute of Public Works Engineers Australia

ISO – The International Organisation of Standardization

LOS – Level of Service

MSC – Maroochydore Shire Council

MCP – Multiple Logistic Regression

NSC – Noosa Shire Council

OH & S – Occupational Health & Safety

PNN – Probabilistic Neural Network

QTC– Queensland Treasury Corporation

RCBC– Reinforced concrete box culvert

RCP– Reinforced Concrete Pipe

SAMP – Stormwater Asset Management Plan

SCCCM - Sunshine Coast Council Core Model

SCC – Sunshine Coast Council

SWD – Stormwater Drainage

WDV – Written Down Value

WSAA – Water Services Association of Australia

WRC – Water Resource Center

NPV – Net Present Value Analysis

BCA -Benefit Cost Analysis

CEA – Cost Effective Analysis

1.0 Introduction

1.1 Overview

Sunshine Coast Council like the majority of local councils exists to provide services to the local community. Council has acquired infrastructure assets by purchase, by contract, construction by council staff and by donation of assets constructed by developers and others to meet increased levels of service (SCC, 2014).

In 2008 Caloundra City Council (CCC), Maroochydore Shire Council (MSC) and Noosa Shire Council (NSC) amalgamated to form the Sunshine Coast Council and as a result three separate Stormwater asset classes were formed into one asset base. In January 2014 Noosa Shire Council de-amalgamated from Sunshine Coast Council therefore reducing the Stormwater asset to its current status. Prior to 2008 both Maroochydore and Caloundra Council managed their assets differently from both a financial stand point and more relevant to the dissertation **-** their maintenance and construction procedures.

The plan is to demonstrate responsive management of assets and is developed with reference to the following planning documents:

- Sunshine Coast Planning Scheme 2014;
- Sunshine Coast Council Operational Plans 2015 – 2016;
- Local Government Act 2009;
- Sunshine Coast Transport Infrastructure Act 1994;
- Sunshine Coast Council Corporate Plan 2014 – 2019.

1.2 State of the Assets

The asset classes that are not part of the report are as follows:

- Private Stormwater infrastructure – including inter-allotment drainage (all pipes <300mm, rural driveway access pipes and internal field inlets;
- Waterways maintained by other Government Agencies – rivers and creeks, open ocean, locks, weirs, dams and Main Roads infrastructure (Nicklin Way);

- Infrastructure controlled by other local council units – bridges, canals, lakes, road table drains, kerb and channel, drains contained within parks and council properties, inter-allotment easements and flood warning systems;
- Swales – intended to facilitate overland or inter-allotment flows. These swales may be required for council drainage but not necessarily located within council drainage easements and therefore designated as private drainage assets.

Sunshine Coast Council recently revised the Stormwater Core Asset Management Plan (AMP). The plan detailed the following Stormwater infrastructure asset classes listed below in Table 2.1. The written down value (WDV) is derived from age-based predictions, and does not necessarily reflect the current structural condition. This is evidenced through current CCTV inspections, which have shown more rapid deterioration than expected. The State of the Assets Report (2015) considers stormwater assets to be in a satisfactory and serviceable condition and on average $6 million per year of renewal capital expenditure is required to sustain current levels of service (LOS). Table 1.1 displays the breakdown of overall stormwater asset condition into three separate classes – good, fair and poor.

Table 1.1: Asset replacement value (Financial Asset Infrastructure Management SCC. 2015)

Asset Grouping	**Quantity**	**Current Replacement Cost (CRC)**	**Written Down Value (WDV)**	**% of asset base consumed**
Pipes	1,122 km's pipe ranging from 300 – 3600mm diameter	$807m	$635m	21%
Pits	47,376 units	$179m	$148m	17%
Culverts/Structures	73.5 km's of box culverts.	$85m.	$69m	19%
Open Drains	147,736 metres	$24m	$16m	33%
Water Quality	1269 units	$12m.	$11m	8%
Miscellaneous Infrastructure		$3m	$2m	33%
TOTAL / AVG		**$1110m**	**$881m**	**21%**

Table 1.2: Stormwater asset condition (Financial Asset Infrastructure Management SCC. 2015)

Asset Category	**% Good**	**% Fair**	**% Poor**
Pipes	18	61	21
Pits	18	61	21
GPT's	24	56	20
Open Drains	15	55	30
Culverts (box)	17	65	18
Average	**18**	**60**	**22**

It is clear from the data in Table 1.2 that the majority of the stormwater assets are in a fair condition but with an ageing asset base and current maintenance schedules not meeting council expectations then this will no doubt only increase the number of assets falling into the poor condition percentage.

1.3 The Research Problem

Due to the upheaval with amalgamation and then de-amalgamation plus the fact that local Councils prior to 2008 placed minor importance on asset management, Sunshine Coast Council is now dealing with an ageing infrastructure that in some areas is reaching end of life prematurely. Council has over the years underfunded maintaining existing infrastructure whilst new infrastructure is being handed over from developers on an annual basis. This ongoing process of expanding asset base only compounds the issue.

One goal of Sunshine Coast Council in managing infrastructure assets is to meet the required level of service in the most cost-effective manner for present and future consumers (SCC, 2014). Due to insufficient long term planning in asset management, council is restricted and tentative in how they direct funding to accommodate for future failures. The aim to develop an advanced asset management plan with modelling will not only assist stormwater assets but other asset stakeholders within local council and assist implementing a more robust and sustainable asset management plan.

2.0 Background Information

2.1 Aims and Objectives

The main purpose of the dissertation is to report on the development of the improved Stormwater Asset Management Plan (SAMP) and research various models/systems within Local Government. It is envisaged that the research outcomes will provide a better knowledge base for Local Councils when forecasting and planning Advanced Asset Management Plans.

To achieve this, the aim of the dissertation will cover a number of specific objectives.

1. The first objective is to identify and describe the existing asset classes that are listed within the Sunshine Coast Council Stormwater Asset Management Plan.
2. To identify and assess sample networks across the local regional network. The condition data and information gathered from these networks will assist in preparing predictive modelling.
3. To report on the processes when undertaking condition assessments with particular emphasis on risk and criticality and how these may influence current asset conditioning and future modelling.
4. To develop an effective and achievable level of Service that will benefit local council in the long term.
5. The research project will develop and complete an Advanced Asset Management Plan

It is necessary to develop a generic systematic approach that includes predictive modelling to provide an effective Asset Management Plan (AMP) for local council. The model will be developed for advanced stormwater asset management but may also be implemented for other asset classes and corresponding asset stakeholders within local government.

Predictive modelling can be utilised to assist asset stakeholders obtain the most cost-effective means of delivering service levels over long term (IIMM 2015). Most predictive modelling relies on large volumes of data and is based on age and condition so for the purpose of the project this type of modelling will be researched (IPWEA, Practice Note 5 v2 2015). The research will report on factors that are having an adverse impact on the asset such as poor installation, environment and materials. Sunshine Coast Council has hundreds of individual networks so only a sample of networks in different environments and catchments will be identified and assessed. The model will be used to gather the information and results. These results will then be analysed and discussed on how they formulating an advanced asset management plan.

A core business of any local council is to meet customer expectations of how the stormwater network is to be maintained and overall performance considering long-term implications. With any infrastructure it is important to assess the desired level of service expected from the asset owner and the customer. A core and advanced approach will be applied to discuss the levels of service and value to the customer.

Current networks will be identified at various locations within Sunshine Coast Council and these networks will be assessed utilising a condition rating of 1-5. From this an analysis of the results will be undertaken and final conclusions discussed.

2.2 Brief Methodology

The proceeding section of the report details the approach as outlined in the Project Specification in Appendix A. The research undertaken will have an emphasis on developing an advanced asset management system and researching predictive modelling to assist with strategic goals.

An analysis of Sunshine Coast Council's stormwater asset management practices will provide a benchmark from where to begin. The aim of this study is to identify gaps in the current asset management processes including risk and criticality in the decision-making process.

A review of asset conditioning and how renewal and maintenance procedures affect the life of the asset will be discussed. This information will assist in developing the advanced asset model.

2.3 Consequential Effects

Consequential effects are considered when undertaking this research with particular consideration to sustainability, ethical and professional approach and occupational health and safety (OH&S). A main aim of the research project is to identify 'best practice' management and to promote a more sustainable infrastructure for future generations. All the best management skills must be applied to ensure infrastructure networks are robust and resilient to provide a sound economic service. IIMM (2015) describe some of these services:

- Provide economic development;
- Social investment;
- Good infrastructure is the cornerstone of public health and safety;
- Good infrastructure supports sustainable societies.

2.4 Ethical Responsibility

It is imperative that when undertaking all research activities that it is done with professional and ethical conduct as per the Code of Ethics documented by Engineers Australia (2016). To ensure this is adhered to during the course of research activities the following principles have been listed as reference:

- Demonstrate Integrity by:
    - Acting objectively when reviewing and assessing all resources;
    - Ensuring all information gathered is properly referenced and acknowledged;
    - Respect the confidentiality of all participants and organisations.
- Practise Competently:
    - Seek to always research and endorse the most up to date standards/codes;
    - Strive to develop better knowledge of the scope of the subject matter of the project;
- Exercise Leadership:
    - Engage responsibly when debating or discussing issues relevant to the project with others;
    - Provide opportunities for all engineering practitioners on the basis of merit and include diversity in leadership;

    - Provide clear and timely communications on research resources to others and be mindful of others commitments;
    - Always communicate effectively and be honest with all aspects of the research;
- Promote Sustainability:
    - When conducting field research be sensitive to public concerns;
    - Inform all stakeholders of the likely consequence of proposed activities on the community and the environment.
    - Balance the needs of the present with the needs of future generations – what outcomes and conclusions provided by the research project may impact on.

2.5 Summary

The dissertation will aim to summarise current asset management practices with Sunshine Coast Council and how these processes and systems relate to local government. The research is expected to identify any knowledge gaps within asset management pertaining to stormwater networks. This information will review current data and models that will assist stakeholders in making better decisions to achieve the goals and targets for a more efficient asset management plan. The International Infrastructure Management Manual (IIMM), the Institute of Public Works Engineering Australia (IPWEAQ) and Asset Management Council (AMC) will be the main sources of information for the dissertation.

3.0 Literature Review

3.1 Introduction

This chapter will review literature to establish the demand for asset management of stormwater networks. The review will also look into advanced asset management processes relating to predictive modelling of asset failure. This chapter will cover the following elements:

- Asset management systems and sustainability;
- Advanced asset management;
- Predictive modelling focusing on stormwater pipe failure;
- Risk and criticality;
- National and state overview.

3.2 Asset Management Systems and Sustainability

IIMM (2015) describes Asset Management as;

"The systematic and coordinated activities and practices of an organisation to optimally and sustainably deliver on its objectives through the cost-effective lifecycle management of assets."

Bloomfield, Ritter and Fortin (2013) described asset management aims in a broader sense to ensure good decision making, minimizing lifecycle costs, evaluate, understand and manage risk, improve reliability, enhance knowledge management and decision making, improve communications with internal and external stakeholders and the public, and make use of infrastructure's lifecycle. To have effective asset management it is important to define asset management systems (AMS) as these systems will produce the optimum outcome for local council. IIMM (2015) describes the Asset Management System as a set of people, processes, tools and other resources involved in the delivery of AM. Any AM system begins at the strategic level by establishing a number of policies and then delivers through the operational level. Figure 3.1 displays the hierarchy in a typical AM system.

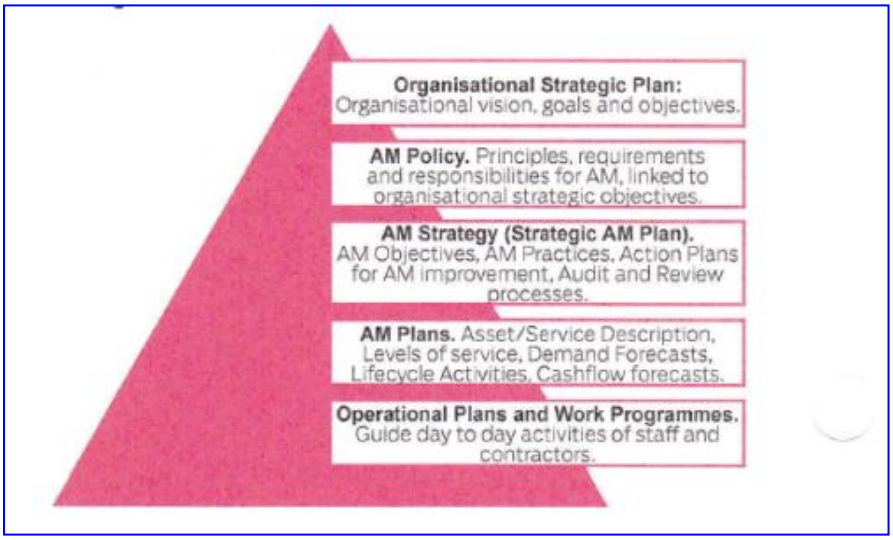


Figure 3.1: Plans in the Asset Management system (IIMM 2015)

Hudson, Hass and Uddin, (1997) describe infrastructure management systems as consisting of the operational package (methods, procedures, data, software, policies, decisions, etc.) that links and enables the carrying out of all the activities involved in infrastructure management. Hudson, Hass and Uddin (1997) further describe the ideal infrastructure management system as being one that would coordinate and enable the execution of all activities so that optimum use is made of the funds available while maximizing the performance and preservation of assets and provision of services.

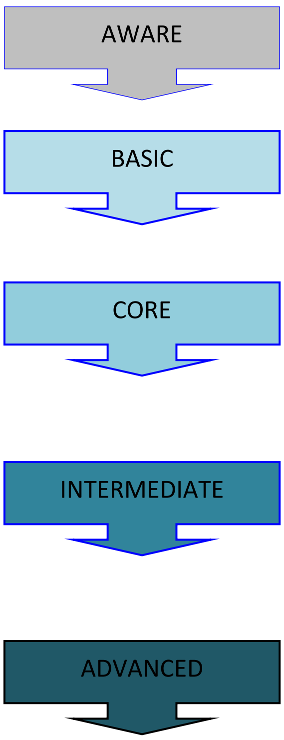
IIMM (2015) describes sustainability as meeting the needs of the future by balancing social, economic, cultural and environmental outcomes or needs when making decisions today. Improving on local council AM systems will deliver more sustainable decisions and the use of physical resources as a key element of infrastructure management. While asset management and sustainability are both sometimes limited in practice, integrating the two frameworks proves to be a robust and effective use of best management processes which better meets the intent of both frameworks.

Bloomfield, Ritter and Fortin (2013) describe the inherent relationship between asset management and sustainability allows for a broadened definition of an asset as an infrastructure, or even more specifically, a piece of equipment, a structure, or a pipe, to encompass an organization’s people and natural resources. This pushes asset management into a more holistic framework, driving a greater set of operational goals than capital stewardship alone. Integrating asset management and sustainability frameworks proves to be a robust and effective use of best management processes.

3.3 Advanced Asset Management

IIMM (2015) describes advanced asset management as optimising decision-making techniques by implementing risk management and predictive modelling to establish asset lifecycle treatment options and related long term cash flow predictions. Typically, most organisations start at a basic level or “core” approach and then develop to a more advanced level as is sometimes described as a “bottom up” approach. Sunshine Coast Council AM plan (2014) is based on a core approach with future revisions moving towards advanced model for gathering asset information for individual assets to support the optimisation of activities and programs to meet agreed LOS.

IIMM (2015, p. 2-55) introduced the AM maturity index to show AM development on a continuum from aware to advanced levels illustrated in Figure 3.2. The index can assist organisations to determine the appropriate level of advancement of AM practices.



Asset information in combination of sources and formats. Awareness of need for asset register

Basic physical information recorded in a spreadsheet or similar (e.g. location, size, type), but may be based on broad assumptions or not complete.

Sufficient information incomplete asset valuation (basis attributes, replacement cost and asset age/life) and support prioritisation of programmes (criticality), Asset hierarchy, identification and attribute systems documented. Metadata held as appropriate.

A reliable register of physical, financial and risk attributes recorded in an information system with data analysis and reporting functionality, systematic and documented data collection process in place.

Information on work history type and cost, condition, performance, etc. Recorded at asset component level, systematic and fully optimised data collection programme with supporting metadata.

Figure 3.2: The maturity Index for Asset Data Management (IIMM 2015)

The degree of advancement of an AM plan will differ according to an organisation’s corporate needs. Organisations should always take a step by step approach to development of AM practices to the defined appropriate level. IIMM (2015) lists the characteristics of an advanced AM organisation by having confidence in the following areas:

- Understanding of the Strategic Context;
- Knowledge of asset ownership;
- Knowledge of AM objectives and levels of service;
- Ability to predict future demand from customers;
- Knowledge of physical condition of assets;
- Knowledge of performance of assets (reliability);
- Knowledge of current utilisation and ultimate capacity;
- Ability to predict performance failure;
- Ability to analyse alternative options to address performance gaps;
- Ability to prioritise AM programmes;
- Ability to optimise operations and maintenance activities;

In some cases, organisations may only require to adopt a core approach and this will depend on factors such as Costs and Benefits, Legal/Regulatory requirements, risk and nature of assets and customer expectations. IIMM (2015) is an effective resource to assist in developing these AM plans with a variety of case studies to study.

3.4 Predictive Modelling of Stormwater Pipe Failures

The research is based on developing a more effective Stormwater asset management plan for local Council and to ensure that long-term processes are in place to optimize key elements of an AM and in particular:

- Condition and performance management;
- Identifying obsolescent assets;
- Sensitivity testing;
- Development of investment envelopes.

A clear objective of the modelling is required and in this instance it will predict pipe asset failure to assist local council in determining ongoing maintenance and renewal of the asset base and life-cycle costs.

3.4.1 What is Predictive Modelling?

IIMM (2015) describes predictive modelling as using condition and performance deterioration curves to protect the lifecycle costs of each asset for different maintenance or renewal strategies and identify the optimal treatment strategy. The model can be providing for a single asset or a group of assets and relationships are developed such that knowledge of current parameters can be used to project future parameters. One such example displayed in IIMM (2015) is the current age and condition of the asset to determine when the renewal is required. Predictive modelling techniques are in general heavily data dependant (IIMM, 2015) and for the purpose of the research much of the outcomes will be driven by existing data and obtaining new data focussing on condition of the asset.

3.4.2 Condition Assessment of Stormwater Pipe

Engineer Australia’s (EA) Infrastructure Report Cards over the past 15 years has rated the nation’s stormwater pipe network poor to adequate condition rating with the 2010 report rating it a C meaning there is still a lot of changes required for it to be fit for present and future purposes (Engineers Australia 2001, 2005, 2010). Engineer Australia’s report (2010) further describes how some jurisdictions face the challenge of improving stormwater asset management information. Given that they are both worth billions of dollars and provide an essential community function, data needs to be provided as the first stage towards improving asset management.

Tran, Perera and Ng (2009) describes the challenge for researchers is to use the sample of inspected pipes for developing mathematical models that can predict the structural condition of remaining pipes as well as the future condition of the assets. The paper further describes using two mathematical models, multiple logistic regression (MLR) and probabilistic neural networks (PNN) to develop predictive models for structural conditioning of pipes. These models were developed using complex numerical techniques along with software packages i.e. MATLAB. These models are mentioned as to ascertain what level you can take predictive modelling to.

Tran (2007) describes the structural deterioration of sewer and stormwater pipes, characterized by structural defects that directly reduce the structural integrity i.e. shape and load bearing capacity of the pipes. Water Research Centre (1986) divides the deterioration process into structural deterioration (cracks and fractures) and hydraulic defects (intrusion of tree roots, infiltration and sediment deposits).

Kennedy and McPherson (2005) describe a cost effective model to calculate condition based depreciation to much better represent the actual deterioration and depreciation of the stormwater assets and is based more on in field condition information and sound engineering judgement that requires adequate field data. Some of the deterioration mechanisms – installation defects, selection of pipe and maintenance will be discussed when developing the model rather than focusing on complex numerical models.

IPWEA, Practice Note 5 v2 (2015) implements a commonly adopted rating system for stormwater drainage (SWD) systems as the basic 1 – 5 where condition 1 is very good and 5 is very poor and approaching being unserviceable. It is important that condition assessment is undertaken in an objective way to assist decision-making about the (LOS). Rating system for (SWD) condition assessment can be conducted by way of a 'Core' or more 'Advanced' approach and can be reflected through guidelines set down by Water Services Association Australia (WSAA) Conduit Inspection Reporting Code of Australia.

A more 'Advanced' approach may take more factors into the condition assessment including location of the SWD catchment or areas that require a higher LOS or high priority for remedial intervention measures. Local Council by programmed condition assessment can develop its own model with regard to age and condition curves. The models would be used as triggers to undertake routine and preventative maintenance in the early condition phases. The more critical phases would focus on rehabilitation and renewal projects and all outcomes of the model would assist in developing financial models for both operational and capital programs (IPWEA 2015).

Figure 3.3 displays a typical degradation curve that can enable an organisation to begin to address how a stormwater asset might degrade over time taking into account the environment, materials and soil conditions etc. (IPWEA 2015). The shape of the curve can be improved on as better and more data is developed through the assessment process.

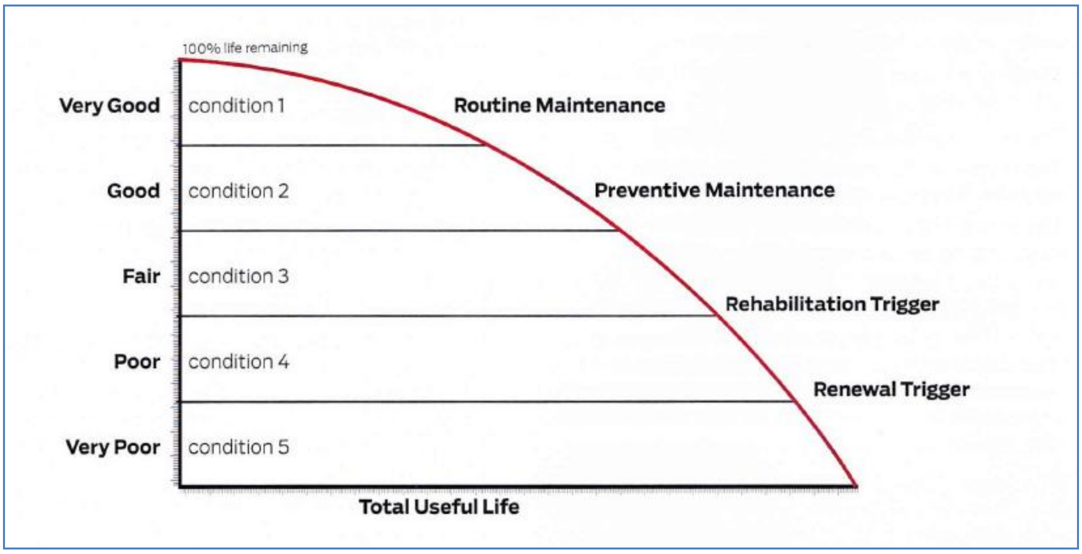


Figure 3.3: Typical Asset Degradation Curve (Y=1-x^2) (IPWEA 2015)

3.5 Risk and Criticality

IIMM (2015) describes risk management as;

> *"Coordinated activities to direct and control an organisation with regard to risk."*

Marsh (2016) discussed risk management in the context of best practise that covers operation and maintenance but also manages the risk involved in owning and use of the asset. Marsh defines risk management into two areas; 1) assessment and identification; 2) management and controls. ISO 14224 (cited in Marsh 2016) listed the four step model to be used in managing risk:

- Establish context;
- Risk assessment, identification, analysis and evaluation;
- Risk treatment;
- Monitor and review.

IPWEA, Practice Note 5 v2 (2015) outlines the 'Core' and 'Advanced' methods as part of setting up a condition assessment strategy. The 'Core' approach is to identify critical assets and associated risks and outline risk management strategies for these. The 'Advanced' approach the risk management is applied to all significant and critical assets at an individual level rather than to a group or overall system. Toy (n.d.) discusses risk as a combined measure of the consequences of failure and the likelihood or probability that such a failure will occur.

IPWEA, Practice Note 5 v2 (2015) defines critical elements in (SWD) systems as those that have a high or serious consequence if they do not meet their LOS and their risk rating can then be determined by also considering the probability of them failing. Toy (n.d.) when reporting on condition reporting for local council through a proactive CCTV programme set-out three clear phases:

- Define the criticality of the council's stormwater infrastructure;
- Defining the likelihood of failure of the pipeline;
- Using the combination of criticality and likelihood to prioritise proactive CCTV inspection of gravity pipelines.

Assets that pose a high risk of failure can be managed on a more regular maintenance program and programming the pipe to repaired or fully replaced can occur prior to total failure. Risk and criticality will be discussed more in depth when developing decision-making procedures relating to condition performance.

3.6 National and State Overview

Findings from the State of the Assets Report (2015) suggested Australia's ageing infrastructure networks are struggling to remain effective and historically infrastructure planning and funding across Australia has been fragmented and reactive. The report shows gross replacement value of local government infrastructure for all Australian Council's is estimated to at $438 billion s with $47 billion (11%) of assets are in poor or very poor condition and of the $33 billion of stormwater assets under management, $3.1 billion (9%) are in a poor to very poor state. The figures reinforce the need for better more sustainable asset management at all levels of government.

Roorda (2015) describes planning, building and maintaining infrastructure without a big picture perspective is counteractive and the key issue is overcoming the fragmentation between different levels of government. The key component is that infrastructure is inter-generational and long term strategic planning and a stronger approach on what needs to be achieved to support economic prosperity for the next generation.

Magarry (2010) summarised the changes within local government in Queensland and the impact of various initiatives had on asset management. A number of these initiatives in particular the Size, Shape and Sustainability (SSS) program were undertaken but were unsuccessful in providing any significant reform. At this stage no major reforms at a state level have been implemented since the introduction of the *Local Government Act 2009*. Local councils under the Act and in particular Section 4 which states:

> '…sustainable development and management of assets and infrastructure
> and delivery of effective services…'
> (Local Government Act (QLD), Section 4)

Local councils will need to invest in long term asset management planning for a sustainable future. As a result of Queensland local Council amalgamation in early 2008 many councils were not only attempting to manage their own assets but then were required to inherit a neighbouring council's asset base and any type of management system in place. For many council's, amalgamation was not the answer and they regarded this process as a reactive one stemming from the Queensland Treasury Corporation (QTC) report into the financial sustainability of local council. Roorda (2015) says evidence has shown amalgamations are not necessarily a solution to local government infrastructure problems, adding that the current solutions available to Commonwealth and State Governments to better manage local government infrastructure have not been very successful.

3.7 Summary

The review has covered important elements of asset management and each area has a vital to play in building an effective and financially sustainable model. To manage any asset base and making it sustainable for the long term requires these two fundamentals to work together for the overall benefit of both asset owner and the broader community i.e. rate payers and other key stakeholders.

Advanced asset management provides a clear understanding on local council's short term and long term plans in a more proactive manner. Local council's to achieve an effective advanced asset management plan will need to work from a 'Core' approach before transitioning to the more 'advanced' model.

Implementing predictive modelling is necessary to develop an advanced asset management plan. The level an organisation wishes to take this modelling to is governed by the effective management and availability of resources. Sophisticated and complex mathematical models are available but for many local councils this may not be the best approach. More relevant to the stakeholder may be a conditioning of the asset and rate of deterioration to project lifecycle costs.

Condition assessment is essential as a ‘Core’ approach to more advanced asset management and this may also require taking stock of what data the local council possesses. Clear parameters have to be outlined and understood as to the level of the reporting.

Identifying risk and criticality are both essential in setting up a condition assessment strategy and must be considered in any advanced asset management plan and the processes and models of that plan.

At both a national and state level, infrastructure management has focused on broken infrastructure where different political parties have brought their own agenda causing fragmentation. It is essential that governments at all levels find a sustainable strategy and balance affordable service levels of infrastructure with fair funding systems in pace for the long term.

4.0 Methodology

4.1 Introduction

This section will cover the project methodology in a more detailed approach. By following this approach, the project will be able to cover all aspects of the aim of the project. Upon completion of the following steps the remaining sections of the project will analyse and discuss the results of the model.

4.2 Detailed Approach

To achieve the desired outcomes, the following approach shall be undertaken:

1. Identify assets to be reported on and assess current data collection processes. This will involve meeting with support staff and external contractors and inviting them to assist with collection of data. Unit leaders and management will be advised of the scope the research and invited to contribute on any technical knowledge and asset management processes.
2. Once current data collection processes are detailed a desktop analysis will be conducted to identify suitable networks that can be utilized. These sample networks will cover various conditions and catchments i.e. residential, industrial, rural and coastal. The networks will be classified as individual case studies that will be assessed for current conditioning and data for predictive modelling. Any previous knowledge of maintenance issues related to these networks i.e. upgrades will be included in the report.
3. Reporting on how the condition performance is managed will be beneficial in moving forward to more advanced asset management systems. This will also involve researching how risk and criticality factor in the decision-making procedure. Therefore, an overview of current stormwater assets conditioning procedures will be undertaken including relevant databases and include asset information such as age, materials, asset type (pipe) and condition. CCTV surveys will be analysed as part of condition assessment and then tabulated in Microsoft Excel spreadsheet.
4. From this information a generic predictive model/approach will be developed targeting age and condition of the asset. This section of the report will detail

factors that may influence the model, i.e. environment, installation and placement, chemical and physical attributes. This model/ approach will work towards developing an advanced asset management plan and identifying any gaps in the current local government management process guided by case studies referenced in IIMM.

5. Research into the various types of predictive modelling will be conducted and compared. This type of research will detail the attributes of the models and conclude with what is the most appropriate model for stormwater. It is important to mention that actual development of the models will not be undertaken but rather an overview of the predictive modelling available to key stakeholders. The models will provide outcomes that will assist in determining the possibility of failure.
6. An important part of developing an advanced asset management plan is to minimise overall lifecycle costs while meeting minimum levels of service. This section will discuss renewal and maintenance strategies and current levels of service will be reported on to determine if any changes are needed to improve on the asset management plan. Various renewal and maintenance processes will be researched to provide best outcomes for the organisation.
7. A comparison of how the model predicts failure in the various networks will be recorded and analysed. This information and data will then be utilized to develop an advanced asset management plan aiming at more strategic asset conditioning.

If time permits further reporting on 'best practice' methods and also the feasibility of utilising these models over a range of class of asset will be included in the dissertation. The project will also hopefully open more possibilities for further research in developing more advanced strategic models that may assist other local councils.

These elements of the research project may be stipulated for further research beyond the scope of the final dissertation.

4.3 Resource Planning

To undertake the project successfully it is paramount that all resources required have been identified. All planning should be finalised at the early stages of the project and any issues with availability of resources need to be resolved immediately. The project will rely on obtaining readily accurate data and the ability to utilise this data in the most cost effective time without large delays. Any associated costs have been finalised and budgeted into the Sunshine Coast Council Asset Management program for 2016-2017.

Resources identified are:

1. Availability of support staff and external contractors that may be called into assist with obtaining network data from selected networks;
2. Computer and internet access both private and at place of employment;
3. International Infrastructure Management Manual (IIMM);

Determining the associated costs and availability of the resources listed are as follows –

The availability of support staff and external contractors i.e. CCTV operators is critical in assisting with obtaining the desired data and information for the project. Some of the data and footage has already been identified but may require further investigation to ensure there are no discrepancies in the data. Further investigation relating to condition of piped networks may be required and this will involve Sunshine Coast Council civil maintenance crews to assist with using heavy plant i.e. excavators and skid steers. The costs involved on some CCTV footage have already been fulfilled with the remainder been budgeted in the operational and maintenance costs with assurances from management that any further costs will be met.

Access to both private and work computers – laptops and desktops are continuous. Internet access and the use of mobile devices are readily available with unlimited access to 4G network and ESRI ArcMap GIS software for mapping and network data analysis.

Sunshine Coast Council Stormwater Unit have a hardcopy of IIMM 2015 version and also IPWEA Condition Assessment & Asset Performance Guidelines, Practice Note v2 2015. Data obtained will utilise Wincam survey report with full access to software and hardcopies of reports supplied by external contractors.

5.0 Identifying Current Stormwater Assets

5.1 Introduction

The following sections will discuss identifying the existing critical assets, current data collection procedures and suitable networks to be analysed for condition assessment. Further discussion will focus on the importance of risk and criticality and how they factor into the decision-making procedure.

5.2 Identifying Existing Critical Assets

The identification of existing critical assets is important when factoring risk and criticality (refer to 3.2). IIMM (2015) defines critical assets as those that are likely to result in a more significant financial, environment and social cost in terms of impact on organisational objectives. The most common existing critical asset identified within the Sunshine Coast Council Stormwater network is reinforced concrete pipe (RCP). Less common assets are fibre reinforced concrete pipe (FRCP) and reinforced box concrete culvert (RCBC). Other assets include inspection manholes, standard gully and field inlet pits will also be briefly discussed as these assets are necessary when locating pipes. Over the past 5 years Sunshine Coast Council have introduced high - density polyethylene pipes (HDPE) as replacement pipes and these assets will be discussed at a later section discussing renewal and maintenance strategies.

5.2.1 Reinforced Concrete Pipe

The manufacture of concrete pipes was first introduced to Australia approximately 100 year ago. Over the years the technology of producing concrete pipes has rapidly developed along with the changes in standard to the performance of pipes. AS/NZS 4058 states that based on past experiences of concrete pipe installations, a service life of 100 years could be expected dependant on the pipe's manufacture, application and installation conditions. CPAA Design Manual (2013) describes a number of key elements need to be considered when assessing concrete pipes:

- The varying quality of pipe from different manufactures;
- The suitability of the pipe for its intended use including – diameter, load class, watertightness and joint type;
- The quality of the installation – initial bedding type, handling and storage, fill treatment and gradient. Ongoing would include installation conditions and embedment support;
- The external and internal environment and how they change over the service life of the pipeline i.e. tree planting.

The most common pipe used is a Class 2 or marine grade pipe – 2.44m in length with a standard spigot and socket elastomeric seal joint. Poor handling and installation can result in cracking of the join causing displacement. These elements and the age of the pipe are important when assessing pipe condition and possible future failure. The environment is a key component as it includes tree root intrusion, damage from excavations, illegal connections - private plumbing and conflicts with other services (Energex, Unity water and Telecommunication conduits).

Figure 5.1 displays the breakdown of all known pipes that exist within the council's asset base. It is evident from the graphic that the overwhelming type of pipe is RCP with only

Material	Length	Percentage
ACP	*170.35*	*0.01%*
ArmcoSteel	*66.34*	*0.01%*
Concrete	*42.71*	*0.00%*
CSP	*12.19*	*0.00%*
DICL	*43.13*	*0.00%*
GalvSteel	*71.76*	*0.01%*
HDPE	*343.16*	*0.03%*
Matrix	*5,747.69*	*0.47%*
PP	*3,911.09*	*0.32%*
FRC	*3,836.97*	*0.32%*
PVC	*18,979.06*	*1.57%*
RCBC	*33,218.85*	*2.74%*
RCP	*1,137,579.81*	*93.97%*
Reinforced Conc	*-*	*0.00%*
RPP	*9.09*	*0.00%*
Rubble	*3,222.80*	*0.27%*
SLBC	*634.69*	*0.05%*
SlimDrain	*70.49*	*0.01%*
SlottedPVC	*55.98*	*0.00%*
Timber	*12.34*	*0.00%*
UPVC	*2,573.14*	*0.21%*
TOTAL	**1,210,601.64**	

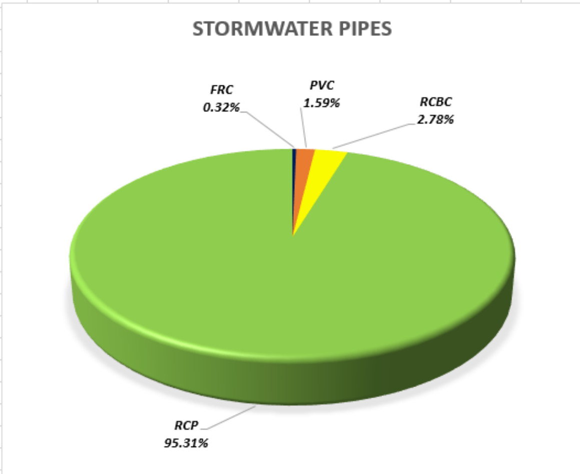


Figure 5.1: Breakdown of Asset Type (SCC GIS, 2016)

Approximately 3% of asset classes being reinforced concrete box culvert (RCBC) and fibre-reinforced concrete pipe. (FRCP).

5.2.2 Fibre Reinforced Concrete Pipe

These types of pipes were installed due to their light weight and durability in coastal areas. The majority of pipes in the Sunshine Coast network are the standard class 2 pipe with a single unit length of 4 metres. The pipes are predominantly flush joint pipe with a 20mm flange. The pipes are manufactured using a variety of cementitious material. (Standards Australia, 2003) list the following reinforcement materials that can be added to the pipe:

- Cellulose fibre;
- Plastics fibre;
- Glass filament;
- Steel fibre;

Sunshine Coast Council no longer install these pipes and they are less common than RCP.

5.2.3 Reinforced Concrete Box Culverts

Like FRCP these assets are mainly used as road and bridge culverts or in areas where there is minimum cover. Box culverts are more beneficial where there are wide flows with low head. Installation of Box culverts requires minimal excavation and backfill and therefore preferred over pipe where there is the possibility of excessive excavation into rock. Box culverts located within Sunshine Coast Council infrastructure network are either pre-cast single units or multi-cell units. Multi-cell units that have three or more cells are predominantly joined by a linking slab to minimise costs. Configuration of joints does not usually require a water tight seal and culverts are common with mainly butt joints.

5.2.4 Standard Inspection Manholes and Catch Pits

Catch pits and inspection manholes have their own specific role to play in a stormwater network. Catch or gully pits are usually located in the low point of a roadway or at the kerb return where at intersections. Inspection manholes are where there are a number of pipe branches meeting at one point or where there is a significant change in direction either horizontally and vertically. These assets will not be assessed as part of the condition process but as mentioned important to describe as they can have an influence on the condition of a network. Pipe location, size, depth and material can be gathered via either desktop analysis or field data inspection.

5.3 Current Data Capturing Processes

For many organisations, accurate GIS asset data is essential to ensure they have a robust decision-making foundation to enable all facets of asset management functions. Sunshine Coast Council currently employ staff to locate and validate data on a day-to-day basis. Data collection on a large scale is resource intensive process particularly on a large network like Sunshine Coast Council own and maintain. IPWEA, Practice Note 5 v2 (2015) describes that a structured and well thought out approach is needed first. The approach must consider the organisation’s needs or the range of the issues the data in intended to address and also consider a balance between the data confidence, cost both internal and external and time needed to gather and process the data.

Considering these issues mentioned and for the purpose of the research, a number of resources are available to ascertain the location of the assets. The general procedure for verifying location of a stormwater asset is:

- Desktop Analysis of Council Mapping system (Arc-GIS);
- Site visit – visual inspection;
- Trimble GeoExplorer 6000 series.
- Surveyors.

5.3.1 Desktop Analysis

Prior to any field work it is essential that a desk top analysis is undertaken utilising the following resources:

- Desktop review of councils’ stormwater GIS system to identify the network or confirm unknown assets;
- Undertake a search of councils’ information management system to locate ‘As Constructed’ plans;
- Utilise Google Map Street view for approximate location.

Information and data gathered will be referenced to assist with field site visit. Majority of desktop analysis utilises council's GIS system as many of the networks are more than 10 years old and therefore 'As Constructed' no longer exist.

5.3.2 Site Visit and Ground Truthing

Once on-site the asset will be cross-checked with the corresponding asset number and location detailed in the information gathered from the desktop analysis. This may include approximate location corresponding to structures, cross streets and adjoining easements. More detailed information such as the pit and pipe type, size can be recorded. To properly gather this information, it may be necessary to access pit and manhole structures. These activities should only be undertaken after a personal risk assessment has been conducted as outlined in Appendix C. A major variance to the asset's location or type, e.g. manhole on map is in fact a gully pit on site then this information would be forwarded to the council's GIS team to update. Any discrepancies would first be reviewed by the Senior Asset Engineer to gauge the severity of the misalignment.

5.3.3 Trimble GeoExplorer 6000 series

A field survey is essential for asset validation and valuation and as previously mentioned 'As Constructed" data may not be available or exist. Sunshine Coast Council owns 2 Trimble GeoExplorer 6000 series devices and these are utilised to capture stormwater assets. For a complete and well defined data capture the following equipment is required:

- GIS computer with GNSS capability;
- GIS Mapping software and desktop computer;
- GPS Pathfinder Office software.

The Trimble GPS Pathfinder Office software is utilised to create a data dictionary. A data dictionary is essential for downloading information pertaining to attributes that are to be mapped. The data dictionary works closely with councils Mapping and Spatial Information Management team.

The Trimble device used in the field has a highly accurate range that can locate within 200mm of an existing structure. The device is attached to a carbon fibre antenna and placed on the centre of the pit or start of pipe. Figure 5.2 displays how the equipment is used and its setup. Once the data has been collected in the field it is transferred to the GPS Pathfinder Office. This is then exported namely as shapefiles and accepted by the GIS mapping software. The files are then transferred into councils ArcGIS system which is the mapping system referenced in this project.

Figure 5.2: Trimble use and set-up (Priest 2016)

5.3.4 Surveyors

There are occasions when it is necessary to engage a qualified surveyor to assist in locating stormwater assets. The GIS mapping system is not always accurate and especially when dealing with location of pipes within easements. This is a crucial point to address as assets located in private property are regarded as a high risk asset. Stormwater unit will engage either a private surveyor or if available a council surveyor to undertake the works. On occasion these field works will be in conjunction with CCTV contractors who have the technology to assist with locating obscured assets i.e. manholes and pipes not indicated on GIS. Once the survey is completed it is drawn in AutoCAD in GDA94 co-ordinates and a separate PDF copy (Figure 5.3) is retained by the asset owner. To ensure the asset attributes and location is recorded accurately the file is forwarded to council's GIS unit where any updates are completed.

On occasion for more detailed asset location, surveyors and CCTV contractors will work together to ascertain the location of hidden or concealed assets. This process would include the use of sonar systems and ground penetrating radars. Discussion on these technologies will be discussed further in the research project.

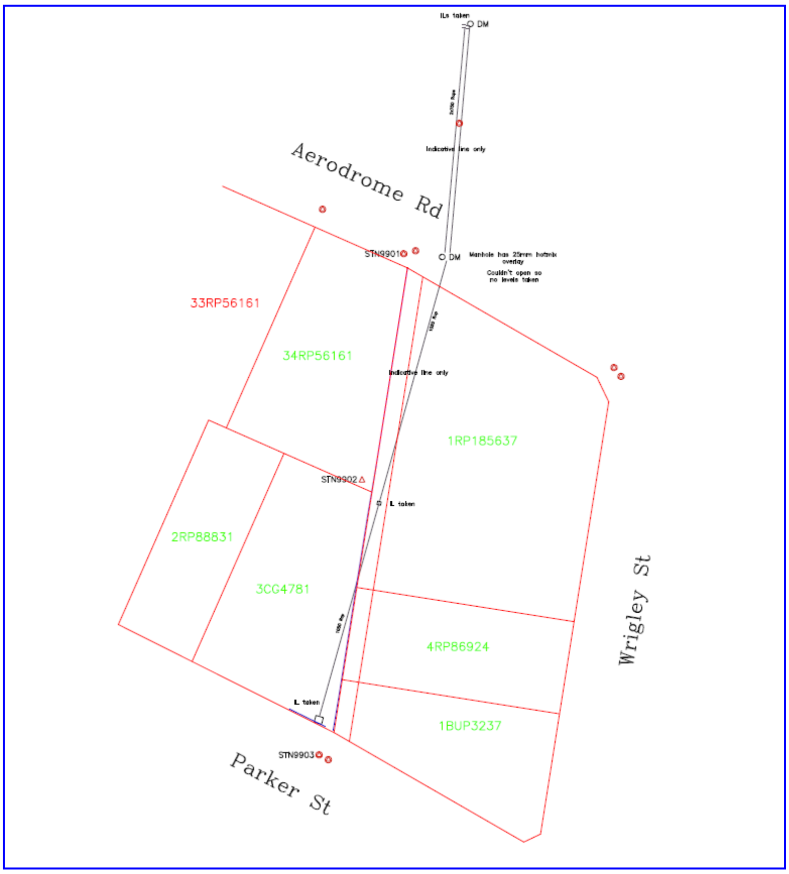


Figure 5.3: PDF file survey alignment (SCC 2016)

5.4 Summary

It is important to clearly define the scope of asset type and how these assets are captured for local councils to progress from a 'Core' asset management system to an 'Advanced' system. Considering the options of data capture will help determine the most cost-effective approach. The more advanced the equipment then the systems and resources to manage these elements would have to be considered to have a good balance over time required to capture the data, cost to the organisation managing the data and finally having the confidence in the data quality and reliability.

6.0 Pilot Network Study

6.1 Introduction

To collect condition data three sample networks were selected as pilot studies. The aim of selecting these networks was to arrive at a more informed overall assessment of the whole network (IPWEA 2015). Once the networks were identified then a full CCTV condition survey was undertaken providing detailed footage of the condition of all the pipes in the corresponding networks. A number of factors were considered when selecting the three networks:

1. Previous CCTV footage and assessment information that can be compared with current condition assessment.
2. Variety of locations covering a number of influencing factors on the condition of the network e.g. Coastal networks exposed to tidal flows, exposed to acid/sulphate soils, under dwellings and roads, exposure to tree roots.
3. History of maintenance works that may influence overall condition and performance of network.
4. Date of construction of network was before 1985.

The following sections will give a brief description of each network including aerial map locations.

6.1.1 Sample Network A – Nambour Hospital

The first network that was assessed was located within the Nambour Hospital area, approximately 1 km west of the town centre, refer to figure 6.1. The upper section of the network is located under Mapleton-Nambour Road – a high order road that services up to 5,000 vehicles per day (GIS 2016). The network outlets into an open natural area within the grounds of the Nambour Hospital. Other important features of the network include:

- Section A - A 525mm reinforced concrete pipe that is located under the western wing of the children's ward;
- Section B - A 525mm reinforced concrete pipe that is located directly in front of the exit gates of the seven storey carpark station;
- Approximate gradient of the network ranges from 1% - 8.5%.

Figure 6.1: Sample Network A - Nambour Hospital (SCC GIS 2016)

General knowledge of past CCTV survey and condition assessment undertaken in 2007 meant the network was a suitable pilot sample to be used.

6.1.2 Sample Network B – Golden Beach

The second network that was assessed is located in Golden Beach just south of the town of Caloundra – refer to figure 6.2. This network is a straight line pipe joined by a number of field inlets and manhole chambers and outlets into the Pumicestone Passage. The area also serves as public access walkway for pedestrians coming from the Golden Beach town centre. Main features and issues with the network are:

- The upper section of the network west of Kitchener Street has had issues with tree roots blocking the 300mm pipe (Section A).
- Towards the outlet and running parallel to The Esplanade is a 225mm water main running directly through the pipe (Section B).
- The network is tidal with some inundation during high tide and has a submerged outlet supported by a rock revetment wall.

The network was chosen due to it being a typical coastal network and over the years there have been numerous maintenance issues with minor flooding in the caravan park and some field inlets surcharging.

Figure 6.2: Sample Network B - Golden Beach (SCC GIS 2016)

6.1.3 Sample Network C – Industrial Estate - Kawana

The third and final network that was assessed is located at an industrial estate, Main Drive Kawana. This network has two main trunk lines running east - west and meet at a third line which outlets into a large canal system. The network is located approximately 1m offset from the kerb and channel running parallel with Main drive. Some of the main features of this network include

- Pipes in this area are subject to heavy axle load traffic, including large concrete trucks and semi-trailers.
- Section A receives runoff from a number of industries including a concrete batching plant.
- Section B is more to the east and receives runoff from Nicklin Way and also a smash repairers and metal recycling yard.
- Section C runs perpendicular to the Section A and B and has large trees growing directly above it and a chemical/detergent workshop on the eastern side.
- The outlet is permanently submerged and constructed as part of a concrete revetment wall.

Figure 6.3: Sample Network C – Industrial Estate, Kawana (SCC GIS 2016)

All three networks provide a comprehensive cross-section of the typical type of stormwater networks that are managed by Sunshine Coast Council. The networks have their own specific problems and are ideally suited to a comprehensive condition assessment for data and information purposes.

6.2 CCTV Survey Procedure

The following section will describe the equipment and procedures involved in conducting the stormwater condition assessment surveys for the selected networks already discussed. Sample network B – Kitchener Street, Golden Beach has been included as an example in this section. The procedures detailed are the same for sample network A and C but these networks are not described in this section.

6.2.1 CCTV Survey Equipment

Sunshine Coast Council currently engage local contractors to undertake CCTV pipe inspection surveys. The contractors are fully equipped to complete all surveys up to and including 1200mm diameter pipe. The majority of the inspections utilise a non-autonomous tele-operated tractor camera. Data is transferred back to the operator via a communications cable and the operator has a portable monitor and laptop recording the footage. Figure 6.4 displays the tractor camera inside a 300 mm reinforced concrete pipe.

Figure 6.4: Tractor rear view (Priest 2016)

Figure 6.5: Tractor front view (Priest 2016)

The data cable and rear view camera can be clearly visible. Figure 6.5 is taken looking back at the tractor as it takes footage of the pipe.

The use of tractor CCTV survey equipment has long been used at Sunshine Coast Council for capturing the detailed video footage condition of an asset. As part of councils approach to a more advanced system, the stormwater unit has been trialling the use of a commercial high-definition zoom camera to capture overall condition of the pipe for a more cost and time effective outcome. The camera is mounted at the entrance to the pipe on an extension pole and the operator then self-centres the camera into position. Once in place the camera can be operated with the use of an I-pad to take a number of focused images of the pipe detailing any breakages, blockages or possible service intrusions. Some of the benefits are:

- Quicker access to multiple pipes form one central position.
- Ease of operation – using tablets and Wi-Fi back to desktop computers in real time.
- Far less time setting up as compared to conventional CCTV tractor cameras.
- Quick assessment of pipes detailing any pre-cleaning requirements.
- Portability – can be carried by one person.

Figure 6.6 displays the camera attached to the extendible mast. The unit is positioned in the catch pit and is pointing into the pipe.

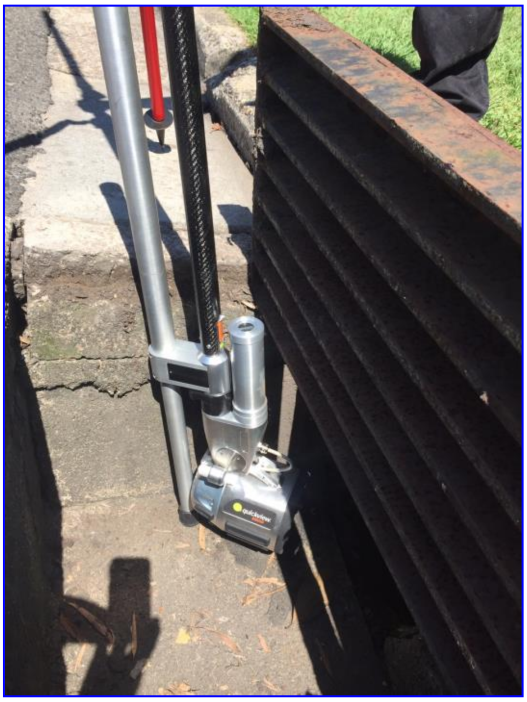


Figure 6.6: Quickview HD camera in position (Priest 2016)

Sunshine Coast Stormwater Unit are still in the process of trialling the Quickview HD zoom camera with further analysis been undertaken in relation to its quality of survey and how it performs over a number of larger networks. The trial will provide a better knowledge base of how it is best suited in an advanced asset management system. For the purpose of this research project only the footage and data from the tractor camera have been included.

6.2.2 Network Survey Scoping Procedure

Sunshine Coast Council Stormwater Unit as previously mentioned engage private contractors to undertake all CCTV survey. This section will outline the procedure on how the information from Council's GIS mapping system is detailed and forwarded onto the contractor to complete the survey. The contractor is supplied with a scope of works as outlined in Appendix D, this document includes the following:

- An aerial view of the network to be surveyed including leaders pointing to each individual asset type - this includes the asset number;
- Various site photos are added both for general knowledge and to highlight areas of concern i.e. location of pits and outlets;
- An attribute table lists all the assets to be surveyed and is effective in ensuring that the assets are correctly identified in the survey process. It is the requirement of the contractor to include this table in their final survey report.
- Any discrepancies detected i.e. conflict data in pipe size or location, would be added to the table as an amendment and can be updated in GIS once survey is completed;

Upon receiving the scope of works, the contractor will complete the survey and detail any apparent asset defects and forward both the hardcopy and video footage to council. The contractor does not include any condition rating on any asset, this action will be undertaken by staff attached to the Stormwater Management Unit.

6.2.3 CCTV Survey Report

A detailed condition survey is undertaken by the contractor and during this phase the contractor may contact the Project Officer regarding any issues with access and/or additional cleaning of the asset for the survey to be completed. An example of the completed report for Sample Network B – Kitchener Street, Golden Beach has been detailed in Appendix E. The report includes:

- Covering Sheet;
- Hand drawn map detailing specific areas of interest;
- Schematic conduit inspection with condition comments;
- Photos of pipe condition.

As part of the reporting process, a separate USB device is required with all completed video/CCTV footage of the network. The video and photo footage is recorded using WinCan software – this software is utilised as an industry standard by local councils and water authorities. The condition coding system is used in conjunction with the *Water Services Association of Australia Conduit Inspection and Reporting Code WSA 05 – 2008.* Figure 6.7 displays the typical layout of the WinCan assessment condition report, included is the video footage of the asset (top right), middle top left is the information pertaining to the asset being viewed and the bottom section is the tabulated field of each

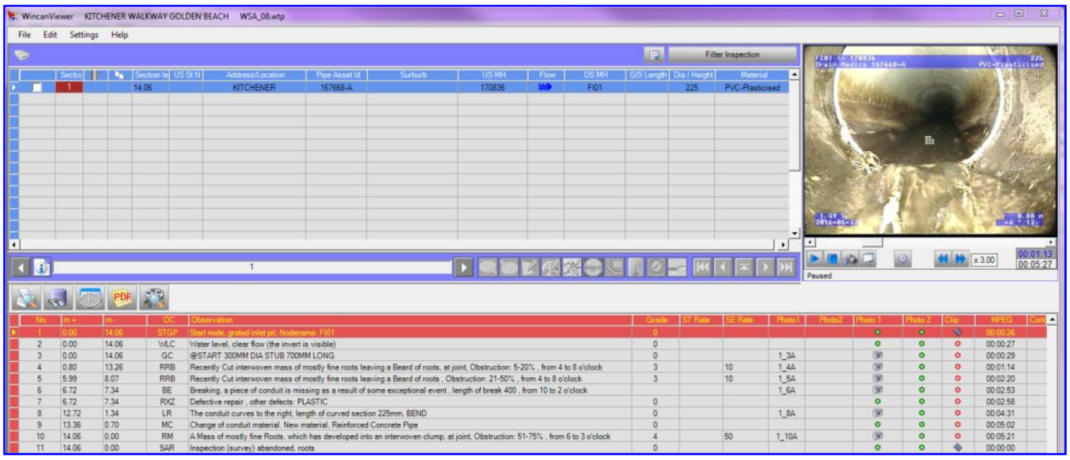


Figure 6.7: Screen shot of WinCan pipe condition assessment software (WinCan 2016)

Section of the network that has been captured and this includes photos and comments from the operator. Survey details from the WinCan software can be compared to the information taken from council's GIS mapping system to validate the accuracy of pipe lengths and diameter.

6.3 Summary

The sample networks discussed in this section represent a good cross-section of the storm water network within the Sunshine Coast Council region. CCTV survey and condition assessment provides the data and information necessary to commence predictive modelling and a better understanding of how the pipes are performing over a period of time.

The use of CCTV tractor cameras is still the standard tool for undertaking CCTV surveys. While this type of technique will always be the accepted tool, it is important for councils and asset managers to keep up with advances in new technologies. As part of streamlining CCTV operations and reducing time and costs, Sunshine Coast Council will continue to trial the Quickview high-definition zoom camera. It is envisaged that the camera will assist in preliminary investigations and some condition reporting but will not fully replace the conventional CCTV tractor camera.

7.0 Sample Network Assessment Outcomes

7.1 Introduction

This chapter highlights the methods undertaken to assess the overall condition monitoring and performance of the selected networks already mention in chapter 6.0. The important role of risk and criticality will also be discussed and how these elements influence decision-making and determining the overall condition of the asset. The completed sample network CCTV surveys will be assessed and distress modes included to ascertain condition rating.

7.2 Condition Monitoring

IIMM (2015) describes Condition Monitoring as follows;

> *"Continuous or periodic inspection, assessment, measurement and interpretation Of the resultant data, to indicate the condition of a specific component so as to determine the need for some preventative or remedial action"*

The condition monitoring/assessment is carried out by qualified and competent technicians who provide data and information about the asset and this in turns provides management with the ability to provide effective strategic asset management decisions (IPWEA, 2015).

To understand the importance of robust condition assessment, local councils and key stakeholders must have sound knowledge of the condition of the assets. This would include background knowledge of any past remedial works undertaken and current maintenance routines. It is important for the asset owners to ensure that the works being undertaken are at a level of quality that provides benefit to the asset and not worsen the overall condition of the asset. This may include regular reporting from maintenance crews on activities that may influence the condition of the asset.

An example could be:

Nature of incident - A sinkhole has appeared at a busy intersection.

Rectification works – As safety of the public is a priority the road surface needs to be repaired. Repairing the pipe involves filling the void/break in the pipe and this requires concrete to be poured over the void. The maintenance crew fill the void and some of the concrete flows into the pipe causing a build-up inside the pipe.

Outcome of the repair – Future internal relining or patching of the pipe has been delayed as preliminary works need to be carried out to remove the concrete that came from the maintenance crew repair work.

Better outcome – Liaise with asset owner to ascertain what type of permanent treatment is planned and how the interim repair works could be completed without minimum disruption. A temporary external fibre or plastic placed over the void and the pipe to be monitored until further works are carried out.

The example outlines the importance of good communication between the asset owner and relevant parties that could influence the overall condition of an ageing asset. Therefore, condition monitoring and assessment needs to be an ongoing activity not just a reactive plan that only focuses on regular CCTV asset surveys.

IPWEA, Practice Note 5 v2 (2015) lists a number of outcomes from Condition assessment:

- Desktop analysis and preparation of the physical inspection plan;
- Physical inspection of SWD systems to assess the actual condition of the assets and compare this with the asset owner's benchmark in quality and design standards;
- Identification of both short-term maintenance works and longer-term renewals or refurbishment to a required level of service;
- Rank or prioritise the maintenance works and longer-term renewals;
- Determination by qualified personnel to identify and mitigate any immediate risk until remedial works or activities can be taken to address problems;
- Confirmation of asset inventory, estimation of remaining useful life of the asset and calculate the depreciated replacement cost as part of the asset valuation process.

Condition monitoring and assessment requires a holistic approach to maintaining the asset over its useful life. Therefore, it is imperative that the appropriate strategies are formulated to ensure the best possible future investments are undertaken on the networks.

7.3 Risk and Criticality

Whilst undertaking any condition assessment, the risk assessment process is a mandatory process that all asset owners must consider. IPWEA, Practice Note 5 v2 (2015) breaks the approach into a 'Core' and 'Advanced' level. The 'Core' approach identifies critical assets and associated risks and all assessment should begin at this level. The 'Advanced' approach applies to assets at an individual level and the importance of risk evaluation is closely looked at. ISO Standard 31000 (2009) defines risk management as;

> *"Co-ordinated activities to direct and control an organisation with regard to risk"*

A number of key areas are considered when an organisation is maintaining risk, ISO Standard 31000 (2009) identifies a wide range of elements including:

- Increase the likelihood of achieving objectives;
- Improve controls;
- Improve governance;
- Encourage proactive management;
- Improve operational effectiveness and efficiency;
- Establish a reliable basis for decision-making and planning;
- Improve loss prevention and incident management;
- Comply with relevant legal and regulatory requirements;
- Effectively allocate and use resources for risk treatment;
- Improve organisational resilience.

Identifying risk is part of the condition assessment process and along with criticality, assist in determining the overall condition of the stormwater pipes surveyed in the sample networks. The risk identification process can be broken into two main areas – failure modes and distress modes.

ISO Standard 31000 defines risk identification as the process of finding, recognizing and describing risks. The standard goes on further to describe the need to identify risk sources, their causes and potential consequences of failure. The identification can analyse historical data, theoretical analysis and expert opinions. In the case of expert opinions this involves the asset owner i.e. Stormwater Asset Manager in consultation with technical staff deciding on a course of action with regard to the asset being conditioned.

7.3.1 Failure Modes

Determining how a stormwater pipe may fail is vital to understanding and predicting future modelling of the component. Pipe failure can either be a minor or catastrophic event affecting the performance of the pipe to total collapse adversely impacting on lives, property and have significant financial implications. IPWEA, Practice Note 5 v2 (2015) lists a number of these adverse impacts:

- Flooding causing property damage;
- Flooding of roads and public areas;
- Flooding of utilities and services;
- Creating hazards to the public and traffic – sinkholes;
- Infrastructure and environmental damage – erosion, pollution and scour.

7.3.2 Distress Modes

Distress modes need to be considered as they will affect the performance of the asset and their level of service. The modes are again considered when undertaking the condition assessment of the pipes and these modes can be separated into two main areas – structural defects and serviceability. Structural defects can cover a number modes including:

- Installation defects due to poor handling of the pipe –
    - Causing longitudinal cracking and circumferential fracturing;
    - Improper bedding and compaction – displacement at joints;
    - Improper cover of pipe under heavy vehicle load – cracking and displacement;
- Chemical and environmental impacts –
    - Tidal areas where there is a high level of chlorides – corrosion of concrete and steel reinforcing;
    - Groundwater containing high levels of sulphates – spalling and corrosion;
    - Acid – sulfate attack both internally and externally – causing invert erosion;

- CO_2 leaching both internally and externally;
- Root intrusion –
    - Causing blockages and build-up of debris and sedimentation;
    - Forcing pipe to crack and creating voids;
- Poor constructability –
    - Incorrect joining of pipes - failure to insert rubber ring seals causing displacement and infiltration.
    - Poor workmanship – breaking into pipes and poor connection into pits;
    - Illegal private connections – private plumbing directly into pipes causing issues such as cracking, voids, infiltration of groundwater and surrounding soils.

A pipe network at different stages of its useful life can exhibit one or a variety of these distress modes and these all need to be taken into consideration when assessing both the condition of the asset and the risk these modes may produce.

7.3.3 Criticality

As part of the research project Sunshine Coast Council Stormwater Unit have developed their own hierarchy of failure and this list is used extensively when considering risk and criticality of the pipe asset. Considering the level of criticality can assist the asset owners in effectively maintaining the high risk assets and therefore undertake activities that extend the useful life of the asset. The list is based on location of the asset and consequence of it failing;

- Directly located under a building – residential, government (hospital), commercial;
- Adjacent or between two buildings;
- Crossing a major roadway;
- Crossing a residential street – local traffic only;
- Within a road reserve in a commercial business district – Main street.
- Within a public area – parks and open spaces.
- Network out letting into a natural waterway – adverse environmental impact.

Sunshine Coast Council refer to the following likelihood of failure rating table listed in IPWEA, Practice Note 5 v2 (2015). The table assists council in programming future CCTV inspection activities.

Table 7.3: Likelihood of Failure Rating Table (Coarse Condition Rating) – Indicative only (IPWEA 2015)

Likelihood of Failure Rating Table (Coarse Condition Rating) – Indicative Only		
Description	**CCR**	**Suggested Inspection Freq.**
Assets > 70 years' old Assets > 50years in saltwater Steel/aluminium pipes Plastic/relined pipes In highly reactive soil/acid sulfate Subject to faulty construction practices – improper compaction	5	1 – 5 years
Assets > 50 years' old Assets > 40 years in saltwater AC or earthenware material	4	5 – 10 years
Assets 30-50 years' old or In close proximity to trees	3	10 – 15 years
Assets 10 - 30 years' old	2	15 – 20 years
Assets < 10 years' old	1	As need arises

Assessing the pipe assets for probable failure is fundamental to any advanced asset management plan. Indicators such as pipe type and material, age, soil conditions and the impact of tree roots will have an influence on the inspection frequency. The process can be improved upon as more of the network is surveyed and details of the indicators become more apparent. Table 7.4 displays the critical rating for assets when considering prioritising maintenance and remedial works.

Table 7.4: Criticality Rating Table – Indicative only (IPWEA 2015)

Criticality Rating Table – Indicative Only	
Description	**Criticality rating**
Systems under major buildings (hospitals) Systems serving a CBD precinct Systems providing drainage to a major transport corridor Systems > 1200mm dia. And > 4.5m	5
Systems under buildings Systems providing drainage to commercial/industrial areas Systems providing drainage to sub-arterial transport	4

corridors Systems > 900mm diameter all depths Systems between 600 – 900mm > 4.5m length	
Systems providing drainage to moderate density urban development Systems providing drainage to collector/distributor road transport networks Remaining SWD systems with depth > 3m	3
Systems providing drainage to low density urban development Systems providing drainage to local road transport networks Remaining SWD systems with depth < 3m	2
Systems providing drainage to parks and open spaces where overland flow escape paths exist that significantly reduce any hazard to property or community users	1

7.4 Sample Network Condition Assessment

As mentioned in sub-section 3.4.2 Sunshine Coast Council Stormwater Unit rate the condition of all assets using the rating system as per IPWEA, Practice Note 5 v2 (2015). The rating system is a basic 1 – 5 where a condition 1 is very good and 5 is very poor. It is important to note that the rating system broadly covers the asset condition and should only be used as a guide. The undertaking of asset condition is purely an objective one (IPWEA 2015) and the final score is determined by the asset owners and technical staff responsible for the asset. Important to note that assets currently being assessed by Sunshine Coast Council do not give a 0 rating for any assets. Decommissioned assets are removed from the GIS database and any maintenance required to make the asset safe are undertaken by council's construction and maintenance crews.

Once the condition of the asset is determined a comparison can be determined using the degradation curve as shown in sub-section 3.4.2. This curve is provided as an example of how an asset degrades over the useful life of the asset. To assist with the condition assessment IPWEA, Practice Note 5 v2 (2015) provides a series of photographs of assets at various levels of condition and a condition grading table for stormwater assets (constructability and serviceability, (IPWEA 2015). Based on the photographs, a comprehensive condition assessment was undertaken of all three sample networks and the completed condition assessment along with a criticality/priority table have been included in Appendix F.

The condition grading table includes the estimated residual life of the asset i.e. estimated percentage of asset life remaining. The residual life will assist in determining an approximate time when the pipe may fail and will be discussed further in the research project.

Upon completion of the condition assessments an overall condition grading is given for each asset. Further to the condition rating the overall criticality of the asset is calculated by multiplying the likelihood of failure and the consequence of each pipe failing.

Using Table 7.3 and 7.4, a more advanced and robust assessment system can be undertaken involving criticality and a priority scoring. Table 7.5 displays a priority risk matrix corresponding to likelihood and consequence of failure. Table 7.6 displays the overall completed tables with priority rating for all pipe assets in the networks.

Table 7.5: Priority Risk Matrix – Indicative only (SCC 2015)

Likelihood					
1	Low	Low	Medium	Medium	High
2	Low	Low	Medium	Medium	High
3	Low	Medium	High	High	High
4	Medium	Medium	High	High	Extreme
5	Medium	High	High	Extreme	Extreme
Consequences	1	2	3	4	5

Table 7.6 – Completed criticality table with priority rating

Sample Map A - Nambour Hospital						
Criticality and Priority Rating						
PIPE ASSET No	CONSTRUCTION DATE	LIKELIHOOD	CONSEQUENCE	CRITICALITY	2016 CONDITION RATING	PRIORITY RATING
107441	1971	3	2	6	3	Medium
124678	1971	3	2	6	3	Medium
107442	1971	4	5	20	4	Extreme
107443	1971	4	5	20	4	Extreme
124817	1971	3	3	9	3	High
Sample Map B - Kitchener Street - Golden Beach						
New Asset	1975	3	3	9	4	High
167668	1979	2	3	6	3	Medium
165752	1975	3	3	9	3	High
165751	1975	3	3	9	3	High
165753	1975	2	3	6	4	Medium
164988	1975	3	4	12	4	High
132208	1975	3	3	9	3	High
164989	1975	3	3	9	4	High
Sample Map C - Industrial Ave - Kawana						
160609	1979	2	3	6	3	Medium
161011	1979	2	3	6	3	Medium
161013	1979	2	3	6	3	Medium
161013	1979	3	3	9	3	High
160607	1980	3	2	6	3	Medium
160608	1979	3	4	12	4	High
160383	1979	3	3	9	3	High
160605	1979	2	2	4	4	Low
160606	1980	2	2	4	3	Low
160604	1979	2	2	4	3	Low
160384	1980	2	3	6	3	Medium
163765	1980	4	4	16	5	High
146360	1980	3	3	9	4	High

7.5 Summary

Importance must be placed on how networks and the individual pipe assets are identified and assessed. By undertaking sample networks, it is possible to determine how certain assets are performing and also how the asset is ageing. Attempting to conduct condition assessment without any type of planning is not feasible and ineffective both from an operational and future capital planning perspective. Importance must be placed on risk management and identifying the issue of criticality when grading the condition of the asset. Asset owners and local councils need to outline certain criteria and benchmarks in condition assessment as this not only provides more effective ways of maintaining the assets but will also aid the ongoing process of predicting failure within the network. Reference to industry standard practices such as IPWEA Practice note 5 is practical but councils must also make condition assessment monitoring programs suited to their particular assets.

8.0 Predictive Modelling

8.1 Introduction

ISO 55001 clause 10.2 requires that:

> *"The organisation shall establish processes to proactively identify potential failures in asset performance and evaluate the need for preventative action"*

The use of predictive modelling to determine the degradation of stormwater pipe assets is essential for future planning and renewal forecasting. IIMM (2015) outlines the benefits of developing models as:

- Promotes discussion between operational managers and financial units;
- Provides a solid base for optimising an organisation's budget;
- Assists and develops long-term planning by providing information and data on the long-term performance of the asset.
- Provides insight into how maintenance and renewal activities have on the performance of the asset.

IIMM (2015) lists two methods to model changes in long-term asset performance – deterministic and stochastic models. The deterministic model uses equations to represent the deterioration of the asset and all assets are assumed to be in a given condition at a given age. The stochastic model relies a more complex probabilistic technique but has a greater level of flexibility but uncertainty (IIMM 2015). For the purpose of the research project the deterministic approach was undertaken where reference to deterioration curves be developed from first principles where knowing how the asset materials respond to the environment and both archival and current data.

The model accuracy is based on technical expertise, and asset data (condition grading and age) taken from the field work at the sample sites. As more data and condition assessments are conducted on larger networks the model accuracy will be more reliable and better management strategies can be developed.

The research project as already discussed is basing the modelling on the useful life of the pipe for the three sample networks surveyed. The purpose of this section is to determine how the research model compares with the financial model developed from *The Sunshine Coast Council – Comprehensive Infrastructure Revaluation* (Cardno, 2014) and the core model developed from *The Sunshine Coast Council Stormwater Unit - Asset Management Plan 2014* (SCC, 2014).

Comparing the models will support and assist in determining how the advanced asset management plan will develop relating to risk analysis, revised levels of service, optimised decision making with regard to maintenance and renewal costs. A final aim of this section is to validate the research model as one that can be used by the asset owner as a more effective sustainable approach. The following sections will discuss each individual model.

8.2 The Financial Model

The Sunshine Coast Council financial model was developed in conjunction with Cardno Engineering Consultants in 2014. The revaluation was conducted in accordance with *Local Government Regulations 2012, Local Government Finance Standard 2012* and Australian Accounting Standards:

- AASB 116 Property, Plant and Equipment;
- AASB 13 Fair Value Measurement;
- AASB 136 Impairment.

Part of this undertaking is to revalue Council's assets at least every three years to ensure fair value is reported in the annual financial reports and asset financial information aligns to Council's Asset Management Plans (Cardno, 2014).

The financial plan places a high priority on obtaining an overview of the financial values of those assets including fair value, residual value, cost to repair and replace, expected initial and current remaining useful lives (Cardno, 2014). The financial model was undertaken by the Finance and Accounting Department and the majority of asset data and current condition was an age based assumption. Cardno (2014, p. 9) defined aged based assumption as.

> Where reliable and accurate condition data is not available for assets, as in the case of the Stormwater Network which is predominantly underground, assumptions are made about the assets depreciating in a straight line over the length of their useful life. Any assumptions made are clearly defined and disclosed and data used is subjected to a test for reasonableness. (Cardno 2014, p. 9)

This assumption works on a straight line degradation of the useful life of the pipe which is contrary to the IPWEA degradation curve shown in Section 3.4. Based on these assumptions and historical pipe data, the finance model therefore assumes that all pipes should have a potential useful life of 75 years across the network (Cardno, 2014). The model suggests that all pipes just prior to reaching 75 years will be re-lined adding an extra 60 years to the existing pipe. Based upon these figures the modelling is guaranteeing a 135-year useful life of all pipes across the network. Figure 8.1 displays the degradation of the pipe as per the financial model discussed. The y axis labels initial construction cost but this can also be interpreted as condition of pipe as the initial construction cost would be at maximum upon installing the pipe.

The financial model does broadly identify the effects of environmental influences that may diminish the useful life of the pipe i.e. Acid-sulphate soils and poor compaction, but does not discuss how these influence the residual life of the asset. There is no evidence of a particular network or field work study being conducted to validate the model. Cardno (2015, p. 16) states 'Whilst this observation is one which has been understood to occur in general areas there is insufficient data to specifically identify areas of risk that are associated with pipe join stress and failure'. At no stage did the Financial Unit confer with the Stormwater Unit to seek clarification and advice on existing data and performance modelling.

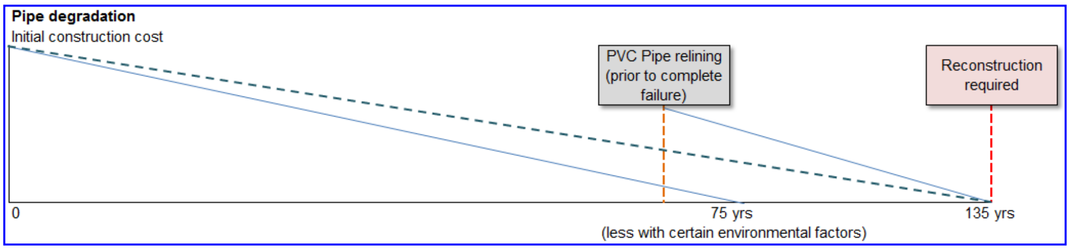


Figure 8.1 – SCC Financial model of degradation of pipe (Cardno 2015)

8.3 Sunshine Coast Council Core Model.

The second model to be discussed is the Sunshine Coast Council Core Model (SCCCM) that has defined the typical useful life of concrete pipe at 70 years (SCC 2014) and is also on best practice based on information from industrial groups such as the Institute of Public Works Engineers (SCC 2015). The model is developed on a similar type of methodology as the financial model where the assets have an assumed condition and will follow a straighter line degradation until reaching a useful life at 70 years. Upon reaching 70 years the pipes will either be replaced or renewed i.e. relined.

The model is closely based on the financial model but there is scope for the condition of the pipe to degrade rapidly towards the final 20% of the residual life of the pipe (SCC 2015). This rapid degradation therefore reduces the effectiveness of the renewal from 60 years to 30 years as there is contingency that the pipe may need extra remedial works prior to any long term relining. The Sunshine Coast model is therefore regarded as a 100-year model assuming the pipes are in a suitable condition to be relined.

The model for the purpose of the project is named a core model as it refers to the Sunshine Coast Council Core Asset Management Plan and relies heavily on data from the GIS data base. A large percentage of this data is not accurate because the construction dates and condition of the assets are assumed and therefore any type of age versus condition modelling would be inaccurate and not showing true representation of the overall condition of the network.

Figure 8.2 displays the degradation of the pipe over its useful life with the early stages depicting the straight line behaviour similar to the financial model. It is apparent that this model resembles the more typical degradation curve as per IPWEA (2015) but is still based solely on assumed condition and archival records gathered from Councils GIS Database. Due to how the data has been recorded, both the financial and Sunshine Coast Council models are assuming the assets will continue to perform for their useful life without any maintenance or renewal triggers being identified over the lifetime of the asset.

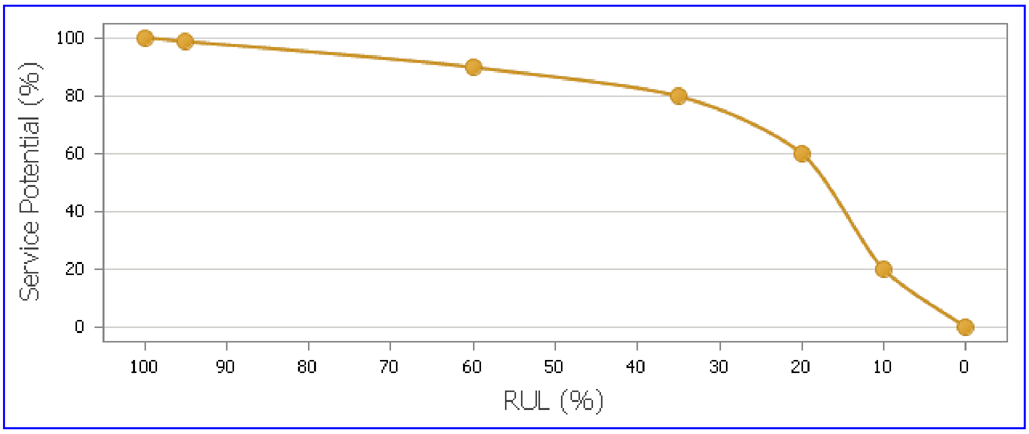


Figure 8.2 – Sunshine Coast Core Model - Degradation Curve

8.4 Remaining Useful Life Comparison

8.4.1 Financial and Sunshine Coast Core Models

The financial and Sunshine Coast Council models have been discussed regarding useful life – the degradation profile replicates the expected behaviour of the asset over its lifecycle. This is measured in terms of remaining useful life and service potential and there is a transition through each stage of the assets condition. Service potential is the measure of performance at each stage of condition – for example, depending on the behaviour of the asset, it could take 50% of the asset's expected useful life to reach fair condition (score of 3) but it could still be at 75% performance (service potential).

Comparing the residual life of assets with regard to each model is effective in determining the different stages of condition and how this can influence maintenance/renewal programs and life-cycle costs. To estimate the remaining useful life, the following scenario is undertaken at different stages of condition for a reinforced concrete pipe. These conditions relate to the residual percentage as tabulated in Appendix F. Table 8.1 displays the relationship between the conditions of the asset, residual percentage and maintenance /renewal trigger.

Table 8.1 – Asset Degradation and Residual Life

Asset Condition (1 -5)	Consumption (% Average)	Residual Life (i.e. Estimated % Asset Design Life Remaining)
Very good (1)	10	100
Good (2)	30	60
Fair (3)	50	35
Poor (4)	70	20
Very poor (5)	90	0

From table 8.1, a prediction of how a new asset has been consumed and this in turn defines the remaining life that can be determined at assumed conditions for the two models. Table 8.2 details the consumption at each condition stage for both models.

Table 8.2 – Consumption Rate/Residual life – Financial and Sunshine Coast Core Model

Condition	Consumption (%)	Consumed Years (financial)	RUL (financial)	Consumed Years (SCC)	RUL (SCC)
0	0	0	135	0	100
1	0-10	13.5	121.5	10	90
2	20 - 40	40.5	94.5	40	60
3	40 - 60	67.5	67.5	65	35
4	60 - 80	101.25	33.75	80	20
5	100	135	14	100	10

8.4.2 Sample Network Models

Table 8.3 displays the three sample networks consumed rate and residual life based on the average condition of the entire network for both the 2007 and current 2016 assessment grading. These comparisons are effective in assessing the condition of the pipe over a set period of time. The sample networks are not assuming age or condition and therefore are good indicators for predictive modelling. The construction date used was the oldest date used in the networks as some pipes were installed at a later date.

As can be seen from the data given in the table the residual life of the pipes is quite different from the financial and Sunshine Coast Council Core Model. The pipes on average were constructed in the early 1970's and they are now showing greater degradation than the financial and SCCCM. Table 8.4 compares the disparity in the residual life of the three models and it is clear that assuming age and condition is not a sustainable approach for the life-cycle of the asset.

Table 8.3 – Consumed/Residual Values - Sample Networks

Sample Network 1 - Urban/CBD - Nambour Hospital							
Construction Date	2007 Condition	Consumed	Residual Life	2016 Condition	Consumed	Residual Life	Total Useful Life
1971	3	18	13	4	31.5	9	54
Sample Network 2 - Coastal Area - Golden Beach							
Construction Date	2007 Condition	Consumed	Residual Life	2016 Condition	Consumed	Residual Life	Total Useful Life
1975	3	16	14.5	4	29	8	49
Sample Network 3 - Industrial Area - Kawana							
Construction Date	2007 Condition	Consumed	Residual Life	2016 Condition	Consumed	Residual Life	Total Useful Life
1979	3	5	13	5	33	3	40

Table 8.4 – Comparison Residual life of all Models

Comparison of Financial, SCCCM and Sample Networks - Residual Lifes			
Model	Condition 3	Condition 4	Condition 5
Financial	67.5	33.75	14
SCCCM	35	20	10
Nambour Hospital	13	9	-
Golden Beach	14.5	8	-
Kawana Industrial	15	-	3

8.4.3 Model Validation

The performance of the sample networks was generally consistent over all conditions and ages. The residual life of the networks indicate similarity in the degradation of the asset condition and indicated a significant reduction in the useful life of the assets as compared to the financial and SCC model. The sample networks were chosen over a number of different environmental and physical attributes to provide a more realistic output and this gave more credence and validity to the outputs.

Table 8.4 clearly displays the variance in the assumed condition models and the three sample networks but not an apparent variance in the sample networks. This output can be attributed to the fact that the models are given larger useful lives than the sample networks and therefore the difference in residual life of the assets are much higher.

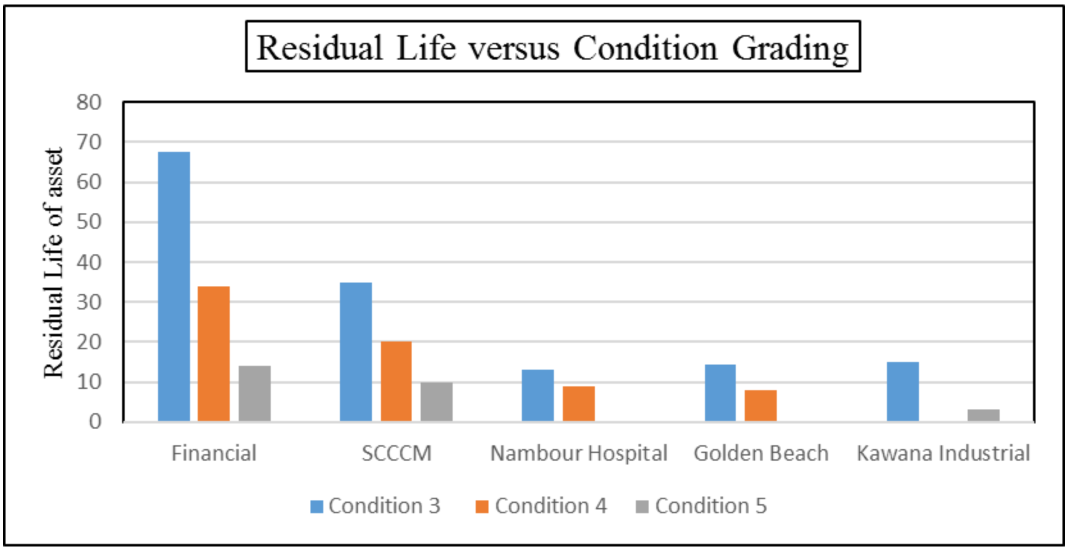


Figure 8.3 – Graph comparing residual life and condition rating of all networks

8.5 Summary

Comparing predictive models assists asset owners in comparing the robustness and validity of the models that best suit the organisation. The section has discussed the different methods in developing a more strategic model rather than just rely on assumed data and information that may result in outcomes that are not sustainable and financially beneficial over a long term basis.

By calculating the estimated residual life of assets through condition assessment it can be clearly seen that there are apparent deficiencies both the financial and Sunshine Coast Council Core Model. The sample network models have proven that both age and assumed condition based on industry knowledge may not necessarily be the best option, if local councils are looking at sustaining better life-cycle costs for their asset base then a more robust proactive approach such as predictive modelling is a good method to assist in a more strategic approach.

9.0 Advanced Asset Management Plan

9.1 Introduction

Developing a more robust and effective asset management plan for local council is essential if an organisation is to provide an improved level of service for the customer and better outcomes for lifecycle decision making. Understanding the future growth and development of a region will assist the council in planning how to maintain and fund renewal projects for both existing and new infrastructures. The development of an asset management plan framework will cover all areas of the plan and be adaptable to all assets not just Stormwater.

9.2 Lifecycle Decision Methods

IIMM (2015) describes decision techniques as a way of providing the most effective approach to delivering asset management objectives. Different types of techniques can be selected including:

- Deciding the optimal time and best options when rehabilitating or renewing the asset to minimise lifecycle costs;
- More involved and complex decisions involving performance of the asset, risk management and cost – covers both operational and capital funding.

Asset management decisions should always be compared and evaluated against local council's asset management objectives and the methodology chosen should be appropriate to the complexity, type and impact of the decision (IIMM 2015).

IIMM (2015) provides a list of various analysis methods and decision making techniques that can assist the asset owner and local councils in determining the best possible outcome for the organisation:

- Net Present Value Analysis (NPV);
- Benefit Cost Analysis (BCA);
- Cost Effective Analysis (CEA);
- Risk-Based Decision Making;

- Multi-Criteria Analysis (MCA).

All these techniques are appropriate in some way or another in the decision making process but they need to be balance between risk, performance and cost (IIMM 2015). Performance criteria addresses such areas as;

- Community expectations and satisfaction;
- Overall levels of service;
- Asset output and serviceability.

Risk includes:

- Risk to the asset owner;
- Risk of the asset failing;
- Risk of service delivery;
- Safety risk to the public;
- Council's reputation as a reliable service provider.

Cost includes:

- Cost of owning the asset;
- Cost of operating and maintaining the asset;
- Net Present Value;
- Any financial return or profit;
- Future costs with renewing the assets;

All these decision methods must involve key stakeholders input including personnel in other areas of the organisation i.e. finance, planning and development, environment. The transparency of the decision making process will assist in organisation achieving the asset management objectives and lead to better communication and trust between departments.

Confidence in the decision making process means that the asset owner and key stakeholders must have good knowledge of how the asset performs over a period of time i.e. Predictive modelling of asset failure. These type of decisions should not be made with 100% certainty that the asset will perform all the time. This will only add to more emphasis being placed on assuming that the condition of the asset will perform to its full potential over its useful life and may also grow a sense of complacency within an organisation. IIMM (2015) suggests that any major asset management decisions should involve a combination of risk and uncertainty in the approach to good decision making. Depending on the size of the local council and the asset type and size then the level of certainty and confidence in the assets performance should reflect this. Sunshine Coast

Council has a large stormwater asset base that requires a high level of certainty that the existing assets will perform at a level that enables confidence both within the organisation and also from the customer. For this to continue the decision making process needs to be continually monitored and have a flexible criterion for alternative methods in the organisation. Figure 9.1 displays how the continuum of certainty can develop within an organisation.

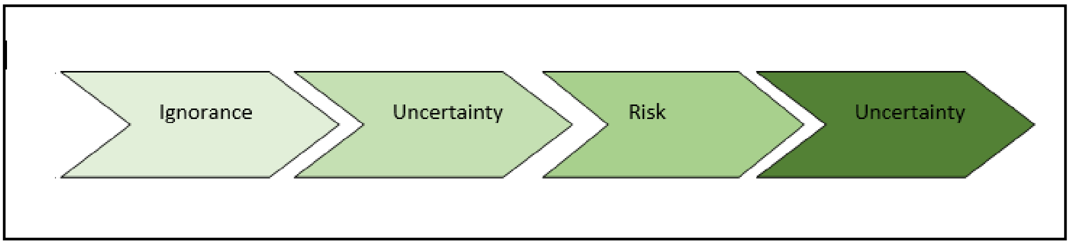


Figure 9.1 – Continuum of certainty (IIMM 2105)

Local council should have in place a robust and efficient process in how they document the decision criteria and methods. This is essential for understanding the basis of the decisions and also display validity in both the current and any advanced analysis (IIMM 2015). The following areas recommended by IIMM (2015) include:

- Connection between organisational objectives and decision criteria;
- Any assumptions;
- Confidence in data and information;
- Processes and principles used for selecting decision criteria and methods;
- Ability to review the decision making process;
- Evaluate and decide on alternatives for different types of decisions.

Part of this documentation could include the processes and decisions made in relation to predictive modelling and how best to formulate a framework to utilise this effective tool. The process could include a simple flow chart detailing how the data can be collected, looking at improving the data and how best to condition the asset over a larger network.

Much of the decisions brought about by the Sunshine Coast plan are by way of assumptions. Assumptions are sometimes necessary as not all the information and data is available but these assumptions should be reviewed on a regular basis. Areas such as unit rates, performance of an asset, useful lives and the residual life estimation is correct should be discussed and reviewed by all stakeholders in the organisation.

9.3 Levels of Service

ISO 55000 (2014) entry 3.3.6 defines levels of service as:

> *"Parameters, or combination of parameters, which reflect social, political, environmental and economic outcomes that the organisation delivers"*

The standard clarifies that the parameters can include safety, customer satisfaction, quality, quantity, capacity, reliability, responsiveness, environmental acceptability, cost and availability (ISO 2014). The research project is developing an asset plan for local council so for this purpose the customer is the community. IPWEA (2014) discusses the involvement of community engagement as an essential part of any asset management plan. This involvement should guarantee informed communication between local government and its community on a number of decision.

Levels of service should create a link between high level asset management objectives and technical and operational objectives (IIMM 2015). With regard to stormwater asset management the emphasis is placed on performance measures – what service is the customer receiving and technical performance on how the organisation is providing the service.

Current levels of service are based on the current 'Core' asset management plan and these may not meet customer expectations. The development of a more advanced level of service requires a balance between what the community wants and what level local council can achieve in a long term and sustainable process. Sunshine Coast Council under the current 'Core' asset management plan does not provide any climate survey for customers to express what they would like from council. As part of the advanced plan the Stormwater unit is preparing a detailed climate survey to ascertain the level of service the community expects.

Predictive modelling can be used as a key component of operational levels of service. The sample networks have indicated that there may be a need for local council to maintain their assets sooner rather than later as indicated by the financial and SCCC models. Pipe failure can lower the community's expectation of how council is managing the asset and raise concerns such as personal safety, protection of properties from flooding and water quality. Local council can meet the community's expectations by providing better outcomes if they have the knowledge and forward planning on how to deal with an ageing asset base.

An advanced level of service framework can be developed to assist local council:

- Monitor and review current levels of service for both funding and operational resources;
- Engage with the community at all levels including feedback from local councillors and develop a relationship with community groups;
- Attempt to adopt a working level of service with the community that can be sustainable for the organisation. i.e. don't promise everything.
- Develop a register to monitor the key areas of concern stemming from customer requests. i.e. hotspots where there is a large number of requests either coming from an area or an asset type;
- Define the accepted levels of service within the organisation including senior management and Councillors.

Outlining key attributes such as responsiveness and reliability may assist the organisation in addressing community concerns about the current level of service. IIMM (2015) cover a number of areas;

- Key attributes are recognisable from a customer point of view.
- Key service attributes are meaningful from an asset management perspective;
- Major aspects of the service and specific areas from a customer point of view;
- Key service attributes are manageable and appropriate to the quality of financial and service level data available.

Asset managers and key stake holders should plan and control technical service levels to influence customer service. It is important that the organisation does not promise a greater level of service to the community if that level of service is beyond the scope of the organisations resource. The importance of monitoring levels of service is important and any areas where this can be improved is valuable.

From the data produced by the sample networks residual life local council may not have an option on when and how to maintain the asset if the asset itself is already beyond its useful life. This is where predictive modelling can be an effective indicator on how maintenance and renewal programs can be developed in both the short and long term.

9.4 Operational Planning

Operational planning covers both operational and maintenance activities. The operational plan will assist the asset owner in maintaining the asset to perform its activity and service the community. A major part of operational works is preventative maintenance that aims to minimise the rate of deterioration and reactive maintenance aims to restore the serviceability of the asset by reacting to failures (IIMM 2015).

The predictive modelling allows asset managers to liaise with maintenance managers and field crews to plan and implement strategies on how best to maintain the asset. This could involve routine inspections of areas of known failures or high incidents of flooding.

Predictive modelling can be a useful tool in planning for extra funding when it comes to renewal programs such as relining and patching of existing pipes. Programming road reseal and pavement upgrades can also benefit from predictive modelling. Communication between the pavement manager and the stormwater asset owner can develop more cost effective ways in co-ordinating works so any pipe replacement needing to be undertaken can be undertaken whilst pavement upgrades are been completed. Asset managers can plan 5 -10 year programs with the road pavement manager to ascertain that an asset is still performing but may need to be replaced on the next round of reseal projects.

As the advanced asset management plan develops and the quality and quantity of data increases then the outcomes of predictive models will hopefully reduce the incidents of reactive maintenance, and these resources can be directed at better ways to undertake preventative maintenance.

Advances in how stormwater pipes are both renewed and replaced is a major part of developing the asset management plan. Traditional methods of fully replacing the pipes is both time consuming, costly and disruptive to the community. New relining techniques such as ribloc and Cure in Place relining is reducing operational and capital works costs. Sunshine Coast Council in the last couple of years has moved on from traditional reinforced concrete pipes to more advanced materials such as High Density polypropylene pipes (HDPE). HDPE pipes are lightweight, highly durable, acid- alkaline resistant and do not require heavy plant to install the infrastructure. Sunshine Coast Council since installing this new product has now phased out the installation of all fibre-reinforced concrete pipe.

9.5 Growth Management

The Sunshine Coast Council has since a large number of major projects undertaken over recent years and with the amalgamation and de-amalgamation of Noosa Council there has been significant changes in how the Council manages infrastructure growth into the future. Listed under The *Sunshine Coast Council Planning Scheme 2014 – Major Projects* are major development programs planned to be undertaken and in some cases already started, some of the larger projects include:

- Caloundra CBD project – including major upgrade to existing stormwater assets;
- Kawana Waters master residential and industrial precinct – includes new development of residential lots with significant stormwater assets planned.
- Kawana University Hospital – One of the largest infrastructure projects in Australia.
- Maroochydore CBD and smart cities development – Creating new CBD hub for Maroochydore with medium – high density apartment living.
- Caloundra South Priority Development Area – four new suburbs to be developed including 50,000 new residential lots, largest stormwater network upgrade in the Sunshine Coast Region.
- Sunshine Coast Airport expansion - $400m dollar expansion of existing airport into an international terminal servicing direct flights to Asia, significant upgrade of existing stormwater network with new assets also to be built.

The list highlights the future demands on the local council and therefore there is a strong need to plan what impacts new development will have on both the physical and economical areas for council. Figure 9.2 displays *The Sunshine Coast Council Strategic Framework Map 4 Infrastructure Elements* highlighting the areas of interest planned for new development under the planning scheme.

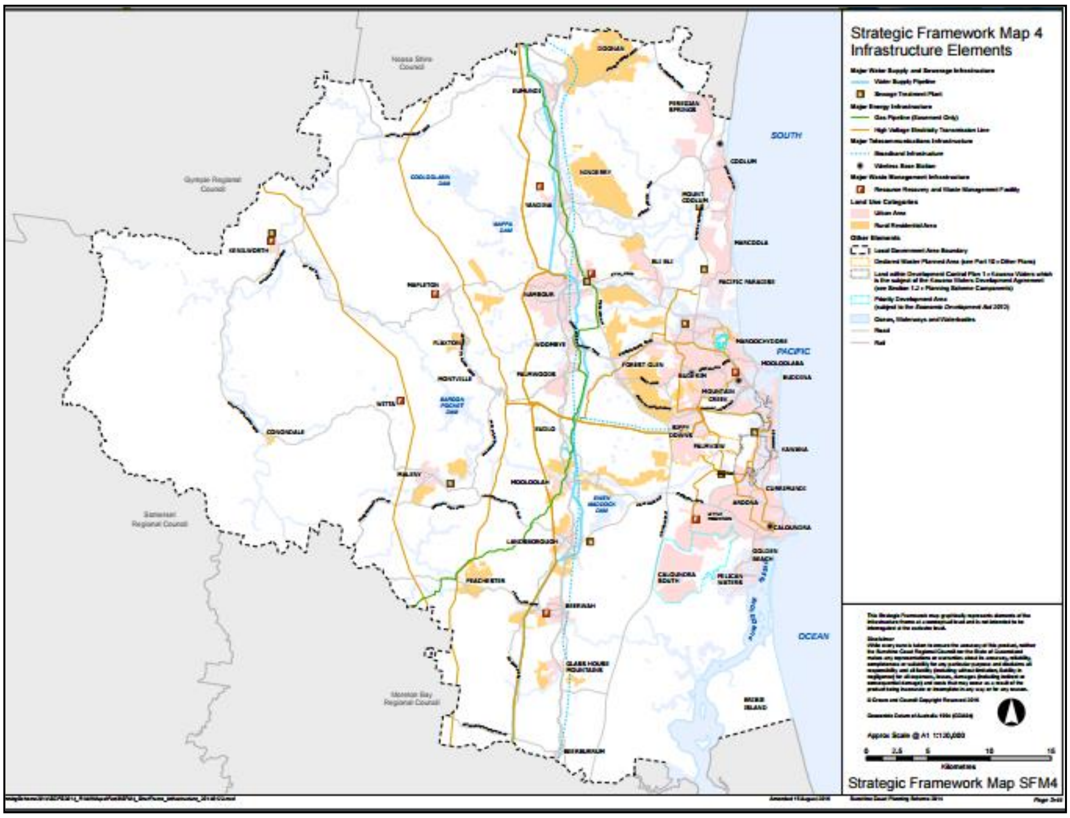


Figure 9.2 – Strategic Framework Map 4 Infrastructure Elements

It is essential that a robust and effective asset management plan be developed to cater for this future demand. The framework map also indicates a number of areas that could impact on future stormwater infrastructure including urban and rural land use. IIMM (2015) discusses how demand is driven by the layout of an area and describes how urban planning involves infrastructure planning and the relationship between urban and rural areas. All elements of future demand require the input of asset managers and consideration to what is the best layout, impact on existing networks and how much will this new development cost to build plus maintain over the long term (IIMM 2015).

The long term demand on stormwater assets must include strategies that include growth within the region and these strategies should be included in the asset renewal and maintenance programs. Senior levels of local council must ensure that policy reflects the demand outputs relating to capacity of existing networks and how they can perform at a level that still meets expectations both internally and externally. Strategic planning must include factors such as population growth, land-use changes, social change, economic development or decline.

Another key area is managing the growth of existing pipe networks that have been installed since 1990. The focus has been on what is occurring now but The Sunshine Coast Region has developed more rapidly since the late 1980's. The result of this increase in growth means that the large amount of stormwater infrastructure that was constructed after 1990 is no longer new and will over the next 10 -20 years fall into the same category as the networks that were assessed as part of the research project. Figure 9.3 graphically displays the sharp increase.

Stormwater Pipes Date Range Report

Data report from GIS 09/08/2016 and does not include culverts

Date Range	No of Pipes	%
Null	2298	5%
Constructed before 1970	625	1%
Constructed between 1970 - 1980	6369	13%
Constructed between 1980 - 1990	7098	14%
Constructed between 1990 - 2000	12285	24%
Constructed between 2000 - 2010	15055	30%
Constructed after 2010	6616	13%

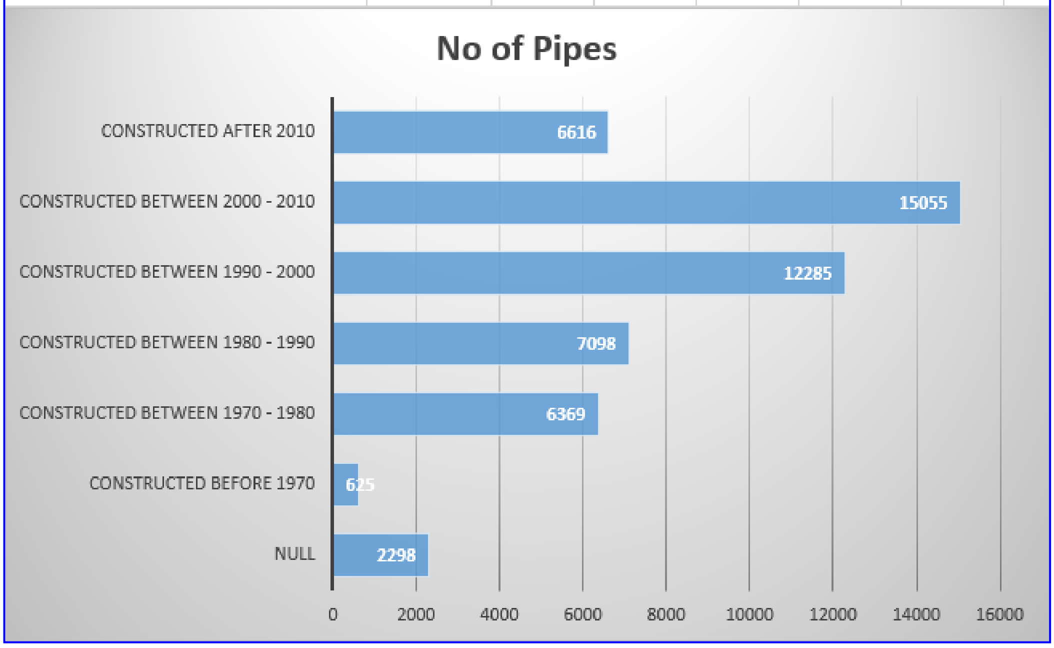


Figure 9.3 – Stormwater Pipes Date Range Report (SCC GIS 2016)

Over 50% of the pipe network (not including box culverts) are at least 7 years old and approximately a quarter of the known assets are more than fifteen years old. The predictive modelling has indicated that on average of the three networks discussed, the useful life at best may need replacing before sixty years. The significance of this could mean local councils reassess not only how they take over new infrastructure but at the same time how they manage a rapid increase in the degradation of their existing infrastructure. Growth management may also impact on the existing infrastructure as there are changes in land use and the older areas of the region become more densely populated due to an ageing population more dependent on public transport and access to essential services such as hospitals. Sunshine Coast Council Stormwater Unit personnel through experience have witnessed an increase in high density living in urban areas such as:

- Nambour;
- Caloundra;
- Maroochydore – Cotton Tree;
- Mooloolaba;
- Golden Beach;
- Beerwah;
- Kawana.

These areas have already large stormwater networks in place and are undergoing more development resulting in a greater demand on the existing networks to perform. An advanced asset management plan will need to address the issue of growth management for it to be effective and sustainable.

9.6 Advanced Asset Management Plan Framework

The advanced asset management plan framework is developed as a way of aligning all the components of the plan to assist local council meet both its own levels of service and that expected from the community. The areas covered in the research project have outlined best practice required to evolve from a standard ‘Core’ plan to a more strategic ‘advanced’ plan specifically looking at stormwater pipes. The framework will compare the existing ‘Core’ activities alongside the ‘Advanced’ outcomes. The framework is developed to allow flexibility and continuous improvement at all levels of the plan. To assist with the development of the framework a number of objectives have been outlined:

- Stewardship – maintain regular programs to keep existing assets in good condition and continually assess levels of service;
- Standardisation – Strive to maintain a good standard in asset management processes and methodologies;

- Budgeting – Improve on how best to plan for future capital and operational cost requirements. Expand on predictive modelling to ensure proper investment in the asset;

A brief over view of the elements of the framework are discussed and an advanced asset management plan is developed. The ‘Core’ component is based upon *The Sunshine Coast Asset Management Plan – Stormwater 2014*.

Asset Management Policy:

- Core – To meet minimum legislative and organisational requirements;
- Advanced – Develop a ‘bottom up’ approach with more emphasis on individual asset types being integrated into organisation’s processes.

Levels of Service:

- Core – Assumed levels of service may not be meeting customers’ expectations
- Advanced – Develop better ways of communicating with customers and ascertain desired levels of service whilst still achieving sustainable outcomes for council.

Asset Data Registry

- Core – Basic information covering all assets based on broad assumptions and incomplete or inaccurate data information;
- Advanced – Proactive development of a formalised registry detailing asset components and programmed activities to optimise data collection in the field. Utilising new technologies and other units (surveyors) to collect accurate data.

Asset Condition

- Core – No proactive asset condition, all short term planning based on assumed condition with no strategic forward planning on maintenance or renewal programs;
- Advanced – Proactive development of a formalised CCTV survey to optimise quality and amount of data and to reflect the assets’ lifecycle cost – introduction of new technologies to optimise outputs i.e. Quickview camera.

Decision Making

- Core – Basic planning on formal decision making techniques applied on operational and renewal programs. Whole of region funding programs lacking detail and scope of areas of spending.
- Advanced – Proactive development of predictive modelling on asset condition to ascertain future failure of pipe assets. Knowledge of current and future asset condition will enable asset managers to allocate funding to specific areas.

Risk Management

- Core – Documented risk management strategies across all asset groups
- Advanced – Formal risk management policy developed by key stakeholders for critical assets. Quantify risk and criticality into all aspects of decision making processes and evaluate risk mitigation options.

Operational Planning

- Core – Reactive works on pipe assets – traditional methods and non-standard - poor workmanship creates further problems for long term solutions
- Advanced – Introduction of predictive modelling will minimise reactive maintenance and improve procedures. New technologies such as internal patch repair and reline will reduce labour and costs and improve useful life of assets.

Funding Strategies

- Core – Short and long term funding based on assumed financial modelling – unsustainable forecasts fall well short of anticipated pipe failures placing increasing pressure on already ageing assets.
- Advanced – sustainable modelling forecasting short term failures in the network – funding needs to be prioritised for emergent works and strategic maintenance and renewal programs.

Growth Management

- Core – Major projects impacting on existing ageing networks and future networks being constantly added onto council asset base with no forward planning on lifecycle costs.
- Advanced – Ensure good communication with other units on new infrastructure assets and monitor the impacts on existing networks.

Improvement Planning

- Core – Current asset management performance to be evaluated and gap analysis to assist the improvement process;
- Advanced – Improvement plans specify key performance indicators and are ongoing;

9.7 Benefits of the Advanced Asset Management Plan

The research project has discussed the development of the advanced asset management plan and a main aim in this development is to benefit local council in how they manage their assets. There are many benefits to having a strategic long term asset management plan and these include:

9.7.1 Predictive Modelling Outcomes

The development of predictive modelling over the network will enable asset managers to forecast how the assets are performing and also a better framework to develop both short and long term strategies. These models give a more realistic outlook than the assumed models developed by the financial unit and the organisation.

9.7.2 Improved levels of service

Local council will be able to achieve a more sustainable level of service expected of the community if they have a better understanding of the current condition of their assets and how they are performing. The cost of improving on the level of service may need to be justified and if a strategic plan is in place then this justification is easier to implement.

9.7.3 Improving Maintenance and Renewal Programs

Upgrading and improving maintenance programs is beneficial to local council as it reduces risk to the public and increases the performance of the asset. Ongoing renewal programs will upgrade the network where it needs it most and at the same time routine maintenance will improve the condition of the asset and therefore its useful life. Predictive modelling can also assist in developing better maintenance programs.

9.7.4 Reduce Risk

Identifying critical assets identifies those assets with a high consequence of failure and understanding these consequences are essential to good asset management. Being proactive and detailing where the risks are and their criticality will ensure overall benefits to council. Having a more advanced approach will develop a more uniform approach to risk reduction and therefore reduce liability and costs if these assets fail.

9.7.5 Proactive Data Collection

Implementing a more proactive data collection program will allow local council to ground truth existing data and verify the location and type of asset. Preliminary investigation through desktop analysis can be gathered and utilising GPS technology in the field will enable the asset owner to develop more accurate data when undertaking condition assessment and predictive modelling.

9.7.6 Increased Funding for Capital Works

Asset owners and capital works managers through long term modelling of networks can develop future capital works projects and like operational funding can prioritise the projects that have critical assets. The predictive modelling can be used as proof that extra funding is needed to reduce liability to council on these critical assets. The projects if too large can be staged focusing on the more critical areas.

10.0 Conclusion

This dissertation has assessed and provided local council with an improved strategic approach regarding stormwater asset management plans. The research has developed basic ‘Core’ asset management plans into an ‘Advanced’ system that will allow councils to be more proactive in how they manage and maintain their networks.

The project has researched how predictive modelling can be an effective method of forecasting future failure in pipe assets and develop a better approach to managing lifecycle costs and future funding. The dissertation set out to cover all aspects of asset management regarding stormwater rather than just legal and statutory requirements.

An overview of the literature review highlights a number of areas that have been researched and the issue of sustainability is very important for any local council to best maintain their efforts in the present for better outcomes in the future. Advanced asset systems utilise the bottom up approach and rather than focus on the overall asset base provide more detail focus on individual assets. Any advanced asset plan must place a lot of emphasis on risk and criticality. Risk management needs to be included in all phases of the asset management phase and identifying consequence of failure is paramount in condition assessment. The dissertation briefly described the National and State overview as this highlights not only the bigger picture but puts the situation facing local council into more perspective.

It was important when discussing ‘Advanced’ systems that critical assets be described. Once this is covered the data collection phase and the options and were discussed and this assists the asset team in looking at options and new technologies that will reduce inaccuracies in the data gathering and assessing.

The field study work conducted on the three sample networks were able to provide evidence that current pipe assets are not achieving their useful life as per the financial and Standard Sunshine Coast model. This small scale study highlighted that assuming age and condition as a straight-line degradation does not truly reflect what is occurring within the networks. The models based on assumptions are not sustainable and may create more problems for council over the long term.

Detailed condition assessment using industry benchmark guidelines is necessary for asset owners to plan for future works. The process of predictive modelling in conjunction with the degradation curve has shown that the residual life of the assets is varied but may still require short term solutions for a large majority of council's networks.

Providing better maintenance schedules is a positive step forward for council in reducing the risk of failure and higher labour costs if the assets are not maintained on a regular basis. The dissertation has discussed better options for councils when dealing with renewals and how new technologies and alternative materials can again reduce labour, materials and costs.

Council needs to be aware of community expectations and the level of service provided. Current levels of service may not be acceptable under the current asset plan. The introduction of predictive modelling and a more proactive approach to assessing the condition of the assets will assist council in providing a more realistic outcome of levels of service that are sustainable and also flexible for everyone. The advanced plan will provide better information when deciding on an appropriate system.

The important area of growth management needs to be part of the plan forward as future development will mean more resources from local council to maintain these new networks and how they may impact on an already ageing network will have to be monitored.

Sunshine Coast Council is fully committed to developing an advanced asset plan but to do this they require a plan of action that they can start with and over due course develop and improve on. The stormwater plan is a good start as it is one of the more difficult assets to monitor. Senior management recognise that this plan will not solve all the issues straight away but they do understand that a bottom up approach and the implementation on new technologies and simple but effective predictive modelling will enable them to plan for a sustainable future.

11.0 Further Research

Further research can be conducted on how the asset advanced system can benefit all asset classes within local council. This would include broadening the scope of some areas such as how the asset owner identifies critical assets and ways in which the condition their asset. The advance system is designed to be flexible and adapt to various frameworks depending on the aims and objectives of the asset owner. The research outcomes would require a level of communication between the units as to what is the best options and part of this may be the area of peer review.

Another research area could include further work on best practice within the organisation and also discussion on improving sustainability at all levels of the plan. As mentioned in the dissertation, balancing growth management and maintaining an existing asset base is vitally important for any local council to manage if they are to provide a level of sustainability and service not only for themselves but the wider community. The research could include further case studies relating local councils planning and development unit and how their decision making process impact on existing infrastructure.

Further work could be undertaken on how the advanced plan could influence future financial planning including 10-year capital works programs. The dissertation concentrated on more of the operational and predictive modelling elements of the plan. Long term financial forecasting opens a whole new area of research from a funding side and there a numerous model that can be incorporated to take the asset plan further.

Continual monitoring of the advanced plan and improvement processes will allow local council to develop an approach that ensures the asset plan is a working document benefiting not only the asset manager but the whole organisation.

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Appendix A: Project Specification

ENG4111/4112 Research Project

Project Specification

For	**Andrew Priest**
Title	Development of Stormwater Asset Management Plan for Local Council
Major	Bachelor of Engineering (Honours)
Supervisor	Dr Nateque Mahmood (USQ)
Sponsorship	Faculty of Health, Engineering and Sciences
	Sunshine Coast Council
Enrolment	ENG4111 – EXT S1, 2016
	ENG4112 – EXT S2, 2016
Confidentiality	at the discretion of any local government involved
Project Aim	to investigate the development of the improved Stormwater Asset Management model and test, compare various models in a regional/metropolitan Council.

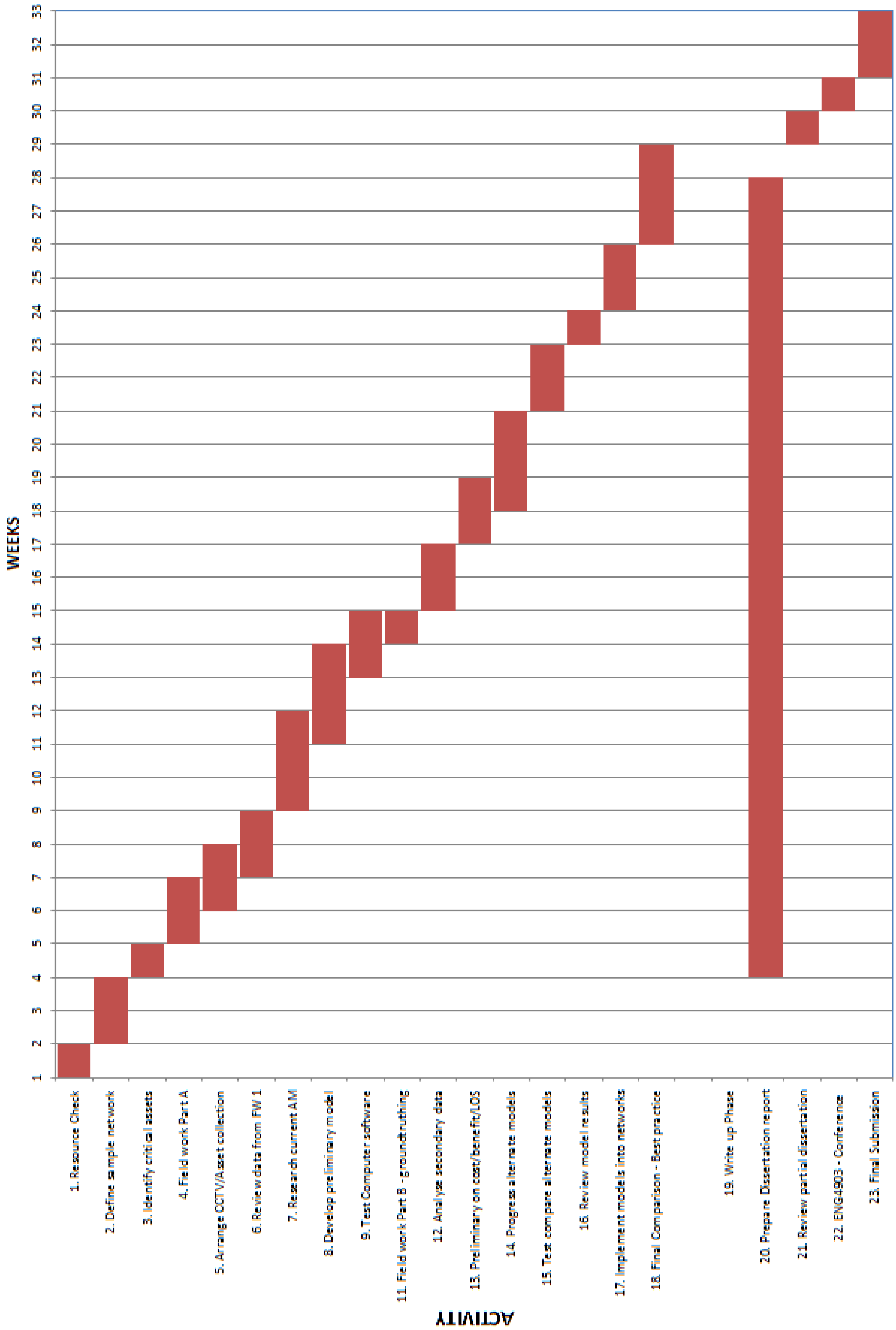
Programme: Issue A, 16th March 2016

1. Identify critical assets and assess current asset data collection processes.
2. Define current Stormwater Asset Management processes within Sunshine Coast Council.
3. Report on condition performance management including risk.
4. Develop a generic model/approach that can be used to provide an effective Asset Management Plan.
5. Compare various predictive modelling techniques to assist with identifying possible future failures of the assets.
6. Provide an overview of the benefit, costs, level of Service of the model.
7. Implement the models into a sample of networks and analyse results.

If time and resources permits

8. Attempt to report on "best practice" methods based on research and data gathered.
9. Report on feasibility of model being implemented over a range of different assets.

Appendix B: Project Timeline Gantt Chart



Appendix C: Personnel Risk Assessment Report

This section discusses the author's risk assessment that may be encountered whilst conducting field work and any potential risks which may arise after the completion of the project. A number of risks were identified at both external field work and office work:

1. Sun exposure and heat stress;
2. Slips trips and falls;
3. Conflict with traffic;
4. Oxygen depletion and exposure to airborne contaminants;
5. Drowning;
6. Neck and back strain through lifting and handling survey equipment;
7. Eye fatigue and back strain due to computer work;

A number of risks were identified with assessing and generating outputs for the report:

1. Limited access to network;
2. Unable to enter data or recall data from operating systems/databases;

The majority of the level of risks for each hazard based on exposure, likelihood and consequences have been measured to be either low or medium, with ne risk being rated as a high risk. All hazards could not be eliminated entirely but with the implementation of appropriate control measures all work places should have a high level of safety. This reporting is a very important activity when collecting and assessing data for asset management purposes. The WH & S risk calculator is used to determine the risk and consequences relating to any activity undertaken by council employees. Any risks identified need to be identified and then a risk assessment is undertaken by relevant staff. Any type of major risk is to be reported and the report will be forwarded to council safety officer for recording and review.

Sunshine Coast COUNCIL — WH&S RISK CALCULATOR

Likelihood	Consequences: Insignificant (None or very minimal injuries)	Minor (First aid treatment only)	Moderate (Medical treatment required)	Major (Major medical treatment required)	Catastrophic (Life threatening injuries or death)
Almost Certain: Expected to occur at most times (eg. 3 per year)	M-28	M-40	H-60	E-88	E-100
Likely: Will probably occur at most times (eg. 1 per year)	L-16	M-36	H - 56	E-84	E-96
Possible: Might occur at some time (eg. 1 per 5 years)	L-12	M-32	M-52	H-72	E-92
Unlikely: Could occur at some time (eg. 1 per 5 to 15 years)	L-8	L-24	M-48	H-68	H-80
Rare: May occur in rare conditions (eg. unlikely during next 15 years)	L-4	L-20	M-44	H-64	H-76

Sunshine Coast COUNCIL — WH&S RISK CALCULATOR

Risk Process

Identify	Identify the hazards/risks of the work
Assess	Assess the likelihood and consequence of the hazards/risks
Control	Control the hazards/risks using control measures considering the hierarchy of control
Monitor	Monitor the effectiveness and use of implemented control measures

Risk Score Legend		Hierarchy of Control	
E	Extreme risk, immediate action required	ELIMINATE	**Eliminate** the process, material or substance completely
H	High risk, prioritised action required	SUBSTITUTE	**Replace** the process, material or substance with a safer one
M	Moderate risk, planned action required	ISOLATE	**Isolate** the person(s) from the process, material or substance
L	Low risk, actioned by routine procedures	ENGINEER	**Design or re-design** the process, material or substance
SCRC - 04/2009		ADMINISTRATE	**Limit exposure** to the risk by job rotation, work procedure and/or providing adequate training
		PPE	Use of **personal protective equipment**

Legend	Low Risk	Medium Risk	High Risk

Task	Hazard	Risk	Minimisation
Data Collection	No data collected due to limited access	L-20	Undertake preliminary site visit to ascertain access and availability
Data input	Unable to enter data enter operating system	L-20	Ensure system is up to date – regular checks with IT and have back up
Data recall	Unable to recall data from database	L-24	Have a back-up of data that is readily accessible

Task	Hazard	Risk	Minimisation
Collect data	Injury being hit by vehicle	**H-68**	Set up traffic management Wear safety PPE and barriers (cones)
Inspect asset	Drowning/injury during inspection	**M-44**	Ensure safe access to asset, wear PPE, inspect with a colleague, and check weather conditions. Use approved lifting equipment
Field work	Exposure to environment	**L-24**	Use appropriate PPE, avoid inspection during middle of the day
Asset inspection	Envenomation	**M-44**	Use appropriate PPE, wear proper footwear and be alert. Avoid long grass or heavily vegetated areas.
Using equipment	Personal injury	**M-48**	Follow proper handling guidelines ask for assistance when lifting

Appendix D: CCTV Scope of Works

CCTV SURVEY – KITCHENER STREET – THE ESPLANADE, GOLDEN BEACH

Date: 15/05/2016

Project officer: Andrew Priest Sunshine Coast Council Stormwater Unit.

Full survey of network to completed as per attribute table.

Attribute Table – Pipe (SCC GIS 2016)

AssetNo	PipeDia	Length	Type	Material	Class	NoOfCell	Condition	ConstructionDate	Comments
165753	600	14.302718	Pipe	RCP	2	1	<Null>	1/01/1975	ASSUMED CONDITION
165751	375	2.977397	Pipe	RCP	2	1	<Null>	1/01/1979	ASSUMED CONDITION
132208	300	46.916054	Pipe	RCP	2	1	<Null>	1/01/1975	ASSUMED CONDITION
167668	600	35.863799	Pipe	RCP	2	1	<Null>	1/01/1975	ASSUMED CONDITION
165752	600	7.248029	Pipe	RCP	2	1	<Null>	1/01/1975	ASSUMED CONDITION
164988	600	79.813747	Pipe	RCP	2	1	<Null>	1/01/1975	ASSUMED CONDITION
164989	600	28.366988	Pipe	RCP	2	1	<Null>	1/01/1975	ASSUMED CONDITION

Attribute Table – Pit/Manhole (SCC GIS 2016)

AssetNo	Dia	Type	InletType	SL	IL	Depth	Condition	ConstructionDate	Comments
205519	1050	CatchPit	Side Entry Pit	<Null>	<Null>	<Null>	<Null>	1/01/1979	ASSUMED CONDITION
205625	1050	CatchPit	Side Entry Pit	2.29	<Null>	<Null>	<Null>	1/01/1975	ASSUMED CONDITION
170836	1050	Manhole	Manhole	<Null>	<Null>	<Null>	<Null>	1/01/1975	ASSUMED CONDITION
175182	1050	Manhole	Manhole	<Null>	0	<Null>	<Null>	1/01/1970	ASSUMED CONDITION
175183	1050	Manhole	Manhole	<Null>	0.76	<Null>	<Null>	1/01/1979	ASSUMED CONDITION
175184	1050	Manhole	Manhole	<Null>	0.36	<Null>	<Null>	1/01/1975	ASSUMED CONDITION
175185	1050	Manhole	Manhole	2.77	0.2	2.57	<Null>	1/01/1975	ASSUMED CONDITION

<u>SITE PHOTOS:</u>

The following photos are to be used as a reference when conducting the site survey.






Appendix E: CCTV Survey Report


DRAIN MEDICS

CCTV SURVEY

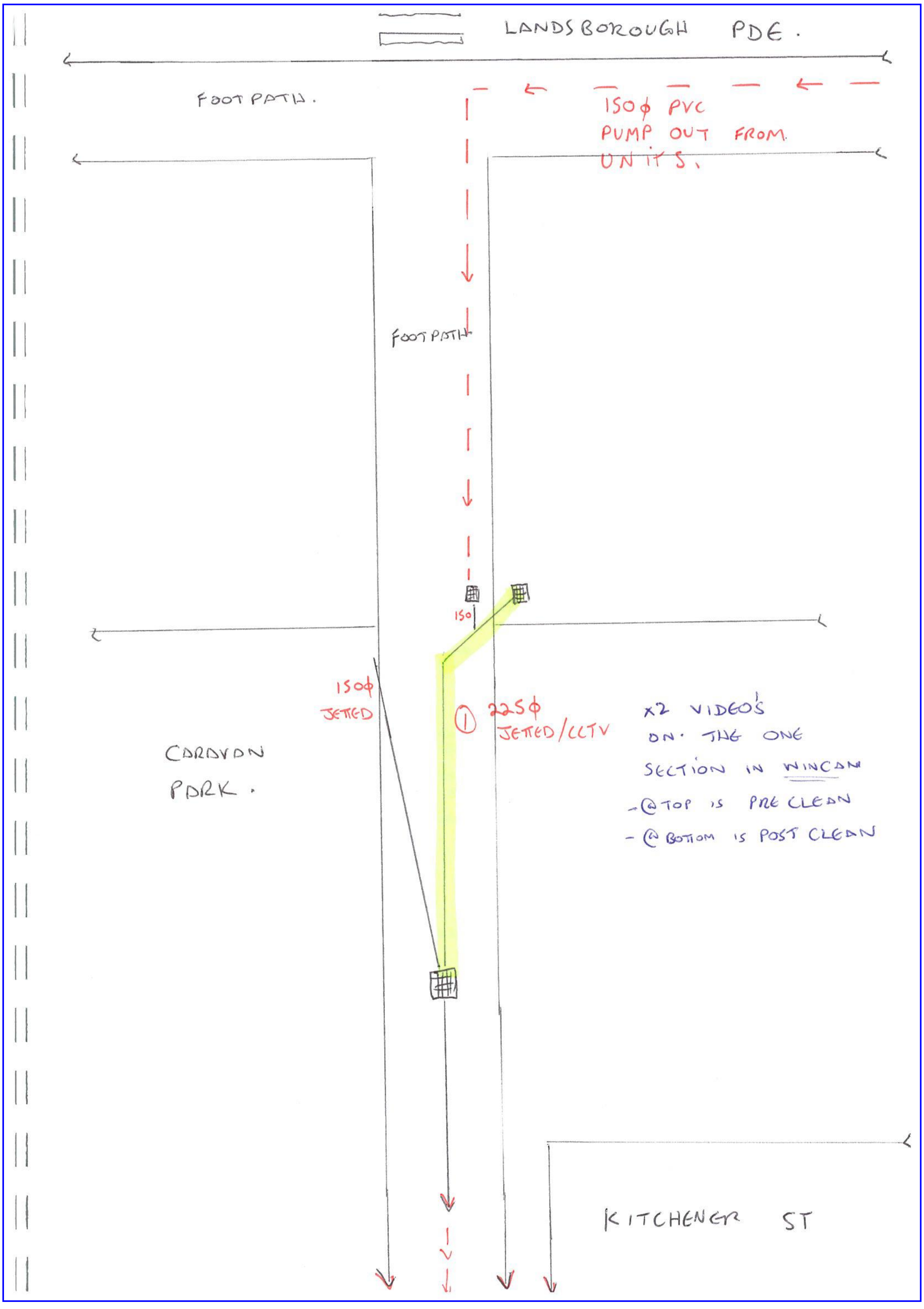
Prepared for: SUNSHINE COAST REGIONAL COUNCIL

Date: 22/06/2016

Location: KITCHENER WALKWAY

GOLDEN BEACH

Pipe: STORMWATER


LANDSBOROUGH PDE.
FOOTPATH.
150ϕ PVC
PUMP OUT FROM
UNITS.
FOOTPATH
150
150ϕ
JETTED
CARAVAN
PARK.
①
225ϕ
JETTED/CCTV
x2 VIDEO'S
ON. THE ONE
SECTION IN WINCAN
-@ TOP IS PRE CLEAN
-@ BOTTOM IS POST CLEAN
KITCHENER ST

DRAIN MEDICS	*Drain Medics* *PO Box: 1243 Buddina 4575* *Contact No: 0419 636 015* *Email: info@drainmedics.com.au*

Inspection Pictures

Location/Street	Town or suburb:	Date :	Section number:	Pipe Asset Id.:
KITCHENER	**GOLDEN BEACH**	**22/06/2016**	**1**	**167668-A**

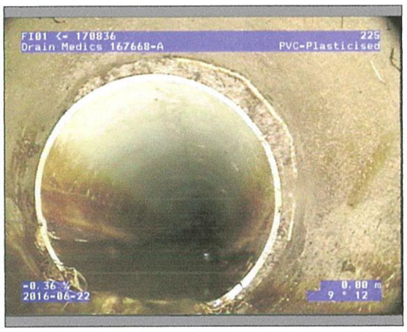


Photo: 1_3A
0m, @START 300MM DIA STUB 700MM LONG

Photo: 1_4A
0.8m, Recently Cut interwoven mass of mostly fine roots leaving a Beard of roots, at joint, Obstruction: 5-20% , from 4 to 8 o'clock

Photo: 1_5A
5.99m, Recently Cut interwoven mass of mostly fine roots leaving a Beard of roots , Obstruction: 21-50% , from 4 to 8 o'clock

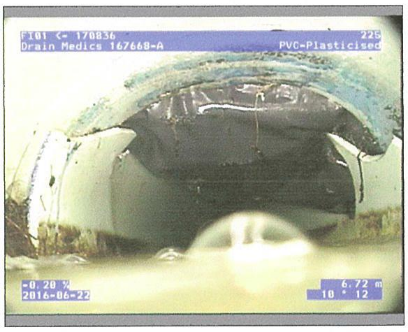


Photo: 1_6A
6.72m, Breaking, a piece of conduit is missing as a result of some exceptional event , length of break 400 , from 10 to 2 o'clock

DRAIN MEDICS

Drain Medics
PO Box: 1243 Buddina 4575
Contact No: 0419 636 015

Email: info@drainmedics.com.au

Inspection Pictures

Location/Street	Town or suburb:	Date :	Section number:	Pipe Asset Id.:
KITCHENER	**GOLDEN BEACH**	**22/06/2016**	**1**	**167668-A**

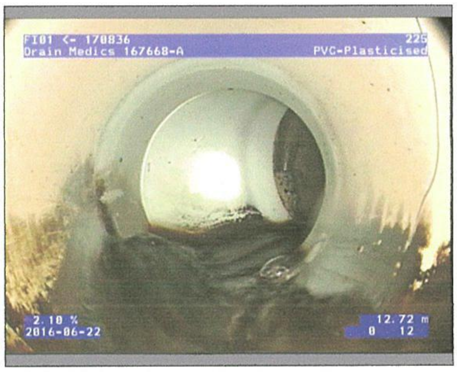


Photo: 1_8A
12.72m, The conduit curves to the right, length of curved section 225mm, BEND

Photo: 1_10A
14.06m, A Mass of mostly fine Roots, which has developed into an interwoven clump, at joint, Obstruction: 51-75% , from 6 to 3 o'clock

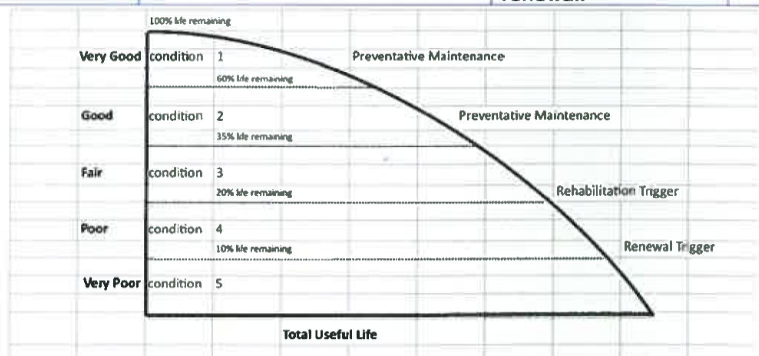
Appendix F: Rating System and Condition assessment of Sample Networks

CONDITION GRADING TABLE FOR SWD ASSETS (Structure and Serviceability)				
Grade	**Condition**	**Description**	**Response**	**Residual Life** (i.e. Estimated % Asset Design Life Remaining)
0	Not Rated	Asset has been properly decommissioned, no longer exists (or should be removed from inaccurate plans), has not been condition rated (or assigned an extrapolated condition), or is unable to be rated due to serviceability issues.	Response will vary subject to circumstances E.G. An abandoned asset may experience infiltration, voids, collapse etc, and pose a real danger that should be both monitored and managed.	NA
1	Very Good	Structural: Sound physical condition. Insignificant deterioration. Asset likely to perform adequately without major work for 25 years or more. Serviceability: No or insignificant loss of hydraulic capacity.	No immediate action required. Maintain standard programmed condition assessment.	60% to 100%
2	Good	Structural: Acceptable physical condition; minor deterioration / minor defects evident. Serviceability: Minor loss of hydraulic performance. Negligible short-term failure risk but potential for deterioration in long-term (20 years plus). Only minor work required (if any).	No immediate action required other than possible cleaning. Maintain standard programmed condition assessment.	35% to 60%
3	Fair	Structural: Moderate to significant deterioration evident; Minor components or isolated sections of the asset need replacement or repair now but not affecting short term structural integrity. Serviceability: Moderate loss of hydraulic performance but asset still functions safely at adequate level of service. Failure unlikely within next 10 years but further deterioration likely and major replacement likely within next 10 to 20 years. Work required but asset is still serviceable.	Take action as appropriate to address defects and if necessary, cleaning, silt removal, root cutting. Monitor with programmed condition assessment for rehabilitation and / or renewal in medium term.	20% to 35%

Source: IPWEA, Practice Note 5 v2 (2015)

Note: Condition rating 0 is not undertaken by Sunshine Coast Council – decommissioned assets are removed from the GIS database.

CONDITION GRADING TABLE FOR SWD ASSETS (Structure & Serviceability) Cont'd				
Grade	**Condition**	**Description**	**Response**	**Residual Life** (i.e. Estimated % Asset Design Life Remaining)
4	Poor	Structural: Serious deterioration and significant defects evident affecting structural integrity. Serviceability: Significant loss of hydraulic performance. Substantial work required in short-term to keep asset serviceable. Failure likely in short to medium term. Likely need to replace most or all of asset within 10 years. No immediate risk to health or safety but works required within 10 years to ensure asset remains safe.	Take immediate action as appropriate to address the defects. Immediately undertake risk assessment and further investigate options. Schedule appropriate action – rehabilitation or renewal in short term.	10% to 20%
5	Very Poor	Structural: Failed or failure imminent. Immediate need to replace most or all of asset. Serviceability: Health and safety hazards exist which present a possible risk to public safety, or asset cannot be serviced / operated without risk to personnel. Major work or replacement required urgently.	Take immediate action as appropriate to address the defects. Immediately undertake risk assessment and further investigate options. Schedule appropriate action – immediate rehabilitation or renewal.	0 to 10%



Typical Asset Degradation Curve (Y=1-X²)

Note: **The above degradation curve is provided as a typical example of the way in which infrastructure assets such as SWD assets tend to degrade over their useful life. As further and better condition data is developed for each organisation, taking into account its particular environment, materials and components, the shape of the above degradation curve can be improved and/or validated.**

Source: IPWEA, Practice Note 5 v2 (2015)

The following condition assessment tables contain the data and condition grading of all pipe assets in the sample networks. The condition grading compares 2007 and 2016 CCTV footage. This information is beneficial in assessing the degradation of the useful life of the asset over a defined time.

MAP - Network A - Nambour Hospital

SCC - STORMWATER NETWORK - CONDITION GRADING

DATE	CCTV SURVEY #	US NODE	DS NODE	PIPE ASSET #	STREET	SUBURB	SIZE	LENGTH (m)	MATERIAL	2007 CONDITION	2016 CONDITION
30/07/2016	1	209442 (CP)	209441 (CP)	107441	Nambour -Mapleton Rd	Nambour	375	11.41	RCP	2	3
30/07/2016	2	209479 (CP)	209441 (CP)	124678	Nambour -Mapleton Rd	Nambour	375	9.15	RCP	2	3
30/07/2016	3	209441 (CP)	205307 (MH)	107442	Nambour -Mapleton Rd	Nambour	450	56.56	RCP	3	4
30/07/2016	4	205307 (MH)	205308 (MH)	107443	Nambour -Mapleton Rd	Nambour	525	42.39	RCP	3	4
30/07/2016	5	205308 (MH)	OUTLET (dry)	124817	Nambour -Mapleton Rd	Nambour	525	30.64	RCP	3	3

MAP - Network B - Kitchener Street - Golden Beach

SCC - STORMWATER NETWORK - CONDITION GRADING

DATE	CCTV SURVEY #	US NODE	DS NODE	PIPE ASSET #	STREET	SUBURB	SIZE	LENGTH (m)	MATERIAL	2007 CONDITION	2016 CONDITION
22/06/2016	1	FI 001	107836 (CP)	New Asset	Kitchener St	Golden Beach	225	21.05	PVC	Unknown	4
22/06/2016	2	107836 (CP)	175182 (CP)	167668	Kitchener St	Golden Beach	600	35.87	RCP	2	3
22/06/2016	3	175182 (CP)	175183 (CP)	165752	Kitchener St	Golden Beach	600	7.25	RCP	2	3
22/06/2016	4	205519 (CP)	175183 (CP)	165751	Kitchener St	Golden Beach	375	2.97	RCP	2	3
22/06/2016	5	175183 (CP)	175184 (CP)	165753	Kitchener St	Golden Beach	600	14.35	RCP	3	4
22/06/2016	6	175184 (CP)	175185 (CP)	164988	Kitchener St	Golden Beach	600	79.91	RCP	3	4
22/06/2016	7	205625 (CP)	175185 (CP)	132208	Kitchener St	Golden Beach	300	46.92	RCP	3	3
22/06/2016	8	175185 (CP)	outlet (wet)	164989	Kitchener St	Golden Beach	600	28.4	RCP	3	4

MAP - Network C - Industrial Area - Kawana

SCC - STORMWATER NETWORK - CONDITION GRADING

DATE	CCTV SURVEY #	US NODE	DS NODE	PIPE ASSET #	STREET	SUBURB	SIZE	LENGTH (m)	MATERIAL	2007 CONDITION	2016 CONDITION
6/07/2016	1	176668 (CP)	188031 (MH)	160609	Main Dr	Kawana	375	9.49	RCP	2	3
6/07/2016	2	176889 (CP)	188031 (MH)	161011	Main Dr	Kawana	300	19.28	RCP	2	3
6/07/2016	3	176880 (CP)	188031 (MH)	161013	Main Dr	Kawana	300	15.62	RCP	3	3
6/07/2016	4	176881(CP)	188031 (MH)	161013	Main Dr	Kawana	300	13.79	RCP	2	3
6/07/2016	5	176679(CP)	188031 (MH)	160607	Main Dr	Kawana	300	14.93	RCP	3	3
6/07/2016	6	188031 (MH)	160380 (MH)	160608	Main Dr	Kawana	900	99.53	RCP	3	4
6/07/2016	7	176891(CP)	160380(MH)	160383	Main Dr	Kawana	1650	29.58	RCP	3	3
7/07/2016	8	176667 (CP)	176891(CP)	160605	Main Dr	Kawana	375	17.3	RCP	3	4
7/07/2016	9	176890(CP)	176891(CP)	160606	Main Dr	Kawana	375	9.91	RCP	3	3
7/07/2016	10	176666 (CP)	176891(CP)	160604	Main Dr	Kawana	300	14.06	RCP	2	3
7/07/2016	11	176892(CP)	176891(CP)	160384	Main Dr	Kawana	375	14.11	RCP	2	3
7/07/2016	12	160380(MH)	170869 (MH)	163765	Main Dr	Kawana	1800	81.46	RCP	3	5
7/07/2016	13	170869 (MH)	OUTLET (wet)	146360	Main Dr	Kawana	1800	18	RCP	3	4