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ASSET MANAGEMENT COUNCIL

ASSET MANAGEMENT SYSTEMS – ORGANISATIONAL ASPECTS

An Asset Management Framework across multiple Industries

How an ISO55001-Certified Management System Transformed the Approach to Gas Safety Management

A Structured Framework - Aligning Asset Portfolio and Strategies with the Service Delivery need

ERNST KRAUSS

EDITOR IN CHIEF

Asset Management is a social activity – it cannot be done in isolation, it requires all parts of an Asset owning Organisation to work together. Asset management is the process of planning and controlling the acquisition, operation, maintenance, renewal, and disposal of assets, thereby extracting most value form those Assets. It is therefore not surprising that we on the one hand recognise the advantages of an Asset Management system, but on the other hand often see confusion about the way this is to be achieved. Is this the domain of Leadership to unify and align the various parts of an organisation? Does a senior Leadership team have the insight and qualification to direct the organisation in the development of a coherent Asset Management System? Or does the organisational culture promote Leadership in all levels of the organisation to achieve the best outcome in Asset Management?

In recent discussions with UK based organisations it became clear to me that there is still confusion about how an organisation actually sustains an Asset Management system that delivers the best outcomes. Early adopters have now seen a degradation of their system and obfuscation of early clear messages and their meaning. I guess a part of this might be the transition from 'traditional' (mostly manual) forms of dealing with the aspects of managing Assets to digital Asset Management. Software solutions offer more and more insights in how teams, departments, individuals and Assets systems perform by automating against some rules the information generated by data collected.

One of the principles of Asset Management is to know what an organisation owns and what the condition of the Assets is. This directly should relate the Asset's performance to the risk to the overall outcome and the associated cost. Is it enough to use data analytics to arrive at information that enables us to make good decisions? Or do we need to retain and strengthen the framework for Asset Management through continued education, especially as we see a gradual handover to a new generation that also expects a different way of working and has not been exposed to the historic (more paper based methodologies) way of managing organisations.

The strategic view of an Asset Management System and how an organisation needs to sustain the not inconsiderable investment of creating an organisational compliance with the leadership, cultural and competency aspects of the ISO 55001 is required, to make the Asset Management journey sustainable. What would that require apart from the revolution of digital Asset Management and using data models to manage assets? Line of sight between Business objectives and the delivery of these objectives should be embedded in all teams that are involved with assets, regardless whether they are technical, financial, personnel or IT. We are interested to hear this edition about your organisational challenges in Asset Management and hear about your ways of overcoming the hurdles and improve your Asset Management System. I trust that the articles in this edition of "The Asset" will provide some stimulants for your organisation.

On behalf of the whole Asset Management Council team, we wish you a happy and safe Christmas season and a successful year 2021.

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For all enquires please contact: **publications@amcouncil.com.au**
Asset Management Council
PO Box 2004 Oakleigh Vic 3166 Tel 03 9819 2515

FROM MY DESK: CHAIRMAN'S LETTER

CHAIRMAN, DAVE DAINES

This being the last Journal for 2020 it is timely to reflect on the year that has almost passed by. The AM Council started the year on the back of a very successful year in 2019.

Planning was advanced for AMPEAK 2020 in Melbourne and we were well positioned to implement our newly released Strategy. With the advent of COVID 19, organisationally the AM Council was able to react quickly and effectively. Some contingency planning had already been conducted by the Board, however as all would be aware the pandemic presented rapidly changing scenarios that were difficult to pre-empt and comprehend the impact that they would have.

Having open communications channels, understanding our stakeholders and with robust management systems and processes in place allowed the AM Council to move quickly to understand and deliver on the opportunities that were presented.

First and foremost, engagement with the membership was seen as the key priority. AMPEAK was rapidly changed to a virtual Conference – AMSPEAK and was successfully planned and executed, receiving acclaim from the global Asset Management Community. Webinar series and Seminars on a wide range of technical topics were also run on a regular basis by Chapters and SIG groups with attendance at record levels. A key opportunity that the AM Council Board recognised is the ability to appeal to a broader audience and engage with more participants in workshop activities. This has resulted in two key international projects - the Global Forum's Maintenance Framework and the initial review of ISO 55001 receiving significant input for our Membership.

I am reminded of a comment made by Ian Maxted, a former AM Council Director, at the key note for AMSPEAK in April. He observed that people refer to "when things return to normal after Covid" when in fact things are not going to return to the previous "normal" at all. Against this sentiment the AM Council Board continues to work hard to ensure that as an organisation we deliver on our objectives and meet the needs of our Members. Our success can be measured by an increasing membership base, ongoing engagement in key projects with other stakeholders and a continued strong financial position.

On behalf of the Board, I would like to thank our small group of dedicated staff and our hard working volunteers and you all as Members of the AM Council for your engagement and contribution throughout a difficult year. There is a confidence that we can continue to expand our influence and deliver value to our members and personally I am looking forward to the continued opportunities ahead.

David Daines
National Chairman, Asset Management Council.

ARTICLE 1 – An Asset Management Framework across multiple industries

Chris Wong, Downer Group, Melbourne, Australia

ABSTRACT:

Downer have successfully applied an asset management framework across multiple industries and been certified to ISO55001 using that framework. The benefits realised are; a standard framework is available for future implementation at reduced cost, and providing that common thread of AM understanding, a corresponding increase in AM maturity and knowledge across the business. In applying the framework successfully across multiple industries; knowledge of the asset classes, contractual boundaries, operating environments and business objectives needs to be understood and translated. This paper will provide the following areas that Downer addressed to successfully implement an as-set management framework across multiple industries, various contract models and different asset classes.

Keywords: Multiple Industry, Strategic Alignment, Framework, Risk

1. INTRODUCTION

Downer is currently the largest diversified services provider in Australia and New Zealand. Downer operates across Transport, Rail, Utilities, Facilities Management, Mining and Engineering, Construction and Maintenance and employs more than 56,000 people. This is important to note as there are large parts of the business that have been acquired and therefore there are many approaches to asset management.

Downer have successfully applied an asset management framework across multiple industries and been certified to ISO55001 using that framework. Based on our experience the key areas to achieve effective cross industry framework application are the strategic alignment, software or applications that support asset management, risk profile agreement and the use of an integrated management system or similar. Addressing these four key areas enabled Downer to successfully deploy a framework across multiple industries and we are currently in the process of moving the framework to our large facilities management business.

1.1 History/Background

The number of acquired businesses and consolidation of operating divisions over time has resulted in multiple approaches and frameworks being utilised throughout the Group in the asset management space.

To address this a central Asset and Data Management Office (ADMO) has been established to consolidate and ensure collaboration amongst the asset management staff across the Group. One of the first activities for the ADMO Council was the successful application of a common framework within a division on multiple industries.

Downer was successfully certified in July 2015 by an accredited independent body to ISO55001 on a water recycling facility, the first accredited ISO55001 certification in Australia. In the following years Downer has been certified on a road network management contract using the same framework. Based on the application of the standard framework the following lessons were learned.

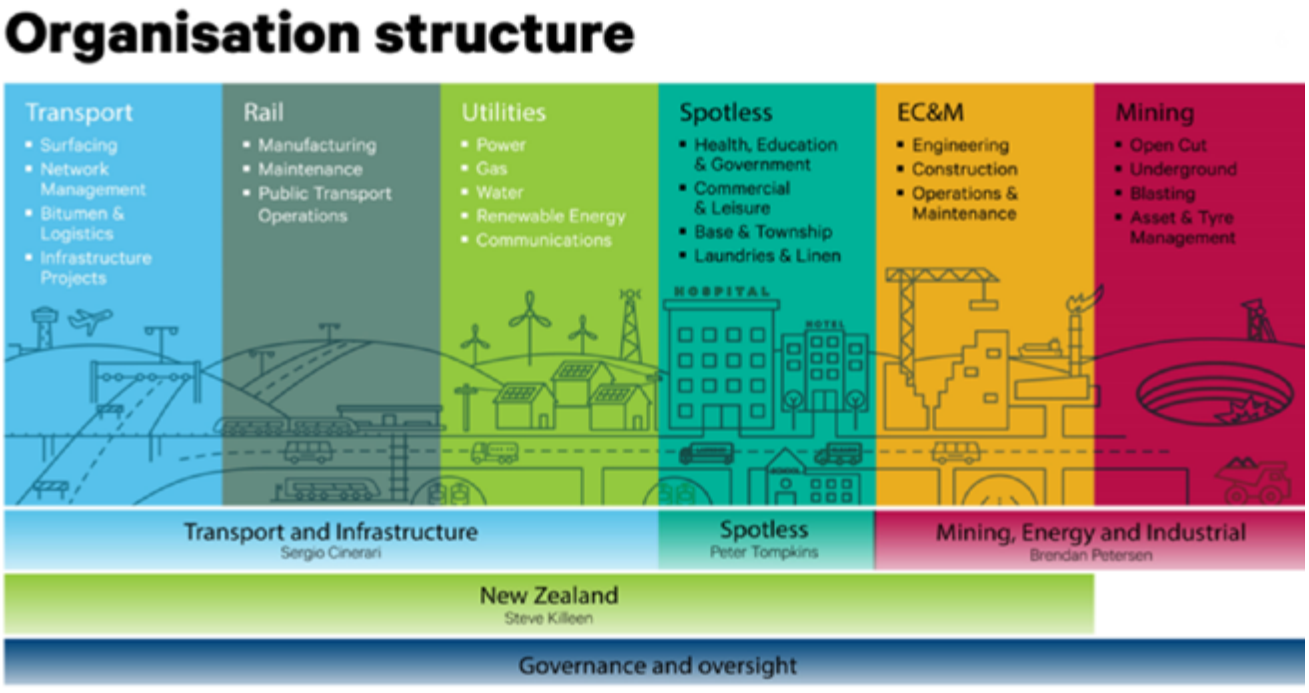


Figure 1 – Downer Group Service Lines and Operating Divisions

1.2 Strategic alignment

One of the key questions around strategic documentation is at what level within the business to pitch the strategy. The strategy may be pitched at various levels, business wide (enterprise), business unit, sector/regional or contractual. To have an all-encompassing asset management strategy needs to sit at the enterprise level.

This ensures the key requirement of strategic objective alignment is maintained. Consolidating the strategy and the documentation at the enterprise level allows for a single asset management policy.

One of the main difficulties with consolidating policies is around stakeholder management more than the content changes. To address this Downer ensured that all policy owners were bought into the consolidation exercise. This enabled us to quickly and effectively consolidate policies across the business and have all business units pointing at a single policy.

In applying the framework successfully across multiple industries; knowledge of the asset classes, contractual boundaries, operating environments and business objectives needs to be understood and translated to ensure alignment with strategic objectives.

1.3 Software packages supporting asset management activities

Not unlike many large organisations, Downer is a company that has been built by acquisition, with a core business resilience strategy of having a diverse portfolio of industries, given the number of industries and their individual preferences for different computerised maintenance management systems, how a framework that allows and can consider this is important.

At a high-level view, asset management frameworks should allow for any tool to be utilised, that is, not so rigid that only one tool can be used. There may be instances where this is the case, however, in the most part a framework should allow for any tool that fulfils the systematic requirements to be used. As is the case of the framework that is shared by both utilities and roads services businesses, two separate computerised maintenance management tools are used. Interestingly they vary significantly in size and complexity.

This is interesting to note as they both still achieve the required outcomes in asset management to be part of certified systems.

The key areas to consider when setting up the framework to allow for multiple computerised maintenance management software tools is to ensure that the requirements for effective asset management are the basis for the framework rather than the output of the system or tools being the constraint.

1.4 Risk profile and alignment to corporate resilience

Risk appetite and profile amongst the different industries is variable, the framework allows for this key consideration and how to capture it in a logical manner.

Risk is a key area for asset management, identification, mitigation and then management of residual risk are very common practices. Having a singular framework that then enables easier alignment of risk appetite and profiles amongst asset bases. One of the bigger hurdles is the granularity of risk, corporate risk profiles are often so high level that asset based risk can be hard to justify as a high-level risk to the business. Therefore, a framework that allows further granularity of asset risk such as the one utilised by Downer is a good way to ensure that asset.

Integration into an Information Management System (IMS) is one of the greatest challenges and doing that in a large diverse business is critical to uptake, alignment and success of the overall framework.

1.5 Integrated Management System

Integration to business practices to ensure alignment is critical, utilising an IMS is a key way to achieve the alignment to business systems as per the requirements of ISO55001. This allows uniformity of processes that already exist within the business and based on Downer's experience this allowed for rapid uptake or deployment to other parts of the business operating in other industries. The more integration of systematic processes such as change for example allows the business to apply a framework and deploy it with far less new processes and therefore training required.

2. BENEFITS

The following is a summary of the key benefits obtained from the implementation of a common framework across multiple parts of the business. A key consideration is that the learnings and benefits for Downer are equally as translatable to businesses that operate across single industries or multiple areas of the same industry.

2.1 Cost efficiencies

A standard framework is available for future implementation at reduced cost, the standard nature of the framework allows for immediate pickup and play by the business and therefore less time figuring out what key items are needed in a framework and even what templates exist. The fact that people can easily find a reference framework saves time let alone the time to populate those templates within the framework. It also allows for business continuity as it isn't reliant on a single person or team, but is a systematic process.

2.2 Common language / templates

Providing that common thread of AM under-standing, is a benefit as the common framework allows for consistent use of asset management language throughout the business and the templated nature of a framework allows the ability to share resource and expediate the implementation onto new contracts where necessary. Because the business suddenly has a larger pool of upskilled or knowledge staff.

2.3 Asset management maturity

In line with the increase of knowledgeable staff a corresponding increase in AM maturity and knowledge across the business is generated. A key outcome of ADMO is to increase the maturity of the asset management practice across the business.

3. SUCCESS LOOKS LIKE ALIGNMENT

Downer is a large multi sector business, as any business with continuing and changing market pressures, having a business that aligns to a single asset management framework is an essential business strategy and critical to a business. Alignment provides a singular focus to ensuring a business that can continually develop and understand the changing business needs of their own assets and the assets it looks after for customers to support their business needs.

Paper presented at AMPEAK19 April 2019.

ARTICLE 2 – How an ISO55001-certified Management System transformed the approach to gas safety management

Matt Henson, Jemena, North Sydney, Australia

ABSTRACT:

The energy sector is subject to extensive safety and technical requirements throughout Australia, much of which is administered by state government aligned technical regulators. Whilst the required safety outcome to minimise risk to consumers and the public to as low as reasonably practicable is common across Australia, specific regulatory compliance obligations vary. Historically, documentation for individual safety management systems was produced for each asset in each jurisdiction, resulting in multiple representations of what was effectively the same one approach. Jemena's ISO55001-certified Asset Management System (AMS) has introduced a developmental efficiency for compliance documents issued to technical regulators explaining the safety management system. This efficiency has primarily been achieved by highlighting how safety is considered a key business objective and how the AMS delivers on this objective via systemised processes, procedures and documents. Jemena's AMS provides the principle framework for the organisation to direct, coordinate and control asset management activities and provides assurance that Jemena's safety, operational, societal and environmental objectives are achieved on a consistent basis. It brings together the external influences, asset management drivers, business values and selected strategies to deliver sustained performance for the benefit of all stakeholders, notably greater transparency of regulatory

compliance and assurance across a range of assets and jurisdictions.

Keywords: Asset Management System, AMS, safety management, regulatory compliance, efficiencyk

1. INTRODUCTION

This paper explores the vastly improved approach Jemena has been able to achieve in responding to various technical regulators regarding safety submissions in utilising the process-orientated consistency afforded by the Asset Management System (AMS).

Economic regulation for energy assets is nationally based, whilst that for technical regulation is state / territory based. Historically, submissions to technical regulators have been bespoke approaches recognising their differing requirements, this despite the approach to safety typically being uniform across Jemena.

Jemena is an Australian-based energy utility with an extensive asset portfolio comprising interests in electricity distribution, gas distribution and gas transmission. Jemena's area of operations incorporates five states and territories across eastern and northern Australia. Spanning various markets and jurisdictions, the regulatory approach for Jemena has at times proved tedious.

2. CLARITY FROM ISO55001-CERTIFIED AMS

In late 2016 Jemena commenced a project intended to culminate with certification of the AMS to both ISO55001 (asset management) and ISO27001 (information security). Much of the activity contributing to certification was undertaken to improve the discipline of asset management and information security to better support the achievement of business objectives. The associated external recognition from certification notably improved the efficiency with which Jemena could justify decision making with both economic and technical regulators.

Amongst other things, the AMS brought consistency across all asset classes via the development of a template-orientated document hierarchy. Whilst many supporting documents were developed in response to AMS requirements, at the highest level aside from the Asset Management Policy, a suite of five templates was developed to collectively satisfy the intent of a Strategic Asset Management Plan (SAMP) and Asset Management Plan (AMP) as per Figure 1. These five documents being the Asset Business Strategy (ABS), Asset Class Strategy (ACS), Asset Investment Plan (AIP), Capital and Operational Work Plan (COWP) and Delivery Plan. Whilst five documents rather than two might appear inefficient, the prudency with which investment decisions are undertaken, structural alignment of roles and responsibilities and the outsourced approach to operations and maintenance has largely dictated the requirement for five hierarchical documents.

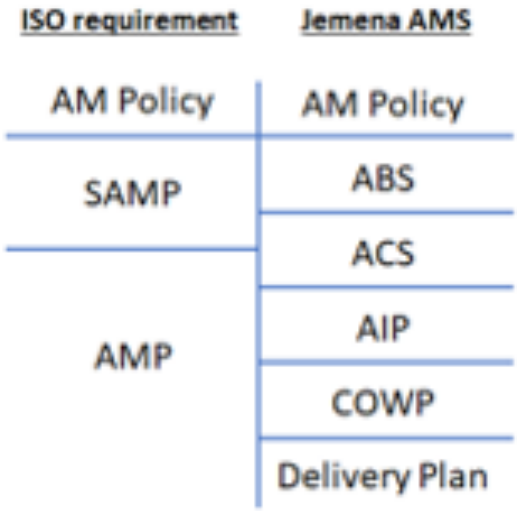


Figure 1 – Representation of ISO55001 requirements from Jemena AMS documentation

The ABS distils corporate strategies and objectives for the sake of informing the drivers that will dictate responsiveness from the ACS. The ACS justifies the technical and engineering risk-based decision making necessary to maintain an asset class in consideration of its life cycle, whilst the AIP justifies the financial and economic scenario-based decision making in optimising the viable approach to life cycle investment having considered proposed activities from the ACS. The COWP provides a detailed plan of activity to achieve the business objectives whilst the Delivery Plan identifies the required resources necessary to deliver the activities identified in the COWP.

The hierarchical approach to the development of high level AMS documentation promotes the alignment of lowest level activities to the highest level objectives they are endeavouring to achieve. The business objectives, otherwise referred to as 'the pillars' (upon which the business is supported)

and distilled by the ABS to guide asset management outcomes, are Customer, Performance, Growth, People and Safety. These pillars are supported by four highest level asset management processes that drive cyclical activity within the discipline of asset management (for that which is scoped within the AMS) and can be characterised as follows

1. Asset Business Strategy Development - Define and maintain the ABS by analysing asset and long term planning requirements and investment performance in consideration of strategic options.
2. Asset Planning & Prioritisation - Defining and maintaining the capital program as well as defining, designing and planning the execution of asset construction, maintenance programs and asset operation throughout the asset life cycle.
3. Technical Specifications Control & Change Management - The design and management of guidelines, standards, policies and manuals in relation to asset management.
4. Asset Performance & Integrity Management - The monitoring and management of asset performance, risk, controls and continuous improvement.

3. SAFETY MANAGEMENT WITHIN THE AMS

In focussing on the gas side of the business and the safety business objective, asset management outcomes are very much driven by threat-based assessment of associated risk, otherwise referred to as As-Low-As-Reasonably-Practicable (ALARP). ALARP , aligning to an arbitrary level of tolerance (typically incorporating the lower ordinal levels of a risk rating, e.g. bottom two of five levels) within the corporate risk matrix (hence defining the corporate risk profile), considers the threat to public safety from asset failure and associated mitigatory actions that justifies resulting investment. Technical regulators consider ALARP as the cornerstone of any integrity approach to the management of gas assets, driving the necessary investment to achieve the defined level of residual risk.

Table 1 – Jemena AMS Documentation Supporting Safety Management

Cycle	ISO Clause	Typical Documentation	Dominant AM Process
Plan	4. Context	AM Policy, ABS	ABS Development
	5. Leadership	AM Policy, AMS Manual, ABS	ABS Development
	6. Planning	ABS, ACS, AIP	Planning & Prioritisation
Do	8. Operation	COWP, Delivery Plan, Scope of Works, Field Manuals, Technical Specifications	Tech Spec Control
Check	9. Performance Evaluation	Engineering / Risk / Condition / Control Assessments, Asset Records, Performance Reports	APaIR
Act	10. Improvement	Risk Registers, Opportunity Briefs, Business Cases	APaIR

[1]ALARP dictates the balance of performance, cost and risk. Being risk orientated and with performance framed as the requirement to maintain containment, there is a baseline of associated cost that should not be unfunded

Considering 1) ALARP as the procedural constant within Jemena (incorporated within the Asset Risk Management Guideline), and 2) the AMS providing a standardised approach to overall safety management,

Why were safety submissions still being individually prepared for each technical regulator?

Whilst the answer mostly points to historical expectation and the legacy of structural inefficiency (as well as the unavoidable specific requirements of each regulator), the ISO55001-certified AMS has very much provided the catalyst for developmental efficiency of safety submissions. This is highlighted by 1) safety being considered a key business objective, and 2) the AMS delivering on this objective via a common system of processes, procedures and documents, as described in Table 1 from a Plan-Do-Check-Act perspective.

For those familiar with the structure of ISO55001 and notably the processes, procedures and documents that typically support it, there is nothing standing out from Table 2 that suggests gas safety management doesn't align. The challenge presented by ISO55001 to articulate and define the direct connection between an organisations objectives and the asset management strategies and decisions is largely what has contributed to the efficiencies possible from certification, particularly since a majority of the elements already existed.

Whilst some may argue that nothing has really changed regarding how gas safety management is represented, regulators have an increased level of confidence as well as understanding for how safety controls are firmly entrenched within the common AMS framework, irrespective of whether the control is physical or administrative. This single representation for how safety is at the forefront of risk-based decision making has been central to realising the efficiencies of the AMS, providing what is effectively a regulatory compliance matrix that explains and identifies the specific AMS documents or records to meet regulatory obligations.

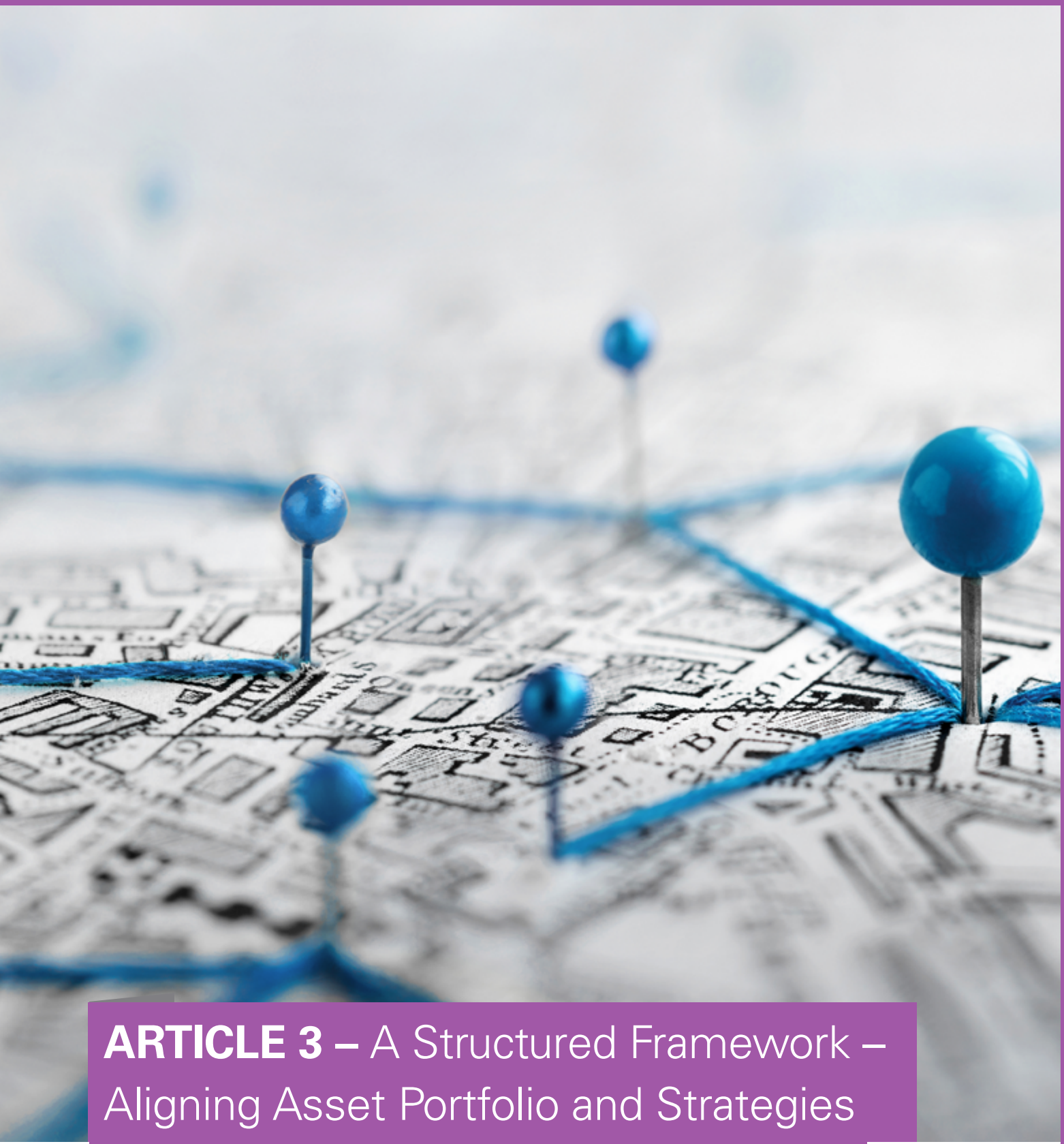
4. CONCLUSION

Jemena's AMS is an integrated management system that delivers safety as one of its core objectives, whereas safety submissions are guides for external stakeholders to understand how the AMS delivers safety and compliance to regulatory obligations. By better documenting the AMS and aligning the various processes, procedures and documents, Jemena is able to represent the decisions culminating in asset management outcomes and identify opportunities for continuous improvement more effectively. This has markedly increased the efficiency in how such submissions are developed in providing better and consistent articulation for what is core business.

Understanding and documenting the linkages of the AMS into core delivery processes has been identified as critical to achieving Jemena's corporate objective of being a customer driven, process centric organisation.

Facility description	Competency	Change management
Policy document	Specifications/procedures	Performance review
Organisational structure	Control system/s	Investigation framework
Roles and responsibilities	Machinery & equipment	Records management
Risk assessment	Emergency planning	WHS
Operational interaction	Communications	Legislation

Table 2 – Typical elements expected within gas safety submission



ARTICLE 3 – A Structured Framework – Aligning Asset Portfolio and Strategies with the Service Delivery Need

Lucio Favotto, Transport for NSW

SUMMARY:

Transport for NSW (TfNSW) currently manages a portfolio of assets valued at over $130 billion. With a growing service demand and a significant pipeline of capital projects, the Transport cluster faces many challenges in effectively managing these assets. To help address the challenges, TfNSW has implemented an Asset Management Framework (AMF) across the organisation. Work is continuing to build asset management knowledge within the organisation.

Through innovative strategies, effective collaboration and whole of life asset management thinking TfNSW has improved the integration and implementation of aligning asset portfolio and strategies with the service delivery need. A cohesive approach was implemented in developing a framework aligning service requirements, performance targets, asset strategy and capital investment information across transport.

Creating alignment between service need within long-term plans across the cluster was paramount for Transport in understanding service requirement, investments, risk, cost and maintenance. Bridging these silos has ultimately resulted in greater clarity of vision across the organisation as well as generating opportunities to collaborate and share information for effective decision-making.

This key information was provided to service providers in development of their asset management plans. This allowed an assessment of impact to changes and was paramount in identifying solutions for the long-term sustainability of assets across the Transport portfolio.

Key Words

Asset item, thing or entity that has potential or actual value to an organisation

Asset management is the coordinated activity of an organisation to realise value from assets (ISO 55000)

Service Providers operator / maintainers, designers, constructors providing services to TfNSW to manage the day to day operation and maintenance of the TfNSW assets

TfNSW Transport for NSW

Transport cluster the term commonly used to refer to the group of all operating agencies and private operators represented by TfNSW.

1. INTRODUCTION

1.1. Background

Transport for NSW (TfNSW), as the asset owner, manages a diverse and complex transport system. TfNSW is responsible for managing and shaping the future of the transport system in NSW. TfNSW is focused on establishing an integrated transport system in which all modes of transport work together effectively and efficiently to deliver sustainable outputs that are valued by all stakeholders.

The customer is at the centre of everything TfNSW does and can range from:

- Residents and communities
- Public Transport Users
- Road Users
- Pedestrians and Cyclists
- Service Providers
- Infrastructure Managers
- Local and Global Business
- Visitors and Tourists

TfNSW's objective is to align our business to quality requirements as we work towards achieving the NSW Premier's and State Priorities, implementing our Corporate Plan Connecting NSW and providing transport services for the people of NSW.

2. CURRENT STATE

2.1 Services

Transport for NSW (TfNSW) includes an extended network of agencies including road, rail, buses, taxis, ferries, light rail, cycling, walking, community transport services, regional air services and freight transport and owns assets valued over $130 billion.

In addition there are a number of TfNSW Internal Service Providers supporting customer and services outcomes. These are provided next page:

3. SERVICE PLANNING

3.1. Challenge

There is a growing demand for the services we deliver and as a result the way we plan, design, build, operate/maintain and dispose of assets is critical. With a growing population, demand on transport in Sydney is higher than ever.

Figure I – Service Providers

Transport Modes	Services
Heavy Rail	Metropolitan Rail Network
	Intercity and Regional Services
	Country Regional Network (CRN)
	Sydney Metro – Future
Light Rail	Inner West Light Rail (IWLR)
Act	CBD South East Light Rail (CSELR)
General	Parramatta Light Rail (PLR) - Future
Buses	Metropolitan Bus Services
	Outer Metropolitan Bus Services
	Rural and Regional Bus Services
Ferry	Inner Harbour and Parramatta River Ferries
Roads and Traffic	• Education and licencing of drivers and vessel operators. • Tolling services • Road and waterways management • Registration of vehicles and vessels. • Heavy vehicle and vessel inspections • Enforcement of road regulations
Multi-modal	Newcastle Integrated Services (NIS) – Light Rail, Bus and Ferry

Figure II – Internal Service Providers

Transport Support Systems	Services
IT Systems	• IT Services
Transport Management Systems	• Transport Management and Coordination
Customer Services Systems	• Customer Channels • Ticketing and Concessions
Interchanges	• Interchanges (Gap Assets) • Secure Bike Sheds & Lockers • Wayfinding

We are planning for the delivery of multi-modal infrastructure projects across Sydney, as such a total asset management to approaching the service needs is paramount for effective value for money sustainable network.

The service demand and customer requirements vary from mode to mode and from location to location. Aligning asset portfolio and strategies with service planning need i.e. developing an asset portfolio which best responds to each service is crucial. This may include four key decisions across the asset life cycle:

- Maintain
- Rationalise
- Upgrade
- Integrate

A framework has been developed to further understand the alignment of asset portfolio and strategies to asset portfolio needs. This included developing a strong alignment of service requirements, performance, asset strategy and capital investment programs.

3.2. Service Requirements

Services requirements describe current and future target service delivery levels including operational responses to meet desired future service provision for customers.

3.3. Performance

Developing Asset Performance Measures to evaluate the effectiveness and efficiency of assets in their role of supporting service delivery.

3.4. Asset Strategy

The asset strategy defines long-term Transport strategic objectives and customer performance standards for asset maintenance. Also details the level of maintenance activities and investment required to deliver services and results to customers for all modes of transport.

The Asset Strategy provides the platform for Transport for NSW to demonstrate the relationship between the performance of their physical asset portfolio and the services they deliver. This may include the strategy for decommissioning assets (rationalisation) or strategies in upgrading network to cater for future service.

3.5. Capital Program

Capital investments describes future improvements to the functionality of existing physical assets and the creation of new assets to meet the growing needs of the community. Assessment of feasibility of delivery of capital program is essential in identifying required access level for construction as this inherently leads to customer disruption and the risk of reducing access required to maintain the network sustainability.

4. STRATEGIC FRAMEWORK

The framework below has been established to explain the clear alignment of services plan with the transport services and operations planning inputs. As a result there is a clearer understanding of operations, maintenance and growth and improvement programs.

Figure III Transport Asset Management Plan Framework

4.1. Benefits

The benefits of creating the alignment between service, strategy, performance and capital investment include:

- Assets are developed to meet a service delivery outcome
- Enhance the link between service outcomes delivered to customers and the maintenance of the assets involved in the delivery;
- Asset costs associated with service delivery can be identified and considered in the long term;
- The performance of the asset can be reviewed to suit service delivery needs;
- Better understanding of how asset portfolio will meet service delivery needs of the future
- Sustainable funding to meet service need
- Consideration of available resources and operational capability

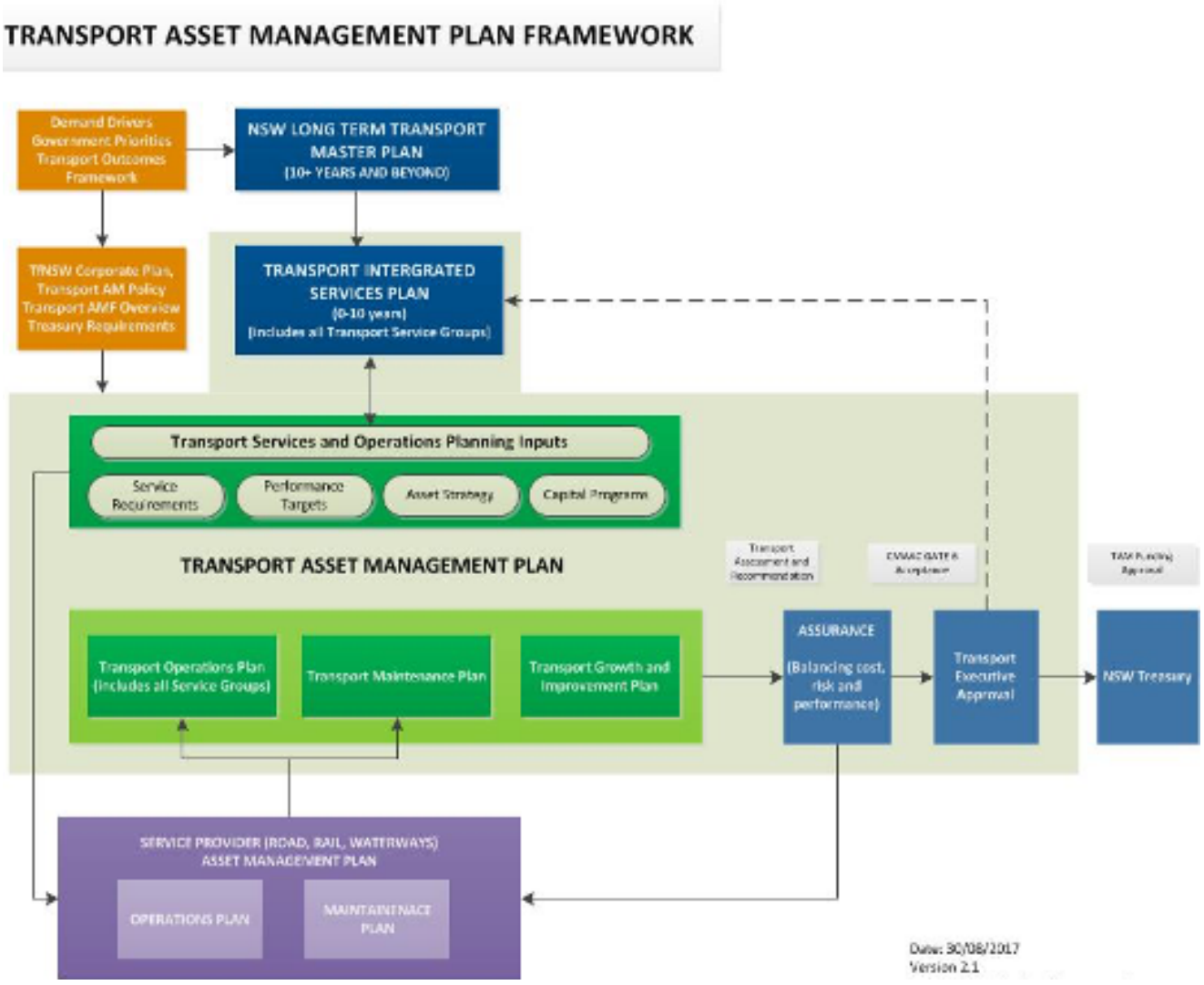


Figure III – Transport Asset Management Plan Framework

5. ASSET MANAGEMENT JOURNEY

Transport for NSW through the development of the Asset Management Framework will continue to develop Asset Strategy processes. This process will provide the ongoing assurance and justification for the capital investment. The initiatives currently in place include:

- An approved Asset Management Policy
- A draft Asset Information Policy
- An approved TfNSW Asset Management Framework overview
- Draft TfNSW SAMP & Asset Management Plan
- Service Provider Asset Management Plan Standard
- Asset Performance Reporting Standard
- Quarterly Asset Management Community of Practice sessions

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[1] ISO 55001

[2] Total Asset Management Manual – NSW Treasury

[3] AMBOK Framework for Asset Management – Second Edition

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ASSET MANAGEMENT FUNDAMENTALS

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Where to next?

Advancing your career in asset management

On the 30th November the Asset Management Council facilitated a conversational session, hosted by Dr. Monique Beedles, Director on the AMCouncil Board and internationally recognised thought leader for asset management, interview a panel of previous Asset Management Fundamentals (AMF) alumnus who started with CAAM (Certified Associate in Asset Management) and have since gone on to progress their asset management careers. It was a chance for AMF graduates to reflect on their asset management journeys so far and think about where to next. Thank you to our guest panellists on the day for sharing their experiences; Shane Bissmire CPAM, Jenny Ratsep CPAM and Robert Sciberras CPAM.

Introducing CAAM Alumnus, Steven McCann CSAM:

What is your current asset management role?

I'm the Manager of the Asset Improvement Program for the Victorian Department of Transport's Rail Assets, Projects and Compliance Branch. Prior to that I was at VicRoads, responsible for the team that designed and implemented the Asset Management Accountability Framework program.

What is your personal asset management journey to date?

It's probably best summarised by saying that I've had numerous roles over the last 15 years and have always had a strong interest in organisational improvement. I have a business background and have built that experience into government through delivering

public value in managing non-routine, complex situations. This includes designing performance evaluation frameworks, scoping contract management capability for PPP projects, developing organisation-wide asset management policy for large public sector organisations, conducting Gateway Review and managing asset assurance programs. I have worked in multiple economic and social infrastructure environments, including transport, education and justice.

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evaluation frameworks, scoping contract management capability for PPP projects, developing organisation-wide asset management policy for large public sector organisations, conducting Gateway Review and managing asset assurance programs. I have worked in multiple economic and social infrastructure environments, including transport, education and justice.

As part of the journey, I've worked hard to broaden my skill-base and now have internationally recognised and certified expertise across multiple industries including asset management, procurement, contract and commercial

management, risk management and project management. This enables me to identify better practices from one discipline and adapt to another.

Why did you decide to become CSAM qualified?

It's part of the evolution of my professional journey. When I undertook a PhD (Built Environment) in improving public sector governance of PPPs, it quickly became evident that contract management and asset management are two sides to the same coin. Therefore, both need effective management to achieve value-for-money propositions and intended business case outcomes. However, there aren't many practitioners that specialise both in contracts and assets at a program level. There is a strong capability need to do the conceptual work and also drill down into the detail when required. I recognise this as is a source of competitive advantage.

So, knowing that the Victorian Government, as with other governments in this country and abroad, have invested heavily in infrastructure programs, becoming a CSAM has been a way to formalise my experience and be recognised for my knowledge and skills by senior decision-makers within government, and more widely by my peers. I became CSAM qualified in 2019.

How did you take the step from CAAM to CSAM and what did it entail?

For me, the transition wasn't linear. I became a CAAM in 2017 along with quite a few others from VicRoads through a corporate arrangement with the Asset Management Council to improve organisation-wide asset management knowledge. CSAM is different because it requires demonstrated experience to an evidentiary standard, so the basis for certification is reflective in nature. It requires articulation of deep experience across multiple competency sets, in specific situations.

How has certification progressed your career?

This is a really good question because success over the last few years is intertwined with my experiences and successes in different professional disciplines, so it's a bit like a chicken and egg scenario. If I talk about success more broadly, I can say that I have used my asset management experience to move into more senior and challenging roles. Other successes that have been derived from my asset management experience include:

- Appointment as an Editorial Board Member of Public Works Management and Policy, and the Journal of Strategic Contracting and Negotiation (both SAGE Publications)
- Engagement as an Expert Panel Member by the Department of Treasury and Finance on the Contract Management for PPPs course that is delivered by the University of Melbourne
- Some of my PhD content is used as part of the CP3P global PPP Certification Program Guide, which is an innovation of a group of multilateral development banks including the World Bank Group

Being the recipient of the Victorian Secretaries Board Policy Innovation Award for providing tangible and implementable policy advice on how to enhance Victoria's economic performance and productivity by delivering better outcomes for Victoria's PPPs (the Victorian Secretaries Board comprise the CEOs of all Victorian Government Departments)

An Achievement Award for developing a best practice model for responding to the requirements, accountabilities and processes of the Victorian Government's Asset Management Accountability Framework, at VicRoads.

Any tips for those thinking of undertaking CSAM?

My first piece of advice is not to underestimate the rigour and commitment required for a successful CSAM application. It will take a while to plan how to tackle this, and from start to finish, it took me almost a year to prepare for and have the application assessed. Another piece of advice is to carefully map out your experience against each discipline and individual competency to self-assess whether you have enough relevant experience before formally embarking on the process. It's also worth reaching out to the Asset Management Council to ask questions about what assessors look for as part of successful portfolio submission – it's best to know this early.

STAR PROFILE – Lalinda Karunaratne

1. Why asset management?

It was not a conscious choice at the beginning of my asset management journey. But my educational background in Civil Engineering and general affinity for social studies helped me to generate passion for this field. Asset management, especially managing public infrastructure, is essentially an art of balancing of technical engineering aspects with social needs considering sustainability and affordability.

2. How long have you been working in the asset management sector?

I am working in the asset management sector for close to 10 years now. I have been fortunate to be in a variety of roles in the asset management field related to asset condition monitoring, maintenance program development and treatment design, predictive modelling and asset management plans and strategy development areas. Also, I have had experience working in consulting, research, and asset owner roles within both the private and public sectors. Those various roles and experiences helped me to get an all-round experience in asset management and assist in developing a clear career path.

3. What is your speciality?

My specialty is infrastructure asset management, with the most experience in road asset management. While asset management principles apply universally to all industries, road infrastructure asset management provides unique challenges.

It is the largest and most valuable public asset and provides the backbone for most economic and social interactions. Asset management of road networks requires thorough engineering knowledge and a sound understanding of people's behaviour and needs.

5. What's the best career advice you've ever received and who gave it to you?

It is along the lines of "pursue what you enjoy doing, and the success will come". I have read many variants of this, including the quote "do what you love" by late Steve Jobs. When I first started in asset management, I was not sure how far I could progress. And I did not see a clear path in front of me. But I thoroughly enjoy what I was doing. That drives me to explore and learn further, ultimately bringing a lot of success and satisfaction.

6. What makes a great asset manager?

A successful asset manager needs to be able to balance short term urgent needs with long term strategic goals. Also, they need to balance the technical aspects and resource management, both human and financial. And they need to be a rational decision-maker and a great communicator. An asset manager plays a vital role in being a custodian of physical assets and requires having a passion for delivering larger organisational goals and satisfying stakeholder needs.

7. What is the most exciting trend that you've noticed in asset management today?

I think it is the evolving trend in using data for consistent and transparent decision making. Over the years, many organisations have spent a lot of time and effort in collecting massive amounts of data. However, until recently, there was no tools or know-how to consume that data consistently. But with the advances in data science, machine learning and artificial intelligence, now may organisations are moving towards data-driven decision making.

Use of this 'big data' in asset management is generating a new kind of 'business intelligence' helping organisations to meet its stakeholder expectations.

8. What is the biggest challenge facing up-and-coming asset managers today?

Manage the expectation of how to consume the vast amounts of data collected is becoming very critical in asset management. There is much expectation that, since data is available, asset managers can make the best decisions. However, that is always not the case. Nowadays, asset managers need the skill of how to convert data into information for consumption and decision making. That requires a different set of skills such as data modelling, analytics and visualisation on top of traditional asset management skills.

9. What advice would you give to an up-and-coming asset manager today?

You will notice that there will be resistance to change the prevailing asset management practices at both individual and organisational levels. While we can learn so many things from experience, with some innovation, almost always we can find better solutions to the problems. With the availability of enormous amounts of data and the tools to analyse those data, you can confidently make decisions based on what data tells you and not solely relying on someone's opinions. Data-driven decision making and innovative thinking are what helps you to be successful.

11. What is your proudest career achievement?

I think it as a series of achievements in my career so far. Since I moved to asset management, I was able to complete two Graduate Certificates in Infrastructure Asset Management and Pavement Engineering. Last year I became a Chartered Engineer in asset management. To top it off, I obtained CAMA certification for ISO 55000 and became a CPAM earlier this year.

The most significant achievement of all is the satisfaction I get when applying what I have learned to serve society by helping to improve the management of public infrastructure.

12. What's next for you?

I want to explore more about leadership and business management areas. It will help me to contribute further in asset management by complementing my engineering skills and ISO 55000 management system knowledge gained through CAMA accreditation.

13. When you're not busy at work, what do you enjoying doing to unwind/relax/explore

At the moment, I am spending most of my free time with my two boys and watching them grow up. I like reading books about personnel growth and development and enjoy occasional computer gaming session.

Lalinda recently achieved his Certified Practitioner of Asset Management (CPAM). To find out more about our internationally recognised certification scheme, visit www.amcouncil.com.au/certification

STAR PROFILE – Tammy Falconer CPAM

1. Why asset management?

II came into asset management by accident – I started my career in IT and had the opportunity to do business side support for an enterprise asset management system implementation. This gave me a fantastic opportunity to understand the value that asset management can provide to an organisation, it's stakeholders and customers so I never went back to IT!

2. How long have you been working in the asset management sector?

I've been working in asset management for 10 years now, predominantly in water and power utilities. Last year I joined KPMG's Engineering and Asset Management team which gives me a fantastic opportunity to work with a range of clients helping them to solve their asset management challenges.

3. What is your speciality?

I love helping organisations uplift their asset management capability, and my favourite space to work in is asset information. Well managed and used, asset information has the power to transform the way organisations make decisions about their assets. It can support efficiency, drive continuous improvement and provide transparency and trust. My speciality is to help organisations develop and implement data strategies; apply best practice information management such as master data and data quality management as well as implement technology and analytics solutions for decision support.

4. What drew you to explore more about this particular speciality?

Asset information was a natural alignment for me given my IT background. It enabled me to leverage my knowledge of the benefits of data and technology can provide in an asset management context.

6. What makes a great asset manager?

A great asset manager never loses focus on why the assets exist and the service that they provide to customers or stakeholders. They are excellent people leaders and support their team to have a continuous improvement focus, consistently striving to increase the value that their assets provide.

7. What is the most exciting trend that you've noticed in asset management today?

I think it's exciting to see organisations elevating their focus on asset management to balance cost, risk and performance supported by ISO55000. Having worked in the water industry for many years, I'm excited to see this focus shift from simply managing the assets in a cost effective way to the benefits that good asset management can provide for customers, the community and the environment.

9. What advice would you give to an up-and-coming asset manager today?

I'd love to see more women in asset management as there is clear evidence that greater gender diversity drives innovation. There's no single path to a career in asset management. We need engineers, risk management professionals, technologists, strategists, environmental scientists, supply chain professionals, financial managers and community engagement specialists to successfully manage assets, so my advice is to women who have these skills to consider asset management as a profession and help us innovate for the future.

10. What is the biggest challenge facing the asset management sector today/your particular field of asset management today?

The proliferation of technology is both exciting and challenging. The sheer volume of asset information being created is difficult to manage and joining disparate data sets to gain insight is something I see many organisations struggle with. Whilst technology trials and proof of concepts can show significant benefit, it can be difficult to scale and operationalise. I believe it's important for organisations to have a strategy and standards for their asset information as well as the right analytics environment that will enable ingestion of static and dynamic data from multiple sources to support asset management decision making. I think it's time to ditch the myriad of spreadsheets and aim for a single pane of glass that integrates data and supports strategic and real time asset management decision making with clear alignment to organisational objectives.

12. What's next for you?

The best part of my role at KPMG is working with our clients to uplift asset management capability. I love the variety of clients and challenges I get to work on as well as the opportunity to grow and develop my team. So I never know what is next for me, it really depends on what our clients need!

13. When you're not busy at work, what do you enjoying doing to unwind/relax/explore?

Aside from binging the latest series on Netflix, I love catching up with friends, going for a run or playing volleyball.

Tammy recently achieved his Certified Practitioner of Asset Management (CPAM). To find out more about our internationally recognised certification scheme, visit www.amcouncil.com.au/certification

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The purpose of the program will be:

- An opportunity to reflect on professional challenges and achievements
- Personal and professional development gained from problem solving and constructive guidance
- Satisfaction from helping others and contributing to the future success of the industry

Who can apply?

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Express your interest today:
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Interested in being a **MENTEE** or **MENTOR**?

www.amcouncil.com.au/mentoring

STAR PROFILE – Scott Bacon CPAM

1. **Why asset management?**

   I am drawn to asset management because I am a practical, solutions-focussed person. I enjoy the systematic nature of the discipline and seeing the productivity and efficiency gains it can deliver - it just makes good business sense to me. I also love the challenges asset management presents. Personally, the most challenging aspect is the very thing that ensures its success – the people. When an organisation's strategy, systems, processes and culture are aligned, and underpinned by a philosophy of continuous improvement, it enables people to achieve amazing outcomes. This has certainly been my experience at Port of Newcastle.

2. **How long have you been working in the asset management sector?**

   My entry into the asset management sector began in 2009 when I joined Port of Newcastle (then state-owned Newcastle Port Corporation) as the Maintenance Contracts Manager. Prior to that, I was in construction/project management. Not long after I joined the Port, I was introduced to John Hardwick (current AMCouncil representative on GFMAM and WPiAM). I had the opportunity to be mentored by John and, under his guidance I learnt what good asset management practice look like. This has inspired me to further my knowledge in asset management and share that expertise with my colleagues at Port of Newcastle.

3. **What is your speciality?**

I am particularly passionate about the port and marine industry, and the assets that support its function. At Port of Newcastle, we are custodians of some of our region's most critical assets. The Port is integral to the prosperity of our region and the state, enabling businesses across the Hunter and around New South Wales to successfully compete in international markets. Every day we are striving to create a safe, sustainable and environmentally and socially responsible Port for current and future generations.

4. **What drew you to explore more about this particular speciality?**

   It is all about helping people do things more efficiently and effectively that drives me to keep learning. I have been lucky enough to connect with some amazing people in the asset management sector and I grateful for the knowledge they are willing to share. You never stop learning and this knowledge has given me the confidence to challenge the status quo. One of Port of Newcastle's employee-led values is Curiosity, and this is something we practice every day.

5. **What is the best career advice you've ever received and who gave it to you?**

   This is not necessarily career advice, rather it is something I learnt in a leadership course at Port of Newcastle. I continually ask myself these two important questions; 1) What am I supposed to be doing and why? 2) How is what I am doing adding value to the business? This helps me to prioritise my work and eliminate unnecessary waste.

6. What makes a great asset manager?

To me, the difference between a good asset manager and a great asset manager is leadership skills. Great asset managers know who their internal and external stakeholders are, and they engage with them frequently to identify what is working while advocating and supporting areas that require change. They also support and empower their teams, building a culture of continuous improvement and helping them understand how they contribute to the organisation's success.

7. What is the most exciting trend that you've noticed in asset management today?

There is a huge opportunity and much excitement with advancements such as Internet of Things (IoT) and Automated Innovation (AI) in the Assets management sector, particularly around the collection and management of data. Software advancement is truly exciting, particularly in optimising resources for the control and management of assets. The essential ingredient is understanding, documenting and agreeing on the needs of the business prior to purchase. There are also risks if this type of new technology is implemented without being well understood, embedded or resourced properly.

8. What is the biggest challenge facing up-and-coming asset managers today?

I see one of the biggest challenges being the rapid pace of technological advancement within our sector. It presents immense opportunities but also risks with an increased threat of premature obsolescence and reduced asset life expectancy. Understanding the true cost of ownership, and the risks during asset initiation and concept phase, can result in substantial cost savings over the asset's life cycle. Concept phase can quickly move to delivery phase prior to understanding the true benefits of systems integration and configuration. Asset managers must plan for disruption and become more agile if they are to navigate the changes ahead and deliver more sustainable asset outcomes and operations.

9. What advice would you give to an up-and-coming asset manager today?

My advice would be to avoid over-complicating the objective of good asset management principles and tackling too much at once. Set clear milestones and engage frequently with your stakeholders to ensure they understand and support your objectives. Successful asset management is about creating alignment between your organisation's strategy, its culture and its approach to asset management.

10. What is the biggest challenge facing the asset management sector today/your particular field of asset management today?

Implementing sustainable asset management practices and a whole-of-life approach asset management are important priorities for many businesses. The port industry is a dynamic, fast-paced environment, with many diverse stakeholders and supply chain partners involved. Frequent, proactive stakeholder consultation and collaboration is vital to ensuring the industry can implement these changes successfully. The challenge for Asset Managers is to align the asset portfolio to deliver sustainable, efficient, profitable outcomes.

11. What is your proudest career achievement?

In 2014, I was invited to collaborate on the development of Ports Australia's Wharf Structures Condition Assessment Manual. This reference manual is widely used throughout the port industry to ensure there is a consistent approach for condition assessment of wharf structures in Australia.

More recently, I was responsible for developing and implementing an Asset Management Policy at Port of Newcastle. This is an important milestone that demonstrates the Port's commitment to developing fit-for-purpose processes that align to the ISO 55001 standard and industry best practice.

12. What's next for you?

With the new Asset Management Policy implemented at Port of Newcastle, I now have the privilege of leading the strategic asset management framework initiative; internally referred to as Enterprise Portfolio Management (EPM). This is an exciting opportunity to work with the Port's internal and external stakeholders to implement a new platform for managing the Port's critical assets.

There is an increased focus on sustainability and growing pressure for organisations to demonstrate they have sound asset management processes embedded. I'm excited about the future of asset management and committed to investing in my own professional development to stay across these important developments within the sector.

13. When you're not busy at work, what do you enjoying doing to unwind/relax/explore?

Regardless of life and work demands, I am a keen runner (medium to long distance) and I try to average 60 to 80km per week. I also love family time and social sports - my wife and I have an active and sporty 10-year-old son, so we have no choice but to be active. It certainly makes life fun and helps me keep things in perspective. Apart from sleep, these activities provide the balance I need to meet life's demands.

Scott recently achieved his Certified Practitioner of Asset Management (CPAM). To find out more about our internationally recognised certification scheme, visit www.amcouncil.com.au/certification

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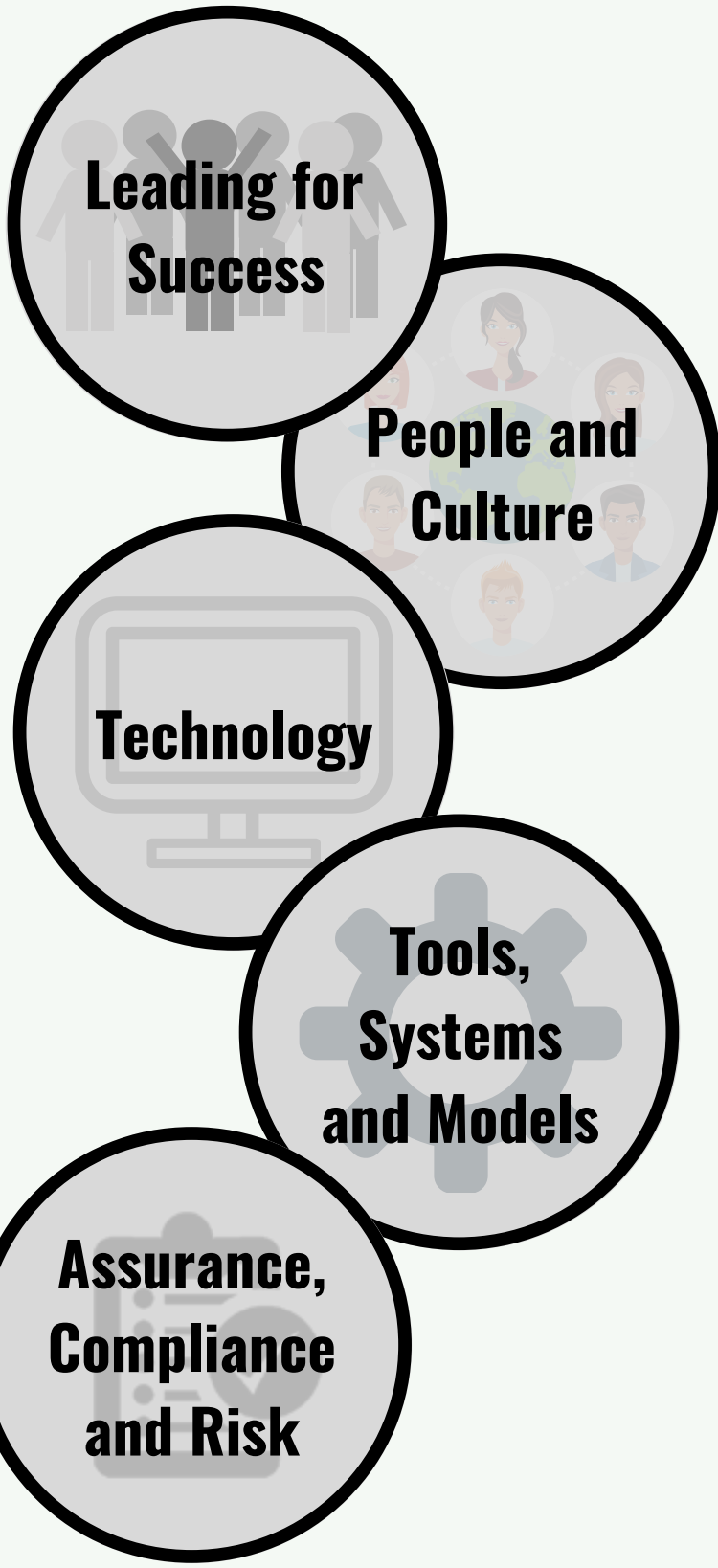


Maintenance and Reliability improvement by Reliability analysis and its outcome implementation by optimising Preventive Maintenance intervals

Md Omar Sharif1, G. Chattopadhyay2, Tanveer Choudhury3
1Post Graduate program for Maintenance & Reliability Engineering,
2,3School of Science, Engineering & Information Technology Federation University, Churchill, Australia

ABSTRACT

The performance of machines depend on the reliability of the equipment used, the operating environment, the maintenance effectiveness, the operation process, the technical expertise of operators. As the size and complexity of equipment continue to increase the implications of equipment failure become more critical. Therefore reliability analysis is required to identify the bottlenecks in the system and to find the equipment with low reliability and high criticality for achieving required performance. It is important to select a suitable method of data collection from manufacturer and historical data from Computerised Maintenance Management System related to failure and costs.

In this study for the Gold processing plant, failure events, maintenance records, downtimes and costs are collated from the system and various sources. The result of the analysis shows useful for deciding and optimizing preventive maintenance intervals.

Keywords – Reliability Analysis, Preventive Maintenance Interval, Weibull Analysis, Critical equipment

I. INTRODUCTION

The effectiveness of the mining equipment is mainly influenced by the reliability, availability and maintainability (RAM) of the system, and its capability to perform as expected. Reliability analysis techniques have been gradually accepted as standard tools for the planning and operation of automatic and complex mining systems since the mid-1980s.

Since failure cannot be prevented entirely in complex plants similar to gold mining and processing, it is important to minimize the likelihood of occurrence and the impact of failures when they occur [1]. The effective maintenance is characterized by low maintenance cost and improvement in RAM. Maintenance costs are a major part of the total operating costs of all manufacturing or production plants, and depending on the specific industry, maintenance costs can represent between 15% and 60% of the cost of the goods produced [2]. A major part of the mining system's operating costs is due to unplanned system stoppages and/ or unscheduled repair of the system and/ or components.

Preventive maintenance is widely considered an effective strategy for reducing the number of systems failures, thus lowering the overall maintenance cost [3].

The primary goal of preventive maintenance is to prevent the failure of equipment before it actually occurs. Preventive maintenance activities include equipment checks, partial or complete overhauls at specified periods, oil changes, lubrication and so on.

Gold Processing Plant, in this study, had issues related to several critical equipment failures resulting in downtime and reduced productivity. The identification of equipment and its Key Performance Indicator's (KPI's) were outlined. Weibull analysis in Microsoft Excel is used for Reliability Analysis. The output of the analysis is used for optimized preventive maintenance interval.

II. METHODOLOGY

In a probabilistic approach, a statistical method is employed to find the underlying distribution of failures. The failure distribution model is then used to predict the failure behavior of the components and to find the preventive maintenance interval to achieve the desired level of operational reliability.

The different types of equipment used in the process are shown in Fig.1 [4].

Criticality analysis of equipment was analysed using Failure rate, Safety Environmental Impact, Ease of repair, Mean downtime and Cost of breakdown as shown in Table 1 [5].

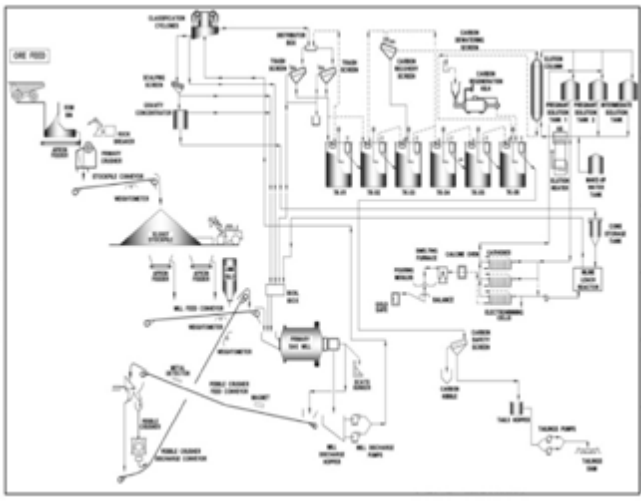


Figure 1 – Process Flow Diagram

	A	B	C	D	E	F	G	H	I
	Equipment name	Number of	Failure rate 1=Low 2=Medium 3=High	Safety Enviro Impact 1=Low 2=Medium 3=High	Ease of repair 1=No shut down reqd 2=Shut down of area 3=Shutdown of plant	Mean Downtime 1=Low 2=Medium 3=High	Cost of Breakdown 1=Repair cost only 2=Minor production loss 3=Major production loss	Criticality 3 x C x (D+E+F+G)	Comment
1	Crusher	2	2	3	2	2	1	48	
2	Apron Feeder	3	2	1	2	1	2	36	
3	Rock breaker	1	2	3	1	1	1	36	
4	Conveyors	3	2	3	3	3	3	72	
5	Sag Mill	1	1	1	2	2	2	21	
6	Agitators	6	2	2	2	2	2	48	
7	Slurry pumps	2	2	1	1	1	1	24	
8	Water pumps	2	2	1	2	1	1	30	
9	Thermal Oil Heater	1	1	1	2	2	2	21	
10	Gravity Concentrator	1	2	2	3	2	3	60	
11	Carbon Regeneration Kiln	1	2	2	3	2	2	54	

Table 1 – Criticality Analysis

Critical equipment with issues as shown in Table-1 are selected for analysis. The data for the selected equipment's are collected for 5570 working hours for each equipment. The time between failures (TBF) for each equipment is shown in Table-2. It is used for Reliability analysis in excel [6].

Values of Weibull parameters (β and α) for each equipment are analysed as shown in Table-2.

A target reliability of 90% was set by the organisation for Preventive Maintenance.

III. RESULTS

Results from analysis for selected equipment (here crusher) are shown in Table 3. Similar method applied for all other equipment's.

No	Crusher TBF (hours)	Apron Feeder TBF (hours)	Rock breaker TBF (hours)	Conveyor TBF (hours)	Sag Mill TBF (hours)	Agitator TBF (hours)	Slurry pump TBF (hours)	Water pump TBF (hours)	Thermal Oil Heater TBF (hours)	Gravity Concentrator TBF (hours)	Carbon Regeneration Kiln TBF (hours)
1	380	610	390	395	430	1120	480	830	1300	1420	940
2	470	730	280	285	300	870	650	650	1200	1150	650
3	510	480	320	325	600	1000	800	490	1270	950	1020
4	600	390	600	545	720	1200	340	900	800	1350	550
5	320	450	450	445	370	730	600	730	1000	700	770
6	370	1070	580	280	490	650	710	1020	-	-	1120
7	810	870	500	595	750	-	400	430	-	-	520
8	780	970	620	220	650	-	520	520	-	-	-
9	630	-	630	605	780	-	300	-	-	-	-
10	700	-	610	495	560	-	770	-	-	-	-
11	-	-	590	700	-	-	-	-	-	-	-
12	-	-	-	680	-	-	-	-	-	-	-

Table 2 – Failure Time analysis

	A	B	C	D	E	F
1	Crusher (TBF in hours)	Rank	Median Ranks	1/(1-Median Rank)	ln(ln(1/(1-Median Rank)))	ln(Crusher- hours)
2	320	1	0.067307692	1.072164948	-2.663843085	5.768320996
3	370	2	0.163461538	1.195402299	-1.723363111	5.913503005
4	380	3	0.259615385	1.350649351	-1.232023115	5.940171253
5	470	4	0.355769231	1.55227888	-0.821998815	6.152732909
6	510	5	0.451923077	1.824561404	-0.508595394	6.234410726
7	600	6	0.548076923	2.212121957	-0.236365445	6.396929655
8	630	7	0.644230769	2.810810811	0.032624362	6.445719819
9	700	8	0.740384615	3.851151852	0.299032932	6.551080335
10	780	9	0.836538462	6.117647059	0.593772717	6.65929392
11	810	10	0.932692308	14.85714286	0.992668929	6.697234248

Table 3 – Crusher

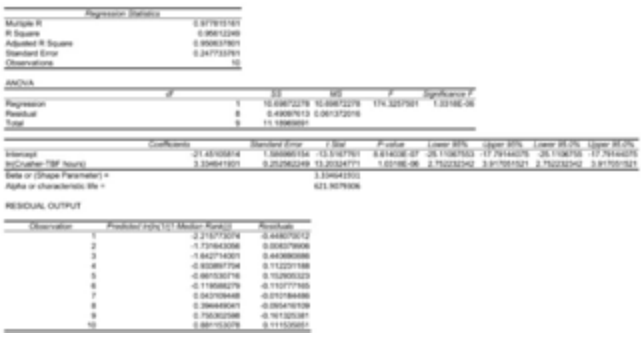


Table 4 – Parameters for Crusher

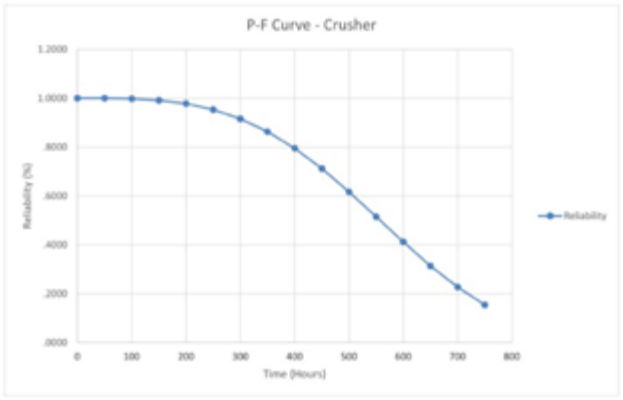
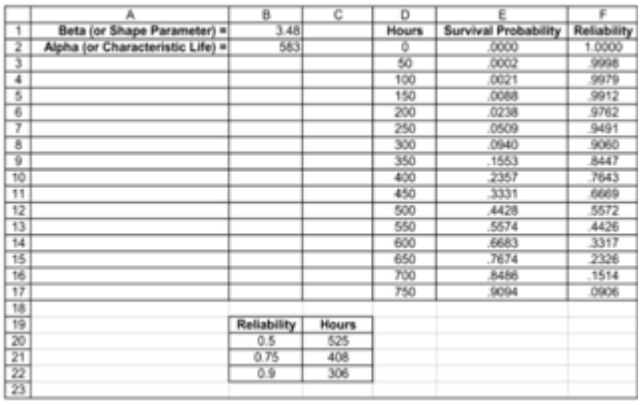


Figure 3 – P-F Curve for Crusher



	A	B	C	D	E	F
1	**Beta (or Shape Parameter) =**	3.48		**Hours**	**Survival Probability**	**Reliability**
2	**Alpha (or Characteristic Life) =**	583		0	.0000	1.0000
3				50	.0002	.9998
4				100	.0021	.9979
5				150	.0088	.9912
6				200	.0238	.9762
7				250	.0509	.9491
8				300	.0940	.9060
9				350	.1553	.8447
10				400	.2357	.7643
11				450	.3331	.6669
12				500	.4428	.5572
13				550	.5574	.4426
14				600	.6683	.3317
15				650	.7674	.2326
16				700	.8486	.1514
17				750	.9094	.0906
18						
19		**Reliability**	**Hours**			
20		0.5	525			
21		0.75	408			
22		0.9	306			
23						

Figure 2 – Weibull Plot for Crusher

	A	B	C	D	E	F
1	**Beta (or Shape Parameter) =**	2.81		**Hours**	**Survival Probability**	**Reliability**
2	**Alpha (or Characteristic Life) =**	787		0	.0000	1.0000
3				50	.0004	.9996
4				100	.0031	.9969
5				150	.0095	.9905
6				200	.0212	.9788
7				250	.0393	.9607
8				300	.0647	.9353
9				350	.0979	.9021
10				400	.1392	.8608
11				450	.1883	.8117
12				500	.2445	.7555
13				550	.3067	.6933
14				600	.3735	.6265
15				650	.4431	.5569
16				700	.5136	.4864
17				750	.5830	.4170
18				800	.6494	.3506
19				850	.7113	.2887
20				900	.7674	.2326
21						
22		**Reliability**	**Hours**			
23		0.5	690			
24		0.75	505			
25		0.9	353			

Table 6 – Apron Feeder

	A	B	C	D	E	F
1	**Beta (or Shape Parameter) =**	3.33		**Hours**	**Survival Probability**	**Reliability**
2	**Alpha (or Characteristic Life) =**	622		0	.0000	1.0000
3				50	.0002	.9998
4				100	.0023	.9977
5				150	.0087	.9913
6				200	.0225	.9775
7				250	.0468	.9532
8				300	.0842	.9158
9				350	.1368	.8632
10				400	.2051	.7949
11				450	.2882	.7118
12				500	.3831	.6169
13				550	.4851	.5149
14				600	.5882	.4118
15				650	.6861	.3139
16				700	.7732	.2268
17				750	.8455	.1545
18						
19		**Reliability**	**Hours**			
20		0.5	557			
21		0.75	428			
22		0.9	317			
23						

Table 5 – Analysis for Crusher

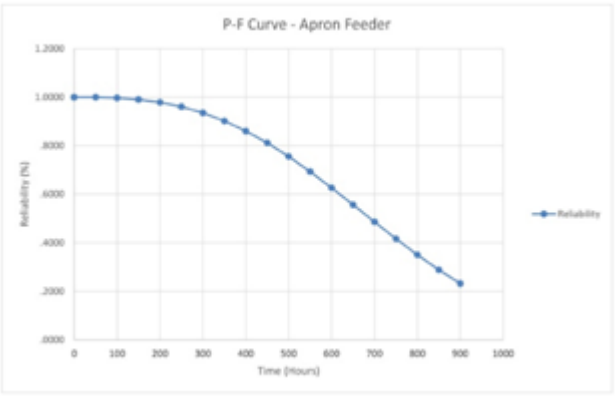


Figure 4 – P-F Curve for Apron Feeder

	A	B	C	D	E	F
1	**Beta (or Shape Parameter) =**	3.48		**Hours**	**Survival Probability**	**Reliability**
2	**Alpha (or Characteristic Life) =**	583		0	.0000	1.0000
3				50	.0002	.9998
4				100	.0021	.9979
5				150	.0088	.9912
6				200	.0238	.9762
7				250	.0509	.9491
8				300	.0940	.9060
9				350	.1553	.8447
10				400	.2357	.7643
11				450	.3331	.6669
12				500	.4428	.5572
13				550	.5574	.4426
14				600	.6683	.3317
15				650	.7674	.2326
16				700	.8486	.1514
17				750	.9094	.0906
18						
19		**Reliability**	**Hours**			
20		0.5	525			
21		0.75	408			
22		0.9	306			
23						

Table 7 – Rock breaker

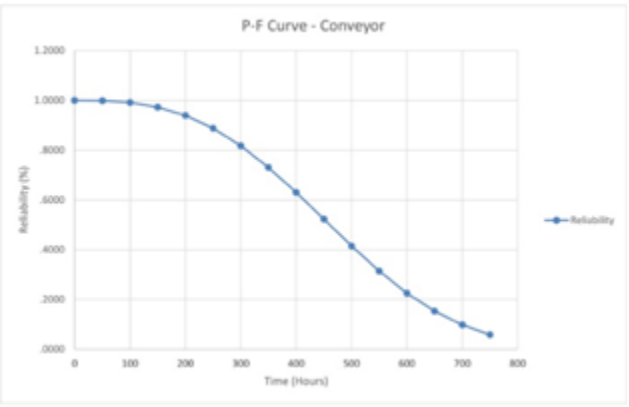


Figure 6– P-F Curve for Conveyor

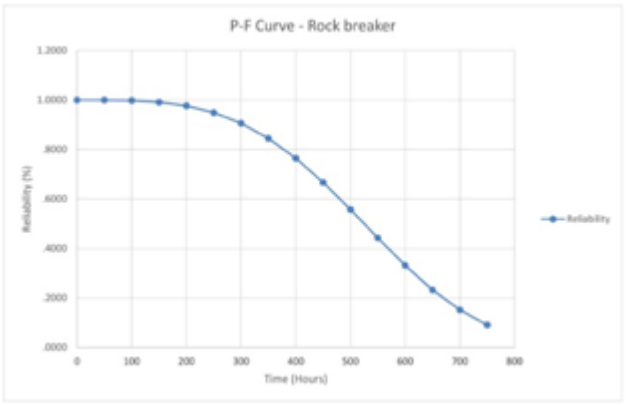


Figure 5 – P-F Curve for Rock Breaker

	A	B	C	D	E	F
1	**Beta (or Shape Parameter) =**	3.59		**Hours**	**Survival Probability**	**Reliability**
2	**Alpha (or Characteristic Life) =**	619		0	.0000	1.0000
3				50	.0001	.9999
4				100	.0014	.9986
5				150	.0062	.9938
6				200	.0172	.9828
7				250	.0379	.9621
8				300	.0716	.9284
9				350	.1211	.8789
10				400	.1881	.8119
11				450	.2724	.7276
12				500	.3713	.6287
13				550	.4797	.5203
14				600	.5904	.4096
15				650	.6956	.3044
16				700	.7881	.2119
17				750	.8630	.1370
18						
19		**Reliability**	**Hours**			
20		0.5	559			
21		0.75	438			
22		0.9	331			
23						

Table 9 – Sag Mill

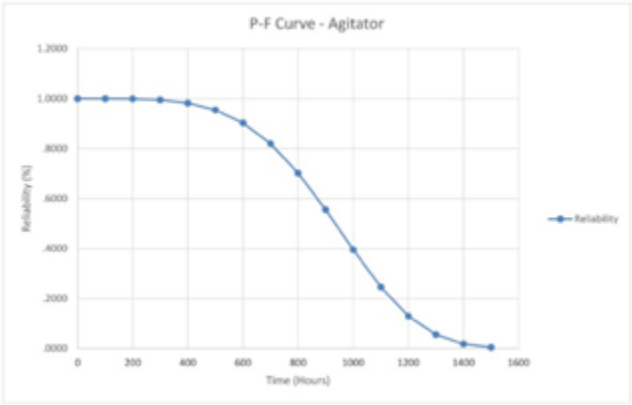


Table 8 – Conveyor

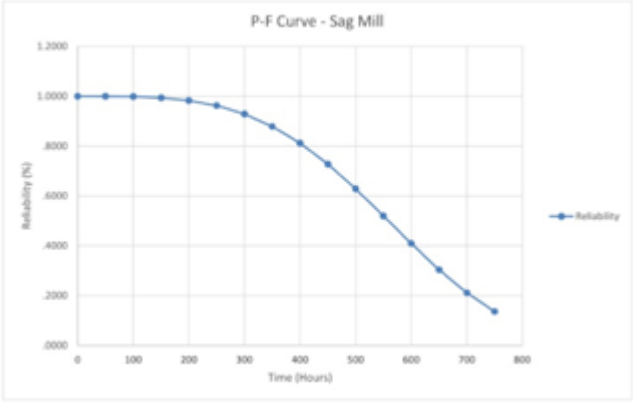


Figure 7 – P-F Curve for Sag Mill

	A	B	C	D	E	F
1	**Beta (or Shape Parameter) =**	4.33		**Hours**	**Survival Probability**	**Reliability**
2	**Alpha (or Characteristic Life) =**	1,018		0	.0000	1.0000
3				100	.0000	1.0000
4				200	.0009	.9991
5				300	.0051	.9949
6				400	.0175	.9825
7				500	.0452	.9548
8				600	.0967	.9033
9				700	.1798	.8202
10				800	.2975	.7025
11				900	.4444	.5556
12				1,000	.6042	.3958
13				1100	.7534	.2466
14				1,200	.8699	.1301
15				1,300	.9441	.0559
16				1400	.9812	.0188
17				1500	.9953	.0047
18						

Reliability	Hours
0.5	935
0.75	763
0.9	605

Table 10 – Agitator

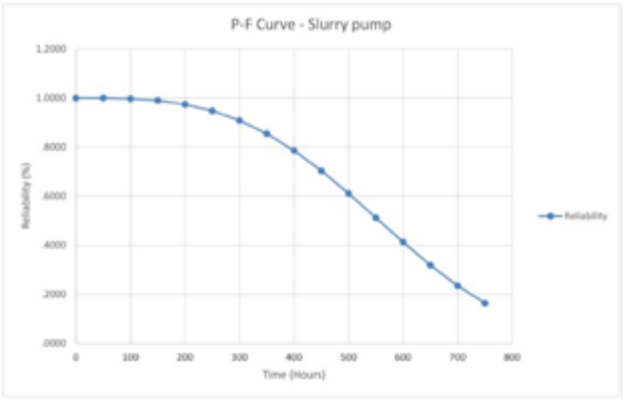


Figure 9 – P-F Curve for Slurry Pump

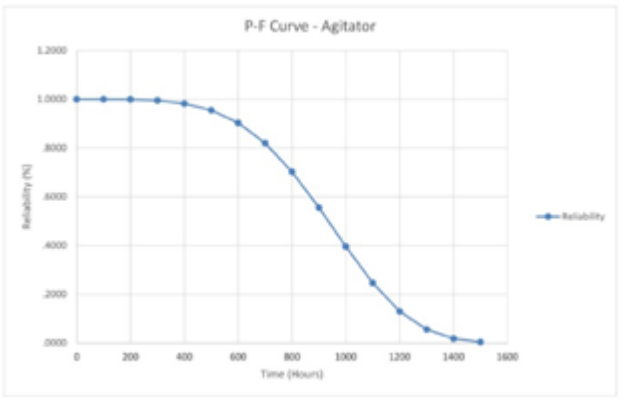


Figure 8 – P-F Curve for Agitator

	A	B	C	D	E	F
1	**Beta (or Shape Parameter) =**	3.43		**Hours**	**Survival Probability**	**Reliability**
2	**Alpha (or Characteristic Life) =**	776		0	.0000	1.0000
3				50	.0001	.9999
4				100	.0009	.9991
5				150	.0035	.9965
6				200	.0095	.9905
7				250	.0203	.9797
8				300	.0376	.9624
9				350	.0630	.9370
10				400	.0978	.9022
11				450	.1429	.8571
12				500	.1985	.8015
13				550	.2643	.7357
14				600	.3389	.6611
15				650	.4200	.5800
16				700	.5047	.4953
17				750	.5895	.4105
18				800	.6708	.3292
19				850	.7454	.2546
20				900	.8108	.1892
21						

Reliability	Hours
0.5	697
0.75	540
0.9	403

Table 12 – Water Pump

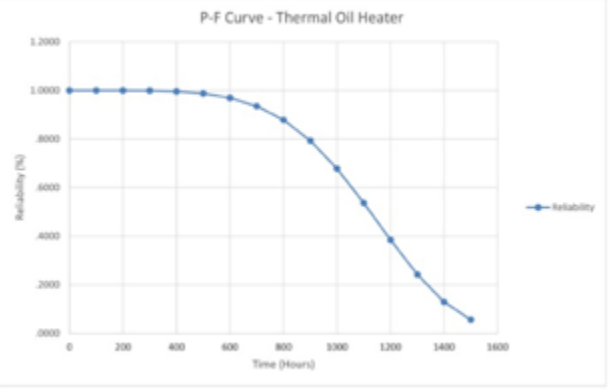


Table 11 – Slurry Pump

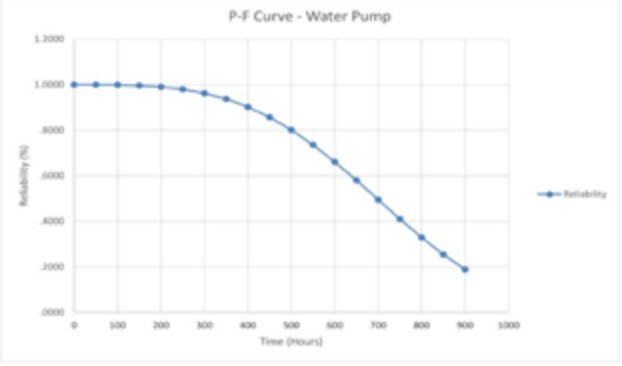


Figure 10 – P-F Curve for Water Pump

	A	B	C	D	E	F
1	Beta (or Shape Parameter) =	4.93		Hours	Survival Probability	Reliability
2	Alpha (or Characteristic Life) =	1,211		0	.0000	1.0000
3				100	.0000	1.0000
4				200	.0001	.9999
5				300	.0010	.9990
6				400	.0042	.9958
7				500	.0126	.9874
8				600	.0308	.9692
9				700	.0647	.9353
10				800	.1212	.8788
11				900	.2063	.7937
12				1,000	.3219	.6781
13				1100	.4630	.5370
14				1,200	.6153	.3847
15				1300	.7578	.2422
16				1400	.8705	.1295
17				1500	.9434	.0566
18						
19		Reliability	Hours			
20		0.5	1,124			
21		0.75	941			
22		0.9	768			
23						

Table 13 – Thermal Oil Heater

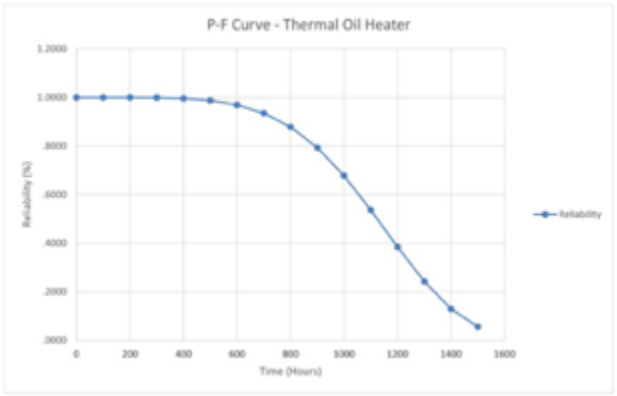


Figure 11 – P-F Curve for Thermal Oil Heater

	A	B	C	D	E	F
1	Beta (or Shape Parameter) =	3.56		Hours	Survival Probability	Reliability
2	Alpha (or Characteristic Life) =	1,239		0	.0000	1.0000
3				100	.0001	.9999
4				200	.0015	.9985
5				300	.0064	.9936
6				400	.0178	.9822
7				500	.0389	.9611
8				600	.0730	.9270
9				700	.1229	.8771
10				800	.1901	.8099
11				900	.2743	.7257
12				1,000	.3727	.6273
13				1100	.4802	.5198
14				1,200	.5900	.4100
15				1300	.6944	.3056
16				1400	.7862	.2138
17				1500	.8608	.1392
18						
19		Reliability	Hours			
20		0.5	1,118			
21		0.75	873			
22		0.9	658			
23						

Table 14 – Calculated Reliability for Gravity Concentrator

	A	B	C	D	E	F
1	Beta (or Shape Parameter) =	3.43		Hours	Survival Probability	Reliability
2	Alpha (or Characteristic Life) =	776		0	.0000	1.0000
3				50	.0001	.9999
4				100	.0009	.9991
5				150	.0035	.9965
6				200	.0095	.9905
7				250	.0203	.9797
8				300	.0376	.9624
9				350	.0630	.9370
10				400	.0978	.9022
11				450	.1429	.8571
12				500	.1985	.8015
13				550	.2643	.7357
14				600	.3389	.6611
15				650	.4200	.5800
16				700	.5047	.4953
17				750	.5895	.4105
18				800	.6708	.3292
19				850	.7454	.2546
20				900	.8108	.1892
21						
22		Reliability	Hours			
23		0.5	697			
24		0.75	540			
25		0.9	403			
26						

Figure 12 – P-F Curve for Gravity Concentrator

	A	B	C	D	E	F
1	Beta (or Shape Parameter) =	3.43		Hours	Survival Probability	Reliability
2	Alpha (or Characteristic Life) =	888		0	.0000	1.0000
3				50	.0001	.9999
4				100	.0006	.9994
5				150	.0023	.9977
6				200	.0060	.9940
7				250	.0129	.9871
8				300	.0240	.9760
9				350	.0404	.9596
10				400	.0631	.9369
11				450	.0929	.9071
12				500	.1306	.8694
13				550	.1763	.8237
14				600	.2300	.7700
15				650	.2910	.7090
16				700	.3581	.6419
17				750	.4296	.5704
18				800	.5036	.4964
19				850	.5778	.4222
20				900	.6496	.3504
21						
22		Reliability	Hours			
23		0.5	798			
24		0.75	617			
25		0.9	460			
26						

Table 15 – Carbon Regeneration Kiln

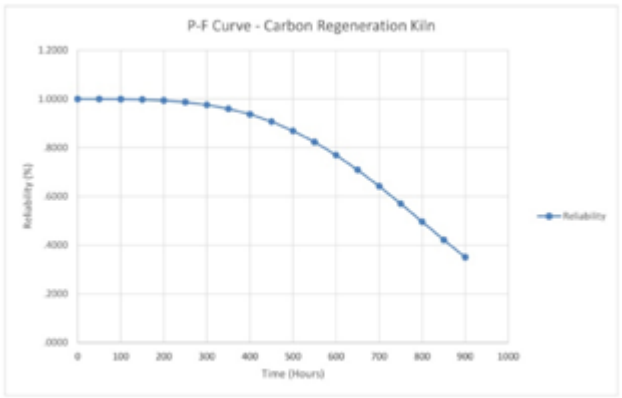


Figure 13 –P-F Curve for Carbon Regeneration Kiln

From the Analysis, we can see that in some cases the beta value is quite higher. Values of beta greater than 1 indicate that the failure rate is increasing with time and are associated with failures related to mechanical wear out modes. A high value of the shape parameter (beta), as long as the corresponding value of the scale parameter (eta) is high, can provide acceptable overall reliability [7]. Less variability means that failures occur in a more "controlled" manner. For example, it would be ideal for a preventive maintenance program to have a component that fails at 1,000 hours of operation. The optimum replacement time would be just before the expected failure, at 999.9 hours. Eleven major equipment with issues were selected for analysis. All these equipment are functionally arranged in a series configuration, which means that the plant is in a working condition only when all the equipment are working. The reliability of the crushing plant (Rs), as a whole, can be calculated by Eq. (1) where Ri is the reliability of the different equipment [8]:

$$R_s = \prod R_i \qquad (1)$$

The reliabilities for all eleven are analysed using excel as shown in Table 5 to 15. Then the reliability of the plant is tabulated in Table 16. It is seen that there is only a 0.67 probability that the plant will not fail for 250 hours of operation.

Fig. 14 shows that the conveyer has 81% reliability where all the other equipment's has over 90% reliability at 300 hours of operation. From Table 16 and Fig.14 we can see that the conveyor, Slurry pump, and Sag mill are most critical among other equipment's. To improve reliability of the overall system effort should first be concentrated on improving the reliability of conveyor, Slurry pump, and Sag mill.

Table 17 is the summary of analysis for all equipment. The number of days for 90% reliability is compared with existing maintenance interval.

The new preventive maintenance interval for 90% reliability level was used for optimization.

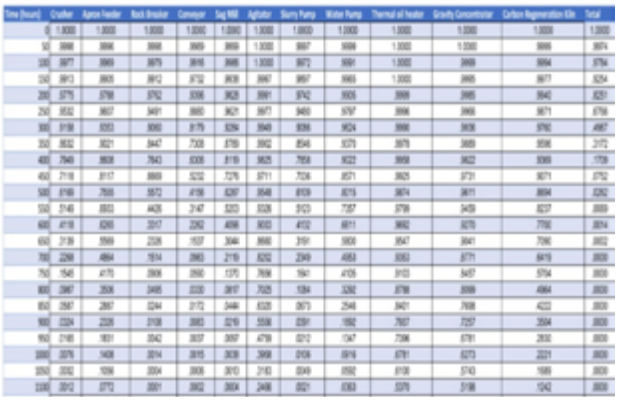


Table 16 – Analysis for the plant

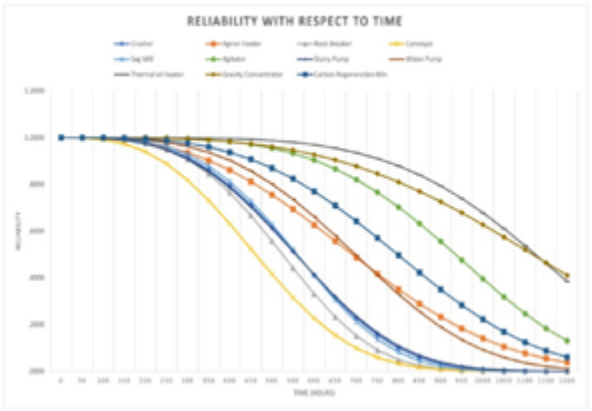


Figure 14 – Reliability importance plot for the selected critical equipment's

Nos.	Equipment name	Time for 90% reliability (hours)	Existing Preventive Maintenance Interval (weeks)	Proposed Preventive Maintenance Interval (weeks)
1	Crusher	317	4	2
2	Apron Feeder	353	5	2
3	Rock breaker	306	3	2
4	Conveyor	240	3	2
5	Sag Mill	331	4	2
6	Agitator	605	6	4
7	Slurry pump	309	4	2
8	Water pump	403	5	3
9	Thermal Oil Heater	768	7	5

Table 17 – Optimal Maintenance Interval

IV CONCLUSION

The main objective of this project was to eliminate/ significantly reduce equipment downtime, production loss and ongoing high operating cost due to the failure of some critical equipment. The result obtained from the analysis is compared with the current preventive maintenance interval. The maintenance interval is optimized for a target reliability of 90%. From the reliability analysis of the plant, it is observed that Conveyor, Sag Mill, Slurry pump are the most critical equipment. There is opportunity for improvement of this analysis combining with root cause analysis of failures. After review of benefits obtained in terms of cost, safety and operational effectiveness of the equipment maintenance intervals might be further adjusted for achieving target reliability or further enhance reliability of the plant.

V ACKNOWLEDGMENT

The author would like to greatly thank the asset management team of Duketon Gold Processing Plant for their support and help to provide necessary information.

VI REFERENCES

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Value Stream Mapping in Total Productive Maintenance of a Meat Processing Plant in Australia

V. Chundhoo, G. Chattopadhyay, G. Karmakar and G. Kahandawa
School of Engineering and Information Technology, Federation University, Churchill, Australia (v.chundhoo@federation.edu.au, g.chattopadhyay@federation.edu.au)

ABSTRACT

T – Total Productive Maintenance (TPM) is seen as a solution in reduction of losses due to breakdowns, setup and adjustment, small stops, slow running, start-up defects and production defects. It is implemented in a major meat processing facility in Melbourne, Australia in key areas of the business. This includes raw meat processing, cooking, thermoforming and packaging with the aim of reducing wastes and further enhancing productivity and quality. Overall Equipment Effectiveness (OEE) is evaluated for analysing how effectively manufacturing assets are utilized and is expressed in terms of Performance, Availability and Quality.

OEE is used as Key Performance Indicators (KPI) and is measured in terms of whether plant is operated as per expected speed, reduced speed or with minor stops. Production data recorded by line operators has been compiled and analysed with asset availability being influenced by breakdowns and product changeover. Quality is determined in terms of acceptance and rejects in start-up, during production runs and customer returns. Value Stream Mapping is used for this TPM program. Findings from this study have been passed on to the meat processing facility for implementation in the entire plant.

Keywords — Total Productive Maintenance (TPM); Value Stream Mapping; Loss Reduction; Key Performance Indicator; Asset Management.

I. INTRODUCTION

The main food Industry in Australia has a range of other sub industries within its umbrella and the largest of them is the meat processing with $ 11, 725, 415 000 export value in 2016-2017 [1]. It is very important that the meat industry moves on the same track with the agricultural megatrends. Agricultural megatrend simply means that the meat industry needs to be leaner and produce less wastage in order to be keep up with population growth and demand [2]. Total Productive Maintenance (TPM) is seen as a solution in reduction of losses due to breakdowns, setup and adjustment, small stops, slow running, start-up defects and production defects. TPM is also known as an advanced manufacturing technique that focuses on maximizing the overall equipment effectiveness of any asset utilized in the production of goods and services [3]. TPM techniques have been used by various organizations to increase business performance [4]. Significant research has been conducted for various sectors and used for improving equipment effectiveness, eliminating breakdowns, reducing costs and promoting autonomous maintenance [5]. Maintenance performance and its measure is an important part of reducing losses and productivity improvement [6]. Reliability improvement has been used in various organizations including design and configuration changes and maintenance intervals. TPM also focuses on proactive and preventive techniques for improving equipment reliability.

Areas considered are:

- Focused Improvement
- Autonomous maintenance
- Planned Maintenance

- Quality maintenance
- Cost Deployment
- Early Equipment Management
- Training and Education
- Safety Health Environment

In 1950, Seiji Nakajima father of TPM first started it by studying American preventive maintenance (PM). TPM is, in fact, American – style productive maintenance, enhanced to fit the Japanese industrial environment and it is productive maintenance carried out by all the employees through small group activities [7]. TPM emerged during 1970s. At first, Nippondenso, a Japanese automotive component manufacturer used first time Total 'Productive Maintenance with Total Employee Participation' for improvement in manufacturing performance. TPM was then spread to Toyota, Mazda, Nissan and their associated vendors [8]. There was limited success regarding the earliest Japanese TPM implementations and only a small number of companies adopted it [9]. In the early 1970's, adoption of TPM began to accelerate to improve manufacturing effectiveness, soon after Japan faced a decline in economy [10]. Adoption of TPM was started in prestigious companies such as Dupont, Exxon, Kodak, Alcoa, AT&T, Ford, Heweltt-Packard and Proctor & Gramble [11]. Today TPM has a global reach and has the following structure as per Fig 1:

The author would like to greatly thank the asset management team of Duketon Gold Processing Plant for their support and help to provide necessary information.

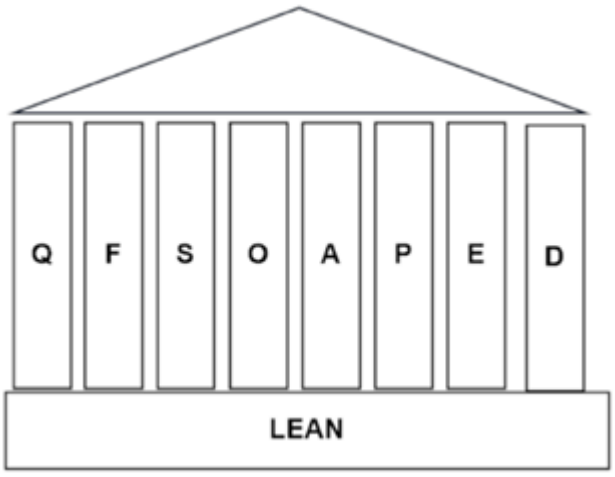


Figure 1 – TPM structure

Q- Quality Maintenance
F – Focused Maintenance
S – Safety Health and Environment
O – Office TPM
A – Autonomous Maintenance
P – Planned Maintenance
E – Education and Training
D – Development Management
LEAN – Lean Techniques, 5S, Kaizen, SMED, JIT and VSM

With TPM, key performance indicators are used to monitor improvements and overall equipment effectiveness (OEE) is the most common form of KPI. OEE evaluates how effectively a manufacturing operation is utilized and is expressed in terms of Performance, Availability and Quality. Performance is measured in terms of whether plant is operated as per expected speed, reduced speed or with minor stops. Availability is influenced by breakdowns and product changeover Quality is determined in terms of acceptance and rejects in start-up, during production runs and customer returns [12]. OEE can be considered as an indicator of the health and performance on assets being monitored for productivity. Six big losses can be monitored and measured through OEE.

The six big losses are:

- Breakdowns
- Setup and Adjustment
- Small stops
- Slow running
- Start-up Defects
- Production Defects

Effectiveness (OEE) can be expressed as a function of availability (ã), utilization (U) and quality (Q).

$$= \tilde{a} \times U \times Q \quad [1]$$

In addition, there is a strong evidence of positive correlation between TPM pillar and key performance indicator Overall Equipment Effective (OEE) [13]. Lean principles are at the base of the TPM structure and without being lean, implementation of TPM is impossible. Lean is a terminology that is well known and defined as elimination of waste in operations through managerial principles. Lean can also be considered as effective use of time and resources to yield zero defect or optimum process output.

METHODOLOGY

A TPM system is also a team-based approach that will help both maintenance and production operation [14]. It is implemented in a major meat processing facility in Melbourne, Australia in key areas of the business with the aim of optimizing production processes.

Lean techniques applied in this study are:

- Value Stream Mapping
- Kaizen Events
- Single Minute Exchange of Dies
- Just in Time
- 5s

Value stream mapping (VSM) has been used to reduce the manufacturing lead-time, improve information flow and production quality [15]. VSM has under its umbrella all materials and information as well as their flow through the production system [16]. In this study value maps were kept simple and straightforward to favourite management acceptance.

Kaizen (continuous improvement) is a team-based approach. Kaizen events are structured projects in which dedicated teams apply lean manufacturing techniques with a focus on continuous improvement [17]. At the manufacturing facility it consisted of production supervisors, engineering and production planners with the main aim of identifying bottlenecks and improving processes. Kaizen events can be achieved by applying manufacturing tools such as process analysis, time observation, waste identification, workstation documents and Yamakuni charts (17). In this study time observation using Go See events were helpful in completing Kaizen.

Single-Minute Exchange of Dies (SMED) is a Lean Manufacturing technique used to achieve waste reduction [18] through a four stages improvement process [19]. SMED was used to reduce change over time and the 4 steps are listed hereunder:

- Analyze Internal and External Setups in Preliminary Stage.
- Separate Internal and External Setup
- Convert Internal Setup to External Setup
- Streamline both Internal and External setup

Just in time, a technique used to improve operational performances, was developed by Toyota. [20]. It is the philosophy of producing or procuring the right items at the right time and in the right amounts. Just in time is the goal and Kanban system is the tool. The just-in-time concept is growing with several manufacturers adopting a supermarket concept [21]. Kanban board helps monitor inventory levels and ensures you have what you need when you need. Kanban boards were implemented in the warehouse.

5s processes are commonly used for kaizen events. Considered as the foundation of TPM, 5S principles were applied by finding a place for everything and putting every- thing being in its place. Elimination of waste using the 5s principles is possible [22]. According to [23] TPM starts with 5s which in this Study 5s was used for the different workstations. Details of 5s principles is given in Table 2.

5S	Definition
Sort	Removing from workstation unnecessary items not required for production
Straighten	Organize and label items for easy retrieval when required
Shine	Clean and inspect. Ensure items required and workstations are clean and clear
Standardize	Create standards to minimize variability.
Sustain	Make it common practice.

Table 2 – The 5s methodology

III. METHODOLOGY

TPM has already been rolled out to key areas of the business such as Slicing and Packing area of the plant. Fig 3 is a summary of the overall production processes.

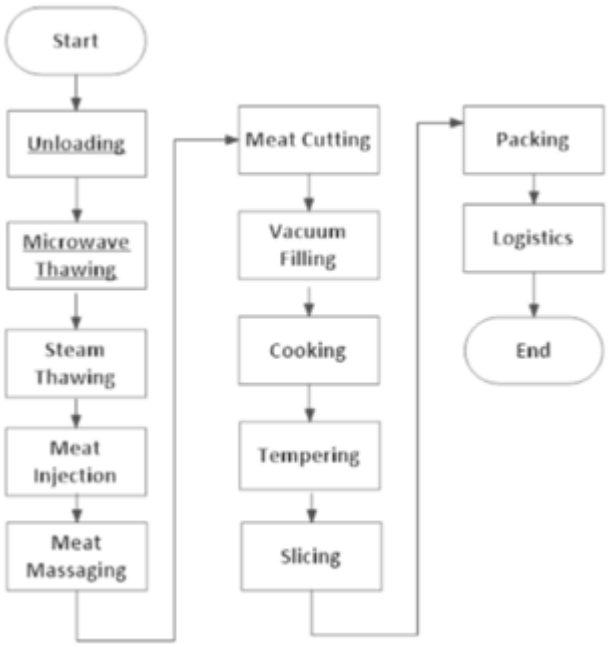


Figure 3 – Process flow at the Manufacturing Plant

The aim was to create a maximum positive effect by applying TPM in key areas. This positive effect has been used as a TPM marketing strategy to secure continued management support. TPM is now being rolled out throughout the plant. In this study, focus has been laid on the thawing, injection and tumbling (massaging) processes. Lean techniques considered the foundation of the TPM program have been applied. Data collected on site were analyzed and current value maps drafted and finalized with management for Decartoning, thawing, injection and massaging processes. Lean techniques were applied, and future value maps were completed indicating productivity improvement. The optimization process were over 6 months. In addition, Single-Minute Exchange of Dies (SMED) previously applied in this plant within the thermoforming area of the business has now been used for machine changeovers within the meat tumbling machineries setups in the raw area. Value stream maps reported in the next section with VSM legend in Table 4.

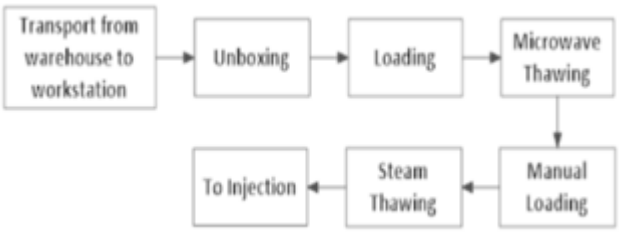
Object	
	Kaizen Burst. A team activity aiming at urgent improvement.
	Go See. Confirming an event visually
Demand	Units per day that must be produced
Takt Time	Takt time (a measure of production performance) Takt time= (Effective work time per shift / Customer Requirement per shift) higher Takt time means lower productivity
Process Cycle Efficiency (PCE)	PCE = (Value Added time+Non Value Added Time)/ (Value Added time) [2]

Table 4 – VSM legends

IV. FINDINGS

Unloading/Thawing current and future value maps are given in figure 6 and 8. The current value map is based on processes represented in fig 5. Frozen meat boxes are transported to the production facility. Manually unboxed at the Decartoning station and loading to the thawing rooms consist on an initial stage of microwave thawing and a final stage of steam thawing.

Figure 3 – Unloading and thawing internal processes



Bottlenecks identified Current State (Fig8) are:

- a five minutes waiting time for meat to be delivered from the warehouse for loading.
- manual unboxing

Current state has Takt time 6.27 mins and Process Cycle efficiency of 98.4 % as calculated below (with demand set as 70 pallets processed for the day).

$$\text{Takt time} = \left(\frac{\text{Effective work time per shift)}}{\text{Customer Requirement per shift)}}\right)$$
$$= \left(\frac{439}{70)}\right) = 6.27 mins (current\ state)$$

$$PCE = \frac{Value\ Added\ time}{Value\ Added\ time + Non\ value\ added\ time}$$
$$= \frac{439}{439 + 6.75}$$
$$= 98.4\ \%\ (current\ state)$$

Future Value State Map. Unboxing/Thawing

Significant reduction of bottlenecks would increase productivity. Just in Time approach is used to deliver unboxed pallets straight from the warehouse in a sealed meat tub and with liners already taken out. To achieve Just in time Kanban boards (Table 7) were implemented to ensure unboxed meat is always available when needed from the warehouse. Kaizen burst at the manual loading process brought the time to 2.5 mins from 5 mins as indicted in current (fig 6) and future value maps (fig 8). This resulted in decrease in takt time and increase in Process Cycle efficiency compared with the Current state map values.

$$\text{Takt time} = \left(\frac{432}{70)}\right) = 6.17 mins\ (future\ state)$$

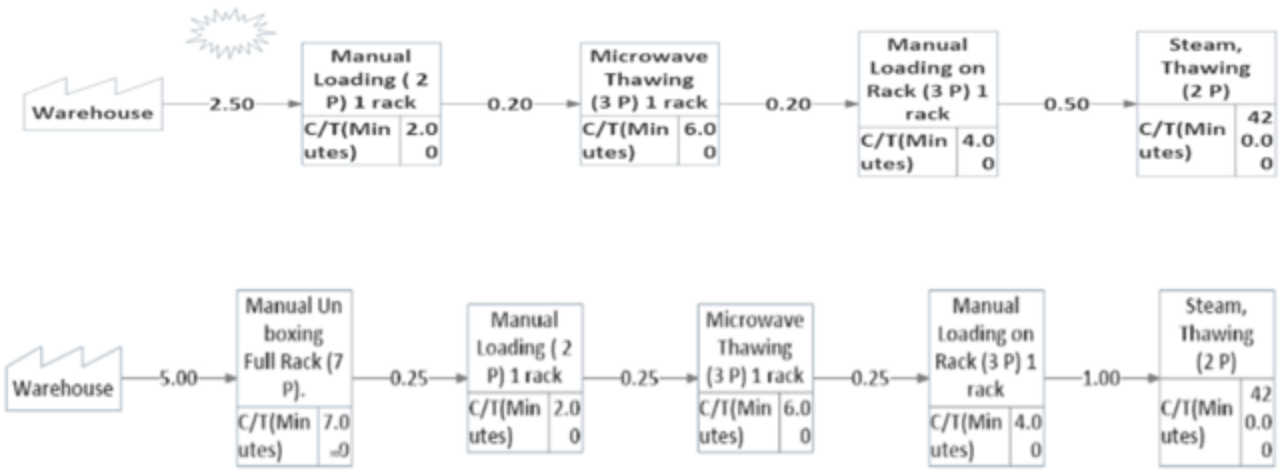


Figure 6 and 8 – Current and Future state map. Unboxing /Thawing

$$\text{Takt time} = \left(\frac{221}{70)}\right) = 3.16 mins (current\ state)$$

Backlog	Ongoing	To do	Done
Sort of broken wooden pallets	Service on Forklift	Order 6 pallets of product A by 11/09/19	Forklift Hire
2	a	Organize leaks to be fixed	Ordered 6 pallets of product B
3	b		

Table 7. Kanban board extract.

Table 9 summarizes the current and future state leading indicators values before and after productivity improvement.

Leading Indicators	Current State Map	Future State Map
Non-value-added time	6.75 mins	3.40 mins
Value a dded Time	439 mins	432 mins
Process Cycle Efficiency	98.5 %	99.22 %
Takt Time	6.27 mins	6.17 mins

Table 9 – Leading indicators summary for Decartoning/thawing process optimization.

CURRENT STATE VALUE MAPS THAWING/INJECTION

Figure 10 – Injection/Massaging Internal processes

Meat droppping – Taking thawed meat from racks coming from steam room and manually dropping into industrial tubs for weighing. Meat Pickle – Special brine solution is prepared for injection process. Once injection is completed, meat is transferred to the meat tumbler for massaging.

Injection/Thawing Calculations (with demand set as 70 pallets processed for the day):

Bottlenecks identified during current state mapping are:

- Change over time on the massager delivered from the warehouse for loading.
- Meat weighing is considered as a simple process. Yet it takes 3 mins to complete.
- Massagers performance level dropped with reactive work > 20 %.

$$\text{Takt time} = \left(\frac{221}{70}\right) = 3.16 mins (current\ state)$$

$$PCE = \frac{222}{222 + 19} = 92.1\ \% (cuture\ state)$$

FUTURE STATE VALUE MAPS THAWING/INJECTION

Before any further optimization, performance level of massager was restored through two Original Equipment Manufacturers services completed within 6 months.

The 5s principle was also applied at the meat weighing workstation with daily Audits completed. At the end of 6 month, the average time for meat weighing dropped to 1.5minutes. Single minute exchange of die method implemented at the massager reduced the overall changeover time to 12 mins.

$$\text{Takt time} = \left(\frac{211.5}{70}\right) = 3.02 mins (furrent\ state)$$

$$PCE = \frac{211.5}{211.5 + 14.4} = 93.8\ \% (future\ state)$$

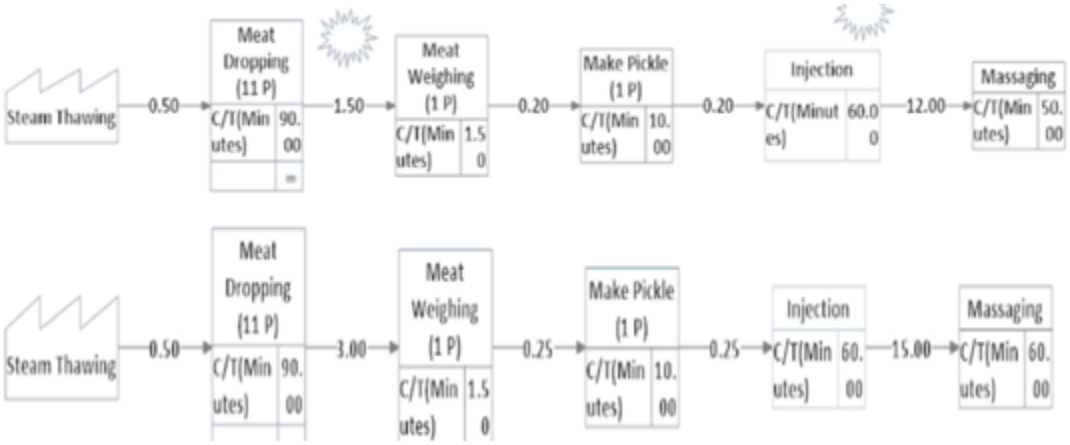


Figure 11 and 12 – Current and Future state map. Injection / Massaging

Leading Indicators	Current State Map	Future State Map
Non-value-added time	19.0 mins	14.4 mins
Value added Time	221.5 mins	211.5 mins
Process Cycle Efficiency	92.1 %	93.6 %
Takt Time	3.16 mins	3.02 mins

Table 13 – Leading indicators summary for injection/ massaging process optimization.

Table 13 – summarizes the current and future state leading indicators values before and after productivity improvement.

V. CONCLUSION

The findings in this study is in line with the TPM structure given in Fig 1 with TPM positively related to lean productions [24]. Processes covering unboxing, thawing, massaging and injection were selected. These processes have been optimized through Value Stream Mapping with the application of Kaizen, SMED, JIT and 5s. JIT and TPM has strategic practices that are shared among each other [25]. In this study, Kanban systems was used to ensure raw meat was delivered when needed and on time during the Decartoning process. For simplicity and for managerial acceptance the current and future value maps were kept simple and straightforward.

However, more resources are required to improve the value maps with the possible inclusion of first-time pass, uptime, defects, distances, timelines and any other hidden inefficient flow within the raw meat processes. Current value maps can serve as a leading indicator for productivity improvement. Productivity improvement could then be quantified as proven in this study with application lean techniques proposed above, go see events and appropriate data collection. Organizational culture play an important role when implementing TPM [26]. To support the TPM system more functional teams should be deployed to promote the lean approach proposed. To achieve this deployment appropriate transformation is required in this meat manufacturing organizational culture and practices. Research studies on TPM topic reveals several barriers such as behavioral barriers, technical barriers, human and cultural barriers, strategic barriers and operational barriers [27]. The TPM promoters at the facility need to be aware of these barriers and plan for the future of the TPM program. (3) The future of TPM relies on three basic areas.

- Management Acceptance
- Technology
- Management Techniques

Wireman stipulates that maintenance is hard to sell and managers in todays' world need to face the question of whether to adapt to change to be competitive or face extinction.

VI. ACKNOWLEDGEMENT

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Correlating qualitative and quantitative impact indicators to prioritize integrated urban and peri-urban water management

C. E. Torrecillas Nuñez, T. Miguel, A. Singh, A. C. Ravelo, A. M. Planchuelo

ABSTRACT

It is becoming accepted that Integrated Water Management (IWM) planning and Low Impact Design (LID) ameliorate the adverse impacts due to unplanned urbanization and land use changes. The challenge for water management implementation lies in the source of reliable information to allow step by step prioritization and to obtain the best management options and results. Governmental institutions and other organizations quite often do not have the ability to collect water quality and quantity data and need to have the help of research institutions in combining efforts to resolve the problems. To bridge this gap, a methodology was designed for the Twin Streams basin in Auckland, New Zealand as a case study which can be applied to any watershed and be validated by analyzing abiotic and biotic ecological factors affecting river or small stream in an urban and peri-urban zone.

The environmental studies included analysis of quantitative indicators such as: water quality, sediment quality and environmental physical factors. These indicators were analyzed using Pearson´s correlation coefficient, Principal Components Analysis (PCA) and Hierarchical Cluster Analysis (HCA)

Qualitative indicators developed from field observations were evaluated using Ward's theory and Multi-criteria Analysis (MCA).

PCA and HCA enabled the identification of the most important contaminants and the location of their impacts. Coupled with a MCA of qualitative indicators, a framework was developed for prioritizing IWM and determining LID design objectives. The methods used allowed the identification of contamination sources and prioritizing impacts, which in this case were flooding, erosion, sediment, metals, hydrocarbons and bacteriological pollution.

Keywords— Water pollution, Hierarchical Cluster Analysis, Principal Component Analysis, Integrated Water Management Planning

I. INTRODUCTION

ATER management in 21st century cities has become increasingly challenging. The need to cater for population growth in the context of climate change projections, resource constraints, environmental degradation and evolving community expectations requires cities to look toliveability and resilience [1]. Addressing these issues requires Integrated Watershed Management Planning (IWMP) and implementation of Low Impact design (LID), all of which depend on reliable information on the environmental impacts that need to be managed.

Worldwide research has established that that the main sources of river pollution are sewage and urban wastes produced by industrial and agricultural activities [2], [3]. Reference 4 established that suspended sediments reduce water clarity, light levels, food quality, and the feeding efficiency of animals.

C. E. Torrecillas Nuñez is with the Universidad Autónoma de Sinaloa, Mexico (corresponding author phone: +5216672283175; e-mail: cruztn@ hotmail.com).

T. Miguel is with ANA Group, Auckland, New Zealand (e-mail: tony.miguel@anagroup.co.nz).

A. Singh is with ANA Group, Auckland, New Zealand (e-mail: amar.singh@anagroup.co.nz).

A. C. Ravelo is with CREAN, Cordoba, Argentina (e-mail: ravelo43@gmail.com).

A. M. Planchuelo is with CREAN, Cordoba, Argentina (e-mail: aplanch@gmail.com).

Urbanization typically involves clearing a catchment of vegetation, compacting soil, and ditching, draining, piping, and ultimately covering the land with impermeable surfaces [5]. These changes profoundly affect the hydrology of streams [6]. This study focuses on the Twin Streams watershed in Auckland (New Zealand), where regional studies have been found very high concentrations of Zn, Cu and Pb in streambed sediments, suspended sediments and biofilms, at concentrations that are almost certainly toxic to aquatic animals that ingest this material while feeding [7]. The primary sources of zinc are building roofs, vehicle tire wear and atmospheric deposition [8]. Primary sources of copper are atmospheric deposition, building materials and vehicle brake pads.

This watershed generates a significant proportion of the contaminant load to the mid-Waitemata Harbour, which is a major feature of Auckland, the most populated region in the country [9].

II. MATERIALS ANDMETHODS

A. Description of the Study Area

The watershed is located in the west of Auckland; its area is 103.57 km² and consists of two Hydrologic Systems: Henderson Creek (System I) with an area of 63.69 km² and Huruhuru Creek (System II) with an area of 39.88 km². The watershed has a semi temperate climate with the wettest months in winter; spring and autumn have moderate rainfall and precipitation is lower in the summer.

The two systems were divided into three sub-systems corresponding to the upper, middle and lower watersheds. The headwaters in the upper watershed in both systems comprise largely regenerating native vegetation. Average annual precipitation is 2,000 mm in the upper watershed, 1,500 mm in the middle watershed, and 1,200 mm in the lower watershed. The impervious area of System I is 10.89 km² (26% of this watershed), equivalent to 55% of the entire watershed's impervious cover. Based on the 2013 Census [10], the population was 62,703 inhabitants, projected to increase to 107,315 inhabitants by 2051. The impervious area of System II is 20.4 km² (31.98% of this watershed), equivalent to 45% of the entire watershed's impervious cover. System II had a population of 56,175 inhabitants in 2013, which is projected to increase 104,399 inhabitants by 2051. Land use is mainly rural, residential and open spaces for both systems.

B.Quantitative indicators and evaluation methods

Qualitative data was derived from 19 monitoring points that had been established by the local municipality to monitor environmental and water quality indicators; 15 points were in the sub-watersheds for System I and four sites were located in System II. The water quality quantitative indicators analyzed were as follows: conductivity (EC), dissolved oxygen (DO), pH, temperature (TE), Total Suspended Solids (TSS), turbidity, Escherichia coli (E. coli), ammonium (NH4-N), total nitrogen (TOxN), dissolved phosphorus (DRP), dissolved copper in water (Cu), dissolved zinc in water (Zn). The indicators of sediment quality were: lead (Pb1), copper in sediments (Cu1) and zinc in sediments (Zn1). Physical indicators of environmental effects were Macroinvertebrates Community Index (MCI) and habitat score (EPT). Data was obtained from reports prepared by [11] to [15].

The results were assessed with reference to applicable regional and national standards and guidelines to evaluate the qualitative and quantitative indicators that affect the current state of the watershed.

C. Statistical analysis

To assess the quantitative indicators, multivariate analysis using Principal Component Analysis (PCA) was performed as an exploratory tool for designing natural groupings in the Hierarchical Cluster Analysis (HCA) of the dataset. Analyses were then performed with Varimax rotation to select the factors involved by performing an orthogonal rotation of factor axis, in order to establish the correlation of each of the variables as closely as possible to one (1), so that only the directly impacting factors are considered and close to zero (0) with all other factors [16]. In addition, the multivariate data was represented as a Biplot graphic [17], [18].

A multivariate analysis provided the statistical description of the values (range, mean and standard deviation). The principal component analysis (PCA) was used to group the data of water quality following the methodology established by Boyacioglu and Boyacioglu [19], which included a correlation matrix, extraction of factors by the Pearson coefficient and the use of the Varimax rotation. Four factors were identified that accounted for 80.0% of the variance in System I and three factors that accounted for 100% of the variance in the System II in the model. The data was processed in the XLSTAT programme for Microsoft Excel available from Addinsoft.

For the selection of the factors a Pearson correlation was performed with a significance level of 0.05 determining the eigenvalue, variability and the cumulative environmental variables that were included in the study such as percentage EC, DO, pH, TE , TSS, TU, NH4-N, TOxN, DRP, Cu, Zn,

Pb1, Cu1, Zn1, MCI, EPT and E. coli.

For System I, four factors were selected after the Varimax rotation of the PCA showing that F4 had an eigenvalue > 1 and the cumulative variance was greater than or equal to 80% in the three years evaluated. For System II, three factors were selected after the Varimax rotation of the PCA result that F4 had an eigenvalue α 1 and the cumulative variance was greater than or equal to 100% in the three years.

D. Qualitative indicators and analysis

Field environmental assessments of 152 sampling sites were conducted in January 2009, and February to March 2014 to provide qualitative data. From these a representative sampling of 60 sites was selected, 30 sites in each System. The sampling sites were listed from 1 in the highest part of the watershed to 60 in the lowest part, so as to follow the concepts of Ward

[20] which implies that the starting point of any assessment should be from the headwaters progressing to its discharge point downstream. Torrecillas and Cardenas developed a framework for developing an IWMP based on qualitative indicators [21]. Some of these sites are the same as those monitored by [11] to [15]. One site was located in the highest part of the watershed which was less severely affected and selected as the reference point to enable comparison with the other sites.

The qualitative assessment consisted of field observations based on the four dimensional approach as published by Ward [20], as well as an evaluation of land use to indicate the origin of contaminants in the watershed, and flooding potential. Fifteen qualitative indicators were established based on the principles of systems thinking [22], with the objective of filling gaps in previous environmental monitoring programs. These indicators were assessed through MCA and validated against the quantitative analysis. Land use was obtained from the Auckland Council GIS database and classified in ten categories.

The criteria for evaluating qualitative indicators was established by an ordinal scale multi- where (0) means the natural state of the watershed or no impact, (1) represents slightly impacted, (2) moderately impacted and (3) severely impacted. The problems identified were entered into the matrix columns and the field data provided the basis for the qualitative indicators matrix for the Systems, consisting of 72 rows (F1...F72) and 16 columns (C1...C16), enabling the formulation of matrices in tables for each System.

III. RESULTS AND DISCUSSION

A. Quantitative evaluation

The PCA for System I established the variables of pollution that are associated with different factors: for the first factor (D1) they are pollutants derived from roofs, vehicles and industries (TOxN, NH4-N, Zn, Zn1 and Pb1); the second factor (D2) relates to urban wastewater (EC, pH, DRP, MCI and EPT); the third factor (D3) indicates weathering of rocks and soils (Cu1) and those associated to the fourth factor (D4) were caused by human and animal waste (TSS, TU, DRP, E. coli).

System II showed the following variables: D1 represents weathering of rocks and soils, and metals derived from roofs and vehicles (Cu, Cu1, Zn, Zn1, Pb1 and MCI); D2 was associated with stormwater runoff such as entrainment of organic materials and agricultural residues (TSS, TU, TOxN and NH4-N) and D3 was associated to pollution from human and animal waste (EC, OD, EPT and E. coli).

Fig.1 shows the typical results for the Systems.

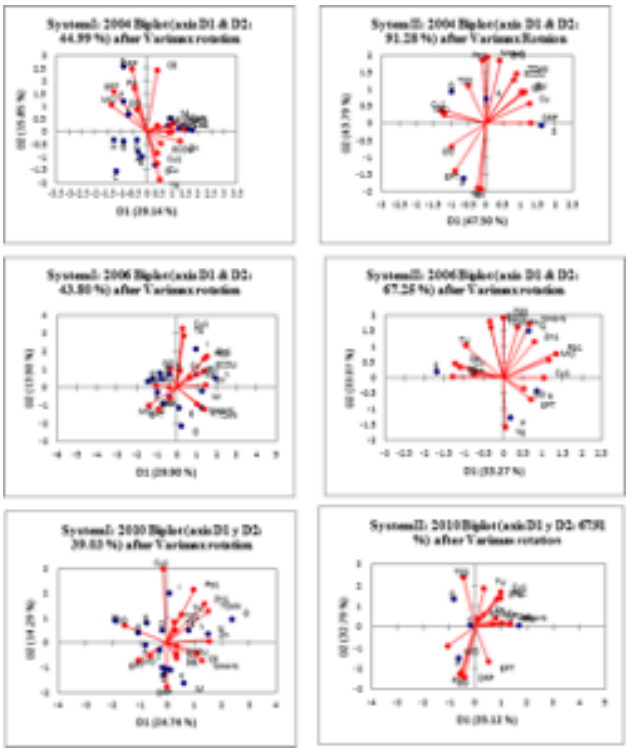

Figure 1 – Typical results of the PCA and HCA for the Systems

The Biplot graphs represented by the Cartesian coordinate axes D1 and D2, show the position of the sampling sites and the 17 physical chemical and biological variables measured at the water monitoring sites. The analysis of the main components was performed according to the following evaluation order:

1) Sites in quadrant D1+ and D2+ which are those that have the largest pollution impacts from heavy metals generated by runoff from roofs, vehicles and industries (TOxN, NH4-N, Zn, Zn1 and Pb1) and from wastewater discharges (EC, pH, DRP, MCI and EPT).
2) Sites in quadrant D1+ and D2- which are pollutants present in runoff from roofs, vehicles and industries (TOxN, NH4-N, Zn, and Zn1 Pb1).
3) Sites that are in quadrant D1- and D2 + where contamination is derived from wastewater contaminants discharges (EC, pH, DRP, MCI and EPT).
4) Sites in quadrant D1- and D2 are not affected by the aforementioned contaminants.

B.Qualitative environmental assessment of watershed condition

The significant environmental impacts in System I and II were derived from the MCA of the quantitative indicators identified in 2009 and 2014. The results of the MCA are consistent with the PCA and HCA of water quality indicators for 2004, 2006 and 2010; proving that the field observations can be relied upon to develop an IWMP when there is insufficient quantitative data. Overall there is a downstream gradient of contamination which will have a significant environmental cumulative impact on the Waitemata Harbour as the ultimate receiving environment with consequent economic and social impacts.

In rural areas the significant impacts observed included sediment, weeds, algal blooms and wastewater pollution. In urban areas the impacts arise from the alteration of the natural hydrology due to increased impervious areas, and high loadings of copper and zinc, which originate mainly from runoff containing metal from roads and roofs as found by [8]. Water quality and ecological health is better in the upper watershed where there is greater vegetative cover, but deteriorate progressively downstream due to urbanization. This is consistent with results of the PCA and HCA for 2004, 2006 and 2010.

Discharge of untreated stormwater causes environmental impacts as it is a pathway for contaminants. There are some stormwater treatment devices; however during the field assessments it was observed that the lack of maintenance prevents proper operation of the treatment systems, potentially increasing pollution in the watershed.

Bacterial contamination was observed due to overflows of sewage networks in the urban areas and the poor condition of on-site wastewater treatment systems in rural areas; these impact on the health of humans and ecosystems.

There is a risk of flooding for 432 properties in a 1 in 100 year storm event, thus implementing LID should be given a priority in the watershed so as to reduce peak flows and assist in mimicking the natural flow regime

IV. IMPLICATIONS FOR IWMP AND LID

The methods used proved to be efficient for determining contamination sources and assessing the cause and effect relationship. PCA and HCA enable the identification of the most important contaminants and the location of their impacts.

Coupled with the MCA of qualitative indicators, they provide a framework for developing a prioritized IWMP and determining the LID objectives to help control pollution at source and prevent contamination of the receiving water bodies.

LID is an approach to land development (or redevelopment) that works with nature to manage stormwater as closely to its source as possible; by promoting infiltration, evapotranspiration, and harvesting throughout the landscape, LID preserves and restores the natural water balance. Planning for LID [23] should initially include consideration of the ultimate receiving environments, receiving water and its catchment, which will then enable the determination of strategies at sub-watershed, neighborhood and site specific level.

Sustainable management of a watershed can be achieved through IWMP with strategies to manage growth and development, supported by monitoring of social, economic, environmental and cultural indicators. As well it is essential that a wide range of actions are considered, such as: environmental education, maintenance programs, LID implementation, enforcement and compliance with the regulations in force for the entire watershed, and ongoing evaluation, control and monitoring.

LID principles should be applied for land use planning to minimize the impact of growth. The combination of LID devices, reducing the equivalent impermeable area, control measures and the implementation of regulations in Systems I and II could reduce sediment by 47.2%, metals by 19.6% %, thus contributing to reduce the impact on streams and the Waitemata Harbour, based on analysis published in [9]. It is essential that maintenance programs be implemented for existing and future LID devices; otherwise they will fail and could actually increase the impact on the environment.

V. CONCLUSIONS

The particular problem in the case of water quality monitoring is the complexity associated with analyzing the large number of measured variables [24]. In this research PCA and HCA methods have been used to reduce this complexity and identify the priority impacts that should be managed. The systemic and holistic focus enabled the identification of the natural and anthropogenic factors that cause impacts in the Twin Streams watershed. In turn the methodology can be adopted as the basis for developing an IWMP approach for the sustainability of any other watershed. Monitoring could be limited to the indicators of interest which will reduce the cost of monitoring and provide a more efficient and effective program as the number of indicators can be reduced from 17 to 12.

Although physical-chemical pollution indicators are very important factors, the comparison of qualitative and quantitative results provides clear indications of the other factors which affect adversely water quality and aquatic biota, hence the importance of a systemic approach.

It is recommended that future studies should include an analysis of climate change and droughts. After completing the initial assessment of environmental effects, emergency planning, monitoring, evaluation, prognosis and occurrence of drought mitigation should be established since this phenomenon can adversely affect the overall management of the watershed [25]. Even in areas with abundant rainfall is important to consider climate variability manifested in negative anomalies in water flows and availability through a system of monitoring and evaluation of drought.

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Water Security and Scarcity: Challenges and Solutions

T. Miguel, C.E. Torrecillas Nuñez, A. Singh, A. C. Ravelo

ABSTRACT

Nearly half the world's population are already living in potential water scarce areas with at least one month per year and this situation could increase to some 4.8 to 5.7 billion people in 2050. About 73% of the affected people live in Asia (69% by 2050). Over 2 billion people live in countries experiencing high water stress. Recently the city of Chennai, India, (population of nearly 9 million) completely ran out of water. In 2015, the dams which supply water to over 9 million residents of São Paulo, Brazil, were so low that large parts of the surface of the reservoirs were dried mud.

Hence our objective was to incorporate asset management disciplines as part of Integrated Water Management (IWM) planning to overcome water scarcity.

The methodology is based on the principles of the Five Waters approach: cultural water, drinking water, wastewater, stormwater and groundwater integrated with asset management, ecosystems, land use planning and management, transport, parks and buildings. This is underpinned by the principle of the closed loop of the water cycle, where intervention in one part of the cycle could have positive or negative consequences in another part of the cycle. An important aspect of the methodology is the consideration of cultural aspects as paramount for the success of the IWM. The process steps included stakeholder workshops, development of a database, applying the principles of ISO 55000:2014 Asset Management, development and evaluation of options (asset and non-asset solutions), planning and assisting with the implementation of preferred options, monitoring and reviewing effectiveness and efficiency. We demonstrated the application of this methodology in developing drought management plans for Mexico, based on our experience in Argentina and New Zealand.

The results showed that water scarcity can be avoided through robust asset management and planning. Application of Industry 4.0 offers great hope for smart management of water systems. However, implementation of measures to ensure water security can be hindered by institutional barriers and stakeholders' lack of knowledge and motivation. Often the response to water scarcity leads to a crisis response which is forgotten once the situation improves. One of the results was the total lack of appreciation of asset management.

In conclusion the concept of including asset management as part of IWM will ensure a secure water future for our world, provided that there is sufficient time for stakeholder participation and decision making.

Keywords — Asset Management, Five Waters, Integration, Scarcity.

T. Miguel is with ANA Group, Auckland, New Zealand;
(corresponding author phone: +6421718909, e-mail: tony.miguel@anagroup.co.nz).
C. E. Torrecillas Nuñez is with the Universidad Autónoma de Sinaloa, Mexico (e-mail: cruztn@ hotmail.com).
A. Singh is with ANA Group, Auckland, New Zealand (e-mail: amar.singh@anagroup.co.nz).
A.C. Ravelo is with CREAN, Cordoba, Argentina (e-mail: ravelo43@gmail.com).

I. INTRODUCTION

HIS paper provides an overview of the role of Asset Management Systems (AMS) and Information Systems (IS) together with the concepts of integrated water

management for drought planning in Mexico. The results are applicable to ensure water security for the world.

Water use has been increasing worldwide by about 1% per year since the 1980s, driven by a combination of population growth, socio-economic development and changing consumption patterns. Global water demand is expected to continue increasing at a similar rate until 2050, accounting for an increase of 20 to 30% above the current level of water use, mainly due to rising demand in the industrial and domestic sectors. Over 2 billion people live in countries experiencing high water stress, and about 4 billion people experience severe water scarcity during at least one month of the year. Stress levels will continue to increase as demand for water grows and the effects of climate change intensify. Water use has been increasing worldwide by about 1% per year since the 1980s, driven by a combination of population growth, socio-economic development and changing consumption patterns. Global water demand is expected to continue increasing at a similar rate until 2050, accounting for an increase of 20 to 30% above the current level of water use, mainly due to rising demand in the industrial and domestic sectors. Over 2 billion people live in countries experiencing high water stress, and about 4 billion people experience severe water scarcity during at least one month of the year. Stress levels will continue to increase as demand for water grows and the effects of climate change intensify [1].

In many arid countries water is used inefficiently and there is a lack of planning. Several are relying too heavily on groundwater, which instead they should be replenishing and saving for times of drought. In those countries several big cities have faced acute shortages recently, including São Paulo, Brazil (2015); Chennai, India (2019); and Cape Town, South Africa (2018).

Transitioning from intermittent supply to continuous is not an easy task and should be done in a cost-effective manner combining improved operations with targeted capital works. This approach has to be based on sound data, good technical modeling, the introduction of good management practices, particularly related to commercial and technical efficiency and the assessment of different options to find the most cost-effective solution. Furthermore, it is imperative to create a well-functioning water utility that has the capacity, know-how and expertise to operate the system through the introduction of modern management systems, procedures and equipment [2].

Additionally there is a need for a combination of engineered and non-engineered solutions such as demand management, pricing, education and Nature Based Solutions (NBS). NBS address contemporary water management challenges across all sectors, and particularly regarding water for agriculture, sustainable cities, disaster risk reduction and water quality. NBS use or mimic natural processes to enhance water availability and provide a basis for implementing green infrastructure combined with traditional grey infrastructure.

Integrated water management is a collaborative approach to planning that brings together organizations that influence all elements of the water cycle, including waterways and bays, wastewater management, alternative and potable water supply, stormwater management and water treatment. It considers environment, social and economic benefits [3].

Asset Management (AM) is the combination of management, financial, economic, engineering and other practices applied to physical assets with the objective of providing the required level of service in the most cost effective manner. It includes the management of the whole life cycle (design, construction, commissioning, operating, maintaining, repairing, modifying, replacing and decommissioning/ disposal) of physical and infrastructure assets. AMS and IS are the foundations for accountability mechanisms that ensure institutions responsible for water services can fulfill their as service providers.

The principal considerations to successfully implement ISO 55001:2014 Asset Management are the organizational structure, communication, culture and leadership including sequence activities, scheduling and project deliverables. ISO 55000/55001/55002 defines asset management as the coordinated activity of an organization to realize value from its assets.

ISO55001 implementation can typically be divided into three stages:

- Stage 1 covers preliminary assessment to define the scope of AMS; detailed maturity assessment, gap analysis and roadmap, preparation of draft AMS manual and define business activities to achieve ISO55001 requirements including community engagement and service review.
- Stage 2 covers the preparation of Integrated Planning and Reporting documentation to align with the AMS.
- Stage 3 includes implementation: training & monitoring and pre-certificate audit to achieve ISO55001 requirements [4].

Fig. 1 shows the common response cycle by institutions and members of the public to drought/ water security issues, known as the Hydro-Illogical Cycle [5].

Mexico has a history of climate extremes including flooding and droughts, and in 2011 and 2012 it experienced a series of droughts from Abnormally Dry to Drought – Exceptional which affected different parts of the country; the most severe drought in the last 70 years. Consequently the National Program Against Drought (PRONACOSE, for its acronym in Spanish) was initiated in 2013 to provide a basis for Drought

Management Plans (DMP's) to include a programme of drought prevention and mitigation measures.

AM has been implemented in Australia and New Zealand since the early 1990's, where it was first formally documented in 2000 in the International Infrastructure Management Manual (IIMM). However, as AM was not practiced in Mexico at that time, there was an opportunity to apply AM as a framework for developing and implementing the DMP's.

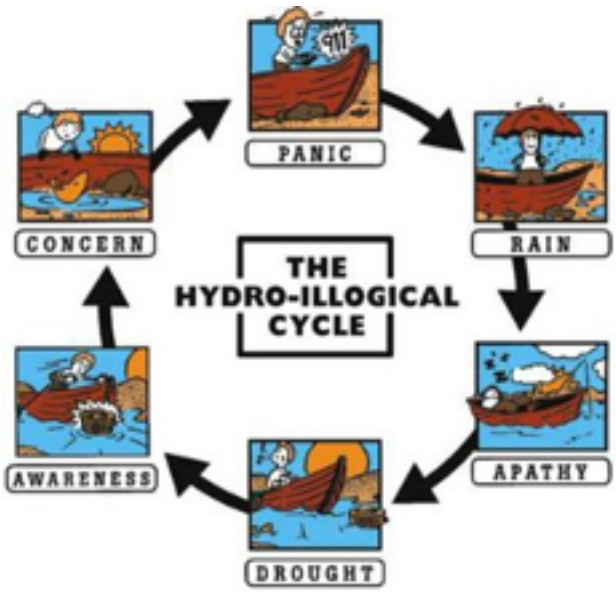

Figure 1 – he Hydro-Illogical Cycle

II. PROJECT OBJECTIVES AND SCOPE

The project objectives were to develop DMP's for three watersheds: Rivers Fuerte and Sinaloa, Rivers Mocorito to Quelite and Rivers Presidio to San Pedro, and for three cities: Culiacan, Durango and Mazatlan. The scope included two stages: Stage 1 preparation of the DMP's (2013 and 2014) and Stage 2 implementation, review and updating the DMP's (2015 and 2016).

III. METHODOLOGY

The methodology included the following:

- Developing the DMP's for the three watershed based on the Guidelines for Developing Drought Prevention and Mitigation Measures (Guía para la formulación de Programas de Medidas Preventivas y de Mitigación de la Sequía in Spanish) [6].
- Guidelines for the Preparation of Drought Prevention and Mitigation Measures by Urban Water Users (Guía practica para la elaboración del PMPMS para usuarios urbanos, in Spanish) Version 2.0 [7].

- Running a series of stakeholder workshops in various locations in the watersheds to define the problems, objectives, actions and programs using the Logical Framework Approach. The stakeholders included representatives selected by the Watershed Committees and included a wide range of interest groups. The determination of actions and programs was supported by
- high level benefit/cost and multi-criteria evaluation analysis.
- A Watershed Technical Group was established to provide an overview of the work program and recommend the DMP's for consideration by the relevant authorities.
- Overall, the process in the IIMM (2011) [8] was adapted to help formulate the DMP's; note that some of the elements could not be implemented due to the lack of AM practice in Mexico and thus were included in the DMP's for future development.

IV. UNDERSTANDING AND DEFINING THE REQUIREMENTS

A.Legislation

The applicable legislation is the National Water Act (Ley de Aguas Nacionales in Spanish) applies for managing national water resources; its provisions are of public order and social interest and its purpose is to regulate the exploitation, use or exploitation of these waters, their distribution and control, as well as the preservation of their quantity and quality to achieve integral sustainable development of the resource.

B. Strategic Plans

The DMP's had to be consistent with the National Development Plan 2013-2018 (Plan Nacional de Desarrollo in Spanish) and the National Hydrologic Program 2014-2018 (Programa Nacional Hídrico – PNH in Spanish).

C. Policies

The Federal Government decreed two policies that had to be included in the DMP's:

- On 25th of January 2012, actions are instructed to mitigate the effects of the drought that various federal entities are going through including: emergency water supply; financing/ compensation/ reactivation of agricultural activity; drought support projects and programs.
- To reduce vulnerability and ensure informed participation, the "Guidelines that establish the criteria and mechanisms for issuing general agreements in emergency situations due to the occurrence of drought, as well as preventive measures and mitigation measures" are published on 22nd of November 2012. These are to be implemented by users of national water resources to achieve efficient use of water during droughts.

D. Watershed Parameters

The Rivers Fuerte and Sinaloa Watershed is located in the Northeast of Mexico, and includes the south of Sonora State, the west of Chihuahua State and parts of Sinaloa State. It has an area of 56,000 km2 and a population of 1,086,666. In the upper watershed annual average rainfall ranges from 613 to 1,209 mm per year; in the middle watershed it is 993 mm per year and in the lower watershed precipitation is 267 mm per year. Total water resources available in this watershed amount to 7,754.8 Hm3/year (91.9% is surface water) and demand is 4,205.2 Hm3/year (96.7% is used for agriculture).

The Rivers Mocorito to Quelite Watershed is located in the Northeast of Mexico and includes the west of Durango State and parts of Sinaloa State. It has an area of 49,000 km2 and a population of 1,340,266. In the upper watershed annual average rainfall is 1,234 mm per year; in the middle watershed it is 1,077 mm per year and in the lower watershed precipitation is 698 mm per year. Total water resources available in this watershed amount to 7,486 Hm3/ year (92.2% is surface water) and demand is 4,370 Hm3/year (92.2% is used for agriculture).

In spite of having seemingly abundant water resources in these catchments, the water storage dams reached critical low levels in 2011 and 2012 mainly due to the lack of forward planning and inefficient water use for irrigation and municipal water supply.

In the Rivers Fuerte and Sinaloa Watershed dam levels reached 9.6% of total storage and in the Rivers Mocorito to Quelite Watershed dam storage levels reached 3.43% on the 1st of June 2012.

The Rivers Presidio to San Pedro is also located in the Northeast of the country and includes parts of the states of Durango, Zacatecas, Nayarit and Sinaloa. It has an area of 52,000 km2 and a population of 1,750,466. In the upper watershed annual average rainfall is between 379 and 1,487 mm per year; in the middle watershed it is between 615 and 2,425 mm per year and in the lower watershed precipitation is between 740 and 1,525 mm per year. Total water resources available in this watershed amount to 8,546 Hm3/year (90.3% is surface water) and demand is 1,275 Hm3/year (47.3% is used for agriculture). In this watershed 6 of the 15 aquifers are over-extracted.

E. Water Supply Systems in the Cities

The city of Culiacan is the capital of Sinaloa State and had a serviced population of 761,333 in 2015, projected to increase to 895,245 by 2030. In 2013 water demand was 264 liters/person/day, total water produced was 70.4 Hm3/year, but only 45.8 Hm3/year was billed (a loss of 34.9%). Most of the water is supplied as surface water with only 17.1% supplied from groundwater resources.

The city of Durango is the capital of Durango State and had a serviced population of 639,477 in 2015, projected to increase to 722,825 by 2030. In 2013 water demand was 392.5 liters/person/day, total water produced was 81.2 Hm3/year, but only 34.7 Hm3/year was billed (a loss of 57.3%). All the water is supplied from groundwater resources, although the aquifers are over-extracted.

The city of Mazatlan is a major tourist destination in Sinaloa State and had a serviced population of 479,349 in 2015, projected to increase to 529,230 by 2030. In 2014 water demand was 362.7 liters/person/day, total water produced was

55.4 Hm3/year, but only 28.6 Hm3/year was billed (a loss of 48.4%). In 2014 surface water supplied 50.2% of demand and groundwater resources supplied the remaining 49.8%.

V. WATER AND ASSET MANAGEMENT PROGRAMS

A. Watershed Programs

In general, water resources in the watersheds are abundant, but there is a tendency to overexploitation due to the lack of decision support models for integral management of the watershed that allows establishing operating rules for water resources management to guarantee the satisfaction of demands.

Another priority measure that is recommended is the development of models to forecast and monitor the impact of the El Niño phenomenon, this climatic anomaly is becoming increasingly recurrent and it has been evidenced that it causes extreme droughts that directly impact river flows.

When analyzing the historical records of storage in dams, a trend is observed of low critical levels, possibly due to the lack of adequate operating rules for water resources. Therefore, the development of decision support models with the participation of stakeholders is recommended. Another priority measure that is recommended is the development of models to predict the impact of El Niño and the impact on the drought in the watershed.

The implementation of asset management based on ISO 55000 is also recommended, offering a comprehensive system to ensure efficiency in the management of all water infrastructure and the development of Low Impact Development and Design methodology and green infrastructure for the restoration of watersheds.

A database of native vegetation should be developed to design strategies for the restoration of the basin. Salinity as an indicator (electrical conductivity) should be incorporated in the Water Quality Index, due to the fact that in scenarios of drought would be expected to increase the content of soluble salts in water flows, an aspect of relevance for irrigation areas and especially those areas where there are already problems of soil salinization.

A budget adjustment is suggested to boost non-structural measures. For example, out of the total amount allocated to infrastructure works, a percentage that could be between one to ten percent should be allocated to generate a fund for the application of research, scientific development and technology transfer programs through demonstration projects that promote environmental education and water culture; as well as socio- economic studies of the impact of drought in the watershed to design a sectorial program of communication and motivation, and establish communication programs in the mass media and social marketing. This fund can also be applied to strengthen the Watershed Council for its evolution to achieve its function of coordinating drought and water resources management with the involvement of users and citizens.

In order to strengthen the integral sustainable management of water, and to guarantee its access to the population and ecosystems, the portfolio of projects that recommend for the period from 2016 to 2021 is a total investment amount of 439 million dollars distributed in the following programs:

- Recovery of watersheds;
- Recharge of aquifers;
- Measurement of the hydrological cycle in hydrometric and climatological stations;
- Improving water quality in watersheds;
- Strengthen water governance and management;
- Increasing in water security against droughts and floods;
- Urban coverage of drinking water;
- Rural coverage of drinking water;
- Urban sewer coverage;
- Rural sewer coverage;
- Efficiency of wastewater collection generated;
- Municipal wastewater treatment coverage;
- Increase the efficiency of the operating agencies;
- Increase the technical, scientific and technological capacities of the sector;
- Ensure water for agricultural irrigation in a sustainable manner;
- Consolidate the participation of the Watershed Council in the international context of water [9] – [11].

B. Municipal Water Supply

The following three main strategies are proposed:

1. Promote a preventive approach of continuous alert and preparedness to avoid drought impacts within the operating agencies and municipalities.
2. Reduce and manage water consumption and improve efficiency before increasing sources of supply.
3. Establish and continuously improve an asset management system for the operating agencies that will improve efficiency and service.

To implement these strategies, the development and implementation of an Integral Efficiency Program of the Operating Agency, a Demand Management Plan, a Water Safety Plan and a Drought Contingency Plan are recommended.

With the objective of defining strategic guidelines for the Program for Preventive Measures and Drought Mitigation, the following lines of action are proposed for the operating agencies:

- Permanently monitor the phenomenon of El Nino and drought according to the thresholds suggested in this DMP's, publish the results and according to the value of the indicator, deploy the previously planned strategies. Monitor water deficit based on the availability and demand of water in the production and distribution system to ensure security of supply.

- Implement, before and during the presence of the drought phenomenon, an intensive awareness program for the efficient use of water using different mass media, direct visits at home, in schools, in collection centers and in public places. Each activity must be monitored and evaluated based on the coverage and results obtained. It is proposed to strengthen the Water Culture Program with a broader vision for the awareness and motivation of all sectors of the community.
- Design proposals for comprehensive efficiency programs of the operating agencies through asset management (ISO: 55000).
- Development and implementation of a program for demand management, with the aim of reducing water supply per capita by 20 percent by 2022.
- Establish a preventive and corrective maintenance program for water production and distribution infrastructure.
- Monitor water leaks in conduction and distribution lines with different devices and techniques, as well as in storage infrastructure.
- Ensure the establishment of new sources of water supply according to a demand analysis of the various users that guarantee supply for the next 20 years. To this end, Low Impact Development and Design (DDBI) technologies, also known as green infrastructure or sustainable drainage systems, should be promoted. In the case of surface water, intermittent and ephemeral currents may be included, where small ponds can be built that can also function as flood controls.
- Plan for new infrastructure and rehabilitation in stages, so that the investment in future water supplies is identified, as well as the investments for the modernization of the present infrastructure.
- Propose measures for the rehabilitation of wells for water supply in compliance with the provisions of NOM-004-CNA-1996 and in the case of drilling new wells, verify the quality of the water they will produce and compliance with NOM-003- CNA-1996.
- Increase the efficiency in charging for water services delivered based on the list of delinquent users and the history of consumption by type of users.
- Identify during the presence of the drought phenomenon, the most vulnerable areas of the city and the municipality in terms of supply and according to water availability, optimize the distribution so that users have the resource available daily.
- Establish a limited water supply program for users with high consumption and prohibit the use of water in superfluous activities in cases of considerable water deficit.
- Monitoring of water use domestic consumption and in cases when the system detects large increases, verify the origin of the increase and recommend repair and maintenance.
- Establish a consumption monitoring system for the various users that allows diagnoses and propose alternatives to reduce consumption if it increases.
- Promote the update of the Municipal Urban Development Program, and Regulations [12]-[14].

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Asset Management Council – Asset Management Excellence Awards 2020

The Virtual Asset Management Awards for Excellence ceremony was held on Friday 16th October 2020. You can re-watch the presentations

And the winners are…

The winners of the Asset Management Council's Asset Management Excellence Awards were announced on Friday 16th October 2020. Here's a list of the winners in each category:

- **TransGrid,** Digital Substation – Winner, Asset Management Innovation Award
  - The bulk of the substations managed by TransGrid were constructed in the 1970s and 1980s, utilising technology that was appropriate at that time but is now reaching the end of its reliable life. TransGrid's digital substations will be implemented on future and replacement capital projects, to maintain a safe and reliable transmission network.
- **TransGrid**, Asset Monitoring Information Platform – Winner, Asset Management Information Management Award
  - TransGrid has developed a bespoke 'Asset Monitoring Information Platform' that allows monitoring and managing asset information from multiple systems into different viewports (or contexts) in a purpose-built Asset Monitoring Centre. This solution is providing better response and reduced outage time, lowering cost and improving reliability.

Assetic & Department of Transport Victoria, The Moonshot Project – Winner, Asset Management CRP Award

- The Department of Transport (DoT) and Assetic partnered to provide a balance between cost, risk and performance across all transport modes, with a focus on customer-centric, outcome-focussed asset management through The Moonshot Project. Named in honour of President Kennedy's 'Moonshot challenge' in 1961, it hasn't yet been achieved nor its path to being achieved been defined.

- **Jemena,** Goulburn Gasworks Remediation Project – Winner, Asset Management Environmental/Social Award
  - The Goulburn Gasworks remediation forms a critical part of the Jemena Asset Management System, and demonstrates the company's commitment to managing the full-life cycle of its assets including maintaining, monitoring for compliance and ensuring the correct retirement of an asset.
- **Sydney Trains,** Electronic Rail Lubricator Project – Winner, Asset Management Safety Award
  - The project replaces the existing network of 428 mechanic lubricators with 119 new electronic units. The new units employ remote monitoring capabilities that enable fundamental changes to rail lubricator maintenance practices to improve staff and rail corridor safety.
- **Gladstone Regional Council,** Diversity – Winner, Asset Management Diversity Award
  - With a proud focus on diversity to support growth in the region, Gladstone Regional Council aims to make true connections with the community, reflected in its inclusivity and innovative opportunities across its vast landscape.

The Asset Management Council would like to congratulate the above-named winners.

We also wish to sincerely thank each of the finalists in the Asset Management Excellence Awards 2020. This year, we were honoured to receive a record number of entries in each category and we thank you for the time and attention taken to produce your submission.

We also particularly thank our panel of judges who spent much time deliberating over the entries in each category.

Re-watch the Asset Management 2020 Awards for Excellence Ceremony **https://www.amcouncil.com.au/news/56-member-news/100015-asset-management-council-%E2%80%93-asset-management-excellence-awards-2020.html**

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MEDIA RELEASE

October 26, 2020

World Partners in Asset Management (WPiAM) launches Global Certification Scheme

In keeping with its vision of "Globally recognised Asset Management credentials" the World Partners in Asset Management (WPiAM) has developed a framework for the alignment of professional credentials in Asset Management.

With the introduction of this framework, WPiAM are seeking to align worldwide efforts to develop, assess and recognise competence in Asset Management and to establish a system of assurance of quality while respecting the needs for variation of application according to the history and culture of each region.

The scheme provides a laddered career path for asset management professionals who are looking to advance their skills and improve their ability to contribute to the success of the organisations they serve.

This competency-based scheme will provide a common base for organisations to ensure that the individuals they hire anywhere in the world have the knowledge, skills and experience to apply asset management principles in various contexts.

The Global Certification Scheme provides a three-level designation framework that has been shaped around the key Asset Management roles.

- **Level 1:** Certified Senior Principal in Asset Management (CSAM)
- **Level 2:** Certified Practitioner in Asset Management (CPAM)
- **Level 3:** Certified Technical Specialist in Asset Management (CTAM)

These designations focus on core roles across Asset Management teams that may be operating in a range of industries, at various scales, in widely disparate environments and delivers continued professional development opportunities.

More information is available on the WPiAM website at wpiam.com.

- End –

For further media information contact:
David Daines (WPiAM Director / Company Secretary) dave.daines@wpiam.com

ABOUT WORLD PARTNERS IN ASSET MANAGEMENT

World Partners in Asset Management is a not-for-profit organization whose mission is to enable individuals and organizations to develop, assess and recognize competence in Asset Management. WPiAM has seven member organisations including the ABRAMAN (Brazil), the Asset Management Council (Australia), GSMR (GCC Countries), JAAM (Japan), SMRP (USA), PEMAC (Canada), and SAAMA (Southern Africa). **www.wpiam.com**

WPiAM
World Partners in Asset Management

RECOGNITION

What does the Global Certification Scheme mean for AMCouncil Members?

The AMCouncil certification scheme is to be aligned to the WPiAM Global Certification Scheme for the CPAM and CSAM designations only. This means that your CPAM and CSAM certification now holds greater value and is recognised throughout the world!

HOW DO I APPLY FOR GCS?.....

For those who already hold CPAM and CSAM: No need to do anything. Your CPAM or CSAM certification will be automatically recognised as a Global Certification as it was obtained through AMCouncil Certification scheme.

CAN I GET A CERTIFICATE TO PROVE THAT MY CPAM AND CSAM CERTIFICATION IS ALIGNED TO THE GLOBAL CERTIFICATION SCHEME?.....

Yes! When it is time for your CPAM or CSAM certificate to be renewed the AMCouncil will issue a certificate which contain the Global Certification Scheme logo on it. In the meantime your current CPAM or CSAM certificate issued with the AM Council logo on it will automatically be recognised as part of the Global Certification scheme for the designations of CPAM and CSAM.

FOR THOSE WHO WANT TO ENTER THE GLOBAL CERTIFICATION SCHEME IN THE CPAM AND CSAM.....

Visit the AM Council website individual certification portal and apply on line https://www.amcouncil.com.au/certification. Any questions – email certification@amcouncil.com.au or give us a call at 03 98192515

I HAVE CAAM. HOW DO I ENTER THE GLOBAL CERTIFICATION SCHEME?.....

Unfortunately CAAM is not currently recognised in the Global Certification Scheme – only the designations of CPAM and CSAM. You can apply for CPAM or CSAM by visiting the AM Council website individual certification portal and apply on line https://www.amcouncil.com.au/certification/. Any questions – email certification@amcouncil.com.au or give us a call at 03 98192515

I HAVE CAMA. HOW DO I ENTER THE GLOBAL CERTIFICATION SCHEME?.....

Just send through your CAMA Certificate to certificaiton@amcouncil.com.au and we will contact you with next steps to obtain a CPAM certification under the AM Council certification scheme.

I HOLD A CPAM AND WANT TO UPGRADE TO CSAM UNDER THE GCS. HOW DO I DO THIS?.....

You can apply for CSAM by visiting the AM Council website individual certification portal and apply on line https://www.amcouncil.com.au/certification/. Any questions – email certification@amcouncil.com.au or give us a call at 03 98192515

I HAVE A CFAM CERTIFICATION. HOW DOES THIS FIT WITH THE GSC?.....

Unfortunately CFAM is not currently recognised in the Global Certification scheme – only the designations of CPAM and CSAM. We are working with WPiAM to have the designation of CFAM globally recognised.

Asset Management for Infrastructure Resilience – using Circular Economy

Article written byLinda Kemp based on a presentation by Matthew Lugg, Head of Profession, Local Government, WSP, UK, October 2020

Asset management is a strategy that builds value for the enterprise. At its heart, asset management encompasses a whole-of-business approach, taking into account the leadership and culture of the organisation, as well as maintenance and operations, lifecycle management, and balancing cost, risk and performance of the asset.

The principles of asset management places the sector in prime position to incorporate the methods of the circular economy into asset management plans, particularly for those who own and manage infrastructure.

WHAT IS THE CIRCULAR ECONOMY?

Many readers will undoubtedly have heard of the circular economy. And that's because it's a concept that is being discussed more frequently. For anyone who may have insufficient or scant knowledge, it is easy to assume the circular economy is an umbrella term for recycling. The fact is circular economy encompasses much more than recycling.

Traditionally, industrial processes and even the way we live our lives have taken on a linear form: we take materials, make them into a product, then dispose of that product once it becomes broken or no longer useful. The recycling approach goes some way to fixing this, by providing loops within that linear method; instead of take, make and dispose, recycling introduces us to take, make, repurpose, refashion, repurpose again, and finally dispose.

But the circular economy is, well, circular. Broadly, it is the process of managing materials more sustainably, while using symbioses to share resources, continuously in a loop, wholly avoiding the disposal of the product. More specifically, it's a system aimed at:

- Eliminating waste and wasteful thinking – create solutions that minimise waste but offer the same outcome, and challenge the throw-away mentality.
- Using resources wisely – incorporate durability in products, and find ways to build flexibility, offer services NOT consumables.
- Protecting and regenerating natural capital – find ways to restore products and seek green solutions to grey problems. Use our renewable resources.
- Incorporating a systematic management approach – from the top down, embody leadership and governance in innovation, collaboration and stewardship.

INFRASTRUCTURE RESILIENCE:

Infrastructure management, too, has fallen victim to the linear economy. In the overall haste to build cities that match the exponential rise in population, most infrastructure is not resilient, inflexible, and the demands placed upon it by the public bring on both a loss in value for infrastructure owners, and, more crucially, negative impacts to the natural environment, including noise and air pollution, and the release of toxic substances that spike carbon emissions. In addition, an ever-increasing pressure from climate change and natural disasters, and the pandemic caused COVID-19, demonstrates the need for infrastructure to be resilient.

Unsurprisingly then, many cities around the world are adopting circular economy principles as a means to an effective lifecycle management of public infrastructure and a restorative influence for the environment.

The circular economy is the answer to the conundrum of how to respond to the shortcomings in our traditional methods of infrastructure management.

ADOPTING THE CIRCULAR ECONOMY IN ASSET MANAGEMENT:

As noted above, asset management is well-placed to play a collaborative role in the wide adoption of the circular economy. Asset owners and managers ought to take the lead in implementation strategies to sell the benefits of a circular economy, particularly within public infrastructure.

There has never been a more important time to implement a systematic approach and build circular economy strategies into current asset management plans. In addition to the usual suspects in any asset management plan, one that focuses the circular economy should include:

- methods to protect natural capital and resources
- training to upskill staff in understanding the circular economy
- targets to reduce carbon emissions
- strategies to reduce waste and repurpose materials
- pathways to engage with supply chain management
- strategies to share waste materials with other organisations

Practically speaking, all those outlined above can be achieved in small steps. During a rebuild of a public building, bricks and concrete can be crushed on-site and repurposed in the renovations. Businesses can retrofit waste reduction opportunities to existing sites and facilities. Lease products necessary for the business, rather than use CAPEX. Consider future possible services in design stages and employ provisions accordingly.

BENEFITS OF THE CIRCULAR ECONOMY:

The circular economy is the missing link to the world's current predicament.

Currently, the concept of a circular economy is undervalued, but it is becoming more well-known and increasingly regarded. It is critical to organisations and has a huge role to play in greater sustainability and net zero carbon economy.

It's time to take the circular economy on board, and asset management stands as the connector. Be the voice in your organisation, the one who gets the circular economy rolling.

CSIRO – Climate and Disaster Resilience Report

Article written by Linda Kemp based on a presentation by Mark Burgess, CSIRO, October 2020

Following the bushfires over the Australian summer of 2019/2020, the CSIRO was commissioned by the Prime Minister, Scott Morrison, with the task of sourcing practical options to support and improve Australia's climate and disaster resilience. The report was published in July 2020. Six key themes and twenty-five recommendations were outlined.

At the Asset Management Council's recent government symposium, Mark Burgess from the CSIRO presented on building better climate and disaster resilience in our public infrastructure. Drawing from Chapter Eight, entitled Improving Built Environment Resilience, which he co-authored with Justin Leonard, Mark addressed some of the complexities in managing infrastructure assets.

It is a well-known fact that infrastructure assets are critical to the way we live our everyday lives. Communities around the world are now so reliant on infrastructure such as roads, water, energy and communication assets that we barely notice their importance.

However, during a global crisis or a natural disaster, society glimpses with devastating clarity the level with which we depend on the smooth functioning of these assets, and how closely they each are linked.

These moments of collective distress proves the interconnectedness of our infrastructure: when one asset is negatively impacted, other assets are equally affected. Throughout the bushfires in the Australian summer of 2019/2020, for example, failure to power pole assets caused many roads to be impassable, leaving residents scrambling for safety, and asset infrastructure owners bringing into action their organisation's risk mitigation plans.

Similarly, during the initial panic brought on by the COVID-19 pandemic, individuals were desperate not to be caught in lockdown without access to supplies. This led to panic buying of goods, particularly toilet paper, instigating a market failure in supply chains, caused not by stakeholders or in the infrastructure itself, but by ordinary people hoarding stock.

It is therefore evident that the complications for governments and organisations charged with the management of critical infrastructure are complex. Identifying where risk lurks is not always easily surmised; this poses significant challenges to organisations and businesses in predicting the impact of events on infrastructure assets. Additionally, the level of complexity is increased due to the private ownership of many physical assets and networks, some even based external to Australia. International proprietorship can negatively impact the ability to consider intangible benefits felt by the diverse range of actors; chiefly, a lack of cognisant knowledge held by management surrounding the natural environment that houses the assets. Private ownership of public infrastructure can also expose opposing motivations and objectives in reference to resilience, ultimately steering away from the required asset management outcome.

Infrastructure assets traditionally possess a linear nature, increasing the multi-jurisdictional element. Physical assets such as roads, water and power all traverse state and regional borders, therefore impacting all levels of government. This places decision-making surrounding the resilience of infrastructure, its lifecycle management and decommissioning processes into the hands of numerous stakeholders. While is it widely acknowledged that all tiers of government support and understand the need for resilience in infrastructure, oftentimes critical decisions relating to its management are left dangling, a casualty of poor communication between internal departments and council shire offices.

However, many stakeholders at the private and public sector recognise the importance of improving resilience within infrastructure. History and previous natural disasters demonstrate that although planning and standards have improved from past practices, there is still more to be learned and implemented. The application of new designs and structural standards now can improve the overall resilience among infrastructure assets, and any future natural disasters and global events will have a less disastrous effect on operations and linkages particularly during such times. The crucial role infrastructure plays in making communities more resilient overall must be acknowledged and understood. Where communities are flexible and adaptable, recovery from disasters is hastened and negative impacts in general are minimised.

Hence, businesses and governments that place due diligence in implementing risk reduction frameworks boast a prime position in terms of their planning for resilience in public infrastructure. In order to build back better, it is necessary to lose the mindset of replacing like for like. Any risk reduction framework ought to be applied while recognising the multi-dimensional aspect in resilience, the complexity of infrastructure, and the many different actors and stakeholders involved along with any competing motivations and priorities.

There is no doubt that planning for resilience in infrastructure is a challenging goal. However, the difficult nature of implementing resilience should never be an excuse for avoidance. Our communities, nation and the world demand that we continue with attempts to build better resilience in infrastructure.

MEDIA RELEASE

Asset Management Council (AMCouncil) & CPEE celebrate Australasian launch of new Asset Management Course

We are currently experiencing the largest ever construction build of infrastructure in many states across the country. Australia's focus on delivering projects in the built environment as a pathway to recovery post COVID, means delivering excellence in infrastructure, roads, construction and transport. Understanding, managing, and optimizing the asset base sustainably in this environment is essential for success.

A collaborative partnership has been established between the Asset Management Council (AMCouncil) and the Centre for Professional Engineering Education (CPEE) to create a course to meet current industry needs delivering best practice, resulting in the launch of the new four unit Graduate Certificate in Asset Management in 2021. This program directly addresses upskilling in the area of infrastructure and roads, with the two core units being "Asset Management Principles" and "Economics of Financial Management".

The Asset Management Council is an internationally recognised organisation at the forefront of asset management knowledge and development who are a founding member of both the Global Forum on Maintenance and Asset Management (GFMAM) and World Partners in Asset Management (WPiAM) and a Technical Society of Engineers Australia.

National Chair Dave Daines said "we are delighted to be collaborating with CPEE who are known for delivering excellence in education in roads, pavements and asset management, whilst leveraging the expertise of AMCouncil to deliver this new course to the industry starting in semester one, 2021".

The course has been designed to be delivered fully online with ongoing interaction with Unit Chairs during the Semester. The first core Unit available deals with Asset Management Principles and meets with CPD requirements for Engineers Australia. For further information please email CPEE at **Enquiries@CentreforProfessionalEngineeringEducation**

AMCouncil CPAM and CSAM provide recognised prior learning for the first unit so those who hold current CPAM and CSAM certification are 1/4 of the way to obtaining their Graduate Certificate in Asset Management

New Members

Victor	DSilva
Matthew	Whitten
Phillip	Kowalczyk
Fairuz	Bin Abu Bakar
Drew	Wolfendale
Chantelle	Cox
Andrew	Smith
Mark	Mazzarolo
Dave	Martin
Brendan	McNamee
Natalie	Papaioannou
Lalit	Sonawane
Ben	Anderson
Magnolia	Garcia
Jarkko	Laukkanen
Sakib	Sarker
Edward	Brooks
Andrea	Phillips
Jillian	Meehan
William	Schuh
Peter	Nussey
Trileven	Balaba
Ian	Walters
Natalie	Thorne
Brian	Jacobs
Ken	Lewis
Darren	Jones
Samantha	McGrath
Patrick	Lamb
Mohsin	Ayub
Ian	Cameron
Roshan	Thomas John
Paul	Johnstone
Mick	Price
Tracey	Moran
Philip	Pountney
Justin	Lee
Matthew	Masnada
Craig	Callander
Frederik	Preisler
Adrian	Megaw
Matt	Stahl
Michael	Sparrow
Jared	Green

Wayne	Pearson
Mitchell	Burt
Alana	Deghelli
Nikita	Porth
Cameron	McNeil
Anjelique	Lorenz
Russell	Hopkins
Mark	Horton
Satyen	Kulkarni
Jawad	Shah
Niamh	Shuley
Paul	Huth
Shane	Hall
Karolyn	Gainfort
Daniel	O'Hara
Nathaniel	Dunnett
Peter	Howarth
Mark	Louisson
Scott	Campbell
Thomas	Bainbridge
Daniel	Hayes
Drew	Whittaker
Diego	Giraldo
Sean	Jenkinson
Mohammad	Abbasi
Ricky	Jones
Dup Lalit	Sonawane
Richard	Ashbrooke
David	Hindle
Gerard	Meleady
Allan	Wheeler
Bernard	Lauinger
Tenzin	Namgyal
Wayne	Bicket
Wayne	Yee
Gary	McDonald
Carl	Taylor
Ian	Layzell
Jake	Delauney
Rebecca	Garrett
Richard	Gaisbauer
Enaam	Alhashimi
Boyd	McCarron
Rebecca	Walker

New Members

Brian	Saltmarsh
Luke	Saltmarsh
MM Naushad	Ameen
Tarique	Memon
Shane	Walker
Danielle	Channing
Anthony	Woodcock
Johanna	Kieboom
David	Chin
Neil	Bond
Edward	Smelt
Terry	Franklin
Govinda	Pandey
Ryan	Davis
Mark	Rippon
Ali	Arain
Ninh	Ho
Samanthie	Warusapperuma
Jie	Khor
Karen	Miller
Kelly	Dang
David	Jansen
Amutha	Thananjeyan
David	Keam
Simon	Barlow
Jeevan	Pinto
Lillian	Iannello
Yad	Hunjan
Grace	Ashworth
Jason	Sharp
Melissa	Huntbach
Dave	Robinson
Weibin	Gu
Ali	Khan
Jay	Hong
Mayank	Tandel
Linda	Kemp
Gemma	Chandan
Jason	Ng
Prageeth	Gunarathna
James	Salmon
Keith	Blackwood
Roshani	Benedict
Paul	Dwyer

Simon	Murray
Louise	Coulson
Alex	Au
Tim	Clarke
Marie	Kos
Greg	Ellis
Gary	Nisbet
Shaun	Fisher
Puneet	Nangia
Jun	Lu
Ashan	Dissanayake
Samir	Ahmed
Brendan	Walker
Priya	Pathmanathan
Jeremiah	Naidu
Russell	Williams
Hammad	Mirza
Kasey	Kehoe-Cox
Perrine	Parrod
Arthur	Wessling
Amalia	Tsalanidis
Willem	Gouws
Gini	George
Dominic	Clancy
Sean	Ghotbi
Benjamin	Murphy
Michelle	Barkley
Jonathan	Mendes
Mark	Oppenheim
Styfan	Siryj
Manisha	Manisha
Christopher	Dann
Will	Hackney
Maxine	Taylor
Theresa	Maloney
Joe	Schwinge
Khalid H	Qureshi
Dave	Plant
Joseph	Thomas
Nidal	Bilal
Andrew	Compson
Gavin	Roche
Belinda	Hodkinson
Alex	Pejcinoski

Ian	Mortimer
Andrew	Gaff
Sam	Shien
Dean	Jadidi
Steven	Perks
George	Bardis
Annie	Lay
Jono	Griffiths
Chi	Fung
Matt	Kahatapitiya
Carol	Mathew
Stuart	Dick
Eddie	Tsoi
Marc	Cleave
Graeme	Peckman
Ashley	May
Keith	McArtney
Daniel	Cooper
Blair	Porteous
Chris	Coulson
Domingo	Tshiany
Pren	Dodaj
James	McIntosh
Marion	Pennicuik
Kevin	Smith
Heron	Herath
Graeme	Fletcher
Madeleine	McManus
Susan	Rebano-Edwards
Dennis	Canham
Luka	Baresic
Cathal	Codyre
Manuel	Dussault Gomez
Kevin	Chan
Phillip	Conroy
Jamie	Emmart
Stephen	Roberts
Neena	Nandigam
Thomas	Young
Cassandra	Biano
Paul	Eady
Dawn	Spence
Ben	Heywood
Robert	Doig

Catherine	Hodgson
Svetlana	Brengauz
Boris	Yiu
Garry	Brosnan
Logan	Bax
Tony	McQuillan
Jo	Harris
Alex	Castellanos
Luke	Basilicata
Andre	Vidoto
Sonia	Cain
Muhammad	Hussain
Christopher	Dhu
Rhett	Watters
Joanne	Piggott
Nick	Rawlings
Graeme	Pitman
Ross	Antunovich
Christian	Molina
Khalid	Alessa
Jude	Carey
Arthur	Kwok
Tracy	Strawn
Arvinasha	Ludwig
John	Woodhouse
Andy	Long
Luis	Isaza
Paul	Bold
Tim	Davies
Chetan	Watel
Jerome	Pabbruwe
Troy	Morse
Joe	McGinlay
Lakey	Tshering
Lalinda	Karunaratne
Steven	Zheng
Nibu	Paul
Christian	Cano
Nigel	Gravett
Matthew	Cichon
Jai	Patel
Paul	Morris
Raymond	Victor
Priscilla	Nguyen
Clair	Brennan

New Members

Vijaya	Moorthy
Robert	Stacey
Katrina	Holmes
Manny	Aguspina
Clayton	Bishop
Sharyn	Curran
Jarrad	Brown
Abbas	Mohammed
Frederick	Foley
Daniel	Goddard
Murfie	Siqueira
Jordan	Robb
Hamlet	Ghookazian
Brenton	Marchuk
Paritosh	Chaturvedi
Ray	Boskell
Darren	Barlow
Hatim	Essajee
Ibrahim	Qureshi
Rodney	Dietrechesen
Juan	Sebastian Guzman
Rob	Ellis
Peter	Corcoran
Troy	Drewett
Sarah	McMurray
Md Zahurul	Huq
Manoj	Tupkari
Gagan	Bajaj
Graham	Clements-Jewery
Jeremy	Lane
Jon	Kirk
Tim	Moore
Saleh	Forouhari
Thilan	Abeyaratne
Marta	Maszkowski
Matt	Carter
Nathan	Chircop
Scott	Widderick
Kevin	Szczyglak
Deerendra	Luckheenarain
Roger	Makins
Claire	Wilson
Atukoralalage Don Janaka	Seneviratne
Siddhartha	Ampolu
Darryl	Tolentino
John	Gregory
Steve	McMahon
Meredith	Bennett
John	Ijaz
Dean	Helm
Danny	Liston
Andrew	Heathcote
Peter	Kapocius
Marcia	Prelog
Damien	Cutcliffe
Martin	Greaves
Willyan	Andrade
Rahul	Chowdhury
Nicholas	Wilson
Hassan	Monnoo
Terence	McCarthy
Ahmad	Romman
Chris	Van der Walt
Sam	Ainley
Carlee	Stacey
Louise	Beer
Steve	Ebejer
David	Harding
Bryan	O'Sullivan
Siew Wei	Goh
Giovanni	Marsi
Oscar	Weeks
Suresh	Adhikari
Sam	Gard
Shreyas	Rajpurkar
Bruno	Martino
Rob	Whitfield
Joga	Jayanti
Babee	Palanivel
Aaron	Luckman
MD	ISLAM
Sujay	Mondal
Sarah	Lim
Rafid	Morshedi
Alex	McDonald
Isabelle	Moss
Jean	Dupavillon
Miranda	Snowdon
Rachael	Stewart
Arman	Kianpour

Jeremy	Amann
Helen	Gill
Jason	Ambrose
Ravi	Kiran
Simon	Gibbs
Cathy	Small
Richard	Ganski
Ryan	Fletcher
Anurag	Sharma
Naomi	Rogers
Toni	Cappiello
Alex	Torville
Gavin	Sansom
Greg	Brierley
James	Christian
Peter	Nanevski
Samantha	Dias
Bea	Lee
Daniel	Freebody
Lucio	Favotto
Penny	Green
Talia	Zanotto
Niraj	Edwards
Marlene	Marques
Lexi	Christou
Fahad	Shaban
Pete	Keel
Brendan	Luckman
Tom	Mactier
Ahmed	Abdelrehim
Mak	Haty
James	McCarthy
Chloe	Lingard
James	Hansen
Moe	Akindoyeni
Bruce	Rankin
Kristian	Farrugia
Daniel	Gynn
Adam	Moore
Nicholas	Wong
Eddy	Norburn
Bruno	Martino
Paul	Caprin
Cameron	Bacic
Eric	Poon

Jeffrey	Loughran
David	Gordon
Mohamed	Hamidaddin
Geoff	Rutledge
George	Greig
Scott	Zipf
Delene	Kock
Dave	Robinson
Innovyze	
Robert	Sauer
Northrop Grumman Integrated Defence Services Pty Ltd	
Juan	Rocha Pinilla
Francois	du Plessi
New Zealand Defence Force (Defence Equipment Management Organisation)	
Margaret	Daley
Northern Territory Government Dept. of Infrastructure, Planning & Logistics	
Gordon	Hang Gong
Abhijeet	Krishna
NVMS	
Nadia	Alvi
DAS Consulting Quarterbac	
Andrew	Haskins
Transdev	
Department of Treasury and Finance	
Paul	Bragg
Christopher	Jackson
Landcom	
Emma	Tongue
Carly	Gabel
Emma	Abberton
Department of Transport - Network Planning Group	
Daniel	Craig
Rockfield Technologies Australia Pty Ltd	
Matthew	Heath
Daniel	Maloney

How Much KNOWLEDGE & EXPERIENCE Protects Your Assets?

CFAM
Certified Fellow in Asset Management

CSAM
Certified Senior Practitioner in Asset Management

CPAM
Certified Practitioner in Asset Management

CAAM
Certified Associate in Asset Management

ARE YOUR EMPLOYEES ASSET MANAGEMENT COUNCIL CERTIFIED?

Improve Retention ▪ Enhance Recruitment ▪ Increase Portability

Get the facts: www.amcouncil.com.au/certification

Membership Application

ASSET MANAGEMENT COUNCIL

ASSET MANAGEMENT COUNCIL LTD

A Technical Society of Engineers Australia

ABN: 15 141 532 747 www.amcouncil.com.au
Phone: +613 9819 2515 Email: accounts@amcouncil.com.au

Thank you for joining the Asset Management Council. Please complete all sections. Phone or email with any queries.

PERSONAL DETAILS (Please print in BLOCK CAPITALS)

Title (Please circle) Dr Mr Mrs Ms Miss Other (Please specify) Sex (Please circle) F M

Family Name Given Names (in full)

Date of Birth Engineers Australia Membership No

CONTACT DETAILS (Please print in BLOCK CAPITALS)

Preferred Address: ☐ Private Address or ☐ Business Address

Position

Organisation

Postal Address

City State

Country Postcode

Phone Fax

Mobile

E-mail

AREAS OF INTEREST (Please tick)

Technical Topics

- ☐ Reliability
- ☐ Availability
- ☐ Maintainability
- ☐ Performance
- ☐ Spares Planning
- ☐ Maintenance Planning and Scheduling
- ☐ Maintenance Plan development and implementation
- ☐ Maintenance Policy/Strategy development
- ☐ Logistics
- ☐ Shutdown planning and the maintenance interface
- ☐ Asset Management
- ☐ Other:

Issues

- ☐ Skills development
- ☐ Training
- ☐ Other:

Industries

- ☐ Facility Management
- ☐ Consulting
- ☐ Power
- ☐ Transport
- ☐ Defence
- ☐ Oil and Gas
- ☐ Mining and Industry
- ☐ Water and Utilities
- ☐ Infrastructure
- ☐ Other:

Return completed Membership Application with payment to:
Asset Management Council
PO Box 2004, Oakleigh Vic 3166

GROUP AFFILIATION

☐ Young Asset Management Practitioners (18-35 year olds)

CHAPTER AFFILIATION (Please tick one)

☐ Newcastle ☐ Canberra ☐ Sydney ☐ Illawarra ☐ Mackay
☐ Melbourne ☐ Adelaide ☐ Brisbane ☐ Hobart
☐ Darwin ☐ Overseas ☐ Gippsland ☐ Perth

MEMBERSHIP FEES Effective Jan 2015 (Please tick one membership type only)

Individual Annual Fee (including GST)

☐ Member $154.00
☐ Student $33.00

Corporate Annual Fee (including GST)

☐ Platinum $9,570.00 ☐ Gold $3,608.00
☐ Silver $1,804.00 ☐ Bronze $957.00

GST (10%) does not apply to overseas memberships.

CORPORATE MEMBER NOMINEES

Platinum – 30 nominees, Gold – 10 nominees, Silver – 10 nominees, Bronze – 5 nominees

	Name	Email	Date of Birth (Mandatory)	AM Council Chapter
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Contact Asset Management Council to provide more corporate nominee details.

PAYMENT

Method of Payment (please tick one and enclose payment)

☐ Cash

☐ Money Order or Cheque drawn in AUD from an Australian bank) payable to **Asset Management Council Ltd**

☐ International Money Order

☐ Credit Card
(Australian or New Zealand Bankcard only acceptable)

Credit Card Details Please charge my card (tick one card type)

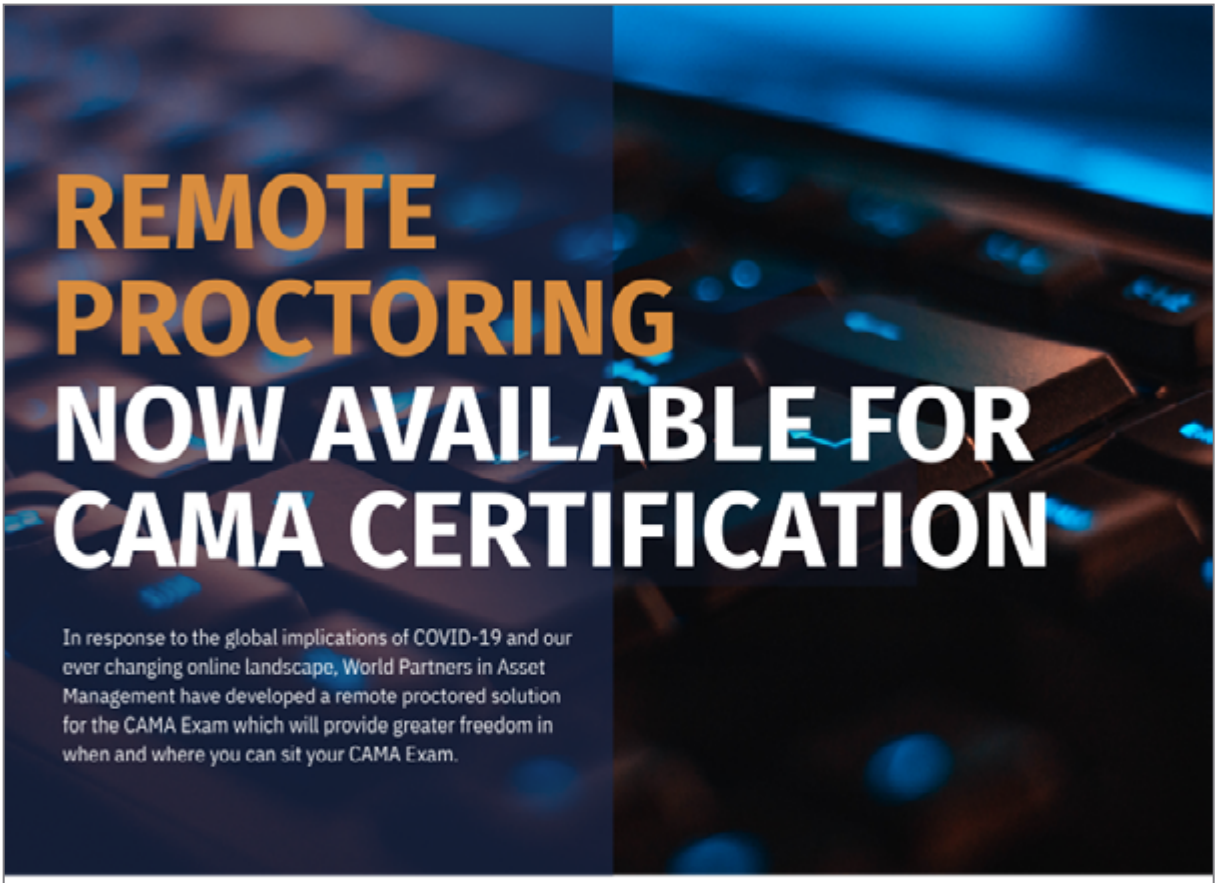
☐ Visa ☐ Bankcard ☐ Mastercard
☐ Diners ☐ American Express

Card no _____

Expiry _____ Amount $ _____

Name on card _____

Signature _____ Date _____



REMOTE PROCTORING NOW AVAILABLE FOR CAMA CERTIFICATION

In response to the global implications of COVID-19 and our ever changing online landscape, World Partners in Asset Management have developed a remote proctored solution for the CAMA Exam which will provide greater freedom in when and where you can sit your CAMA Exam.

ONLINE & SECURE

The online platform uses latest technology to keep your information secure and to allow for a fair and equal testing environment

GLOBAL DELIVERY

Our Remote Proctored Solution will allow individuals to sit the CAMA exam, no matter their location around the globe

FLEXIBILITY

The online nature of this testing solution will allow for greater flexibility in when you can sit the exam.

Introducing the Asset Management Council's

Asset Management Mindmap

Earn badges as you navigate through this interactive asset management learning tool

This interactive asset management learning tool is a visual representation of asset management and all it's interconnected elements.

Starting with the central concept - Asset Management of course! - **work your way through the mindmap,** learning and exploring the different sections that make up asset management, and earn badges as you go.

Visit the link below to get started and earn your first badge:

www.amcouncil.com.au/Asset_Manangement_Mindmap

Corporate Partners and Corporate Members

Partnering Organisations

Broadspectrum | www.broadspectrum.com

STRATEGIC PARTNER

ASC Pty Ltd
iNSW

PLATINUM

ASC Pty Ltd
Asset Management Branch, Transport for New South Wales
Ausgrid
BAE Systems
BGIS
Broadspectrum
Downer Group
Roads and Maritime Services
South32
Transdev

GOLD

Airservices Australia
AssetFuture Pty Ltd
Austal Ships Pty Ltd
Bombardier
Capability Partners
Department of Defence CASG
Department of Fire and Emergency Services(WA)
Department of Health and Human Services
Department of Transport - Network Planning Group
Energy Queensland Limited
Essential Energy
Evoenergy
GHD Pty Ltd
HATCH Ltd.
Health Infrastructure
Infrastructure NSW
Innovyze
Jacobs
KPMG
Lendlease Services Pty Ltd
Naval Ship Management (Australia)
Northrop Grumman Integrated Defence Services Pty Ltd
Parks Victoria
Port of Newcastle
Power and Water Corporation
Public Transport Victoria
Ramco Systems
Rizing
SAP
Stanwell Corporation Limited
Sydney Water Corporation
Thales Australia Limited
TransGrid
Transurban Ltd
V/Line
Ventia Pty Limited
Victorian Health and Human Services Building Authority
Warship Asset Management Agreement Alliance
Western Power
Wood Plc (Australia)
WSP Australia Pty Limited
Xenco Pty Ltd

SILVER

AECOM Australia
AMCL
AssetFuture Pty Ltd
Aurecon Australia Pty Ltd
Aurizon Network
Australian Rail Track Corporation Ltd (ARTC)
Babcock International Group
BGIS
Cardno (QLD) Pty Ltd
City of Gold Coast
Comfort Delgro NSW
Copperleaf Technologies
Court Services Victoria
Department of Transport
Gladstone Ports Corporation
ISS Facility Services
Jemena
John Holland Group Pty Ltd
Kellogg Brown and Root Pty Ltd (KBR)
Lycopodium Infrastructure Pty Ltd
Metro Trains Melbourne (MTM)
Monadelphous
Norship
Northern Territory Government Dept. of Infrastructure, Planning & Logistics
Nova Systems
Origin Energy
Programmed Facility Management
Public Transport Authority
RES Australia
Sutherland Shire Council
Sydney Trains
VicTrack
Western Water

BRONZE

Alinta Energy Loy Yang B Power Station
Anglo American Metallurgical Coal
ANSTO
ARMS Reliability Engineers
Arup
Assetic Pty Ltd
Assetivity Pty Ltd
Atlas Personnel Services Pty Ltd
Atos (Australia) Pty Ltd
ATTAR
Australia Pacific Airports (Melbourne)
Ballance Agr-Nutrients
BHP
Boeing Australia
Brisbane Airport Corporation
Bureau Veritas
Carbontech Composite Systems
CBC Facilities Maintenance
City of Port Adelaide Enfield
Copperleaf Technologies
Covaris Pty Ltd
Crystalise
Cushman and Wakefield
DAMS Safety NSW
DAS Consulting
Delta Facilities Management Pty Ltd
Department of Communities
Department of Jobs, Precincts & Regions
Department of Treasury and Finance
Fremantle Ports
Gladstone Area Water Board
Goulburn Valley Water
GPA Engineering Pty Ltd
Hardcat Pty Ltd
Honeywell Limited
Horizon Power
Hunter Water Corporation
IBM
Indec Consulting
Innovative Thinking IT
Institute of Quality Asset Management
Lake Maintenance Pty Ltd
Landcom
LogiCamms
Logsys Power Services
Maca Infrastructure
Melbourne Water
Meridian Energy
Minset
New Zealand Defence Force (Defence Equipment Management Organisation)
Newcastle Coal Infrastructure Group
Nexus Global Australia
North East Water
NRG Gladstone Operating Services
NSW Ports
NVMS
Ontoit Global Pty Ltd
Oropesa Port Management Pty Ltd
Pacific Hydro
Powerlink Queensland
Powerplan
QENOS
Quarterbac
Queensland Rail
Refining NZ
Rockfield Technologies Australia Pty Ltd
SA Water Corporation
School Infrastructure NSW
SEQWATER
Shoalhaven Water
SMEC Australia Pty Ltd
SPM Assets
Structural Integrity Engineering Pty Ltd
STRUCTURED CHANGE PTY LIMITED
Strukton Rail Australia Pty Ltd
TAFE NSW
Taronga Conservation Society Australia
Tasports
TasWater
Terotek (NZ) Limited
The Asset Management College
Transdev Sydney Pty Ltd
Trendspek
Unison Networks Limited
United Energy Services Pty Ltd
VicRoads
Victoria State Emergency Service
Water Corporation
WaterNSW
Work Management Solutions
Yarra Ranges Council

ASSET MANAGEMENT COUNCIL

THE ASSET JOURNAL

Asset Management Council
PO Box 2004
Oakleigh Vic 3166
Tel 03 9819 2515
www.amcouncil.com.au