

SUSTAINING WATER INFRASTRUCTURE, AFTER THE GOLD RUSH

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ABSTRACT

Much of the infrastructure in the City of Dunedin, was developed during the boom years following the discovery of gold in the region in the 1860s. Subsequent periods of population decline and recession left a legacy of ageing infrastructure and substantial deferred investments in water renewals, which presented a significant problem for the current generation to address. To sustainably meet the present and future needs of the city, a new approach to the planning and management of the water infrastructure was required. The approach by the Dunedin City Council (DCC) to resolve the issue, comprised of four key steps; creation of a business improvement plan, development of a ‘Three-Waters Strategy’ (water, wastewater and stormwater), international benchmarking, and a comprehensive review of governance arrangements. Through the Three-Waters Strategy development work, and the knowledge gained by building integrated hydraulic models of the three-waters on a common modelling platform, a significant improvement in business performance was achieved.

KEYWORDS: Water, three-waters, ageing infrastructure, advanced asset management, utility planning, modelling, governance, sustainability.

1. INTRODUCTION

The purpose of this paper is to discuss the issues relating to the sustainable management of ageing water infrastructure, with particular application to the ‘Three-Waters’ which was developed in Dunedin, during the boom that followed the discovery of gold in the Otago region in the 1860s. This event, coupled with the rapid expansion of the province, established Dunedin as the industrial, commercial, and cultural hub of New Zealand which adorned the city with a rich collection of handsome Victorian and Edwardian structures in the built environment. However, it has also left the city a legacy of ageing water and drainage infrastructure which has suffered some neglect over the ensuing generations.

In response to these legacy issues, this paper outlines the integrated strategic management approach that was commenced in Dunedin in 2006 to overcome the resulting decline in service performance. It presents a method of determining the appropriate maintenance, capital, and renewals response required to ensure that the future investment in water infrastructure to address the problem is appropriate, optimised, and affordable.

1.1 A BRIEF HISTORY OF DUNEDIN

Dunedin was founded in 1848 by the Lay Association of the Free Church of Scotland who named it Dunedin; which is the Gaelic name of her sister city, Edinburgh and so has been termed the “Edinburgh of the South” and the city is modelled on her Scottish sister.

The first public administration was established in 1853 when the Otago Provincial Council was constituted which was later followed by the establishment of the Dunedin Town Board in 1855

(McLintock, 1949). Dunedin had a modest population of less than 2,000 just prior to 1861, when in May of that year Australian prospector Gabriel Read first discovered gold in Otago some 70km inland from Dunedin, in a place now known as Gabriel's Gully (Brooking, 2004). Read had previously prospected in both, Victoria, Australia and California. His discovery sparked the gold boom in Otago and resulted in the rapid growth of Dunedin as the entry port for prospectors and traders.

The rapid population growth of the city (around 15,000 in 1900), gave rise to demands for the civic administration to urgently provide adequate sanitation and water supply to the city, which suffered severe unsanitary conditions. Consequently, the Dunedin Sanitary Commission was established in May 1864 to develop options for improving sanitary conditions in the city, which at that time had an annual mortality rate of over 35 persons per 1,000 population – more than 2 ½ times greater than the highest ever recorded in London during the black plague (Alfred, *et al*, 1865). By comparison, mortality rates today are now between 5 and 7 per 1,000 in developed western countries such as the UK, the USA, Australia and New Zealand. (United Nations Department of Economic and Social Affairs, 2010).

The first sewerage system, as recommended by the commission, was proposed to collect wastewater from the city via a drainage network connected to an arterial sewer interceptor to be discharged into the Otago Harbour. Concurrently, the private Dunedin Water Works Company commenced construction of the first reticulated water supply in the city from the country's first earth dam located at Ross Creek, which would provide 115 days storage (235 megalitres) for the town (Barr & Oliver, 1873).

1.2 PRESENT DAY

The infrastructure built in the latter part of the 19th century was of a very high standard and has proven to be remarkably resilient, as much of it is still in service today. However, whole-of-life asset management of buried infrastructure is a relatively modern concept. With recent techniques, developed for risk based criticality and condition assessment, we are better able to determine the residual life of an asset. From an analysis of the current data it has been established that the majority of the \$1.6 billion of water and waste assets in the city are more than half way through their theoretical useful life. This finding presents a significant problem to both current and future generations in their ability to fund renewals at a sustainable level. Ageing networks also present operational and maintenance problems due to the increasing frequency of blocks, breaks, and bursts as assets age. In early 2006 the water and waste business unit, despite having some large capital projects under way to meet new national drinking water and environmental standards, were operating in a largely reactive mode with a maintenance response focus, and very little strategic planning capability. In order to address the critical issues facing the business unit a new approach was required. This commenced with the creation of a "Vision for Three-Waters", followed by the development of a master plan that would guide the journey to its achievement.

2. METHODOLOGY

2.1 BUSINESS MASTER PLAN

The master plan involved a business improvement initiative, developed through collaboration and workshops with key managers and staff, using external expertise where required.

The four key steps identified to achieve sustainable water infrastructure are summarised:

2.1.1 BUSINESS IMPROVEMENT PLANNING - Defining the problem statements that outline the current shortcomings and recommend the actions required to address each one with a clear timetable and budget, and tasked to a specific individual or group.

2.1.2 THREE-WATERS STRATEGY DEVELOPMENT - A substantive piece of work in two parts, aimed at improving strategic planning and building a greater capacity for advanced asset management through an integrated study and detailed hydraulic analysis of the three-waters network. Together they provide a roadmap for planning and optimising decision-making on future infrastructure investments.

2.1.3 INTERNATIONAL BENCHMARKING - The process of measuring progress towards strategic objectives by benchmarking against like organisations, particularly those that demonstrate industry leading best practice.

2.1.4 REVIEW OF GOVERNANCE ARRANGEMENTS - A process of objectively assessing the governance arrangements of the utility, to deliver the best outcomes for customers while maintaining a clear and professional focus on the sustainable stewardship of the infrastructure.

2.2 BUSINESS IMPROVEMENT PLANNING

The improvement plan had two main parts. The first was to establish an integrated activity management planning process and framework. This would improve the knowledge of infrastructure assets, and bring together disparate parts of the business onto a common planning platform. This was because the water and drainage teams were still working in vertical silos that aligned with their traditional origins of the former Council run Water Department, and the separate Dunedin Drainage and Sewerage Board.

The second part of the plan was to restructure the business unit to better align the people and processes, to fit the new delivery framework and give it a far more strategic focus.

The improvement plan had four key drivers:

- To understand what customers and stakeholders required from their water service provider, in order to further develop appropriate and achievable levels of service, and to establish meaningful performance measures.
- To improve knowledge of the infrastructure, given the significant asset data gaps identified in relation to pipe materials, location, age, condition, criticality and hydraulic performance.
- To embed advanced asset management principles and techniques into planning processes.
- To increase efficiency and effectiveness of the business unit.

A number of outcomes were identified at the start of the project that were expected to be delivered from the implementation of the improvement programme. These included:

- The development of an integrated Three-Waters Strategy for the city, aligned with the Council and community expectations for the next 50 years.
- The development of a sound process for multi-criteria analysis, and optimised decision-making.
- The development of a quality management framework and documentation, to clearly define business processes across the enterprise that would deliver the best overall outcome for the city.
- To establish clearly defined and meaningful performance indicators that could be benchmarked against best practice and easily reported.
- To gain better access to important activity management information, through intuitive graphical user interfaces, from one single data source, using tools such as GIS and data warehousing.
- To ensure that Activity Management Plans were useful and succinct, which clearly outline how the business will manage its responsibilities.
- To formulate policies, procedures, and processes that are derived on the basis of well-established engineering principles and asset management practices.
- To achieve defensible and transparent forward planning for infrastructure capital and renewal investment based on sound economic and sustainability principles.

- To improve data quality, to ensure the right information is available to inform capital and renewal decision-making, and to support major resource consent applications that are pending.
- To ensure compliance with the Local Government Act and other regulatory requirements as an automatic outcome.

The Business Improvement Plan also gave rise to the Three-Waters Strategy Project which ran in parallel with the structural reorganisation of the Business Unit, in order to break down the historical silos and introduce cross-functional teams that would work across all three-waters, and provide the much needed strategic planning focus.

Although organisational reforms of this nature are sometimes difficult, the long-term benefit of having the right people in the right roles, doing the right things, outweighs the short term pain of change.

2.3 THREE-WATERS STRATEGY DEVELOPMENT

With the Business Improvement Plan launched and a change management restructuring process underway, work commenced on developing the Three-Waters Strategy for Dunedin. This was designed to ensure water utility services continued to meet the reasonable needs of the community and statutory obligations out to 2060 and beyond, in a sustainable way.

The initiative had two components. The first was to develop a Three-Waters Strategy document (finally termed the “3 Waters Strategic Direction Statement”), to define the long-term strategic intent and set the priorities for future focus. The second was to complete a technical analysis of the infrastructure known as the Three-Waters Strategy Project. This would improve knowledge of city networks and deliver tangible outputs, including calibrated hydraulic models, system performance reports, integrated catchment management plans, and capital works master plans that would provide a range of solutions to the issues identified in the study.

The work on the Three-Waters Strategy Project commenced in August 2007 when engineering consultants Beca, were engaged to prepare an invitation seeking proposals from consulting firms or consortia for the first stage of the three-water strategy development for the city which would:

- Determine capital and operational costs associated with improvements to the three-waters networks, priorities, and phasing for investment.
- Develop a greater understanding of the networks’ operations and performance through targeted asset data, rainfall, and flow data collection.
- Development of decision support tools, including network models.
- Provide sufficient data in a format suitable to inform the development of stormwater catchment management plans, required to support resource consents to the harbour and marine environment.

The key deliverables in this project were to:

- Review the current levels of service for appropriateness and affordability over the planning horizon of the study out to 2060, and to define and document problems previously identified within the networks (including known areas of high pressure, low pressure, water quality, spills, overflows, flooding, and knowledge gaps).
- Review asset data and collect additional asset data, required to support the development and calibration of hydraulic network models.
- Determine the network deficiencies against the defined levels of service, by completing the models and running future demand scenarios for 2010, 2030 and 2060. These modelling scenarios would take into consideration future population forecasts, as well as the influences of climate change and sea level rise based on the Ministry for the Environment predictions for Otago, derived from the IPCC’s 4th report.

- Develop Master Plans for the water and wastewater networks, which would describe solutions for single or groups of assets for the given future demand scenarios that also addresses the present day issues. These plans would also prioritise where more detailed investigations were required to be undertaken in the subsequent phase of the strategy.

The consultancy contract for the Three-Waters Strategy development work was awarded in December 2007 to a consortia comprising of Opus International and URS, who began the project at the beginning of 2008.

A project governance and review structure was established at the outset which saw the establishment of a Project Control Group (PCG) which comprised of:

- Opus international as lead consultant.
- URS as the co-consultant on stormwater modelling and primary authors of the catchment management plans.
- Beca as project managers and peer reviewers.
- Metrowater personnel (the major Auckland water utility company) as industry advisers.
- DCC water staff, including an Asset Planning Manager, an Asset Strategist and a Modeller.

The PCG met on a monthly basis for the duration of the project and shared information on a web based extranet site, so everyone had ready access to project plans, reports, reviews, agendas, data files, and a host of other information without the need to compromise the security of anyone's enterprise IT environment.

During the three years of the project, the team delivered what is considered to be an outstanding result, completed on time and within budget to a technical standard that can be described as exemplary. It was arguably the first in New Zealand (and perhaps internationally), where such a comprehensive integrated three-waters modelling analysis was carried out across the entire water cycle of a city on a common platform, and the results analysed by a collaborative group in order to develop smart, integrated solutions.

The outputs of the project included:

- A calibrated model of the trunk raw water systems (over 150 km of mains).
- A calibrated, all mains model of the treated water networks (1,350 km).
- A calibrated backbone model of the city's wastewater network, and detailed leaf models of priority catchments (880 km).
- A calibrated model of the city's strategic stormwater systems discharging to the marine environment (365 km).
- 10 integrated catchment management plans that provide not only a future methodology for improving the performance of the stormwater system, but also to support long-term resource consent applications for the discharge of stormwater to the environment.
- A suite of detailed reports; hydraulic performance, rainfall, groundwater, tidal monitoring, water quality monitoring, and issues and options for remedial works.

The key to the success of the Three-Waters project can be attributed to the open collaboration between all of the parties within the partnership, and their commitment to delivering what was best for the project.

While members of the team changed from time to time (for various reasons), the commitment to the project and the open, collaborative culture was retained, even through the most challenging circumstances; such as when key members of the team were personally impacted by the series of earthquakes in Christchurch, between September 2010 and June 2011 (which was where most of the modelling team were based at the time, in the Opus & URS offices). Despite these difficulties, the project was completed by 30 June 2011, as planned.

2.3.1 OPTIMISED DECISION-MAKING

While the Three-Waters Strategy study was in progress, internal staff at the DCC developed advanced optimised decision-making (ODM) tools and techniques, to be applied to project selection using a common quadruple-bottom-line (QBL) decision-making framework. This framework incorporates economic, social, environmental, and cultural considerations, which are required in New Zealand to meet the legislative requirements for achieving or promoting community outcomes. The ODM approach was used to ensure that all capital and renewal expenditure was applied where there was the greatest overall return on that investment, whilst also achieving the organisations QBL outcomes. These complex investment decisions considered a large number of tangible and intangible factors within the decision-making framework, such as:

- The age, condition, capacity, criticality, risk profile, performance, and maintenance cost of the asset.
- The benefits and costs of alternative intervention (renewal or replacement) strategies against each of the QBL outcomes.
- The evaluation of the most optimum intervention response.
- The degree to which the response is influenced by the projected future needs over the “whole-of-life” of the asset under analysis.
- How the proposed response impacts on the present and future levels of service, and what trade-offs (if any) would need to be made.
- What impact will influences of global warming, climate change and sea level rise have on decision-making processes.
- The evaluation of carbon cost of each intervention strategy.
- Determining dependency on and risks associated with oil products while faced with the peak oil crisis and increasing costs of oil based products.
- Local political circumstances that may influence investment decisions.

This optimised approach gives confidence to investment decision-makers and stakeholders that the recommendations from their Engineers and Asset Managers are robust, and based on sound economic principles, as well as critical non-financial criteria.

2.3.1 KEY BENEFITS OF THE PROJECT

The Three-Waters Strategy Project has to-date delivered a number of significant benefits to the Dunedin City Council Water and Waste business unit in a number of key result areas, including:

- **Financial Management** - Improved economic outcomes are now achievable through prudent infrastructure investments, that are optimised to provide the best return on investment.
- **Customer Service** - The project has enabled a clear line of sight between levels of service, community outcomes, and the related costs. It also provided a genuine opportunity for the public and community groups to meaningfully engage in the planning processes for the three-waters.
- **Organisational Performance** - From an organisational perspective, the project assisted the Dunedin City Council to develop a robust and reliable strategic planning capability. It simultaneously addressed many improvement initiatives that had been identified in earlier Activity Management Plans and benchmarking exercises. It assisted the business along the path of developing advanced asset management techniques, and a number of parallel and complimentary processes were initiated, including the development of a condition assessment policy and programme, plus a detailed criticality analysis of assets.
- **Environmental Stewardship** - In environmental terms, the project delivered some significant and immediate benefits in reducing the impact of sewer overflows to the city’s living and marine

environment. Water quality issues that impact on the values of tangata whenua (people of the land) and their traditional food gathering resources were identified through the project. Improved operational efficiencies resulted in reduced power and chemical consumption, and less water wastage.

- **People Development** - The project provided an excellent training and career development opportunity for staff in all the participating organisations, and captured knowledge that will endure to the benefit of future projects. The working inter-relationships developed through the project have been the catalyst for positive culture change within the DCC, which will hopefully continue long into the future.

2.4 INDUSTRY BENCHMARKING

The third key step on the road to sustaining water infrastructure was the commitment the city made to participate in the International Water Association and Water Services Association of Australia (IWA/WSAA) Asset Management Process Benchmarking Project in 2008. The purpose of this project was to chart a baseline for business performance against our international peers. The benchmarking project is conducted once every four years, and it was the first time that the DCC had participated with the 40 other utility companies from Canada, USA, Australia, Hong Kong, Middle East, and New Zealand, to determine where they ranked amongst some international heavy-weights. As one of the smallest water utilities to take part, there was no great expectation to score that well against some of the very large and well resourced utility companies, but it did provide a clear road map of what needed to be done to improve asset management practices and performance. It also provided access to engage with the utilities that demonstrated best practice in particular areas that were identified for improvement.

Across the seven main asset management functions, the DCC scored a “satisfactory” average for a utility of its size, with asset management processes that could be described as basic, but on a path of improvement. However, the DCC was commended as achieving best practice in their peer group, for stakeholder engagement through the use of “Well-Being” forums that were conducted with the community in order to set levels of service.

In a self assessment carried out earlier in 2011, using the IWA-WSAA Aquamark tool (which is a web-based system for assessing asset management performance), a significant improvement against the 2008 scores was observed. It is expected that this will further improve by the time the next formal assessment is carried out in March 2012. This lift in asset management performance can be largely attributed to the effectiveness of the Business Improvement Plan implementation and the Three-Waters Strategy work.

2.5 REVIEW OF SERVICE DELIVERY & GOVERNANCE ARRANGEMENTS

The final step in delivering the original Vision for Three-Waters is optimising the governance arrangements of the water utility to align with international best practice. One of key findings from the IWA – WSAA Benchmarking exercise in 2008, was the identification of the core attributes of high performing water utilities. Those utilities had three attributes in common:

- They were large single purpose utilities organisations with a large customer base.
- They operated in a well-structured, regulated environment with an independent monitoring body.
- A board of professional directors, appointed for their relevant skills and experience, commercially governed them.

In 2009, the DCC commenced a review of the service delivery options for the provision of water services in the city. The review was requested in order to understand the advantages and disadvantages of various options for service delivery including; retaining status quo, creating a

Council Controlled Organisation (CCO), or a Council Controlled Trading organisation that had a profit motive, or an outsourcing model.

After a substantial analysis of all the options over a two year period, and the development of financial models for each scenario by PricewaterhouseCoopers, the DCC agreed that there were sufficient benefits identified that supported serious consideration of a more commercial delivery model for water and waste services.

The DCC has now reached a point where they are about to engage in a consultation process with the community over their preferred option, which is to create a Council Controlled Organisation (with the working title of SouthernWater). The new entity is proposed to be a limited liability company 100% owned by the city, but governed by an independent board of directors. In the proposal, the Council will retain the role of the utility regulator and would control pricing mechanisms, performance standards and strategic direction, through the company's Statement of Intent, which would be subject to annual reviews and regular reporting.

In considering the establishment of SouthernWater, the DCC has gone to great lengths to make clear to the community there is no desire or intent to sell or reduce their 100% shareholding in the water utility, either now or in the future. The community had previously indicated a fear that their water assets could be sold into private ownership, with a resultant increase in water tariffs in order to return a profit to private investors.

However, examples that have been studied in Victoria, Australia and in Scotland, demonstrate there can be significant benefits in commercially structuring water utilities, whilst retaining 100% public ownership. A paper published in the November 2010 edition of the NZ Water Journal, entitled "The Scottish Water Experience" (Mackie, 2010), is recommended for further reading on the achievements of Scottish Water (who are the publicly owned, single water utility provider for all of Scotland).

3. CONCLUSIONS

While the DCC is currently in the final stages of this four-step journey to sustainable infrastructure, significant progress has been achieved in the last few years which has substantially improved knowledge of the assets and the performance of the three-water networks. Some of the early achievements along the journey so far have delighted some customers, where simple solutions have been found for long standing problems (such as nuisance flooding or sewer overflows). It has also provided an improved understanding of the risks, and criticality within the networks, and has increased confidence in the long-term investment strategy for managing renewals that will see improved levels of service to customers, and ensure stable water bills into the future.

In closing, there is no silver bullet that will ensure the sustainability of water infrastructure that was first constructed after the gold rush 150 years ago, but with the right vision, a clear plan, and a committed team working in a close collaboration to implement the four steps outlined within a three-waters strategy, sustainable water infrastructure can be a reality, rather than just a pipe dream.

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