WATER

Issue 185. July 2014

Special Feature – The Ruataniwha Dam

Progress Report: Seismic Impact on Underground Infrastructure

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The New Zealand Water & Wastes Association Waiora Aotearoa

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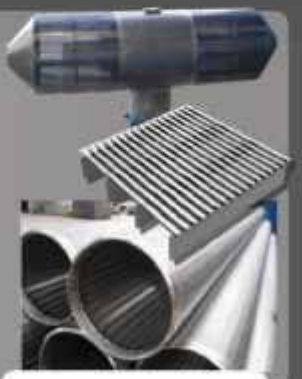

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The next issue of *WATER* will be published in September 2014.

WATER

On the Cover

Water New Zealand News

Features and Articles

Cover photo: Water storage ponds, near Blenheim (i.stock.com)

The official journal of *Water New Zealand* – New Zealand's only water environment periodical. Established in 1958, *Water New Zealand* is a non-profit organisation.

Steve Couper

A Refreshed Vision

In April this year your Board ran a full day strategy workshop to set some strategic goals for the next three years. We took a long hard look at ourselves and considered the previous strategic plan implemented in 2011.

In particular we took a look at our vision, mission, and core purpose, and we considered the seven strategic goals that we had set in 2011 with a view to reducing these to a more manageable number. We also wanted to focus more on our members and their requirements.

In the 2011 strategic plan (available on the Water NZ website) our vision was: *ensuring sustainable water services for New Zealanders.* Our mission: *promoting and enabling sustainable management and development of the water environment*.

This vision and mission, while admirable, was not perhaps something that was in our control, and there is indeed a range of opinions as to what 'sustainable water services' means.

Our team in Wellington led by Murray Gibb has done an excellent job advocating for the New Zealand water sector. They have, over the last five years, moved us from a technical association to one that is now considered to be an active contributor to the debate around water management. This has provided our association with influence, but has also drawn out a range of views around a future model for the delivery of water services. We need to carefully consider exactly what we are advocating for.

Strategic planning is an important part of any organisation, and for us, it is important to ensure we have a member-centric focus. For this reason, the Board this time has gone some way to acknowledge the diversity of our membership and to identify common themes across our members.

The important question is 'what is important to all our members', and 'what are the common goals for the sector as a whole'? Upon reviewing the existing key themes we were able to rationalise these to the following that will hopefully provide a better focus for you, the members. They are:

- Lifting the profile of the water industry making us the 'go to' organisation for informed conversations and debates on water
- Identifying and promoting sound technological trends and innovation
- Advocating for high quality evidence based standards and decisions on water issues, and
- Providing great opportunities to network and learn with a focus on accessing technical expertise

At its core *Water New Zealand* is a network containing New Zealand's water expertise and no other organisation in the country can claim the breadth and depth of water knowledge that we possess amongst our membership. It is therefore fundamental that we use this network of knowledge to achieve the above four goals. In particular, I believe two areas where we could do better are lifting the profile of our sector and providing technical leadership.

The second of these has been identified by the Board as a priority. Once the strategic plan is complete, as part of the business plan, the Board will be supporting further engagement of technical staff and the acceleration of our technical delivery programme. This is currently being led by Nick Walmsley who is doing an excellent job bringing the programme together.

The technical work is gaining momentum and is well supported by the Water Services Managers Group (WSMG) along with the Special Interest Groups (SIGs) most of whom have submitted their own programmes of work and associated funding requests.

Lifting our sector's profile is more difficult to measure as usually we are trying to remain out of the media. It has always intrigued me though that for less than the price of a latte in Ponsonby our sector can deliver ½ a tonne of food grade water as well as remove about a ½ tonne of wastewater from your house for safe disposal or reuse on a daily basis.

Surely this service is worth more than a coffee, yet our public do not see it that way. They are happy to pay an exorbitant margin for their soy latte, but as a society are less forgiving when it comes to our water supply and wastewater services. There is no doubt it is undervalued until the service is suspended. We need to find a way to remind society on a regular basis of the value of the services we provide and the pressures our sector works under (including significant financial constraints) while being continually asked to lift our game.

Are we appreciated? I would say 'no' or at least not enough to obtain the level of funding needed to deliver the services effectively. How do we change this mindset? What should *Water New Zealand*'s role be in all this?

My view is that we have an obligation to, as a minimum, lift the profile of our sector and to ensure where possible that those making the decisions at least have some appreciation of the services we provide, the drivers we have, and the constraints we face. Perhaps we don't need to come up with all the answers on our own, but surely we have an obligation to educate key influencers, and highlight to society the value our sector provides.

Promoting awareness of the value of, and the necessity for security of funding, for water services should be important to all our members both public and private. This along with our technical programme and networking opportunities will be key to the future focus for your association. ■

Steve Couper,
President, Water New Zealand

New Members

Water New Zealand welcomes the following new members:

ALASTAIR HANCOX
ALEX COLIBABA
ALEX WALKER
ALEX WONG
AMY HOLLIDAY
ANDREW KENNEDY
ANDREW STEWART
ANGELI PAGLINAWAN
ARU CHELLIAH
BELLA LEE
BEN CHESTER
BEN JACKSON
BEN MOORE
BILL HOGG
CARMEL GREEN
CAROLYN REID
CHRIS GARTON
CHRIS SMITH
CHRYS KELLY
CLINT NEILL
COLIN MEADOWCROFT
DARREN LADBROOK
DARREN POTTS
DARRYL DE BEER
DARRYL TATANA
EHTESHAM OWAIS
FRANK LIN
GARY DAVIES
GARY MILLS
GEOFF COPESTAKE
GLENN YOUNG
HEATH GORDON
IAN COOK
INKA KRAWCZYK
JACQUELINE ROBSON
JASON SCHARVI-COLES
JEFF SCHRIER
JOE VANGILS
JOHN HOOK
JOHN MCCANN
JOHN SCHERMBRUCKER
JOSAPHATT JIP
JOSEPH CHALONER WARMAN
KAREN STEFFECK
KATE SIMMONDS
KATJA KING-BORRERO
KELLY LAVALLEY
KELVIN WILLIAMS
KEVIN HEAD
MAIRE LENIHAN

Murray Gibb

The Ruataniwha Dam

In April a draft decision was made approving the proposed Ruataniwha Dam and accompanying irrigation scheme. The proposal would allow for 25,000 hectares of the Ruataniwha Plain, currently in dry land production, to be irrigated.

On the face of it, the benefits of such a proposal would seem to be beyond debate.

The Ruataniwha Plain is subject to summer drought, limiting primary production. The predicted effects of climate change suggest the dry eastern parts of New Zealand, including the Hawkes Bay, will become drier in the future, leading to more frequent and severe droughts. There is an abundance of available water in the catchment above the plain which, if harvested and stored, could be used for irrigation to both increase production and mitigate the effects of drought.

With irrigation, both the volume and quality of farm gate output increases. Increased foliage production resulting in more carbon being harvested from the atmosphere is generally thought to be a good thing, whether it be through trees, kiwifruit, or other crops.

Burgeoning demand for food worldwide is putting greater pressure on farmers to produce more food from a fixed supply of land and water. In the face of these supply side constraints the price of food is now starting to increase, reversing a two century decline starting with the agricultural revolution in the late 18th century.

New Zealand has an abundance of land and water, and the juxtaposition of the two can be harmonised by harvesting, storage, and irrigation. Building irrigation infrastructure in the Ruataniwha will allow future increased prices for expanded primary production to be captured.

After forty years of decline following Britain's entry into the European Union, our terms of trade are increasing, thanks to increasing demand for our biological production. For once, New Zealand is in the right place at the right time with the right product mix to meet the growing international demand for food being driven largely out of Asia.

Our politicians take a bipartisan approach to foreign affairs and trade, with both major parties agreeing that we need to grow the tradable sector of our economy, and more freely access markets, to make our nation wealthier. The primary sector is one part of our economy that is genuinely internationally competitive. If people need our products, but can buy better elsewhere, they will. It is a powerful discipline.

Growing the tradable sector is a secure route to growing our living standards relative to other countries. Doing so will make New Zealand an attractive place to live and work for an increasingly mobile skilled workforce with global options. It will drag us back up the ladder of relative wealth rankings in the OECD.

Time and time again our biological production base has been proven to be the backbone of our economy. Furthermore over the last three decades since Sir Roger Douglas separated our farmers from subsidised production, the productivity gains made in primary production have been absolutely mouth-watering. Irrigating more dry land is a sure and proven route to further improving the productivity of New Zealand's agricultural land.

On the face of it, the stars were in alignment for the dam to be approved and the Board of Inquiry duly delivered.

Or has it?

At the same time as it considered the dam, the Board was asked to make changes to the regional plan. Its draft decision placed limits on nitrate discharges from various classes of land. It also set in-stream nitrate limits to *'serve as a check as to the effectiveness of the land use capability leaching rate control'*.

And therein lies a problem.

The general consensus is that with the limits set, there is insufficient freeboard for existing farming practices, let alone future intensification. Many farmers in the region will have to significantly reduce their existing nitrogen footprint to achieve the limit, or, when the proposed changes to the plan become operative, obtain resource consents. There will be no room for intensification of production.

Effectively, in its draft decision the Board has made a Clayton's decision on the dam, allowing it to be built but stopping it being used for its intended purpose.

The Board's draft decision on the limits was made to safeguard ecosystem health in the Tukituki River. That is laudable. Primary production must be environmentally sustainable. What is also clear from the draft decision is that there is considerable debate amongst water scientists as to the best method of achieving that goal. In the context of the Tukituki River water quality, the available scientific evidence wasn't clear cut.

Of note is the recommendation of the reference panel in the February 2014 discussion document on proposed amendments to the national policy statement on freshwater management. The panel proposed bottom lines for nitrate levels required to maintain river ecosystem health significantly higher than those imposed by the Board in its draft decision.

The whole process raises three questions.

Was the investment of several millions of dollars by the interested parties worthwhile?

Should major regulatory decisions such as this one be made on the basis of uncertain scientific evidence?

Is our environmental regulatory delivery framework fit for purpose?

The Board has been considering feedback from the various parties and by the time of printing will have issued a final decision. ■

Murray Gibb
Chief Executive, Water New Zealand

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Cliff Tipler Heads for the United States

Well known past president Cliff Tipler has left URS New Zealand after 18 years, for the golden shores of San Francisco. Cliff held a number of senior roles with URS, most recently as Business Development Manager.

Over his stellar 30 year career in environmental engineering and the primary ITO sectors, Cliff saw many changes in New Zealand's engineering companies, including closures, mergers, and takeovers – and survived them all.

He has worked on many sewage treatment plants and industrial discharges, including meat and dairy processing plants around New Zealand. Leading more multi-disciplinary design teams than can be mentioned in a short brief there are a few that stand out.

Cliff was deeply involved in the design and construction of the award-winning Christchurch City three kilometre ocean outfall and associated micro-tunnelled pipework. He was also the technical lead consultant for the Central Plain Water company's irrigation scheme through the consenting phase, and has taken much pleasure in seeing this project proceed to construction this year.

He is recognised as a technical leader in his field and also a great facilitator. This led to him acting as Commissioner for Environment Canterbury on many resource consent applications.

Away from the engineering sector, Cliff has a deep love of New Zealand rural life. He led the merger of the Agriculture ITO and Horticulture ITO to create the Primary ITO, a significant move to restructure tertiary training. He was chairman of the ITO from 2012 until January this year. As president of *Water New Zealand* Cliff led significant organisational changes that laid the foundations for the strong organisation we have today.

Cliff has brought passion and commitment to all his roles and has played a huge role in the mentoring and development of professionals working with him. He leaves behind big shoes to fill. ■

Research Hints at CCS for Wastewater Industry

Wastewater treatment plants could use captured $C0_2$ to boost their production of saleable methane while reducing their carbon footprint, UK researchers report.

The UK's wastewater treatment industry produces around 3m t/y of $C0_2$, say scientists from Cranfield University, but the varied size and scattered nature of the plants make them unsuited to the technologies for transport and long-term storage of $C0_2$ being developed for the power sector.

The Cranfield team searched for an alternative and hit upon recycling the $C0_2$ coming from a plant's anaerobic digester back into the unit to boost methane production.

Using bench-scale batch tests they found that returning the $C0_2$ to the unit could boost methane production from sewage sludge by as much as 138% and reduce $C0_2$ emissions up to 38%. The team is now running scaled-up trials at 150 and is investigating why production of methane fell shortly after the recycled $C0_2$ was injected.

"We consider the project to be particularly relevant when considered in the context of reducing greenhouse gas emissions," says research co-author Elise Cartmell. "If we further demonstrate the ability of anaerobic digesters to biotransform additional carbon dioxide, it could be a means to positively utilise streams considered a waste until now. Besides, dealing onsite with these streams could have the strong benefit of avoiding transport, for instance, to a final storage reservoir."

The work has been conducted in collaboration with Thames Water and the not-for-profit recycling company WRAP, and is also looking at the effects on methane produced from digesters used to process food waste. ■

Bioresource Technology: DOI 10.1016/j.biortech.2014.02.010

Annual Membership Subscriptions

Your annual membership subscription is now due. Invoices will be emailed to you during July. Please note that hard copies of invoices will not be sent.

We take this opportunity to remind you that paragraph 6.2 of the Constitution reads:

"All subscriptions shall be payable to the Association on demand. Any member for whom an annual subscription has not been paid within ninety days of demand will automatically be removed from the membership list of the Association, with the loss of rights arising from affiliation with other organisations".

Please ensure your invoice is paid promptly to ensure continuation of your membership benefits. If you have any queries regarding your membership subscription, please notify Linda Whatmough, Finance Manager, *Water New Zealand* at accounts@waternz.org.nz ■

Social Media

Follow *Water New Zealand* on **Facebook** and **LinkedIn**.

From our recent social media survey, members have indicated that they prefer these two media.

Connect **Like Us**

Building A Way to Cleaner Water

A new technology could help some of the 100 million people around the world exposed to arsenic create clean water and lock the contaminates away in building materials.

A team at the US University of California, Berkeley, has spent several years working on a sustainable solution to the "insidious" risk posed by arsenic contamination of groundwater. Though several different processes are already used to filter out the deadly material, the team knew the hard part would not just be inventing the technology but also ensuring a way to sustain its long term use.

"A lot of technologies to remove arsenic on the community- and household-scale have been donated. But if you go to these villages it's like a technology graveyard," says Ashok Gadgil, a professor of civil and environmental engineering at Berkeley. "One study found that more than 90% failed within six months, and then were abandoned to rust in the field."

So Gadgil and his team decided to work with two aims in mind. The first of these was to create a technology that is exceptionally effective, inexpensive, and easy to maintain. The second – which Gadgil says is just as important – was to plan out a business model for implementing the technology in a way that creates incentives for its long term use. From this, they developed a process known as electrochemical arsenic remediation (ECAR), which binds arsenic using iron dissolved in water.

ECAR works by using electricity to quickly dissolve iron in water. This forms a type of rust that readily binds to arsenic; the rust can then be separated from the water through filtration or settling. For the remaining waste, Gadgil's team is now working on partnerships with cement and concrete companies to research embedding the sludge in concrete – safely locking it up and creating another product that can be sold.

Arsenic-contaminated groundwater can be found all over the world, including the US, but the problem is particularly acute in South Asia, where tens of millions of people in India and Bangladesh get their drinking water from tube wells highly contaminated with arsenic, almost all of it occurring naturally.

The Berkeley team has already started plans for a 15-month, 10,000 l/d field trial of ECAR, and has licensed the technology to India's Luminous Water Technologies, which plans to bring it to arsenic-affected villages throughout India and Bangladesh. For now ECAR is planning to operate as a village-owned micro utility in the villages where it is installed. ■

WATER September 2014

The next issue of *WATER* will be published in September.

Lead theme: Urban Metering

Sub-topics: Modelling; Asset Management; National Party Water Policy

Please contact the Editor, Bernadette Stevenson (editor@avenues.co.nz), if you have any story ideas, contributions, or photos.

The deadline for the September issue is **Monday 4 August**.

IMPLEMENTING REFORM

Water New Zealand's Annual Conference & Expo

Claudelands, Hamilton | 17–19 September 2014

Conference Registration

Registration is now open for the *Water New Zealand* Annual Conference & Expo 2014 at waternz.org.nz

The preliminary Conference programme is now on the website. For a preview of all presentations on offer in 2014 go to the website and click on the 'conference' link in the banner at the top of the home page.

Nine Weeks Until Conference

Register now to guarantee your attendance at the only New Zealand Conference & Expo that covers every aspect of the water environment and its management.

Conference Theme and Programme

The core theme of the Conference is ***Implementing Reform***.

There will be over 90 presentations on offer covering every aspect of the water environment and its management including ASTT Trenchless Technology, workshops on SCIRT learnings, Asset Management, and a panel led by Nick Walmsley on the *Water New Zealand* Technical Programme.

The programme will include general streams as well as specialist streams of Modelling, Operations, and IWA.

This year's Conference will follow the same format as 2013 with two full days of presentations on Wednesday and Thursday. The *Water New Zealand* AGM will be held on Friday morning followed by a panel discussion on Water Pricing led by Eugenie Sage and Ian McKenzie. Friday morning will also include the exhibitor visitor morning, which is a great opportunity for exhibitor/client meetings.

Expo Demonstrations

The Conference Exhibition continues to be the largest trade exhibition for the sector with over 170 sites. An addition to the programme for 2014 sees exhibitors having the opportunity to hold live demonstrations. Places are limited to two demonstrations held each day during the lunch break on both the Wednesday and Thursday.

Mott MacDonald Poster of the Year

Poster presentations are always a popular component of the Annual Conference.

Entries are welcome on any topic of relevance to the water industry, with entries from students particularly encouraged. Poster summaries must be 250 words or less and submitted in word document format.

All completed posters must be sent by **Monday 28 July** to: Elizabeth Fesherman, *Water New Zealand* Conference, c/- Avenues Event Management, PO Box 10-612, Wellington, New Zealand or email: waternz@avenues.co.nz

Networking Opportunities

Social functions throughout the Conference continue to provide a prime networking opportunity with attendance of people working in the many and varied aspects of the water environment and management sector.

Visit waternz.org.nz and click on the 'conference' link to view the programme and read more about the social functions at the Conference.

- **ProjectMax Welcome Reception**
  Wednesday 17 September
- **Jeff Booth Consulting Ltd Modelling Dinner**
  Wednesday 17 September
- **Applied Instruments Operations Dinner**
  Wednesday 17 September
- **Hawkins Infrastructure Conference Dinner & Awards Presentation**
  Thursday 18 September

Key Diary Dates for Presenters

28 July	Poster Summaries CLOSE
5 September	Authors/Presenters – Powerpoint presentations due

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Water New Zealand Board Election – Call for Nominations

Call for Nominations for election to the Board of *Water New Zealand* closes on Friday 31 July 2014. The Board comprises six elected members and may include two co-opted members. Members are elected for three-year terms. This year one position is available. Sitting member Steve Couper will retire by rotation.

Members contemplating standing for the Board may wish to discuss the role and responsibilities of directors with sitting members of the Board. The candidate, nominator, and seconder must all be financial members of the Association.

Water New Zealand Annual General Meeting

The *Water New Zealand* 2014 Annual General Meeting will take place at 9.00am on Friday 19 September 2014 at the conference venue, Claudelands Conference & Event Centre, Hamilton.

To meet constitutional deadlines any notices of motion for this meeting must be supplied to the Chief Executive by 5.00pm, Friday 15 August 2014.

Notice of Meeting; Agenda, and any Call for Notices will be sent to financial members by Friday 22 August 2014.

At this year's AGM, the Board will ask members to support a motion to increase the number of co-opted members to the Board from the current up to two additional co-opted members, to up to three additional co-opted members. One being the immediate past President, who may be co-opted for up to a further year beyond his or her tenure as President in an ex-officio advisory role to the Board and President.

Please contact Hannah Smith, Association Secretary, *Water New Zealand*, if you have any queries. Phone: 04 495 0897, Email: hannah.smith@waternz.org.nz

Water New Zealand Awards 2014

The following awards will be presented at the 2014 conference:

- Hynds Paper of the Year Award
- ProjectMax Young Author of the Year
- CH2M Beca Young Water Professional of the Year
- Mott MacDonald Poster of the Year
- Ronald Hicks Memorial Award
- Opus Trainee of the Year
- Orica Operations Prize

Call For Nominations For 2014 Awards

Water New Zealand is now calling for nominations for the Awards to be presented at the Annual Conference this year. Members are encouraged to nominate suitable candidates for relevant Awards. Non-members of *Water New Zealand* are eligible for some of these awards.

Closing Dates for Nominations

28 July	Mott MacDonald Poster of the Year
1 August	Ronald Hicks Memorial Award
1 August	CH2M Beca Young Water Professional of the Year
1 August	Opus Trainee of the Year

CH2M Beca Young Water Professional Award

The award will acknowledge and reward one young water professional who has made a significant contribution to the water industry and the general community, and has demonstrated exceptional achievement in the early stages of their career.

To download the CH2M Beca Young Water Professional of the Year nomination form visit waternz.org.nz, 'Annual Conference' and click on the 'Awards' link.

Opus Trainee of the Year

The Award is open to any trainee currently involved in an NZQA approved course applicable to the water and wastes industry.

Send nominations and a short summary of why you think the trainee in question should receive the prize to Peter Whitehouse at *Water New Zealand*. Email peter.whitehouse@waternz.org.nz or phone Peter on 04 495 0895.

Orica Operations Prize

We are seeking examples of best practice in the industry and nominations are welcome for individuals, an operations team, or a particular project that had a strong operations flavour.

Send nominations and a short explanation of why you think your nominee should be the recipient of the prize to Peter Whitehouse at *Water New Zealand*. Email peter.whitehouse@waternz.org.nz or phone Peter on 04 495 0895.

Criteria and Scope for Awards

The definition and scope of each award, the criteria for selection, along with the nomination processes and timelines for submission can be found under the 'Annual Conference' section 'Awards' at waternz.org.nz

Stormwater Conference, Christchurch 2014

Water New Zealand's 2014 Stormwater Conference held 14–16 May at the recently opened Rydges Latimer in Christchurch was a huge success. Floods (in reality, if not in words!) and earthquakes stayed away, and a record number of delegates attended the conference. This was the first time the Stormwater Conference had ventured to the South Island, but it is now more than likely that a shift between the North and South Islands will become the desired model. The conference featured a large number of well prepared and delivered presentations on all aspects of stormwater management, with a significant focus on Christchurch post-earthquake flood risks and restoration works.

Following the welcome and opening by Christchurch Mayor, Lianne Dalziel, our overseas guest speaker, Douglas Howie from Washington State's Department of Ecology, explained his Department's low impact development approach to watershed management involving both rural and urban areas.

Thursday opened with a significant keynote from Mike Gillooly, Christchurch City Council Land Drainage Operations Manager and head of the Mayoral Flooding Taskforce. Mike outlined the extent of the flooding problems faced by the council and some of the short and long term options being considered. He told the conference that 'complacency' had played a part in the flooding. He said, "One of the things about Christchurch in the past 10 or 15 years is that land drainage and surface water has been the poor orphan to the other two waters – water supply and wastewater – and we led ourselves down a path of complacent thinking where everything would be OK when clearly it is not." He told the conference that solutions were needed quickly, with reports of increased respiratory problems and mental illness. This was followed by Graham Harrington who outlined the history of flooding in Dudley Creek and the Flockton Basin with details on possible flood mitigation options.

As well as the keynote addresses there were sessions on topics such as flood hazard and risk management, low impact design, modelling, construction and maintenance, consenting, and treatment.

Complementing the technical presentations given over Wednesday and Thursday, the Conference included optional site visits on Friday. The site visits gave delegates the option of four tours:

- The South West Christchurch tour, which included visiting some of the different stormwater mitigation facilities recently constructed in the Upper Heathcote River Catchment
- The Styx River tour which included site visits along a reach of the river of about five kilometres from the Styx Mill Reserve to the new Preston's development
- The Te Papa Otakaro/Avon River Precinct tour commenced at the Antigua Boatsheds with a walking tour hosted by Opus Consultants to explore the first of CERA's anchor project along an iconic Christchurch waterway. Delegates were met by a range of professionals involved in the redevelopment and shown how the river and adjoining land was being landscaped to provide a high level of functional and visual amenity while respecting cultural and aquatic values.
- Finally, the University Visit gave the Hydrological and Ecological Engineering group at the University of Canterbury the opportunity to showcase a number of stormwater related projects they currently have.

The conference was supported with an extensive trade expo of suppliers and consultants displaying new and innovative products and services.

The conference featured networking opportunities with the Downer Welcome Reception concluding day one in the exhibition area. The Cardboard Cathedral provided a stunning backdrop

Clockwise from top left: Stormwater 360 – Premier Sponsor for 10 years; Delegates enjoying the Conference Dinner; Mike Gillooly, Christchurch City Council, Keynote Presentation; Lianne Dalziel, Christchurch Mayor at the Conference opening; Douglas Howie, Washington State Department of Ecology, Keynote Presentation; Wayne "Buck" Shelford, dinner entertainment

for the Opus Conference Dinner as the conference closure on Thursday evening. Wayne "Buck" Shelford and Mark Wright provided delegates with entertainment for the evening. The support of Downer and Opus with sponsorship of these events was greatly appreciated.

The 2014 Stormwater Conference was Stormwater 360's tenth year as Premier Sponsor. Special thanks go out to Stormwater 360 for their support over the years. *Water New Zealand* would also like to thank Morphum as Conference Partner, Opus for the Conference Dinner, Downer for Welcome Function and Pump & Valve, supporters for keynote speaker Doug Howie's visit and Wifi & Coffee Cart sponsors. Without the support of the sponsors this conference would not be the success it was.

The Stormwater Conference Committee comprises John Palmer, Consultant, Tauranga (Chair); Sue-Ellen Fenelon, Auckland Council, Auckland; Bronwyn Rhynd, Stormwater Solutions Consulting Ltd, Auckland; Nick Simpson, Aurecon New Zealand, Wellington; Dean Watts, Morphum Environmental Ltd, Auckland; Nick Brown, Auckland Council, Auckland (Modelling SIG); Mark Pennington, Tonkin & Taylor, Tauranga (Rivers Group)

The 2015 Conference, typically the South-Pacific Stormwater Conference, will be rebranded as the Asia-Pacific Conference. The Stormwater Committee and *Water New Zealand* have already begun working on making this another exciting event with dates to be announced shortly. ■

The Need for Good Trade Waste Staff

Geoff Young – Chairman, Trade & Industrial Waste Forum, Water New Zealand

Following on from the article in the May issue of *Water*, this commentary discusses the importance of dedicated staff for the management of trade and industrial waste by those territorial authorities (TAs) who operate as utility providers for their resident industries.

With the release of the New Zealand model trade waste bylaw (NZS9201: 2004) a new era started in wastewater management in New Zealand. TAs all went down the track of drafting their own bylaws using the model bylaw as a starting point.

For the larger councils, this also meant the need to establish a position of trade waste officer or pollution control officer within the ranks of their staff. There were also a number of councils who already had a trade waste management team and a dedicated policy and thus this was business as usual. The appointees to these positions were charged with managing and enforcing the trade waste bylaws for their community. As is the case with all of these types of roles, some did a good job and some didn't. Observation of the approach taken by a number of New Zealand TAs to this issue has provided insight into what makes a successful trade waste management policy for a local council.

In more recent years, many councils have restructured either completely, eliminating the trade waste role, or they have combined it with less technically challenging roles with a higher community profile. This has been done in the name of cost savings and zero rate increases. This of course is comparable with not servicing your car in the short term, so cost is reduced. In the long term, a breakdown could end up costing significantly more than the initial saving. Elsewhere, other councils have gone down the pollution control track and have expanded the role to include stormwater from industry, which is a major step in the right direction.

To most people, trade waste is almost entirely made up of larger industries but in fact, across the country, the vast majority of trade waste activities are smaller enterprises, from restaurants to laundries to dentists to vehicle repair shops.

Invariably it is these smaller enterprises that cause the most problems. For example:

- Food outlets can cause major blockages with accumulated oil and grease discharge
- Laundries have temperature and pH issues
- Dentists discharge heavy metals, and
- Vehicle repair operations discharge petroleum products

This is but a small list.

Dedicated staff members with a good technical understanding of the issues and the authority to handle them are essential. As a resource user or applicant, nothing is more frustrating than being stalled at a service desk when you are trying to deal with a complex technical issue. It is a mistake to split the role of a trade waste officer with unrelated internal tasks like health and safety or zero waste coordination because invariably, it is trade waste that takes a back seat.

TA trade waste policy needs to work with industry, not against it. This means open communication between council staff and industry representatives. Open dialogue with the industries as to what the issues are and what the plans are for dealing with those issues is essential. You also need to foster a culture where industries are willing to establish a relationship with the trade waste staff. Relationships take time and can't be provided by service desk personnel.

It is the role of the local councilors to establish policy for the council staff to operate to. It is not the role of councilors to become involved in the day to day operation of specific areas of business such as trade waste. There are examples of cases around the country where political interference has hampered attempts by council trade waste staff to do the right thing by the council policy and by their ratepayers.

Good data collection over the long term becomes the backbone of not only the trade waste charging system but also the infrastructure planning process and asset management. Any projects for improvements to reticulation and wastewater treatment benefit significantly from good data. You can't make good decisions without good data. The old story of the cost of good data being an issue is a fallacy as the cost of inadequate data is invariably significantly more expensive than the long term cost of good data. Also as time goes on good data collection gets cheaper. But it can only be interpreted correctly by those who are trained to do so and understand the context. There is no way to collect and manage data without a dedicated staff member to look after this function. There have been countless examples of data and information being collected then – due to either no system or the lack of dedicated staff – it has been misplaced or worse, disposed of by mistake.

There does need to be support for the model trade waste bylaw, in particular, guidelines for trade waste management. This will not only provide consistency across the country, it will also enable industries to dialogue with the local TA, having a much better understanding of what is required. This will reduce potential issues of conflict and in all likelihood reduce the cost to both TA and resource user. Such guidelines would also make it easier for the TA trade waste staff to make a difference in their local community.

Trade Waste management is a specialised role and while a background in wastewater treatment is certainly an advantage, it is not the whole story. Finding people in the public sector with the right mix of water and waste science, an understanding of industrial practices, and polite assertiveness is extremely challenging. Attempting to overcome the problem by dumbing down the parameter limitations is also not the answer. There will be industry players who will exploit this lack of expertise causing untold damage and costs to infrastructure and operations. Once the parameters have been dumbed down, staff won't be around to police or identify the source of problems.

Integrated infrastructure management gives the best service value to the community. Good trade waste management requires knowledge in the following areas:

- Trade discharge quality and quantity
- Stormwater quality from trade sites
- Effects on reticulation, including asset deterioration, odour, corrosion (and hence asset life and cost)
- WWTP operations impacting capacity and process operations

Trade discharges are a raw material impacting on the above and the trade waste officer is the person who can make a difference in all of the above areas.

The conclusion, therefore, is that knowledgeable trade waste personnel are required in our TAs both now and in to the future as an essential part of doing business. The current trend will pass and those TAs that currently see trade waste as an unnecessary overhead will, sooner rather than later, have cause to reflect and regret this decision. ■

Organic Waste Guidelines Project – Latest Workshop

A highly interactive discussion/workshop session was held on Tuesday 25 April at the second Centre for Integrated Biowaste Research (CIBR) workshop in Hamilton.

Lead by Nick Walmsley (*Water New Zealand*), Jacqui Horswell (CIBR), and George Fietje (Auckland Council and WasteMINZ) the workshop focused on the Guidelines for the beneficial use of organic waste in New Zealand and covered set questions on:

- What issues and roadblocks hinder beneficial use?
- What organic wastes should be included?
- What key control criteria should be included?
- How will such a guideline streamline the regulatory process?

Seven breakout groups of more than 50 delegates were led through lively discussions, with many valuable points and opinions recorded.

The record of responses fed back from each group can be viewed from the *Water New Zealand* website library at: http://www.waternz.org.nz/Category?Action=View&Category_id=404

This is the third such workshop as part of the ongoing project research. Additional tasks are also underway:

- Summarising current knowledge and research on heavy metals, pathogens and organic contaminants
- A survey of resource consents issued for biosolids and similar product applications to land in New Zealand over the last 10 years

Topic and progress reports will be available for view via the website library as the project proceeds. For any project related queries contact Nick Walmsley at *Water New Zealand*. ■

South Waikato District Council Wins with Wastewater Paper

South Waikato District Council's technological advancements under manager John Beale, who manages the district's wastewater and water supply plants, earned accolades at the Water Industry Operators Group conference held in Taupo recently.

Mr Beale wrote and presented a paper entitled *Centrifuge – 30 Years of Waiting, Was it Worth it?* to industry leaders and colleagues and earned the top prize in the Best Operator Paper category. This win means Mr Beale is off to a similar conference of wastewater and water industry leaders in Australia in September, fully subsidised.

The paper was based on improvements to council's own wastewater treatment plant in Tokoroa installed about 18 months ago. Previously council used drying beds to remove moisture from wastewater sludge prior to disposal. The centrifuge is a mechanical dewatering system and was installed for $870,000. The improvements and cost savings include:

- The old system used to produce 10% of dry solid matter; the centrifuge system aimed to increase that to 20%; in reality (18 months on) 25% dry solids is being achieved.
- Council used to transfer around 1,000 tonnes of sludge to the landfill; this has reduced by half to 500 tonnes, reducing the volume of product that goes to landfill, thereby extending its life.
- The process also involves fewer steps and less transportation of material that further reduce operating costs.
- The finished product too is far better for the environment and is now actually used to produce topsoil for the final cover at the landfill rather than a waste product that is disposed of at the landfill.
- The wastewater sludge from all four towns in the district is now processed by the centrifuge in Tokoroa.

"We have retained some of the old drying beds that can be used in an emergency such as plant failure," said Mr Beale.

"However in the 18 months since the new system came on line, we haven't had to use them at all."

Further interest has been shown in the technological improvements in the South Waikato. An Australian delegation visited wastewater and water plants across the middle North Island during the week prior to the conference, including council's fairly recent UV microfiltration installation at the Blue Spring.

Watermark Manager John Beale was presented with an award for Best Operator Paper at the 2014 Water Industry Operators Group conference by Chairman Mike Monaghan. Mr Beale's paper was entitled *Centrifuge – 30 Years of Waiting, Was it Worth it?*

Watermark Manager John Beale with the centrifuge system installed at the Tokoroa Wastewater Treatment Plant 18 months ago

Mr Beale is looking forward to his trip to Victoria in September to attend the trade expo and conference there and to again present his paper to a larger audience of industry leaders.

"It is a huge opportunity to see wastewater and water supply plants and systems in Australia, new emerging technologies and listen to other experts in the field," said Mr Beale.

See page 54 for a detailed look at the installation of the equipment. ■

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Above and right – Newly refurbished premises for Opus in Petone, Lower Hutt

New Premises Signal Exciting Opportunities for Opus Research and Environmental Training Centre

On 24 June Prime Minister John Key officially opened a newly refurbished premises for Opus in Petone, Lower Hutt. These premises will be the hub for Opus Research and Opus Environmental Training Centre.

The easily accessible modern facilities are purpose designed for research and education. They signal a commitment from Opus to the provision of services that were started in the former days of the Ministry of Works and Development. These new facilities will allow diversification of technical training options and a broadening of the research portfolio for the benefit of all New Zealand.

Training

All water training provided from this facility forms part of the training programme offered through NZWETA – a joint venture between *Water New Zealand* and Opus International Consultants. This joint venture is viewed by Opus and *Water New Zealand* as a vital mechanism to lift workplace skills for the water industry.

Opus Training also delivers the Making Good Decisions (MGD) Programme on behalf of the Ministry for the Environment. The purpose of MGD is to help councillors, community board members, and independent commissioners make better decisions under the Resource Management Act 1991 (RMA). It provides RMA decision-makers with the skills needed to run fair and effective hearings, and to make informed decisions.

Future training services will include the delivery of technical short courses through video links to people who can remain at their workplace computer. The use of video computer based training has allowed Opus to expand its water operator training into Australia to service clients as diverse as BHP Billiton and Torres Island Regional Council.

However residential courses from the new Petone facilities will continue. Closer proximity to transport and accommodation will complement the modern classroom facilities to make what can be a challenging time for trainees a positive experience.

For a full summary of technical training programmes go to nzweta.org.nz and opuseducation.co.nz for Making Good Decisions RMA training.

Research

Many readers will be familiar with the former Opus Central Laboratories, which was rebranded as *Opus Research* last year. Central Labs had been established 57 years ago by the Ministry of Works to undertake experimental research to support the design and construction of major national infrastructure projects such as the hydroelectric power dams and national highways.

Today, Opus Research has a team of researchers, scientists and technologists working on a diverse range of infrastructure related issues such as transportation safety, the performance of roads, and the resilience of communities and business to major natural hazard events. In the new premises there is also a number of laboratories to perform materials testing and analysis services for a wide range of engineering construction materials.

For a full summary of Opus Research's services go to: www.opus.co.nz/opus-research.

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Election 2014

To give readers of *Water* an insight into Party policies on water we are giving the Maori, Green, Labour, and National Parties the opportunity to describe the issues they see as important leading up to the General Election. In this issue, the Labour Party outlines its approach to water and its management.

Labour is Prioritising Water

Labour regards water as so important that it created a shadow spokesperson to be the Labour voice on water affairs. Meka Whaitiri has now taken the lead in the water portfolio. This has assured issues around water get sufficient priority among our caucus.

Our environment is important to all New Zealanders – it is a part of our history, it's part of our childhood memories. Labour believes in protecting our environment so that future generations can enjoy New Zealand's lakes, rivers, and streams.

Labour stands for clean water. New Zealanders have a birthright to play and swim safely in our streams, rivers, and lakes and at our beaches – and to have access to safe drinking water as a basic human right. Freshwater (both surface and groundwater) is a common good and a precious and finite public resource. Whether we live in town or country, we are its stewards – and it is a taonga of paramount importance to hapu and iwi. Water is also the most vital component of New Zealand's biological production systems.

We do not have to sacrifice the environment in order to have a prosperous economy. The economy is actually part of the environment, and relies on our clean, green image. We can and must be environmentally sustainable, and the state of our freshwater is a key measure of that and of our image.

Water Quality

We are all responsible for freshwater quality, whether we are urban or rural dwellers. The quality of our freshwater has deteriorated markedly over the last 20 years. This has been caused particularly by agricultural intensification, and the run-off of effluent, nitrate and phosphate. In urban areas, water pollution is being caused by stormwater run-off, sewage and industrial pollution – with some of our most polluted waterways being in urban areas.

We also need to be vigilant about maintaining the purity and value of our freshwater aquifers. They must not be allowed to become contaminated.

Under Labour, freshwater management will be underpinned by strong environmental standards and nationally-set bottom lines. These will safeguard the life-supporting capacity of natural freshwater ecosystems, and avoid, remedy, or mitigate any adverse effects that activities have on them – as is required by the Resource Management Act 1991 (RMA).

Labour commends farmers and other land users who strive for excellence in their environmental stewardship, while running profitable businesses. We are committed to promoting such best practice land use and the innovation that goes with it. But those land users who fail to meet required environmental outcomes cannot expect on-going access to the freshwater resource.

National Policy for Freshwater Management

The last Labour Government initiated an NPS for Freshwater Management. The resulting draft NPS, from a tribunal chaired by former Principal Environment Judge Sheppard, would have required strong action on the impact agricultural intensification is having on water quality.

Labour's position, simply put, is that clean waterways not be allowed to get dirty, and that dirty waterways be cleaned up over a generation.

Labour will introduce a revised NPS on water quality based on the principles of the Sheppard version. That means:

- Clean rivers and lakes will not be allowed to get dirty
- Dirty rivers and lakes will be cleaned up over a generation, and
- Increases in intensity of land use will be controlled rather than permitted as of right
- Improvements to farm practice will be required to offset the additional environmental burden caused by more livestock, fertiliser and effluent

Farming Practices and Freshwater Quality

Labour is confident that dairy and other farm systems can be configured to be profitable while operating with a minimal footprint on the environment. Mitigations can, for example, result from storing dairy shed effluent for low-risk application at optimal times of the year. This captures the most benefit from the nutrients, and allows a reduction in soluble nutrient use such as urea. Practices such as stand-off areas, feeding infrastructure, and appropriate stocking rates are to be encouraged, with a professional and competent agribusiness sector helping apply the latest technology inside the farm gate.

Labour will support and encourage productive, profitable agriculture that protects ecosystem health and prevents pollution of freshwater – by using the latest technology, validated decision support tools, farm system modelling and strategy

planning, and advanced effects mitigation.

We are also facing challenges of urban stormwater, and the stresses stormwater discharges places on our water quality. Stormwater – including runoff from streets and roads – introduces sediment and many pollutants into natural waterways, including heavy metals. To be sustainable, our cities must work harder and smarter to address this problem. A Labour Government will work with urban local authorities, particularly in the main centres, to improve stormwater management, and to maintain or enhance the health of receiving waterways.

Water Allocation and Management

There is increasing pressure on New Zealand's freshwater resources with population growth in urban areas and more agricultural demand. For water use in both urban and rural areas to be sustainable, it must be managed on an integrated catchment basis, and extraction must not exceed natural replenishment. Water must be returned to the environment in good condition (including with proper treatment for sewage and industrial discharges).

Where practicable, the harvesting of rainwater and greywater should be actively encouraged. It can be used when water of potable quality is not required (e.g. for gardens and lawns, and for appropriate applications in commercial buildings and industry).

Labour's 2011 election policy remains. We are committed to encouraging the fair and efficient use of our precious public freshwater resource through a resource rental on large irrigation takes, which comprise the major consumptive use of freshwater. Irrigation accounts for nearly 80% of freshwater consumption. All domestic uses of water, which on a per capita basis are small – whether in cities or rural areas – will be exempt from the resource rental.

Interested parties will be consulted on the appropriate manner and level of charging. All the revenue raised within a region will go back into the region to fund water management and delivery, new storage and irrigation schemes, safe rural drinking water supplies, and projects such as the restoration of degraded waterways.

Water Storage and Irrigation

Labour supports communities, through their local councils, deciding which proposed water storage and irrigation schemes are appropriate. Each project must attract broad consensus from across the wider community, even if the major beneficiaries (and financial contributors) are local

> "Labour believes in protecting our environment so that future generations can enjoy New Zealand's lakes, rivers, and streams."

farmers and electricity generators. Labour believes that any government contribution to irrigation projects should not come from, or be subsidised by, taxation or SOE sale proceeds. They should instead be funded from the resource rental paid by irrigators. Labour will ensure that any funding of new water storage and irrigation schemes comes from the resource rental paid by irrigators. Under a Labour Government, existing Crown funding will be phased out as the resource rental mechanism is phased in and revenue from it becomes available.

Iwi/Hapu Rights and Interests in Freshwater

As Tangata whenua Maori are Kaitiaki of and have a special role in respect of the land and natural resources. Labour will continue to work with hapu and iwi to ensure the sustainability of the natural environment for future generations to use and enjoy and that iwi/hapu will have a role in decision making. The Land and Water Forum stated that for a system of freshwater management iwi rights and interests of freshwater needs to be resolved, Labour agrees that such issues will need to be resolved between hapu, iwi and the Crown.

Protecting Rivers and Estuaries

Rivers

Many of New Zealand's wild rivers have been lost to hydro power development, and the landscape and biodiversity values of such rivers have become scarcer. National has undermined the value of water conservation orders, especially by overriding them in Canterbury. This is the opposite of Labour's view – if anything, water conservation orders need to be strengthened and expanded. Labour will strengthen the National Policy Statement for Renewable Electricity Generation 2011 so it encourages renewable generation with low environmental impacts, with a particular view to protecting rivers from being dammed. A Labour Government will restore the primacy of water conservation orders in Canterbury, i.e. to where they were before National overrode them, as part of the restoration of local democracy in Canterbury.

Estuaries

Labour will introduce an NPS to protect our estuaries. Our estuaries are some of the rarest ecosystems in New Zealand. They are an important filter protecting our inshore fishery from more pollution. They provide crucial whitebait and fish spawning, and juvenile fish habitat. They are a breeding and feeding haven for many birds, and places of recreation.

Too many of our estuaries are in decline.

Labour's NPS for estuaries will control siltation and eutrophication, and stop the insipient reclamation of the edges of estuaries. It could, for example, require all tidal gates to be reviewed and require the removal of those which are inappropriate.

Labour wants to progress the work of the Land and Water Forum and support collaborative processes to better manage our water resources. We will work in partnership with communities, iwi, stakeholders, local authorities, and farmers to ensure water is a priority. Labour will make sure mechanisms are in place to ensure future generations are able to enjoy our beaches, lakes, and streams. ■

Select Committees and Salmon: the Spawning of New Law

Helen Atkins – Partner and Phoebe Mason – Law Clerk, Atkins Holm Majurey

Introduction

Marcel Proust wrote in his seven volume epic *In Search of Lost Time* that "the real voyage of discovery consists not in seeking new landscapes but in having new eyes." The development of the law can seem like this indeed, with developments arising not always from changes in legislation, but from changes in interpretation of the existing legislative landscape.

The Supreme Court's *King Salmon* decision has made a discovery in reinterpretation of the New Zealand Coastal Policy Statement (NZCPS), and may have the effect of forming a new lens through which New Zealand's water law, and particularly the National Policy Statement for Freshwater Management (NPSFM), is viewed.

In this article we traverse a number of current legal developments, which could have wide reaching implications for the water industry – the *King Salmon* decision, the development of the Environmental Reporting Bill, the future reforms of the Resource Management Act (RMA), and the release of the Tukituki Board of Inquiry draft decision. We also cover a recent criminal conviction under the RMA for rough and ready maintenance of a drainage channel.

Environmental Defence Society Inc v New Zealand King Salmon Company Inc [2014] NZSC 41

The New Zealand King Salmon Company (King Salmon) applied for resource consent and a plan change to permit nine new salmon farms in the Marlborough Sounds. A Board of Inquiry approved four of the nine applications. This case related to an appeal by the Environmental Defence Society (EDS) to one of the approved farm site – the Papaatua site at Port Gore. The relevant section of Port Gore was classified by the Marlborough Sounds Plan as Outstanding Natural Landscape (ONL), and EDS argued successfully, that the New Zealand Coastal Policy Statement (NZCPS) used language so directive that it prohibited development in ONLs in the coastal area. While Policy 8 of the NZCPS supports aquaculture development in "appropriate" coastal areas, the Supreme Court found that due to Policies 13(1)(a) and 15(a), which require decision-makers to "avoid" adverse effects on coastal ONLs, the Port Gore site could not be "appropriate" for aquaculture, and in fact had to be declined as a site for such an activity.

There are two schools of thought on the application of the King Salmon decision. The narrow view is that the Supreme Court's interpretation only applies to the NZCPS, given that the decision dealt specifically with the coastal environment and ONLs. However, the broad view predicts far wider implications. The decision could be seen to say that where any RMA instrument – NPSFM, other National Policy Statements, Regional Policy Statements, and potentially Regional or District Plans, use directive language like "avoid", those directive policies provide the interpretation of sustainable management in that specific context, whether it be topical, like freshwater, or geographical by region. As an example, this means that in a case where the RMA instrument precludes development in a certain area, a decision maker could not revert back to Part 2 of the RMA in order to argue that economic well-being in section 5(2) must be considered alongside environmental protection. A Court would assume that the instrument had already undertaken the Part 2 balancing exercise. The proof will be in the application of the decision in the courts in the months and years to come.

In the world of freshwater, the NPSFM contains some examples of directive language, for example "Objective B2: To *avoid* any further over-allocation of fresh water" and "Objective B4: To *protect* significant values of wetlands". Whether these objectives will be interpreted differently in future is unclear, but applicants, stakeholders, and interested parties are advised to keep an ear out for application of the decision in a freshwater context. We will endeavour to update you as developments occur. Notably the Government is still signalling that it will be releasing the National Objectives Framework for Freshwater in the next couple of months. Amendments to the NPSFM are also being signalled for release prior to the election.

Resource Management Act Reform

Some have speculated that the *King Salmon* decision could spur back into action RMA reform given the decision's apparent support for environmental protection over some development. However, others have replied that the decision in fact gives the Government's National Policy Statements, and thus the Government, greater regulatory power.

Either way, the Government has announced that no reforms will be introduced to the House until after the election on 20 September this year. Reforms had been proposed in late 2013, only to lose sufficient support to be passed.

Environmental Reporting Bill – Update

In the last issue of *Water* we set out the content of the recently introduced Environmental Reporting Bill, which proposes tri-annual 'synthesis reports' and six-monthly 'domain reports' to be prepared by the Secretary for the Environment and the Government Statistician, overseen by the Parliamentary Commissioner for the Environment. The Bill's purpose is to "streamline the mechanics and accuracy of data collection so as to focus discussion on the environmental issues themselves."

Submissions closed on 17 April, and 69 submissions were received. The issue which arose consistently was concern over the ability of the Minister to set the topics to be reported on. Submitters considered that this threatened the purported independence of the reports. The New Zealand Law Society for example noted in its submission that as the power to set the topic for synthesis reports lies with the government of the day, there is an ability to limit, by definition of topics, the scope of the report, and to avoid topics which are contentious or politically inconvenient. Rather the NZLS considered that a report on the state of the environment as a whole would be sufficient, and that "topics" are unnecessary.

Another concern was the ability of the Ministers to withhold some of the data relied upon in the reports from the public. Submitters considered that the non-disclosure could make scrutiny of the reports difficult, and threaten the independence, fairness and accuracy of the reports. *Water New Zealand*'s submission noted that this was particularly the case with scientific data where information could be produced of equal quality but greatly contrasting outcomes due to different use of methodology.

In addition to the two points above, the Parliamentary Commissioner for the Environment (PCE), Dr Jan Wright submitted that the Bill needed more focus on the usefulness of the information provided, rather than merely on the accuracy of that information. She also suggested that the purpose of the Bill be simplified to be 'the provision of regular and independent reports on the statement of the environment'.

The Environmental Defence Society (EDS) considered that the PCE should be given a greater role in the process to ensure the independence, fairness, and accuracy of the reports. EDS submitted that the environmental 'domains' on which the reports are based required clarification to prevent both overlaps and gaps – for example that the 'air' and 'atmosphere and climate' domains be combined into one 'air, atmosphere and climate domain' and that the 'freshwater domain' be expanded into a 'freshwater and wetlands domain' in order to specifically recognise and monitor wetlands.

The Bill is currently with the Local Government and Environment Select Committee, with their report due early September. Again, due to the election the progress of this Bill is likely to slow.

Update and Overview of the Tukituki Board of Inquiry Decision

The Board of Inquiry has released its draft report and decision granting consent for the construction and operation of the Ruataniwha Water Storage Scheme in the Tukituki Catchment, Hawke's Bay. The draft decision grants consent for the Dam, subject to comments on "technical points" from the parties to the Inquiry. The Board will consider these comments in making its decision and preparing its final report.

The draft report has thrown up some irregularities, which will be apparent to a reader with some knowledge of nutrient management methods. Parties have raised issues regarding the workability of the nutrient levels in the Board's draft report, some of which would require some farmers to reduce leaching by up to 60%. On a broad scale, the purpose of the dam is to provide certainty of water supply for farmers and producers in the area, permitting them to increase productivity through both certainty and irrigation. The nutrient leaching levels set by the Board in the draft decision could be seen to effectively negate the grant of consent, given that the increased productivity for which the dam was designed would be prevented by the nutrient leaching restrictions.

Prime Minister John Key has said that the Government will not intervene to change the nitrogen levels set, preferring to let the issue go to court first, if parties remain dissatisfied following the release of the Board's final report.

A time extension has been granted meaning that the Board has until late June to release its final decision. The Board will also consider the King Salmon decision, which was released two days after the Board put out its draft report.

A Recent Water Case of Interest: *Woolley v R* [2014] NZCA 178

Without resource consent, Mr Woolley excavated a drainage channel on his property and effectively turned a 0.5m deep creek into a channel of up to two metres deep and seven metres wide. Mr Woolley's actions caused 'collateral damage' – tearing up of vegetation and damaging a wetland through which the channel ran. Mr Woolley was convicted on four counts and sentenced to two months home detention, reparation of $38,253, and costs of $1,628.75. This was an appeal against the convictions, and against the sentence as manifestly excessive.

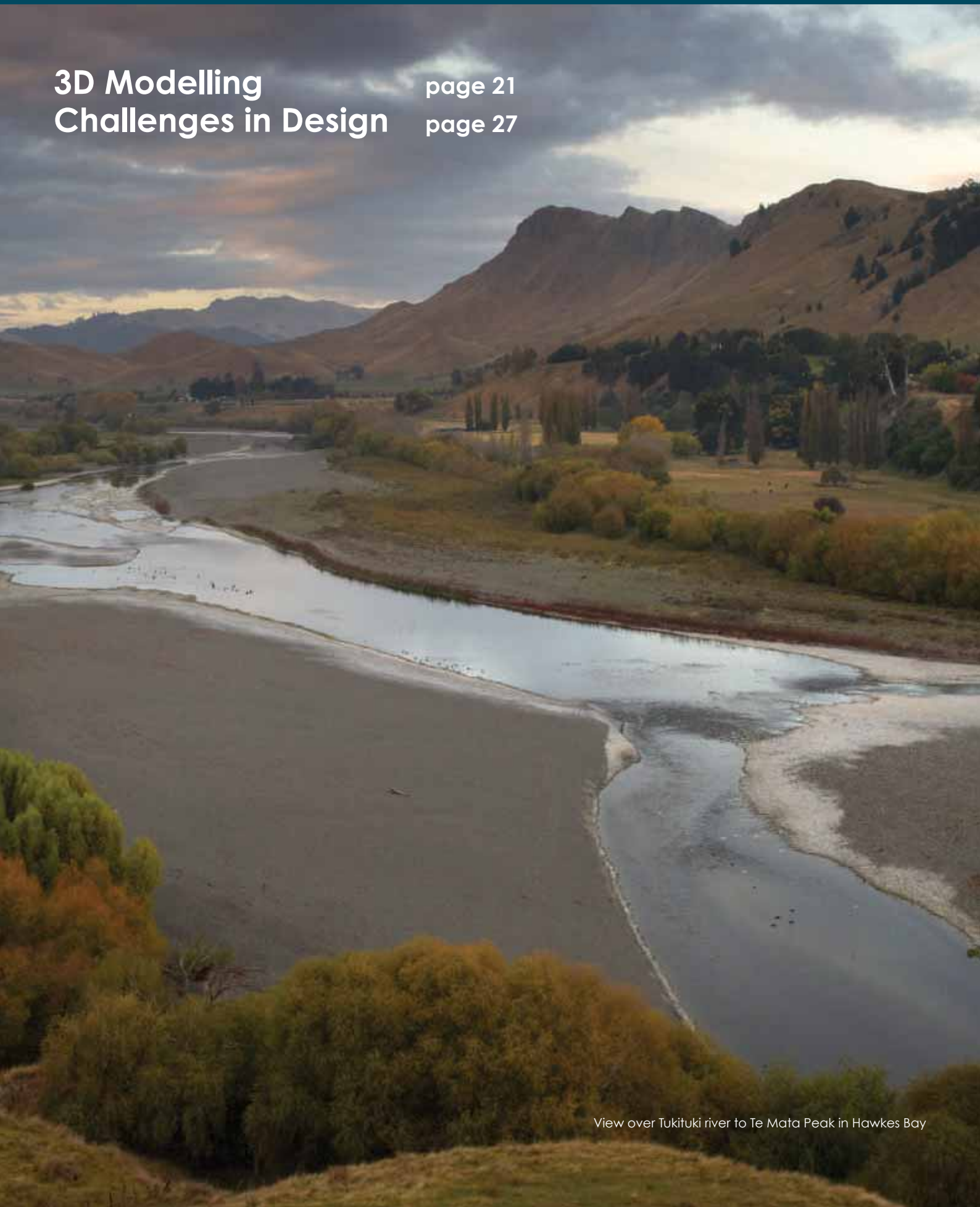
The Court allowed Mr Woolley's appeal in respect of duplicate charges under section 9 of the RMA – land use, and section 13 of the RMA – use of riverbeds. The Court found that although the charges could duplicate each other in general, they could not in Mr Woolley's case. This was because the Judge's definition of riverbed was so wide as to make no distinction between Mr Woolley's activities on land and those on the riverbed. Thus, Mr Woolley had effectively been charged twice for one action.

The Court rejected Mr Woolley's appeal on two counts under the Wairau/Awatere Resource Management Plan. A rule in the Plan permitted maintenance excavation of existing drainage channels. However, the Court held that Mr Woolley's actions went beyond 'maintenance'. Firstly, the channel had not been the size that Mr Woolley made it since 2000, and so rather than maintaining a current state of affairs, Mr Woolley had restored the channel to an earlier state. Secondly, the level of collateral damage caused by Mr Woolley's actions took the excavation well beyond maintenance of the channel, and into criminal damage.

The Court also dismissed Mr Woolley's appeal on the sentence. Mr Woolley argued that the sentence was manifestly excessive. The Court found that Mr Woolley had deliberately flouted the rules; had damaged an environmentally significant wetland and threatened important plant species; and needed a significant sentence to deter him in future. Prior convictions had not deterred Mr Woolley from the present excavation, and Mr Woolley was found to have displayed "arrogance and obstinacy". The sentence was held to be not manifestly excessive but appropriate.

This case is a worthwhile reminder of the reality of the criminal sanctions, which support the rules and regulations made under the RMA. In the case of repeat offenders, who routinely neglect the stewardship of the environment which we all owe, in return for our use of the land, the Court will have to resort to another of our friend Proust's familiar sayings – "Illness is the doctor to whom we pay most heed; to kindness, to knowledge, we make promises only; pain we obey." ■

Special Feature – The Ruataniwha Dam



View over Tukituki river to Te Mata Peak in Hawkes Bay

Ruataniwha Dam – 3D Modelling

Bradley Rudsits – Principal Water Engineer and Glenn Coppard – Senior Design Engineer, GHD

Introduction

The Ruataniwha Water Storage Scheme (RWSS) is a project being lead by Hawke's Bay Regional Investment Company (HBRIC), a Council Controlled Organisation (CCO) of Hawkes Bay Regional Council.

The RWSS project forms a significant element of a range of initiatives designed to address water quantity and quality issues in the Tukituki, Waipawa, and Makaroro Rivers within Central Hawke's Bay. The project was deemed to be a Project of National Significance by the Minister for the Environment and the final Board of Inquiry decision was heard in late June.

The main element of the project is a Central Core Rock faced Dam (CCRD) on the Makaroro River, located approximately 20 kilometres west of Tikokino township. The dam will allow for regulating and meeting minimum environmental flows in the Makaroro, Waipawa and Tukituki Rivers. Further, the dam will allow for large environmental flushing flows (>25 m^3/s) to be regularly released in a controlled manner to replicate freshes in the rivers.

As part of the RWSS, the Ruataniwha Plains will be provided with irrigation water supplied from the dam. The provision of irrigation water from the Dam will allow for intensification of agriculture and horticulture within the Plains. The intensification and regional economic flow on affects were key factors in the RWSS being earmarked for funding contribution through both the Irrigation Acceleration Fund and Crown Irrigation Investment fund.

The irrigation of the Ruataniwha Plains will provide 104ML per irrigation season to ~25,000 hectares. The irrigation water will be delivered through two systems – the primary distribution system which will form the 'backbone' of the irrigation scheme, and the secondary distribution system being a pressurised pipe network to irrigators and water users. The primary distribution system involves major river intake structures, 11 kilometres of canal, 23 kilometres of existing stream rehabilitation and 13 kilometres of large diameter low pressure pipeline. The secondary distribution system includes 19 pressure boosting stations, ~145 kilometres of pressure pipeline (ranging in size from DN1200 to DN150) and up to 180 property offtake connections.

The OHL/Hawkins Infrastructure consortia are the preferred constructors of the RWSS, for whom GHD are both the dam and primary distribution system designers.

Canals vs Pipelines

The construction of pipelines is a 'permitted activity' in regards to planning and consenting requirements. However canals involve the acquisition of sections of private property for construction and ongoing maintenance during its design life. HBRIC and their property consultant have been negotiating with private land owners and GHD has been assisting with preparation of information on the proposed canal footprint.

The canal conveys design flows from 4.0m^3/s to greater than 8.0m^3/s as it flows south through the Ruataniwha Plains. The cross section reduces following the offtakes to the secondary distribution pressure boosting stations. The vertical alignment of

the canal was critical to maintaining the highest water level in the canal as possible, so as to reduce the pressure boosting requirements for the secondary irrigation system.

Unfortunately the Ruataniwha Plains do not have a constant gradient from the foothills of the Ruahine Ranges down toward the Waipawa and Tukituki Rivers, much to the disappointment of designers. Consequently there will be sections of the canal alignment requiring earthworks cutting through regions of elevated topography and engineered fill through lower lying areas to match the required hydraulic energy grade line for the scheme.

Canals are very efficient methods of transporting large volumes of water at high flow rates. There are preferences for the use of large diameter pipelines to conveying flow, however due to the diameters required and length of canal that they would replace for the RWSS the business case was not feasible. An economic cross over point was found to occur when the flow rate was less than 2.0m^3/s and required pipe diameter was less than 1200 millimetres.

Pipelines provided minimal permanent impacts on existing land use and topography as they can be considered "out of sight, out of mind". As pipelines were not considered economically feasible for the top portion of the primary distribution system, a primary canal was adopted. Canals do have a major impact on the topography and land use of properties they traverse.

Canal Geometry

The canal geometry is important for both controlling the velocity and minimising earthworks quantities. Base widths and side slopes are an important consideration for hydraulic designers. For the PDS canals in RWSS the base width ranged from 2.5m to 1.5m depending on the design flow. The project requirements stipulated that the canal was to allow for a minimum 3.0m width for an access road on one side, and minimum 3.0m grassed maintenance access on the remaining side. So any changes to the base width of the canal would only have minor changes to the overall width of the canal from bank to bank.

Geotechnical advice during the canal design identified cut batters of 1:2 and fill batters of 1:2.5 as suitable for the predominant river gravel based material through which construction would occur. Based on these side slopes the canal footprint increases in size by 4m and 5m for every 1m increase in cut or fill respectively. When combined with the access road and maintenance requirements, these dimensions result in the canal footprint being approximately 20m wide before significant cut or fill sections are incorporated into the design.

A canal with an invert 2.0m above the existing topography (embankment conditions) would have an overall width of 37m. Similarly a canal with an invert 2.0m below the existing topography (battered excavation) would have an overall width of 26m.

Both of these situations present major impacts to land owners particularly for issues such as access to land, reduction of useable agricultural land and impacts to existing on-farm irrigation infrastructure.

Land Owner Consultation

The majority of PDS drawings produced by GHD for OHL/Hawkins tender design were at scales ranging from 1 in 10000 to 1 in 2500. As a reference, drawings with a scale of 1 in 2500 displayed 1.5km of alignment. While detailed design plans in the future will display a higher level of detail through use of smaller scales, currently it can be difficult to discern differences in the changing widths of the canal footprint. Thus during discussions between land owners and HBRIC common questions raised when viewing the tender design plans, were:

- "How big will this be?"
- "How will this affect my stock movements?"
- "What will happen to my fences?"

To assist with the land owner consultation, HBRIC engaged GHD to prepare a 3D model of a critical section of canal.

3-D Computer Aided Design

GHD utilised 12D software by 12D Solutions for the tender design of the canals and pipelines. The software allowed for generation of digital terrain models from previous LiDAR surveys over the Central Hawke's Bay region. From the digital terrain model, earthwork quantities for the canal could be directly assessed and incremental changes made to both horizontal and vertical alignments.

The models designed in 12D were exported to AutoCAD for post processing and the production of designs plans. While engineers are able to identify features and symbols on design plans, interpreting this information can be difficult for non-engineers.

The 12D software was used to produce a three dimensional model of the canal section including the addition of scalable indicators to help landowners understand visual effects on properties. The model included:

- Property boundaries (cadastre)
- Fence lines
- Overhead power and telephony cabling
- Vegetation such as stands of trees
- Topographic features such as streams, existing carriageways and driveways, and
- Existing buildings

Aerial photography can be 'draped' over the digital terrain model subject to using suitable file types (vector based compared with raster based imagery).

The addition of scalable objects in the model assists with land owner consultation as they provided a relative reference to known objects. Land owners can judge the impacts of proposed infrastructure to their property by comparing with existing objects that are important to them such as access roads and fencing.

The critical section of canal as modelled runs parallel with a local road. Two options were developed for the canal with each option being on a different side of the carriageway. A camera path was defined in 12D following the centreline of the road. The camera path was then used for a fly through animation to show the impacts of the two canal alignment options.

12D allows for the model including camera path to be exported as a three dimensional portable document format

(*.pdf). The software allows GHD to prepare a title block and overview plan showing the canal alignment with aerial photography background, which appears as a typical engineering style plan as per Figure 1.

The overall file size for the portable document format with the inclusion of the 3D model was approximately 14 mega-bytes. This relatively small file size means that the file can be viewed on a PC screen, with a tablet or even smart phone.

Model View Manipulation

When the right hand plan is clicked (refer to Figure 1), the three dimensional navigation tool bar is activated. This starts the fly through for the alignment and allows the user to pause the animation at any point in time as displayed in Figure 2. The tools also allow the user to pan, rotate, and zoom from any point in the model .

Preset views can be accessed from the drop down box on tool bar as per Figure 3. These were configured to show the canal alignment from a number of locations that were important to the stakeholders, such as existing dwellings.

The 'model tree' feature included in Adobe Reader allows for the individual models created in 12D, or AutoCAD to be turned off to provide clarity when viewing the model. An example is presented in Figures 4 and 5 (over page) where the vegetation has been removed to improve the visibility of the proposed earthworks cut batter extents. The model 'tin xcad PINE' has been unselected from the model tree, improving visibility of the cut batter.

Figures 4 and 5 (over page) also show another way of accessing the preset views, other than through the drop down box.

Design Collaboration

Generally the use of portable document format is the easiest method of providing information to stakeholders, particularly those with non-technical/non engineering backgrounds. However there is an increasing use of three dimensional software containing attributed data for design collaboration. A number of software packages are available (Bentley Navigator, AutoDesk Navisworks and Design Review), which allow for technical multidisciplinary collaboration. The packages allow for designers of separate discrete portions of the works (access roads, buildings or structures, underground services) to store and access design information in a single location.

As well as design collaboration, the software fits within existing workflows specifically around use of latest information/

Top to bottom – Figures 1, 2 & 3

"Multi-disciplinary projects increasingly mean the contribution of non-technical people to project outcomes, rather than those from a different branch of engineering. Stakeholders and their associated communities are formally and informally involved in the direction of infrastructure projects."

Figure 4

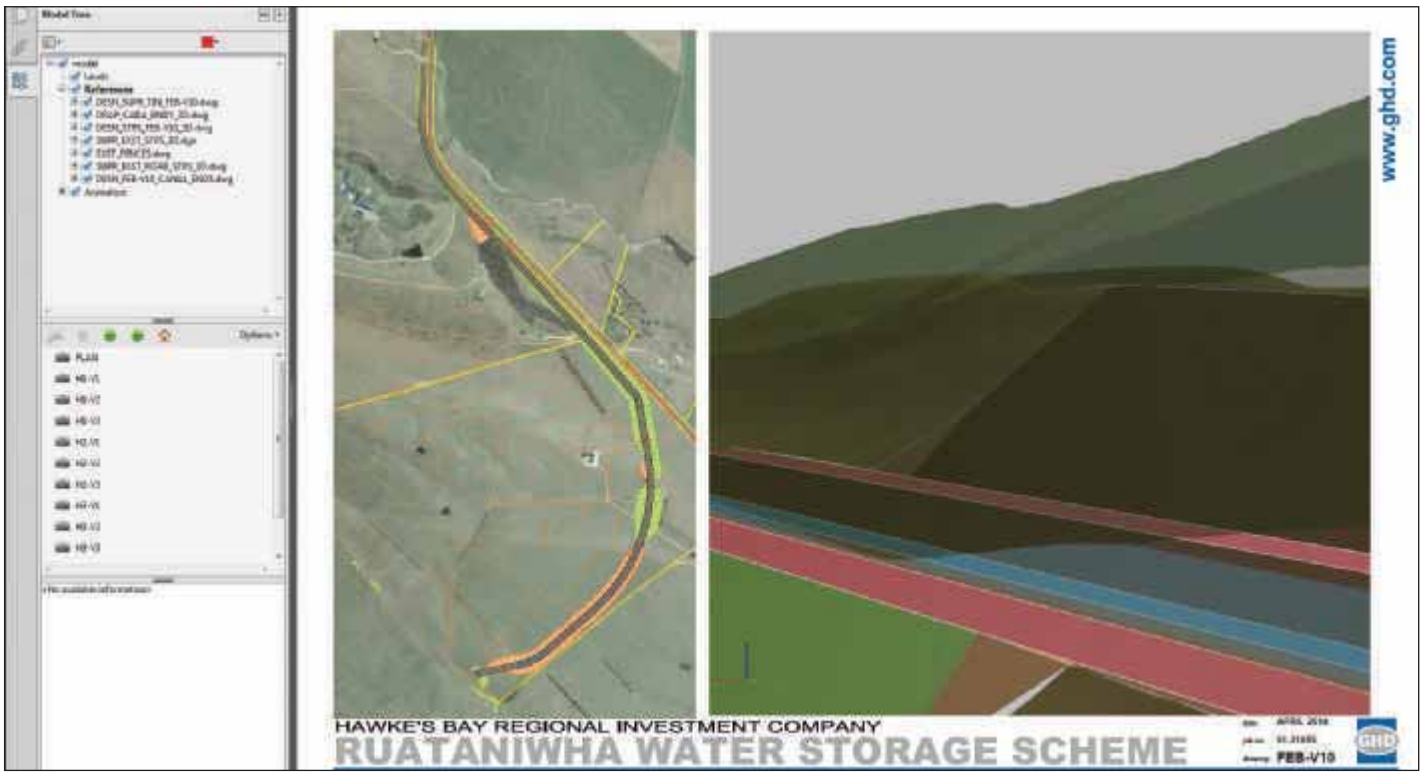
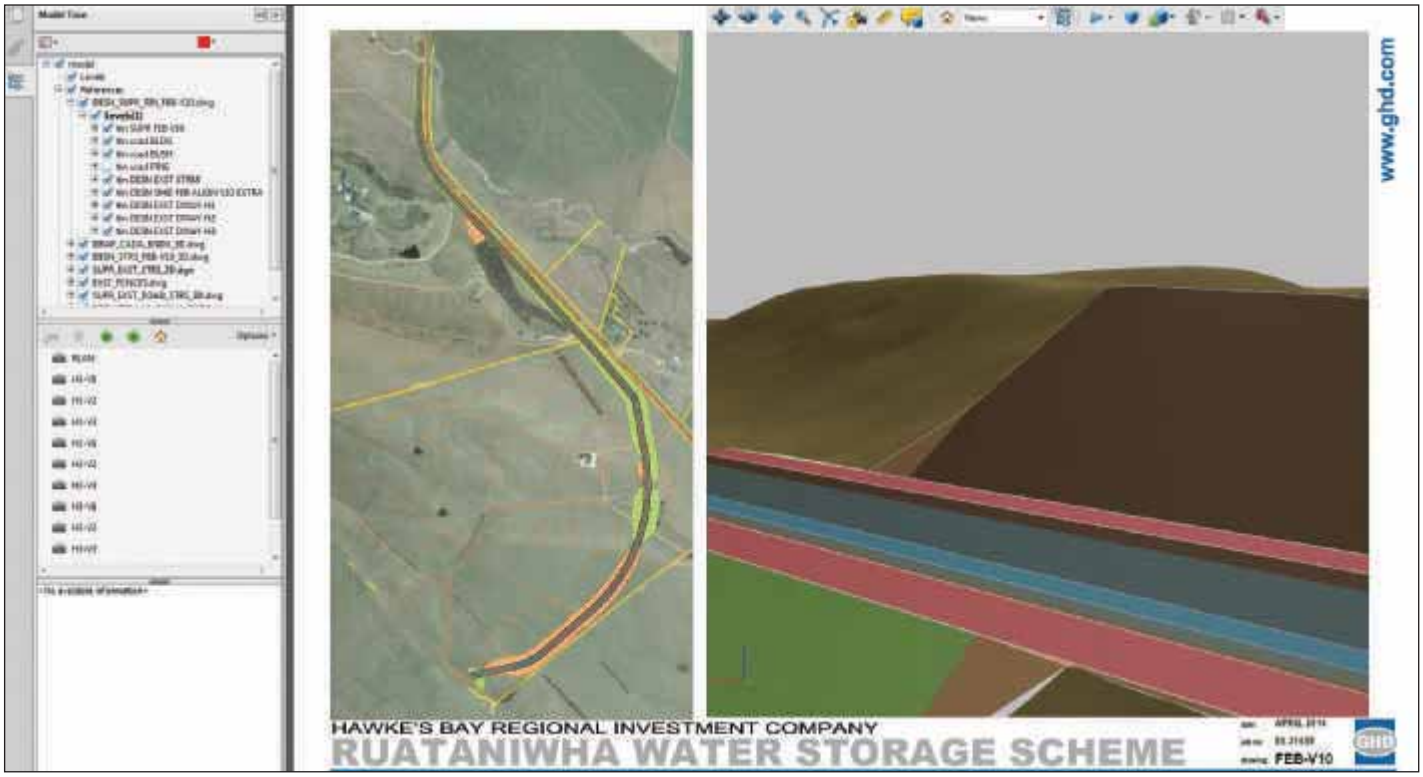


Figure 5



models. Expanding further, the models can be issued to engineering reviewers in lieu of a series of paper plans. Reviewers are able to see how the specific technical discipline of design work they are checking fits within the overall project design.

These packages are frequently adopted for large scale infrastructure but there are no reasons why they cannot be adopted for projects with decreasing scales.

Multi-disciplinary projects increasingly mean the contribution of non-technical people to project outcomes, rather than those from a different branch of engineering. Stakeholders and their associated communities are formally and informally involved in the direction of infrastructure projects. These relationships have become further formalized through steering committees and community boards. The use of three dimensional modelling assists both non-technical and stakeholders with developing a 'sense of scale of the project' and communicating progress on the design.

As design progresses from concept through to construction phases, stakeholders can be provided with updates on how their contributions fit within the overall project. This can include how landscaping contributions have been adopted, or how alignment contributions may not be able to be integrated where they adversely affect design disciplines.

Engaging with Stakeholders

The three dimensional model was displayed to stakeholders so that they could compare the relative impacts of the two canal alignments.

One specific landowner was concerned with the potential impact to the landscape on their properties due to the canal. A preference had been expressed for the canal alignment to be located on a specific side of the road. The preference was based on the canal being less intrusive to the landscape and proposed planting and vegetative screening was considered to increase the visual amenity of the alignment.

Preset panoramic views were configured within the three dimensional model to display the landscape impacts of the two alignments. The panoramic was set up to replicate the view from the stakeholder's house on a ridge line overlooking the canal alignment. The view was based on a panning and rotating camera, configured similar to the fly through.

Figure 6 (over page) shows the preset panoramic view looking north-east from the stakeholders dwelling for their preferred alignment. This can be compared with the same preset view showing the alternative alignment as per Figure 7 (over page).

These two comparable views can then be used in discussions with the stakeholders with regards to the permanent visual impact on the landscape.

Similar to the panoramic views, sectional views can be generated within Adobe Reader as per Figure 8 (over page). The sectional views can be utilised along with the 3D measuring tool within the software. The in-built measuring tools within Adobe Reader can be used for distance and area takeoffs on 'standard' non attributed plans as long as the scale of the plan or view being measured is known. With the use of the 3D model within the portable document format, there is no requirement to know the drawing scale – the model has been produced as per real life. The model units will have a 1:1 scale with the units in which the model has been produced being either metres or millimetres. Further the model units displayed can be altered to "m", or "mm" rather than displaying "model unit(s)".

Figure 6

Figure 7

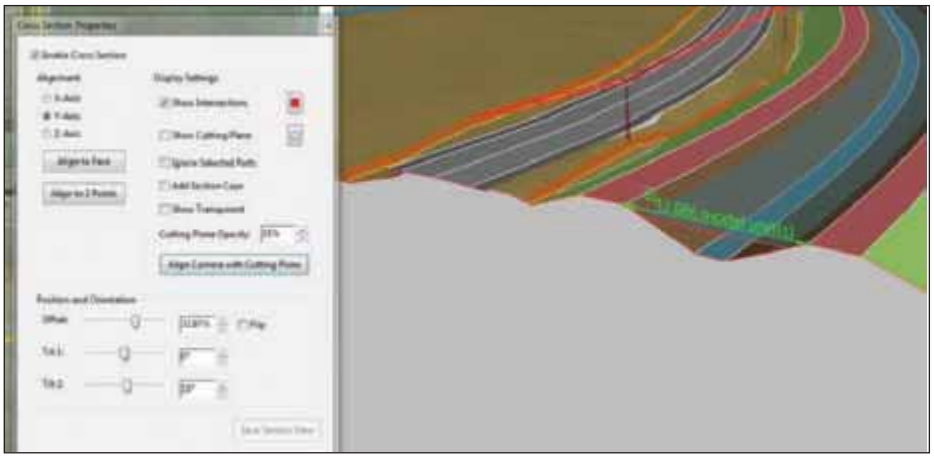


Figure 8

"The use of the three dimensional modelling and fly through can be used for any linear infrastructure project."

Future Modelling Uses

Additional modelling can be undertaken to show the temporary impacts during construction due to activities such as:

- Haul roads
- Temporary site fencing
- Road closures, diversions and temporary access
- Stream diversions
- Erosion and sediment control measures;
- Site establishment compound and temporary materials supply yards, and
- Staging of works particularly with regards to separable portions

While not displayed for these three dimensional plans, these construction impacts can be added as scalable indicators. This allows for the animation and three dimensional model to show the extents of site compounds, where vehicle access from existing roads would be located and temporary fencing to isolate the construction zone.

Summary

The use of the three dimensional modelling and fly through can be used for any linear infrastructure project. The use of portable document format (*.pdf) means that the majority of end users can view three dimensional models and associated fly throughs using commonly available freeware such as Adobe Reader.

Providing information in readily accessible format for stakeholders over the design and construction phases helps with engaging and communicating with those parties.

With the relatively small file sizes, sending the information to clients, stakeholders, and 3rd parties can be accomplished easily using email or file transfer systems such as 'Dropbox'.

Using three dimensional modelling for linear and large scale infrastructure is comparable with the increasing adoption of Building Information Modelling using products such as Revit. The modelling fits within existing project workflows and can be used to assist with reviewing and checking. ■

Ruataniwha Dam – Challenges in Design

James Willey – Principal Dams Engineer, GHD

Note: This article refers to figures used in the previous article.

Project Background

The OHL-Hawkins joint venture, of which GHD is one of two main design partners, was conditionally awarded the design and construction phase of the Ruataniwha Water Storage Scheme. The primary objective of this scheme is to provide a reliable water supply for 6,000 hectares of existing irrigation while unlocking a further 20,000-30,000 hectares of irrigation. The use of the river for conveyance of water from the dam to the canal offtake works will also provide the opportunity to improve environmental flows into the Makororo, Waipawa, and Tukituki rivers over the summer months.

The project involves the design and construction of an 83 metre high dam and 202 kilometres of primary and secondary water distribution systems. In recent value engineering design updates, a long length of primary canal, large river syphon and three small secondary pump stations have been deleted and have been replaced with one new large intake structure/storage pond and a 2.8 m³/s pump station, with this work still in negotiation with the client. Other improvements in the tender design have included changes to the primary canal alignment, which are designed to minimise disruption to farm operations.

The contract is expected to be signed in September 2014 and has a capital cost of NZ$245M.

This article focusses on the design of the dam and associated works, which include the irrigation and environmental outlet works and the spillway.

A view looking down the river towards the damsite showing the relatively steep left abutment is shown on Figure 1 (see page 23). The view across the dam from the right abutment towards the left abutment shown on Figure 2 (see page 23) clearly show the flat right bank terrace with the river gorge at the left abutment.

Geological Setting and Seismic Risks

The proposed dam site is located in Cretaceous sandstones with occasional zones of thin inter-bedded mudstones and sandstones. The sandstones are referred to as greywackes or greywacke sandstones.

The damsite is located approximately 1km to the east of the active Mohaka Fault. GNS Science completed a number of studies and found no evidence for active or secondary faulting within the greywacke rock mass exposed in investigation trenches near the proposed dam site. This covers a time period of at least 10,000 years, as indicated by the geologic deposits overlying the bedrock.

The trench exposures were limited in extent, and the potential for secondary faulting in places that had not been exposed could not be ruled out and the requirement for the design to accommodate a 500mm shear movement was identified as the most significant risk to be considered in the final dam type selection and design requirements.

Summary of Key Risks

The key risks that were identified during the design included the following:

- Construction near the active Mohaka fault located approximately 1km to the west of the site with the potential for secondary fault displacement at the dam site, noting that the project design criteria required the following:
  - » The design must accommodate an estimated fault movement of 500mm that could occur in any direction and orientation, and
  - » Allow repair of the dam in the event of the MDE causing damage
- Identification, selection and management of construction material appropriate for the selected dam type
- The shape of the valley including consideration of potential differential settlement at the interface of the right bank terrace and the river valley leading to cracking through the embankment and the potential for piping through the crack
- Diversion requirement for a 1 in 1000 AEP event

Dam Type Options

The initial dam selection process considered a number of alternative dam types including the following:

- Concrete Faced Rockfill Dam (CFRD) which was the Application Design Dam Type
- Roller Compacted Concrete (RCC) Dam
- Central Core Rockfill dam (CCRD)
- Hardfill Dam (using cement stabilised river gravels)
- Composite Dam (right abutment of earthfill, and central part RCC)

A range of alignments were also considered in the dam type selection phase as follows and shown on Figure 3 (see page 23):

- Application Design Alignment (orange)
- Intermediate Alignment as adopted for tender design (yellow)
- Downstream Alignment (blue) to avoid the projected alignment of a postulated shear zone (shown in red) on the right abutment

Options rejected early in the assessment were as follows:

- Hardfill Dam – When compared with RCC, there was a significant increase in dam volume, which was not sufficiently offset by reductions in aggregate processing cost.
- Composite Dam with concrete gravity river section and earthfill right abutment – based on early costing of the option, it was found this option yielded a significantly greater cost than the single dam type options. In addition to this, the alignment of the fault could not be identified and the dam had to be able to cater for the estimated fault movement along any part of the dam axis.

The dam selection process included multi criteria analysis, however, a key consideration in the final dam type selection was the requirement that the

"GNS Science completed a number of studies and found no evidence for active or secondary faulting within the greywacke rock mass exposed in investigation trenches near the proposed dam site. This covers a time period of at least 10,000 years, as indicated by the geologic deposits overlying the bedrock."

dam must accommodate a 500mm shear movement. On the basis of this assessment, the central core rockfill dam was selected. The adopted cross section is shown in Figure 9 (see opposite page). The intermediate dam alignment shown on Figure 3 was ultimately selected.

This design included the following risk mitigation measures:

- Wide central core with 0.5:1 side slopes on both upstream and downstream slopes
- Wide downstream filter zones with sand filter and transition filter each of 3m horizontal width
- Crest width of 7m
- Re-profiling of the steep transition from the river gorge to the right bank terrace, as discussed below
- Use of high strength river gravels for the shoulder material and internal zoning of the weaker greywacke from required excavations
- Downstream blanket

The coffer dam embankment was incorporated within the upstream rockfill zone in order to reduce costs and footprint area of the embankment within the river valley.

Construction Materials

Potential locally available construction materials for dam construction were identified using pitting and boring as follows:

- Makaroro River gravels (Kaweka Greywacke). These are sub-rounded, well graded, durable gravels, containing cobbles and boulders, suitable for concrete aggregate and dam shoulder material.
- Waioeka greywacke of the Wakarara Range is a low metamorphic grade, zeolite facies, non-durable rock mass, which breaks down rapidly on excavation and working.
- Pliocene Age mudstones / siltstones (Papa), when containing sufficient clay, are suitable as core material for an embankment dam.

Compaction trials were carried out for each of these material types using equipment similar to the proposed construction equipment, as shown on Figure 5 (see page 24). The Waioeka greywacke trials showed significant breakdown of this material, which was considered low durability suitable only for use in the internal zones of the embankment.

The Makaroro River gravels derived from the more durable Kaweka Greywacke has higher strength material, which was identified as the main source of rockfill. Triaxial testing was completed using 100mm diameter samples for the gravels and the data was compared with published data on similar materials to derive the final preliminary design strength data.

The Papa was known to be a difficult material for construction of a clay fill zone, however, compaction trials indicated that adequate moisture conditioning and compaction could be achieved. The Papa borrow areas were found to be variable with the fines content in the selected areas varied from about 28% to 98% and the plasticity index varying from 7 to 19%. A minimum plasticity index of 12% and a minimum of 40% fines was adopted for material to be used in the embankment core zone.

There was some concern as to the ductility of the Papa under seismic loading. Results of triaxial tests clearly showed the material to be ductile with no loss of strength once the peak strength was reached with increasing strain up to 16%.

Sand filter material will be obtained from the river where screening and sieving with washing will be required to achieve the required grading necessary to provide a filter suitable for preventing piping through cracks that may form through the papa in the event of seismic shear movement or other crack initiation mechanisms.

As shown on Figure 9, the final design incorporated each of these construction materials.

Reprofiling of Lower Right Abutment

As mentioned earlier, potential for differential settlement to result in transverse cracking was identified as a significant risk to be addressed in the design. This was largely due to the abrupt change in slope where the valley section opens out onto a terrace on the right abutment as shown in Figure 10 (see opposite page). This was addressed by reprofiling the lower right abutment in order to minimise the potential for vertical strain and cracking through the core zone at the change in slope. A finite element model was used to evaluate the potential vertical deformation and the extent of reprofiling required.

Various options for the reprofiling excavation for the lower right abutment were considered in this analysis including a range of slopes and ultimately a curved profile as shown in Figure 9. This analysis clearly showed that the proposed curved excavation profile resulted in a significantly reduced potential for cracking. In addition to this, a risk analysis was used to evaluate the piping potential for the original and revised profile, to confirm the benefit of the foundation reprofiling.

Summary

The Ruataniwha dam preliminary design presented a number of challenges, which needed to be addressed to meet the design requirements. The most significant change was from the application design concrete-faced rockfill dam to the central core rockfill dam, which was considered the most appropriate design for accommodating the potential foundation shear movement of 500mm.

The design changes resulted in cost reductions while making use of locally available materials for the major sections of the embankment including the river gravels for the outer shell zones, Papa for the core, and screened and sieved river gravels for the filter zones. Careful design evaluation of the stability and the embankment foundation profile as well as careful selection of the internal zoning have minimised the potential for piping through the embankment while maintaining adequate factors of safety for slope instability under the required seismic and flood loads. ■

Figure 9 – Adopted Central Core Rockfill Dam Cross Section

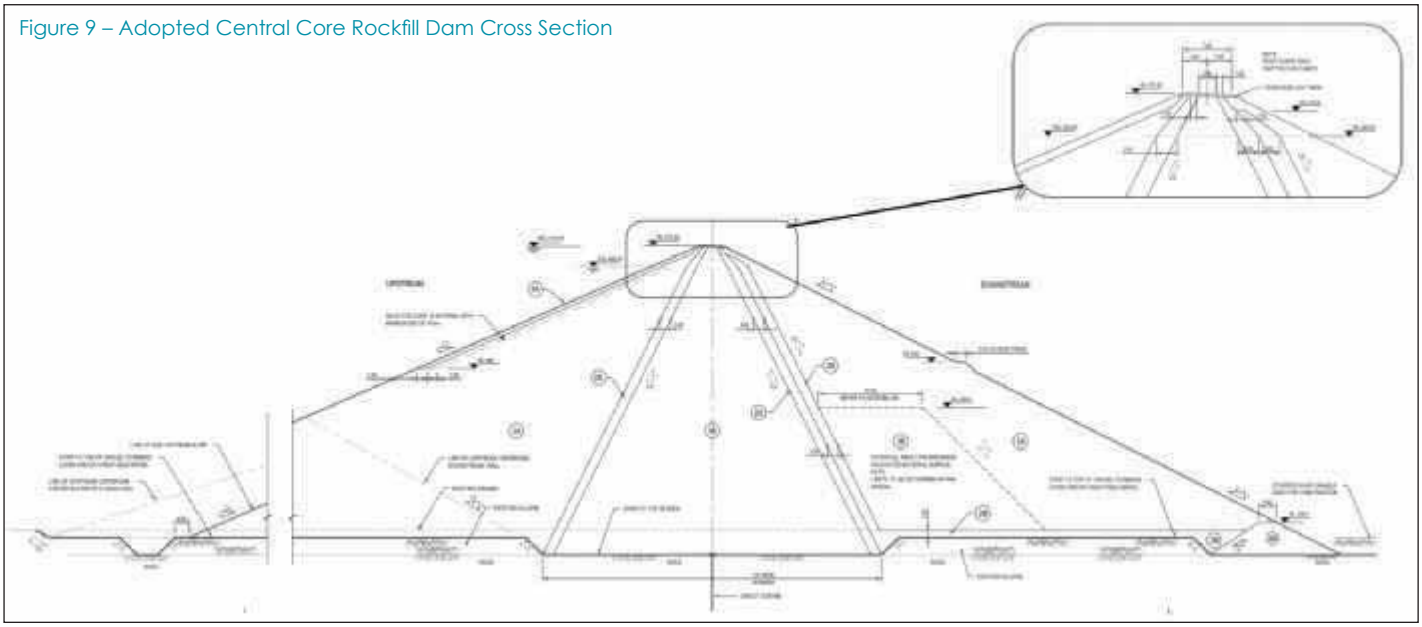
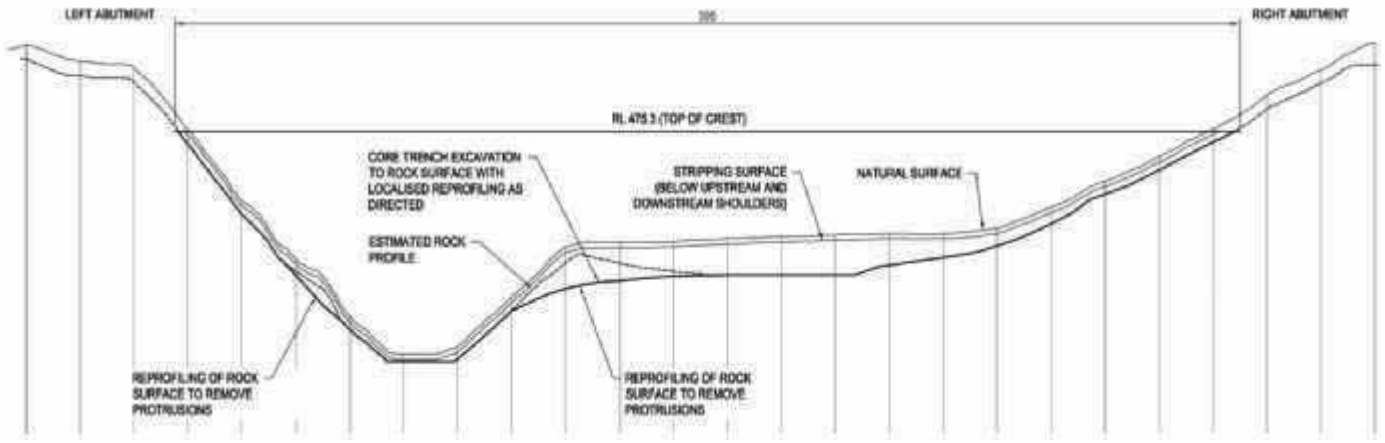


Figure 10 – Valley profile on dam axis



Refurbishment of the Ross Creek Reservoir – Enhancing Resilience of the Dunedin City Water Supply

Ian G Walsh CPEng, FIPENZ – Technical Services Manager, Opus International Consultants Ltd

Background

The Dunedin City Council is progressing a series of projects to enhance the resilience of its water supply. The bulk of the water used in the city is conveyed by pipelines up to 70km long that traverse terrain that is potentially subject to geotechnical and hydrological hazards that could result in supply disruptions that exceed the working storage capacity within the city. As part of their water supply resilience programme to address this risk, council has committed a project to refurbish the Ross Creek Reservoir to facilitate reintegration of this storage into the local network.

The reservoir is impounded by an hydraulic fill embankment dam originally constructed in 1867. This 18m high dam is constructed on a basalt rock foundation, and it impounds some 250,000m^3 gross storage for the original purpose of municipal water supply. Live storage of some 150,000m^3 is provided within the top 4.7m of the reservoir.

The facilities have significant heritage value, as the works are recognised as having engineering heritage status. The reservoir site is also located within a bush reserve that presents high amenity value to the Dunedin community. Unfortunately these positive aspects are offset somewhat by the engineering performance standards of the ageing assets not satisfying current dam safety expectations embodied in the Building Act.

The dam has been subject to past significant leakage incidents that have led to previous substantial repairs. More recently the embankment has been subject to minor shoulder instability following periods of sustained rainfall. As dam owner and operator, the Dunedin City Council (DCC) has a dam safety assurance programme (DSAP) in place for this facility, as required by the resource consent conditions pertaining to its operation. Design deficiencies and asset deterioration concerns have been identified for this ageing facility, and the reservoir is currently operated according to a special dam safety management regime reflecting this reduced level of embankment stability. A lowered reservoir condition is a key element in this interim management regime while a programme of refurbishment is implemented to raise the level of engineering performance and allow this facility is to remain in service in the medium to longer term

Current Refurbishment Project

The primary focus of the current refurbishment project is to address the downstream shoulder stability. Although the facility has performed its required functions for over 140 years, by current standards the downstream batter slope is steep for a clay embankment at 1.85H:1V, and the crest is narrow with a width under 2.7m. The spillway flood discharge capacity also falls below current engineering standards for impoundments in an urban setting with a "High" potential impact classification in terms of the Building Act. Finally the ageing offtake and dewatering facilities including the masonry tower and cast iron pipelines situated within a "tunnel" built on the right abutment through the dam have limited serviceability and seismic resilience.

A shoulder buttress is to be constructed to enhance the stability of the embankment under static and dynamic loading. Figure 2 shows a typical cross section through the dam with the new buttress present.

Unfortunately investigations have revealed that the original dam builders placed the stripping from the dam footprint in the area now proposed for the buttress, so removal of this waste material is required before construction work proper can commence. Our ability to transport substantial quantities of materials on and off

Figure 1 – Ross Creek Reservoir Offtake Tower

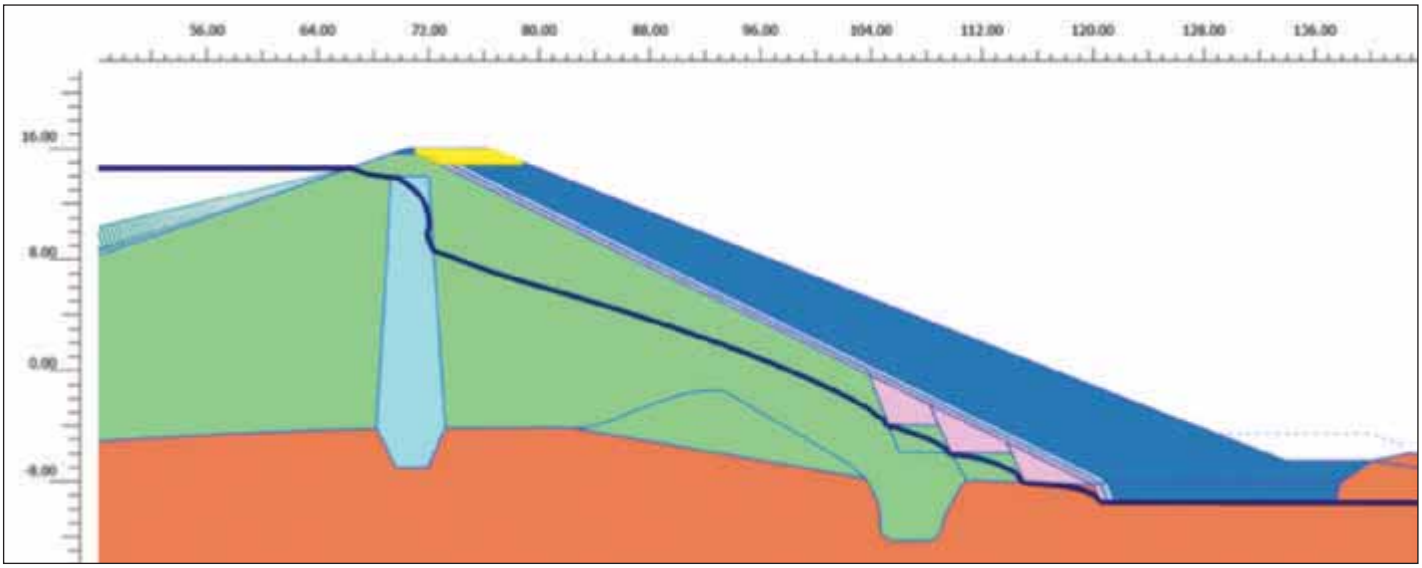


Figure 2 – Typical cross section showing downstream buttress

site contrasts with the realities of pioneering era construction using essentially hand methods to build the original dam.

The buttress layout is unusual in that it is placed to a warped finished surface geometry that avoids impacting on the existing left abutment spillway while still providing the necessary mass of buttress material in vulnerable areas.

Figure 2 also illustrates filter layers that will be sandwiched between the existing clay embankment and the new rock fill buttress. These filter layers comprised respectively of uniform sand and fine gravel are designed to protect the dam against the risk of internal erosion should seepage occur along any cracks that may develop during severe seismic events. Counterforte drains are also proposed to control the phreatic surface at the toe of the clay shoulder.

Seismic loading was not a design consideration in the 1860s, and it is perhaps worth reflecting on the fact that hydraulic fill embankments are no longer considered appropriate in seismically active environments. In retaining the heritage embankment for ongoing use, the matter of accurately predicting the behaviour of

"A precast wave wall is to be added to the crest to enhance freeboard while avoiding adding excessive weight that would compromise seismic performance. Reinforcement of the crest fill zone is also included to improve overall resilience, along with a cut off trench added over the puddle clay core."

the hydraulic fill under all potential loading conditions has become a key aspect of the refurbishment design and analysis. While the existing puddle clay core and shoulder zones have sufficient clay content and plasticity to avoid classic liquefaction response under dynamic loading, their high void content and low stiffness characteristics do make them subject to a significant degree of strain softening behaviour. That is, the normal static stiffness and strength of these materials cannot be relied upon under severe dynamic loading. Extensive stress strain modelling and sensitivity assessment has been applied to the design to ensure that the refurbishment works will deliver the engineering performance required to satisfy current regulatory requirements. Compliance with these requirements is established through procedures published in the, NZ Society on Large Dams Dam Safety Guidelines. These procedures include both independent peer review and technical regulatory review of the works.

The existing narrow crest has little freeboard under flood conditions, and very limited ability to accommodate any slumping that may occur during seismic events. Embankment dams are expected to exhibit some permanent deformation under severe seismic loading, and the objective is to ensure that such deformation does not exceed limits that would expose the impoundment to the risk of uncontrolled release. Additional crest height also provides enhanced security in flood conditions by allowing additional surcharge on the spillway while retaining adequate freeboard against wave action and overtopping.

A precast wave wall is to be added to the crest to enhance freeboard while avoiding adding excessive weight that would compromise seismic performance. Reinforcement of the crest fill zone is also included to improve overall resilience, along with a cut off trench added over the puddle clay core.

The existing spillway crest and discharge chute forms part of a complex flood handling system at the site. While the reservoir impoundment is situated within the original Ross Creek stream bed, interception/diversion channels are present around both sides of the reservoir. That is, it is possible to divert all normal stream flows around the reservoir. The true left channel combines with the spillway crest discharge into spillway chute. There is also an upper impoundment that acts as a sediment trap that is separated from the main reservoir by a small bund. This additional water body is hydraulically coupled to the both the main reservoir and the true left channel in a variable manner depending upon water levels.

Notwithstanding this complexity of flow paths within the site, the existing spillway chute has inadequate capacity to safely handle current design floods for a facility of this potential impact classification. The target flood discharge capacity is to be raised to the probable maximum flood discharge from the existing 500-1000 year recurrence interval capacity with minimal freeboard.

The spillway chute operates as a supercritical channel with velocities up to 18m/s within the 30 degree sloped section. The existing chute contracts too rapidly near the dam crest to handle the current design flow requirement, despite the additional surcharge available from the dam crest raising. It is therefore proposed to widen the chute over a 45m reach to limit choking and the generation of standing waves. As there is potential for floods to occur during the construction period, widening is to be limited to the true left side of the chute where hard rock excavation will be undertaken and the potential for uncontrolled erosion is very limited. Local raising of the existing chute walls will also be undertaken to ensure freeboard is maintained.

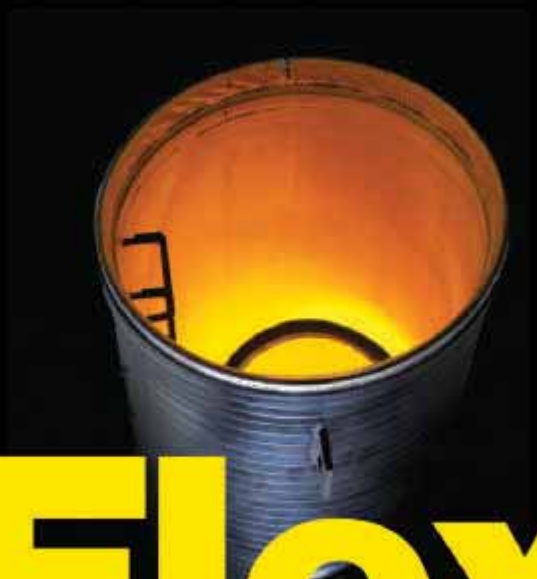
The original masonry offtake tower situated in the reservoir contains valve gear that controls releases to the cast iron offtake and scour pipelines located within a concrete "tunnel" constructed on the right abutment foundation under the embankment. The existing "tunnel" outlet is comprised of a masonry chamber located downstream of the embankment on the true right of the original stream channel. Drainage from the tunnel is provided via pipework discharging through a masonry wall constructed across the original stream channel upstream of the left bank spillway termination.

The refurbishment works will see the existing offtake facilities decommissioned once a new pump station and associated rising main is constructed to convey up to 9,000m3/day to the higher altitude reservoir and treatment plant at Mt Grand. The suction line for the pump station will be constructed around the right abutment of the dam and will not rely on the existing tower or conduits. This will allow the heritage value of the masonry structure to be retained without the need for extensive structural upgrading. The existing conduit "tunnel" will be isolated with a concrete plug to ensure its integrity even in the event of a major earthquake that disrupts the intake tower. The existing cast iron conduits will be fitted with PE liners as a future proofing action in case of future needs.

There is a possibility of further enhancement work in the future involving improvements to the stability of the upstream shoulder of the dam. Although the 3H:1V upstream slope is much flatter than the downstream shoulder, it does not fully satisfy current engineering standards. A membrane liner and associated under drainage layer would effectively address this deficiency, with relief drainage via the PE lined conduit through the "tunnel" plug. However, further detailed assessment of the effects of seepage behaviour through the very low permeability hydraulic fill and the jointed basalt foundation is required together with characterisation of the dynamic strain behaviour of the clay before making any refurbishment decisions.

The refurbishment work is currently being tendered, and it is expected to be completed during 2015. As the remaining packages of work within the overall water supply resilience programme are completed the potential risks to the reliability of the city water supply will be substantially mitigated.

The permission of the Dunedin City Council to publish this article is gratefully acknowledged.



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Locals take a shower in a waterfall in the creek line

Water Supply on the Black Magic Island

Jen Johnstone – Water Engineer, Beca Ltd

Introduction

Ambrym is a small volcanic island in the Vanuatu archipelago, about an hour's flight from the capital of Port Vila. With a population of 7,000, it is rarely visited by tourists. Although the official religion is Christianity, it is considered to be the centre of sorcery and black magic in Vanuatu and there are still strong customs and beliefs that govern the locals' everyday lives.

Aside from religion, Ambrym is largely untouched by western culture, except for cell phones and a few other gadgets. They are almost entirely self-sufficient, and only buy a few items such as rice and noodles to supplement their home-grown diet consisting mainly of kumara, island cabbage and pumpkin.

As an Engineers Without Borders New Zealand (EWBNZ) volunteer, I have been working with the Wawan Fonhal Development Council, based in north-east Ambrym, on a water supply project for the local community. EWBNZ is a non-profit organisation that provides technical assistance to communities in need throughout the Pacific. Our approach is to work with local partners within these communities, and help them to achieve their self-identified needs. The Wawan Fonhal Development Council is one of these local partners, made up of an entirely female council of elected representatives of nine villages in Ambrym. Strongly motivated to drive development in their communities, the council contacted EWBNZ in April 2013 for technical assistance with a water supply project for three of their villages. Rotary already had a relationship with the council through previous projects and they were keen to be involved with this project as the main funder.

These three villages currently rely on rainwater tanks, which run dry for several months every year in the dry season. During this period, the villagers face a two-hour trek to collect water from the nearest spring source or, for those unable to walk this distance, they must resort to drinking water from a local brackish well.

Options Assessment

In October 2013, I travelled to Ambrym, where I spent three months working with the council, assessing the water supply options and carrying out community consultations in the project villages.

The three options that we assessed were a new pipeline from a spring source; a new rainwater harvesting system; and carrying out improvements to the existing rainwater tanks in the community.

I spent time talking to members of the community, to get an understanding of the priorities and opinion with respect to a water supply solution. I did this by visiting households throughout the communities with members of the council, to engage on a family level, and also by holding community meetings in each of the three villages.

I found a wide range of opinions throughout the community, and discovered that many people had opposing views. Some, particularly the older men, were concerned with the status associated with the project – they wanted a new pipeline because a neighbouring village had recently built one and it is perceived as more advanced technology than rainwater harvesting. Others just wanted an increase in the quantity of water available to them and were unconcerned with how the water was sourced. This was a common opinion amongst the women and younger men; the ones responsible for water collection within their families.

From a technical perspective, the pipeline was the weakest option as the spring source almost completely dries up in the dry season. It was also the most expensive and complicated option, meaning it would be harder to construct and maintain.

The funders of this project, Rotary, were also key stakeholders, and were keen to fund a sustainable solution that would provide value for money in terms of maximising water quantity whilst controlling project cost.

Rotary preferred the option to improve the existing rainwater tanks, as this had the highest yield of water for the lowest cost. However,

Roanna from Falibeur, one of the project villages

there was very little community support for this solution and therefore was unlikely to be sustainable long term. Rotary understood the importance of community buy-in, and were willing to compromise to reach a solution that the community would support.

Faced with opposing views, I worked with the Wawan Council to find a solution that would appease all stakeholders. Our compromise solution was to propose installing new rainwater harvesting tanks and roofing catchment areas, connected via gravity pipelines to tapstands throughout the villages. This solution provided the cost effectiveness and sustainability of the tank option with tapstands, which would give the villagers visible high-tech assets to take pride in (the key draw of the pipe option).

The chiefs of two of the three villages were reluctant to support this option, as they were concerned with the status of their villages in comparison to their neighbours. A nearby village had just built a pipeline from another spring source, and they wanted their villages to have the same system. However, the vast majority of the locals understood that a pipeline would be unviable for their villages, due to the location and yield of their nearest spring source, and were keen for the rainwater harvesting system including the taps to proceed.

The chiefs have a reasonable amount of power in their communities, and the community could not agree to support the project without the chiefs' agreement. After a great deal of discussion throughout the villages, the communities convinced the two chiefs to agree to this option.

After my return to New Zealand, I enlisted help from three Beca colleagues, who provided structural design, hydrological analysis and drafting of the design drawings on a voluntary basis.

The Next Stage

With detailed design now complete, I will be returning to Ambrym later this year with another EWBNZ volunteer, Mark Holden, for the construction stage. As project manager, I'll spend one month on the island to facilitate relationship building between the Wawan Council and Mark, and passing on my project knowledge to him.

Mark will remain on the island for the duration of the construction phase, approximately six months. His role will be carrying out the

Jenn with her host family

The locals currently get their water from rainwater harvesting tanks like these, but they only contain water for around nine months a year

Jen with some of the children from her host family

training and construction supervision of the new water supply, whilst also scoping further projects in the area with the council.

Sustainability

Community buy-in is key for the project to be ultimately sustainable, so the villages are raising 10% of the costs themselves. The communities will also be paying a monthly tariff (around NZ$4/household) for maintenance and replacement of the system at the end of its lifespan. Providing that the households pay these water fees throughout the lifecycle of the system, no further external intervention or funding will be necessary for these villages to have access to an improved water supply system for the future.

Appointed locals will receive plumbers' training and will carry out the construction for the system themselves, under Mark's guidance. This will reinforce their training, as well as giving them a sense of ownership.

The Wawan Fonhal Development Council is key to the success and sustainability of this project. The council members are committed to ensuring the success of this project and future projects in the Wawan area. EWBNZ will be carrying out capacity development of the council through collaborative working with them throughout our partnership. This will involve helping them to improve their management and planning capabilities so that they are better equipped to develop their community.

The potential for future work with the council will be included as an integral part of this project. Through continued work with the council, we hope to see a real change in their capacity as an organisation and in their ability to manage and maintain these projects. By considering future projects at this stage, we will increase the likelihood of the sustainability of each project, and hence the long-term improvement of the standard of living in the Wawan area.

We hope that we can continue the relationship between Rotary, EWBNZ and the council to lead to real positive change throughout the Wawan area.

About the Author

Jen Johnstone is a water engineer with Beca Ltd and a volunteer with Engineers Without Borders New Zealand (EWBNZ). ■

Representation of the proposed system

Progress Report: Seismic Impact on Underground Infrastructure

Dr Rosslyn McLachlan – Project Manager, Opus International Consultants

In October 2012, Opus Research was awarded $2.54M over four years from the Ministry of Business, Innovation and Employment's science investment round to conduct research into the "seismic response of underground services". Opus' particular advantage is an ability to implement research findings, which is a key focus for this project. The study is now 18 months in, and is due for completion by 2016.

Led by Project Manager Dr Rosslyn McLachlan of Opus Research in Petone, the study involves determining the impact of seismic events on underground infrastructure such as water and wastewater pipe networks, and telecommunications cables. Typically, damage to this 'invisible' infrastructure – which is critical to the efficient functioning of any modern city – is difficult to determine and can easily be overlooked when damage to above-ground infrastructure such as roads and buildings is more evident.

Although events in Christchurch highlighted the direct impact of seismic forces on underground infrastructure, as with many Opus projects, this research initiative directly involves a wide team of Opus individuals from many different parts of the country and this inter-office approach is a key project strength. The team also incorporates in-house expertise from Opus in Wellington, as well as external expertise from GNS in Wellington and the SCIRT team in Christchurch.

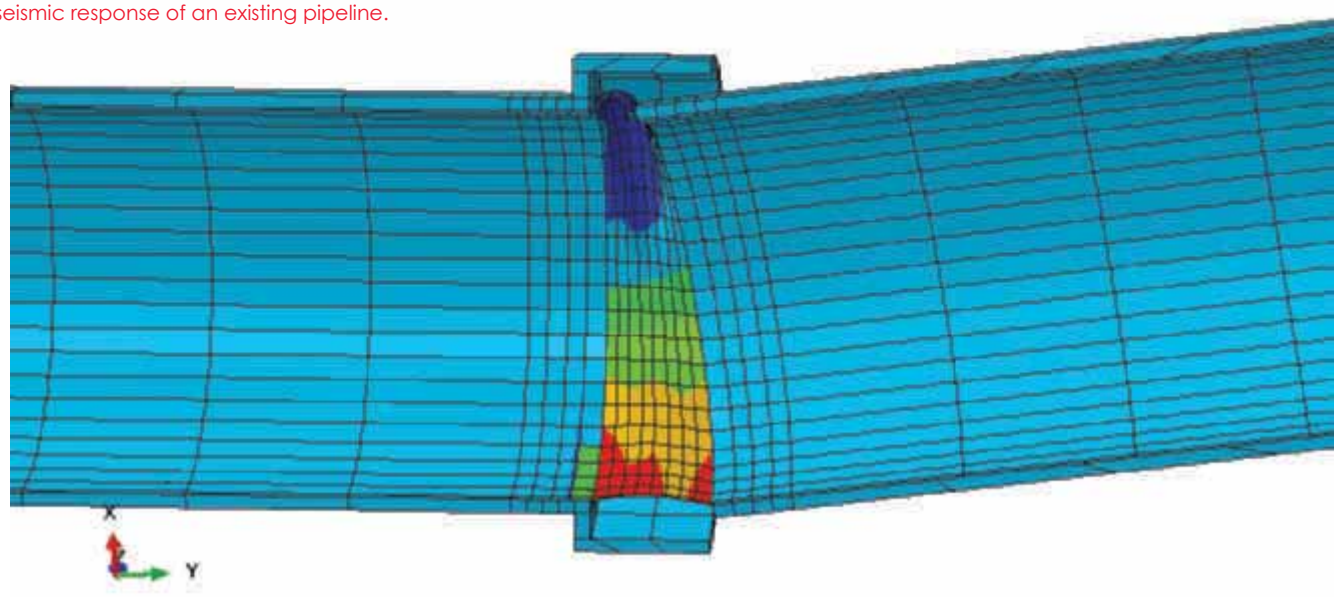
In addition to the project team, the research also includes an industry advisory group that Dr McLachlan regularly keeps updated with research progress. The advisory group, which has a highly technical focus, ensures that project outputs remain practical and directly relevant to industry needs.

There are three main aspects to the research:

- Compilation of a damage database
- Identification and analysis of the behaviour of underground utilities under seismic loading, and
- Implementation of the research work

To date, the study team has completed collection of relevant damage data from Christchurch, and this has been collated onto a specially developed map from GNS. The team now have a damage map with layers showing where infrastructure damage occurred and other layers identifying relevant geological information. The ability to interrogate this highly detailed database helps prioritise areas for further assessment and provides an additional insight into how and why failure occurred.

A preliminary model showing stress distribution in a lined segmented pipe. Models like this will help establish whether linings can change the seismic response of an existing pipeline.



Progress is also underway into an in-depth investigation into utility behaviour under seismic loading. This involves a combination of 3D finite element analysis and physical in-lab testing to better understand how observed damaged occurs. The team is currently investigating a series of case studies and issues raised by the advisory group and by SCIRT and have also undertaken a series of scenario assessments to validate the predictions.

Another important aspect is to understand the impact of seismic damage on the residual life of utilities and on other asset management related activities. These will build on the previous findings discussed above.

As results from the analysis emerge, the team will then focus on implementing the findings. While developments are covered in technical reports, papers and presentation, we expect that final outputs will typically take the form of guidelines and recommendations. In many cases we expect that these will build on work that bodies like SCIRT had developed for use during the reconstruction of Canterbury. The longer-term aim is to provide stakeholders with a series of directly applicable case studies to communicate findings in a way that is directly applicable to situations across New Zealand. ■

A section of steel pipe under compression moments before it failed in buckling. Physical testing helps understand the detailed interaction of pipe, lining, and coating.

The Pressure Is On – The Story of the Valetta Irrigation Scheme Upgrade

Ben Scott, Beca Ltd

With increasing pressure on water, coupled with farmers' desire to improve efficiencies at a time when spray irrigation technologies offer substantial advantages over traditional flood irrigation, irrigation schemes are taking advantage of opportunities to modernise and upgrade their infrastructure.

The Rangitata Diversion Race (RDR) delivers approximately 30m^3/s of water from the Rangitata River at Klondyke along a 67km race to discharge into the Rakaia River through Trustpower's power station at Highbank.

Three community irrigation schemes, two hydroelectric power stations, Ashburton District Council's stock water race system, and various private stock water and irrigation schemes are supplied with water from the race.

The Valetta Irrigation Scheme is one of the community irrigation schemes with an allocation of 4.4m^3/s of water from the RDR and has a contract irrigable area of some 7,300Ha.

In 2007 Valetta Irrigation Ltd (VIL) began investigating an upgrade to their open channel system. It was recognised that there were significant opportunities available through piping; both in the substantial reduction in leakage and evaporation losses (estimated at 28% of total flow) and also the provision of on-demand pressured water to each farmer, saving them on-farm pumping costs. Many of the farmers were beginning to make use of modern efficient spray irrigation, requiring them to install pump stations and intakes from the old open race channels to operate. In addition, the old race system only provided a water allocation to each farmer every few days, so for them to operate on a continuous basis they would have to construct on-farm storage.

In 2012 Beca Ltd was appointed Technical Advisor to VIL and produced and administered an NZS 3910:2003 Design Build Contract for the upgrade of the scheme. Bosch Irrigation Ltd (BIL) was subsequently appointed to undertake design and construction of a piped irrigation scheme. Grant Hood Contracting Ltd was appointed under a similar contract to design and construct the two ponds required by the BIL design.

For the upgraded Valetta Irrigation Scheme, 4.4m^3/s of water is taken from the RDR intake through a screened inlet, and delivered via an open channel and pipe into a balancing and settling pond at the top of the scheme. From here it is conveyed through a piped network, through another balancing pond and out across the scheme area. A total of 73km of PE100 HDPE pipes ranging from 200mm up to 1.6m in diameter make up the network delivering water to 58 farmer outlets. The combined storage volume of the two ponds provides around one day's usage to allow each farmer to have on-demand water for their property and matches the RDR's ordering regime of "today's demand being supplied tomorrow". BIL also has an agreement with VIL to install hydroelectric generation equipment immediately upstream of both ponds. This will allow for the generation of approximately 2.2MW of electricity generation.

What is thought to have been a New Zealand first was BIL's novel approach in erecting a portable extrusion plant in the middle of the scheme. A weather-tight 2,000m^2 tent was built to house three extrusion lines capable of consuming up to 120 tonnes of PE100 material a day at peak production. A total of over 5,800 tonnes of material was used for the production of the pipes within the scheme.

1600mm diameter HDPE pipe being laid across the Canterbury Plains

Pipes were extruded in lengths of up to 300m and loaded onto dolly wheels before being towed out to the location where they were to be installed. The long pipe lengths meant that there was a substantial reduction in the number of welds. This offered substantial savings in time and a reduction in risk of weld failures.

BIL excavated the trenches using traditional excavators for the large pipe diameter and two chain trenching machines capable of cutting trenches up to 2m deep through the stony Canterbury Plains. Excavated trench material was screened either through a grizzly or a screen fitted to the trenching machines. The smaller fraction was used as bedding material with the larger fraction being used for backfill. Initial concerns about the production of large amounts of excess backfill material (1 cubic metre per metre length of the 1.6m diameter pipe) were quickly alleviated with most of the material eagerly taken up by the local farmers to fill in their farm gateways and tracks.

Welding of the pipes was undertaken adjacent to the trenches using plate welders before the pipe was lowered into place for bedding and backfilling. A major departure from traditional bedding techniques of putting people in the trench to compact material around the pipe was for BIL to use a modified hydraulic vibrating plate applied to the top of the pipe as the bedding material is drizzled around the pipe. The pipe transmits the vibration to the surrounding bedding causing the material to move evenly around the pipe creating ideal bedding support. This effectively removed the health and safety risk of having personnel entering the excavated pipe trenches.

With the installation of the pipe network and construction of the ponds complete, focus shifted to the farmer outlets. Each farmer receives water pressurised to 4 bar which allows them enough

Backfilling trench

Top to bottom – Water flowing through energy dissipation structure at the inlet to a buffer pond; 120m length of 1600mm diameter HDPE pipe loaded ready for delivery to site; Chain trenching machine in action – Note the screening separating finer fraction of excavations for pipe bedding

"When combined with the water savings from the removal of channel leakage and evaporation it has been estimated that an additional 37% more land could be irrigated with the same allocation of water."

pressure to locally reticulate and operate their centre pivot spray irrigators. Each outlet is metered and calibrated to operate and maintain flowrate and pressure up to a maximum allocated to each outlet. They are all connected through a telemetry system which centrally logs, records and monitors the flows and pressures throughout the network to ensure the system is working in its correct operational range.

The response from the farmers has been an overwhelming success story. Their ability to now have on-demand water at pressure, allows them increased flexibility to irrigate as they need water. This has increased the efficiency and means that the same amount of water is able to be spread further. When combined with the water savings from the removal of channel leakage and evaporation it has been estimated that an additional 37% more land could be irrigated with the same allocation of water.

Approximately 50ha of old races have been freed up and put back into productive farmland with the installation of the pipe network below ground. In addition, the energy savings from farmers not having to pump water is equivalent to the annual electrical consumption of around 1,000 homes.

About the Author

Gerard van den Bosch the MD of Aquaduct NZ (formally Bosch Irrigation Ltd) received the 2014 IrrigationNZ Innovation Award for his work on the Valetta Irrigation Scheme and was also a Plastics New Zealand Joint Supreme Award Winner 2012. ■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Creating Solutions for Shared Wellbeing

Adrian Mahalingam – Project Manager and Sustainability Leader, Opus International Consultants and Elizabeth Soal – Policy Manager, Waitaki Irrigators Collective

How can New Zealand manage its precious water resource better, optimising its potential over all the important (but often competing) values and uses of water, including its productive capacity? Obviously, what is optimum depends on what we are aiming for, which in turn depends on what is important to us. This is a complex and sometimes polarising issue, with multiple interacting aspects and a spectrum of challenges. But we cannot shy away from it – we must create solutions that take all aspects of community wellbeing into account.

The tools and knowledge for effective water resource management are largely available and waiting to be implemented. Part of the solution for the productive water sector involves taking an integrated approach, bolstering good governance with the right information and risk management, and making decisions that create sustainable farm businesses. Here's the unfolding journey of a farming community that is collectively exploring how it can best use the water that it has been entrusted with.

Waitaki Irrigators Collective – A Case Study

The Waitaki Irrigators Collective (the Collective) has been proactively seeking to assist its shareholders to make robust and informed decisions around their water infrastructure. When one of the Collective's shareholder groups had the water permit for its scheme renewed in 2011, the new consent conditions reduced its annual allocated water volume significantly and required that they develop an upgrade plan to improve the scheme's efficiency.

Instead of simply reacting to the minimum requirements in a piecemeal manner, the Collective recognised that this might be a catalyst for addressing the challenges and opportunities that this and two other adjacent shareholder groups were presented with. Discussions with shareholders and the community led to the Collective commissioning the Lower Waitaki South Bank Integrated Irrigation Study for these three shareholder groups. See the *Info Box: Drivers* for more details. The study sought to provide options for future irrigation infrastructure, whilst taking into account the social, economic, environmental, and cultural contexts within which the schemes operate.

Taking an Integrated Approach

From the outset, the Collective had wanted to take an integrated and balanced approach, which will pay off in the long term through an infrastructure solution that meets the needs of its shareholders and the expectations of the wider community.

In most groups, including these three shareholder groups, there is a multitude of different expectations, needs, and stages in a business life cycle. For example, there would be some farm business owners who would be anxious to ensure that infrastructure improvements would be able to provide water to new areas beyond that currently irrigated, and would readily make the necessary on-farm investments to gain access to this water. Conversely, there would be others who would have a shorter investment horizon, and would therefore prefer to invest only to a level in order to maintain the status quo.

It is probably tempting for most infrastructure owners to jump straight into technical investigation and design work, imagining that we might fast-track progress by quickly identifying an optimal solution in isolation from stakeholder engagement. However, in reality, even a simple process of engaging stakeholders uncovers not only (sometimes undefined) shareholder needs but also a range of environmental, economic-financial, and social-cultural considerations that intertwine with technical constraints.

Often, irrigation and rural water infrastructures are not too technically complex on their own; the interactions between the various stakeholder aspects are what make them complex. Recognising this complexity helps to reduce surprises, allowing the appropriate attention to be targeted to where risks lie. For the Lower Waitaki Study, a workshop was conducted early in the process, which involved several scheme board members and irrigators who were willing to share their ideas with the Opus team. This was an important step because it set the direction for the rest of the study.

Once the various issues, constraints, and stakeholder priorities had been clarified, the various challenges could be better demarcated and then addressed by the respective specialists. It was vital to recognise the path dependencies present – for instance, a recently re-constructed intake would best be incorporated into any new network, and some farm businesses who recently upgraded their border-dyke systems at significant expense would be hesitant to convert to spray in the short term.

Bolstering Good Governance

The Collective recognised that good governance decisions need to be based on good information. This starts with carefully identifying what information would actually improve decision making. Therefore, the study pulled together the expertise of irrigation specialists, engineers, ecologists, social and economic researchers, and water resource scientists.

Based on stakeholder engagement and the subsequent assessments, we recognised that at this early stage, it was not pragmatic to develop to great detail a design that would very likely become obsolete and inappropriate as soon as more information became available. We agreed that it would be more valuable to provide a framework with which to engage stakeholders – a common platform to discuss concepts, to provide ideas and to encourage buy-in for the way forward. Hence, concept designs were modelled and preliminary whole-of-life costs estimated to paint a picture for the farming community to think through what they really wanted for their future.

Dealing with risk appropriately is part and parcel of strong governance. Risks are the effect of uncertainty on our objectives, that is, not all uncertainties are of concern but only those which impact what we actually want to achieve. When appropriately targeted, technical investigations can shed light on specific risks. For instance, the spray conversion assessment identified that the increased power capacity demand from conversions could be accommodated easily after 2015, but any conversions before that should be confirmed first with the local electricity lines company – useful information for individual farm businesses planning their conversions as well as for the Collective.

Often, technical investigations identify new risks that need to be managed, sometimes requiring further investigations. How risks are managed is crucial to the success of the project – they can be accepted with a budgeted contingency, transferred to another party for a cost, minimised through design optimisation or eliminated through a major change of direction. Unmanaged risks can seriously

- The Waitaki Irrigators Collective's shareholders are irrigators covering more than 75,000 hectares of irrigated area in the Lower Waitaki River catchment
- The study covered a command area of approximately 5,600 hectares, incorporating three shareholder groups: the Kurow-Duntroon Irrigation Company (KDIC), the Maerewhenua District Water Resource Company (MDWRC), and the Waitaki Independent Irrigators Incorporated Society (WIII)
- The study received Irrigation Acceleration Fund support from the Ministry of Primary Industries
- Opus International Consultants assessed the environmental impact, the water balance, and the effects of spray conversion, before setting out two broad options with preliminary design models and estimated whole-of-life costs. Rationale Ltd assessed the social and economic impacts of irrigation

damage the success of a project, but risks can also be managed inappropriately. For example, transferring a risk that would have been better retained by the infrastructure owner to a contractor that is unfamiliar with it would likely attract a cost premium that unnecessarily increases the total cost. From stakeholder engagement and design to procurement and asset management, good governance is worth augmenting with the appropriate risk management expertise.

Creating Sustainable Farm Businesses

Many farm businesses desire to be financially, environmentally, and socially sustainable. Sustainability was integral to the study, as demonstrated in the Collective's desire to consider all these dimensions in an integrated manner. The Collective recognised that the sustainability of its shareholders' farms start with responsible water resource management. Developing a water balance model for the command area takes soil and climate data and gives the farm businesses a scientific albeit approximate basis to assess the net water demand (before accounting for efficiency), an important variable in estimating how

DRIVERS

- MDWRC had recently upgraded its scheme intake and headrace in response to flood damage. It had also recently expanded into a new area, which provided highly reliable water to previously independent irrigators. There were already good ideas about how KDIC's and MDWRC's allocations could be better distributed across their combined command areas than its existing legacy arrangements.
- Improving transmission efficiencies of the networks would also potentially release water for irrigating new areas in which there has been growing interest.
- A group of independent irrigators in WIII are facing expiry of their deemed permits ("mining rights" to take water from tributary waterways) in 2021, and will have to apply for new water permits under the Resource Management Act requirements. It was worth considering the possibility of supplying at least some of these areas with scheme network infrastructure, allowing for economies of scale, shared operation and maintenance, and increased supply reliability that would drive more efficient water use.
- There has been an ongoing conversion of farms from border-dyke flood irrigation to spray irrigation, causing uncertainty about the macro effects (such as tree clearances, smoothing of contours, increases in energy requirements, and reduced groundwater recharge).
- The KDIC scheme was historically designed by the Ministry of Works for continuous through flow with unused water returned downstream, but regulatory changes would define such by-wash as wastage that must be minimised.
- Recent developments including the recommendations of the Land and Water Forum, the National Policy Statement for Freshwater Management 2011, and the National Objectives Framework all point towards upcoming changes in how freshwater resources are to be managed in New Zealand. It is worth remembering that it is in this environment of change that affordable, long-term water supply is being sought to support the resilience of the local economy and community.

much land can be irrigated with an allocated supply.

Furthermore, the Collective recognised that farm business sustainability goes beyond water efficiency. It is well-known that many farm businesses that have changed from dryland to irrigated operations or from flood to spray irrigation have also moved to producing more profitable farm outputs, some out of necessity to match the higher associated on-farm costs. This often means converting to higher intensity farm production, which must be matched with an equivalent upgrade in on-farm management practices to mitigate impacts. The environmental study provided a snapshot of the ecological health of the local catchment and realistic recommendations on responsibly managing impacts from current irrigation and potential future irrigation expansion – a combination of mitigation measures which included relinquishing tributary takes and establishing deep retention ponds and wetlands.

We all know that decisions made to achieve a certain positive outcome can sometimes end up causing other unintended consequences. Understandably, there was concern that conversions from border dyke to spray irrigation would negatively affect groundwater levels and downstream wetlands because of the reduced water losses. In this case, the spray conversion study pointed out although data was limited, the Waitaki River's effect on the groundwater system would likely outweigh any irrigation system changes.

Being sustainable requires a long-term outlook, not only by the boards of directors but also the shareholders they represent. This is particularly crucial when we are seeking to develop infrastructure that continues to serve the community for decades. In terms of financial sustainability, an increasing number of farm businesses are recognising the need to look beyond the upfront capital cost and consider whole-of-life costs. Once infrastructure is constructed, there is usually limited scope to influence the operating, maintenance and renewal costs that can quickly outweigh the upfront capital costs over the life of the infrastructure. Ideally, therefore, the whole-of-life costs should be a key point of comparison between options. Having said that, capital costs are still of interest to irrigation schemes – a number that is often key to the farm-level affordability of a proposition because it is more concrete and immediate without the uncertainty of variables like future electricity prices and discount rates. This is perhaps why, in reality, capital costs are still a significant deciding factor for their shareholders and financiers, on whose support the success of these projects depend on. Therefore, the challenge is to optimise both capital and whole-of-life costs based on our understanding of the specific stakeholders involved.

The challenge in addressing community expectations and user needs is amplified because they can change over time. Farming operations and application methods change, shareholders may want more or less water over time, and the expectations around water resource management continue to grow in line with co-evolving scientific knowledge and tools available. Enabling infrastructure to accommodate future uncertain needs generally increases costs, but smart thinking applied early in the process can often identify future-proofing opportunities at little to no cost.

Looking Forward

Across New Zealand, we could manage our precious water resource better. It is our collective responsibility to be good stewards of the resources that we have been entrusted with, to wrestle with what is optimum in our decision making and then to work it through to concrete actions. We can all approach our challenges in an integrated manner, use information and risk management to bolster good governance, and proactively create sustainable solutions.

The Collective recognises that its decisions must balance the needs of the farmer, the irrigation scheme, and the wider community. Hence, it is engaging its stakeholders, pulling together information across a range of indicators, and exploring its options – its journey continues.

About the Authors

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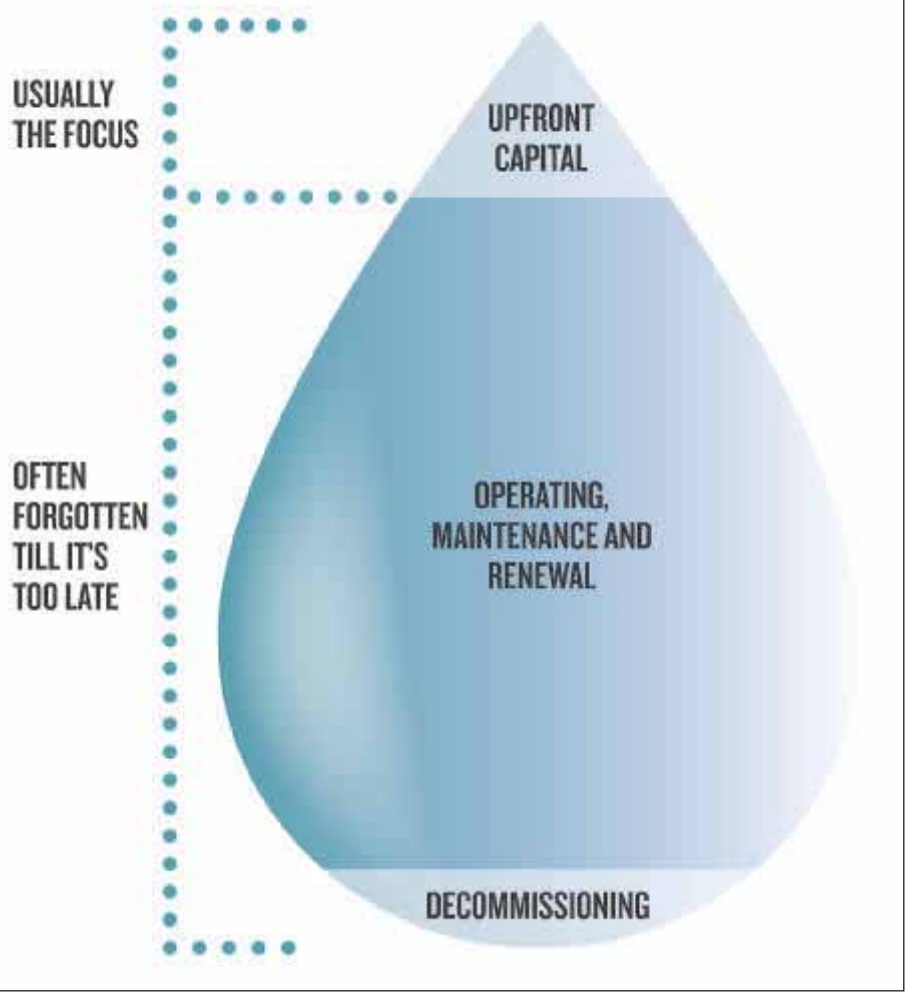
Generalised cost breakdown over the life of water infrastructure



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The step screens that form part of the new domestic wastewater treatment plant on Aorangi Road, Seadown, Timaru. In the foreground, the peak flow pump station.

Timaru District WWTP Upgrade – Journey to an Environmentally Improved District

Graeme Stilwell – Director, Imagine PR!nt Ltd

As sewage system upgrades in a New Zealand provincial district go, the Timaru District Council's almost-completed wastewater revamp is among the largest.

Few districts have embraced such deep-rooted and systemic change facing the parallel challenges of separating a city's domestic sewage flow from its industrial effluent while removing from rivers the wastewater from three outlying district towns and piping it to a coastal outfall.

The works programme, part of the council's Wastewater Management Strategy, follows years of work to improve the way the district's sewage is piped and treated.

At a total cost of around $60 million, the district-wide sewer system makeover was needed to meet new standards in the treatment of wastewater prior to its discharge into the sea. The multi-stage upgrade has allowed the council to be granted sewage discharge rights for the next 35 years by Environment Canterbury.

The project construction spanning almost 12 years is expected to be completed in October this year with the commissioning of new ponds and treatment plant for the now separated domestic flow covering 48 hectares on both sides of Aorangi Road at Seadown, just north of Timaru.

The project systemically changes the way Timaru District's sewage is treated. Industrial flows will continue to be treated in the existing milliscreening plant on Aorangi Road, but domestic flows will be re-routed from that plant and treated in a new wastewater plant alongside. The treated flows then recombine before discharge through the existing ocean outfall a few kilometres further north.

The blueprint earned the approval of Environment Canterbury, which in December 2010 issued a 35-year discharge consent, the maximum length of time available. It came with a raft of conditions, the most relevant being the effluent trigger value exceedence concept whereby there is a reporting and remedial programme required when the allowable trigger values are exceeded by more than an allowable number of times in a 12-month period. The trigger values relate to BOD, suspended solids and fats/oils/greases.

There is also a comprehensive regime of receiving environment monitoring, which provides surety that the ocean discharge is compliant. This in turn drives oxidation pond performance and industrial dischargers' on-site treatment performance and compliance.

The land footprint of the entire system is significant. Adjacent to Aorangi Road more than 30 hectares of primary oxidation ponds, eight hectares of maturation ponds, and 10 hectares of wetlands are now in the final stages of construction.

But although the earthworks are extensive, the construction method used has made efficient use of a natural resource. Timaru District Council drainage and water manager Grant Hall said the Seadown sub-strata on site features a layer of impermeable silt first harvested from the site of the excavation and stored until later being returned to form the liner to the ponds once their shape had been formed. The silt liner has been laid up to a depth of half a metre, he said.

Planting, landscaping and beautification of the area marks the council's emphasis on environmental awareness within the community.

Fundamental to meeting the new environmental standards needed for ocean discharge rights and to achieve the greatly increased sewage capacity for the district essential for growth in both population and industrial development over the next 30 years, was the separation of domestic sewage flows from industrial sewage flows using twin pipelines mostly in industrial zones. That freed up capacity in the milliscreening plant, in use since 1987, for Timaru's industrial wastewater.

But, says Mr Hall, the flow separation was just one of a number of significant components to "the big picture" of environmental sustainability in wastewater management, crucial to any region's health and wellbeing.

The letting of a $5 million contract two years ago for Stage 5 of the twin-pipeline phase, which involved the laying of large-diameter pipes from behind McCain food processors in Washdyke to the council's Aorangi Road milliscreening plant, signalled the closing phases of a $30 million sub-project that saw:

- Large diameter sewer pipes laid from Station Street across Caroline Bay to Virtue Avenue (Stage 1)

- And from a point just north of Alliance Smithfield freezing works around the Washdyke Lagoon to McCains (Stage 2)
- Three 400 metre long, 2.3 metre diameter tunnels around the foreshore through a combination of loess, gravels, and basalt rock (Stage 3)
- And the joining of those tunnels to the new pipelines (Stage 4)

Now the twin pipelines reach right back from Aorangi Road to the city's port, a distance of approximately 6.5km. The pipes, ranging in diameter from a 200mm rising main through to the main line of 1400mm, are of high-density polyethylene, and although the industrial volumes are of a similar volume to the domestic, they are 10-times stronger in concentration.

The separation sub-project joined projects further afield. Timaru District has four main urban areas, namely Timaru, and the inland towns of Geraldine, Pleasant Point and Temuka, with each of these inland towns having a traditional piped sewer network with local oxidation ponds as the wastewater treatment process. The discharge from these oxidation ponds is now piped to the maturation pond at the Timaru Wastewater Treatment Plant by a 42km long pipeline varying from 200mm to 400mm in diameter at a cost of $4.5 million.

"The inland towns' pipeline is generally a gravity-feed system," said Mr Hall.

"Temuka has some low lift pumping, but Geraldine and Pleasant Point flows are gravity fed so getting that inland wastewater out of the rivers and through to the Timaru treatment plant was one major component, a key element to the overall strategy."

A major plus for the council when considering which type of sewage treatment process was best suited for the domestic flow was the fact that it already owned land of sufficient quantity, remoteness, topography, and geology to support the preferred ponds system of oxidation, maturation, and wetlands.

The step screen platform features planting, landscaping and beautification, marking the council's emphasis on environmental awareness within the community.

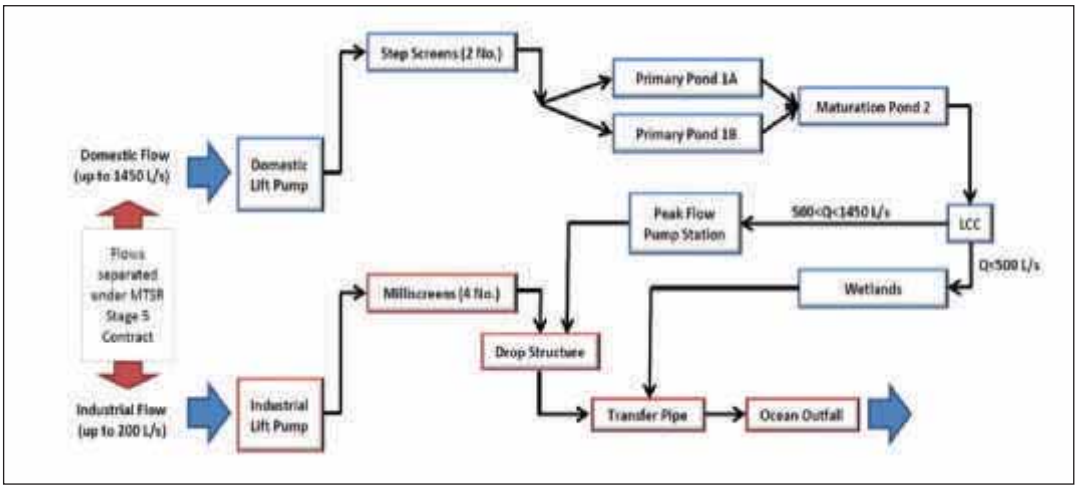
"That was another major component," said Mr Hall.

After an extensive consultation period since 1997, the Aorangi Road land was purchased in 2002. Mr Hall said oxidation ponds are an effective and preferred treatment, "but they do take up land".

"The land we had purchased provided good environmental solutions in terms of wastewater management.

"It was sufficiently remote from urban areas and by the coast. That's an ideal location with good exposure to moderate breezes and temperatures," Mr Hall said.

"And oxidation ponds don't require expensive energy or operational input and byproducts are minimal. You have to de-sludge the oxidations perhaps every 10 to 15 years but compared with, say, an activated sludge plant, byproduct is minimal."



Industrial flows (red) will continue to be treated in the existing milliscreening plant on Aorangi Road, but domestic flows (blue) will be re-routed from that plant and treated in a new wastewater plant alongside. The treated flows then recombine before discharge through the existing ocean outfall a few kilometres further north.

"An activated sludge or bio-media plant has a much smaller footprint but energy costs are a lot higher and there's a lot of byproduct that you have to deal with," said Mr Hall.

However the drainage and water manager's "big picture" also included consultation with communities, industries, designers, and contractors.

Emerging environmental and regulatory issues saw the council initiate a review of its respective wastewater treatment and disposal strategies in 1996. The council supported a community-based approach to identifying a preferred strategy, noting that the strategy needed to be robust and viable and recognise the unique nature of the Timaru District's wastewater.

A Wastewater Working Party was formed in 1997 with representation from the council, Community Boards, Federated Farmers, the South Canterbury Chamber of Commerce, industrial dischargers, the Royal Forest and Bird Society, Central South Island Fish and Game, Tangata Whenua, the National Council of Women, and Crown Public Health. Invited observers represented Environment Canterbury, the Department of Conservation/ Aoraki Conservation Board, and the council's own planning unit.

The Wastewater Working Party was supported by the council's engineering and asset management staff and by specialist consultants such as Beca, Pattle Delamore and Mitchel Partnerships. Meetings were held regularly over a period of years and site visits to existing comparative wastewater treatment plants were made.

To facilitate further feed-back, 30,000 pamphlets with a questionnaire were delivered to all households in the Timaru District. Results indicated around 80 per cent support for the proposed wastewater manage-ment option. Meetings were also held with residents living near to the existing wastewater treatment plant on Aorangi and Meadows Roads.

Mr Hall said the consultation objectives were wide-ranging and specifically sought:

- To include Runanga in the decision-making process in accordance with the roles prescribed in the RMA
- To ensure that the community's views were included
- To ensure all the waste-water issues that affected the community were identified and understood
- That sound information was available and that a range of options was evaluated objectively

The overall programme of works has led to the current domestic uniform annual sewer charge for properties connected to the sewer of $366 per annum including GST. This is very acceptable to residents across the whole district.

Combined with trade waste charges, the entire sewer system is funded by this uniform annual sewer charge. This charge is levied on all toilet pans connected to the sewer network, with each dwelling deemed to be the equivalent of one pan. The uniform annual sewer charge is projected to peak in 2014/15 at $377 per annum including GST.

However, one group in particular faced significant administrative change.

"We have changed the way in which we charge industrial users for their trade waste," Mr Hall said.

The main contributing industries are meat processing, fish

Few districts have embraced such deep-rooted and systemic change facing the parallel challenges of separating a city's domestic sewage flow from its industrial effluent while removing from rivers the wastewater from three outlying district towns and piping it to a coastal outfall. The map above shows the general layout of a sewerage system that has gained the maximum 35-year consent for ocean discharge.

processing, vegetable processing, brewing, pelt processing, woolscouring, and rendering. The new charging regime reflects a fundamental industrial waste principle – individual users have individual agreements and are responsible for any primary treatment required to have their waste meet the conditions of their agreement.

Computer modelling was used to achieve a formula fair to all. "The modelling of the agreements show that on the basis of them doing their on-site treatment, and us having our domestic treatment, when they both get combined we don't breach our discharge consent. This is another key component of the entire project," Mr Hall said.

"The treatment we are providing in the industrial waste stream is channeling it through our milliscreening plant so therefore any other treatment that needs to be made is then moved back to the individual industry.

"But we have worked it so that no one industry needed to spend significantly more money on their treatment systems than anyone else. So it's fair, relative to the size of the industry," he said.

The Timaru urban wastewater stream is unique in that it has a 40:60 volume ratio between domestic and commercial/industrial wastewater and an approximate 10:90 strength ratio.

"You get some trade waste streams that have very high strength so those businesses are having to spend more than someone who is just as big but doesn't produce the same level of contaminants.

"There isn't a default standard that they have to meet as such, their trade waste agreement has been tailored for each individual industry."

Mr Hall said that formerly trade waste costs were recovered by charges based on the volume of the actual discharge. However about 90 per cent of the costs are now fixed, largely for the provision of infrastructure, which don't vary regardless of the volumes discharged. And with milliscreening as the industrial wastewater treatment, charging needed to be based on flow rather than the strength of components such as BOD, TSS or FOG as the treatment process would not significantly reduce these components.

Now, the new and individual trade waste agreements with industry have a fixed charge for about 90 per cent of those costs, providing some certainty for industry.

"They didn't want charges varying from year to year, so part of our new trade waste agreement with each of these industries includes an agreed median discharge (cubic metres per day)," he said.

"The fixed costs are then apportioned over the industries based on their agreed median discharge.

"Then we monitor the individual discharges and the remaining 10 per cent of the costs, which are largely variable such as electricity to run the system, is charged on their actual volume of discharge," Mr Hall said.

Environmental provisions aside, observers will say that the Timaru District Council's sewerage makeover was not just for future generations, it is a vote for the future of one of the country's strongest regional economies, providing opportunities for industrial and business growth.

Grant Hall: "In our previous system, all of the Timaru domestic and industrial sewage went down one pipe to the milliscreening plant and then to the ocean outfall. What we have done is take about half of the total flow that is domestic out of that and put it in its own pipe and treated it so all of the original capacity is now available for future industry allowing expansion and commercial growth in the district." ■

Improvements made at the Tokoroa Wastewater Treatment Plant

South Waikato District Council has made a significant improvement to the Tokoroa Wastewater Treatment Plant by installing a centrifuge to improve the handling of the district's wastewater bio-solids.

Every so often the council has to reapply for resource consent for a number of activities, such as landfill, water supply, and wastewater. In order to satisfy the new resource consent for wastewater discharge it had to make several improvements.

"Technology changes over time, and there is increasing pressure to improve the environmental impact of activities like wastewater plants," said Andrew Pascoe, South Waikato District Council Services Manager.

"Our resource consent conditions are amended accordingly and this improvement was necessary to satisfy these new requirements."

Purchasing various pieces of equipment over the past year and pulling it all together was challenging, taking several months to get all the components connected and working. The system has been running for 18 months with good results.

Bio-solids (or sludge) from the treatment plant are now processed by the centrifuge system that mechanically removes moisture from the sludge. Previously the sludge was fed onto drying beds where the moisture either evaporated (not so well in winter) or drained back to the inlet for further processing.

The solid portion of this material is trucked to the landfill where it is stockpiled, combined with greenwaste to form top soil and used as final capping at the landfill. The liquid that is removed is returned to the wastewater treatment plant for treatment. ■

Images:

1. The tank where the bio-solids are mixed together to form a consistent product.
2. Polymer powder is mixed with water in a concentration calculated from the moisture content of the raw product.
3. The bio-solids are piped into the centrifuge. Here it is mixed with the polymer and the moisture is mechanically removed from the bio-solids. The polymer helps bind the bio-solids.
4. A close up of the liquid waste that is removed from the solid waste and returned to the wastewater treatment plant inlet for further treatment.
5. The bio-filter was built to capture the odour from the process. The bio-filter is filled with wood chips (or bark) and kept moist. It has a sensor to ensure the sprinklers don't come on when it is raining. In this way the system maintains the optimum moisture content. This part of the system was included in the project due to the proximity of the wastewater treatment plant to residential properties.
6. The old drying beds where waste material previously dried.

Assessment of Increased Flood Vulnerability Due to the Canterbury Earthquake Sequence

Tim Fisher – Senior Water Resources Engineer; Mark Taylor –Senior Civil Engineer; Kevin Ng – Water Resources Engineer and Mark Pennington – Senior Water Resources Engineer, Tonkin & Taylor Ltd

Abstract

The earthquake sequence in Canterbury from September 2010 to December 2011 caused widespread land damage to Christchurch. The earthquakes affected the flood hazard in Christchurch due to changes to ground levels and watercourses from tectonic changes, subsidence and lateral spreading. The Earthquake Commission (EQC) is responsible for compensation for land damage to residential land due to particular natural disasters.

Tonkin & Taylor worked with EQC to assess potential increase in flood vulnerability for residential land due to onsite ground surface subsidence caused by the earthquake sequence. Flooding was assessed with models developed for flood hazard management in the Styx, Avon, and Heathcote catchments by Christchurch City Council and EQC. Two types of flood models were used; a river flooding model and an overland flow model (rain-on-grid approach). The flood models were used in conjunction with ground levels based on LiDAR to identify properties with potentially affected properties. This paper describes the engineering methodology and issues that have influenced the methodology.

Keywords

Flooding, Earthquake, Modelling, Christchurch, Subsidence

1. Introduction

As a result of the earthquake sequence in Canterbury, the topography of the land has undergone significant changes. This has changed the flood vulnerability for a number of properties due to the onsite changes in ground levels (subsidence) and the offsite changes to rivers and floodplains affecting the predicted flood levels.

The Earthquake Commission (EQC) with assistance from Tonkin & Taylor (T&T) is undertaking an assessment of Increased Flood Vulnerability (IFV) to fulfill their obligations under the Earthquake Commission Act 1993 (the Act). IFV is a physical change to residential land as a result of an earthquake which adversely affects the uses and amenities that would otherwise be associated with the land by increasing the vulnerability of that land to flooding events (refer Figure 1).

The objective of T&T's IFV engineering assessment is to identify properties with potential IFV land damage, and to apportion that damage to each of the four major earthquake events across 2010-2011. Once the engineering process is complete, properties that have been identified as potentially having IFV are referred to EQC for its valuers to determine whether the increased vulnerability identified has resulted in any decrease in amenity and value to the property. This paper is limited to describing the IFV engineering assessment, which is a small part within the broader EQC process.

IFV is considered for main floodplains of rivers, streams and main channels, and for overland flow paths. Overland flow paths are formed by the runoff of stormwater that exceeds the capacity of the primary (pipe) stormwater systems.

2. The Role of the Earthquake Commission

The EQC provides insurance cover for damage to residential land, residential buildings, and contents caused by particular natural disasters. The scope of cover is defined by the Act.

In general terms the Act limits damage to areas that are insurable. In practice this is considered to be 8m measured from the dwelling and appurtenant structures. It also covers the primary access to the dwelling (driveway).

The EQC has received more than 460,000 claims for damage from the earthquake sequence in Canterbury, with a substantial number of these claims involving land damage.

3. Canterbury Earthquake Sequence

3.1 Major Earthquakes

The Canterbury area was affected by a large number of seismic events following a major earthquake on 4 September 2010. There have been 16 events, which have caused dwelling foundation damage resulting in lodgement of EQC claims. Four significant earthquakes in the sequence caused substantial land damage around Christchurch, including the manifestation of liquefaction, lateral spreading and widespread land subsidence. The four significant earthquakes that caused measurable ground surface subsidence occurred on:

- 4 September 2010
- 22 February 2011
- 13 June 2011
- 23 December 2011

Land damage assessment by EQC is based on the damage caused by individual earthquake events as required by the Act. Therefore, the IFV assessment needs to consider each earthquake independently to the extent possible.

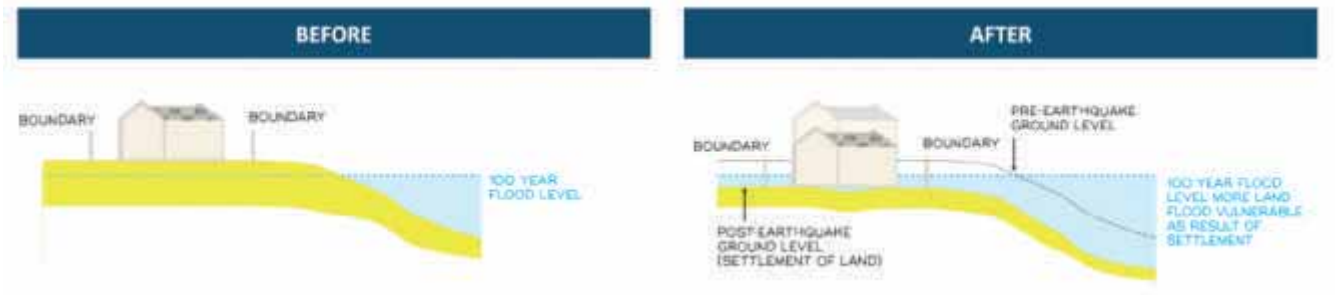


Figure 1 – Diagram showing how ground subsidence from the Canterbury earthquakes has made some properties more vulnerable to flooding (EQC Factsheet May/June 2014)

Table 1 – Flat land damage categories

Damage that can be seen	
Category	Description
Land cracking caused by lateral spreading	Lateral spreading is the sideways movement of land, typically toward watercourses. Blocks of the earth crust (the surface soils above groundwater) move sideways over liquefied soils toward a lower area. Surface damage can include minor or major cracks in the land and tilting of ground crust blocks.
Land cracking caused by oscillation movements	Cracks to land can result from both lateral spreading (see above) and oscillation (backwards and forwards ground movement during earthquake shaking). Cracks resulting from oscillation are typically minor and isolated.
Undulating land	Undulating land is caused by the uneven settlement of the ground surface as a result of the ejection of sand and silt, and, to a lesser extent, the uneven settlement of liquefied soils below ground.
Local ponding	Local settlement or lowering of the land resulting in water forming ponds on the ground surface for extended periods in locations where it did not pond before the earthquake.
Local settlement causing drainage issues	In some areas residential land has settled more than the adjacent land beneath which public services are located (and vice-versa). This results in drains now flowing the opposite way.
Groundwater springs	New groundwater springs have emerged and are now flowing over the ground surface where this was not happening before the earthquake. The spring usually occurs at a specific location on residential land.
Inundation by ejected sand and silt	Sand and silt is ejected to the ground surface from the zone below the water table through cracks in the crust. The ejected sand and silt may be deposited in isolated mounds, under houses, or over large areas.
Damage involving an increased vulnerability	
Increased liquefaction vulnerability	In some areas the ground surface has subsided and the groundwater table has typically remained at a constant level. Therefore the ground surface is closer to the water table than prior to the earthquake. This generally reduces the non-liquefying ground crust thickness. As a result there has been an increase in the future vulnerability to the liquefaction hazard of some sites.
Increased flooding vulnerability	In some areas, the ground surface has subsided. As a result, there has been an increase in the future vulnerability to flooding of some sites. Refer to Section 5 for more details.

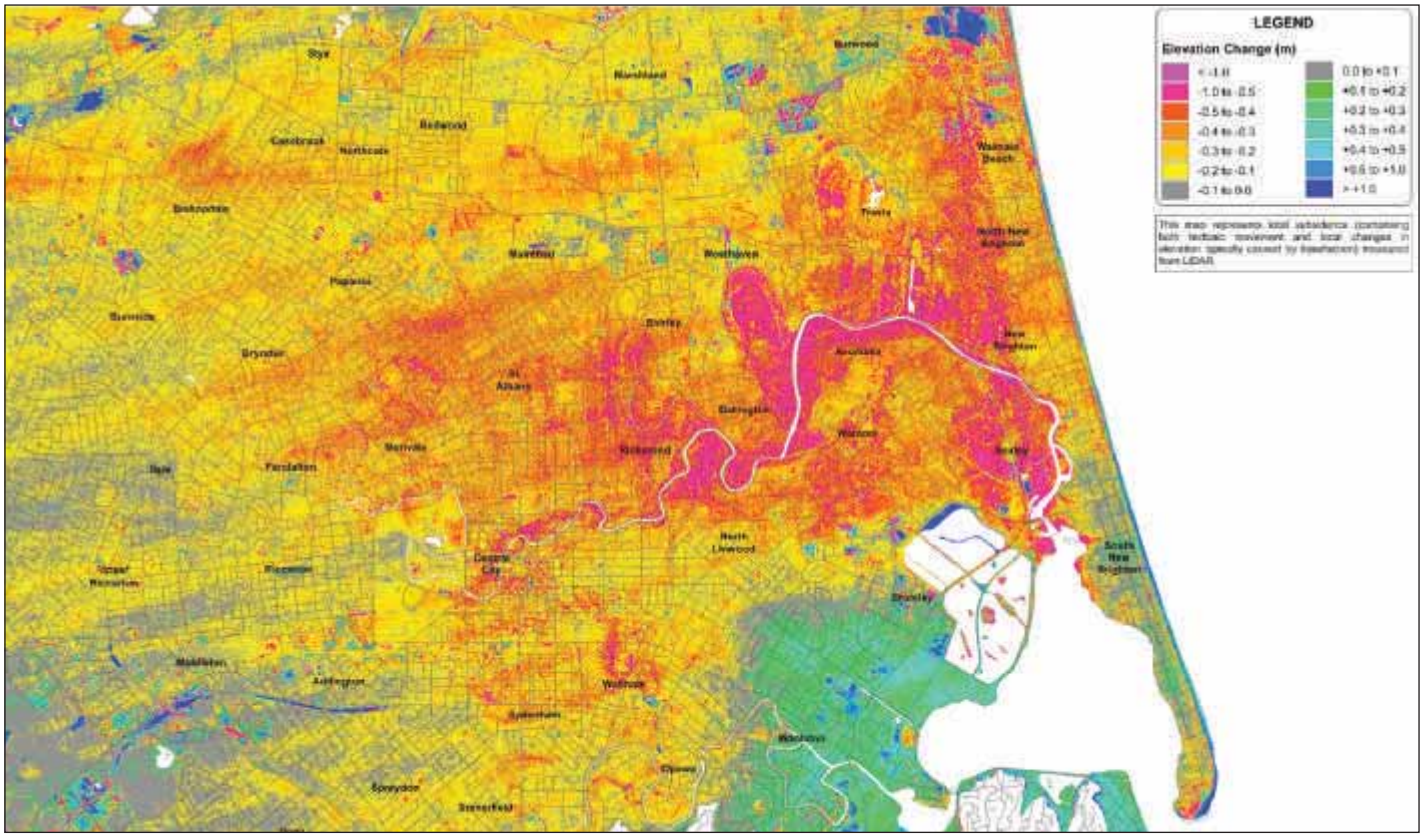


Figure 2 – Cumulative elevation change from Pre September 2010 to Post December 2011

As a result of the earthquakes a number of categories of land damage were developed by EQC. These categories and descriptions of damage are shown in Table 1 (EQC, 2014). The first seven forms of land damage were developed from visual inspections of residential properties following the four significant earthquakes.

The last two forms of land damage, Increased Vulnerability to Liquefaction and IFV, cannot be readily identified from visual observations. Both vulnerability forms of land damage require extensive investigations and modelling to identify areas and properties at greater risk of damage from liquefaction or flooding post-earthquake. T&T on behalf of EQC has developed the methodologies by which properties, which potentially exhibit these forms of land damage can be identified. The ultimate aim for EQC is to compensate property owners for these forms of land damage.

3.2 Land Elevation Change

The land in Christchurch has changed in elevation as a result of the Canterbury earthquake sequence. Local effects resulting in subsidence include ground densification, lateral spreading, liquefaction and tectonic settlements. The effects are particularly pronounced adjacent to the rivers and streams where lateral spreading has occurred. A consequence of this is increased flood depths and extents. An indication of the severity and extent of land subsidence is shown in Figure 2.

4. Christchurch River Catchments

Christchurch is drained by three major river systems, these being the Styx River in the north, the Avon River through the central and CBD

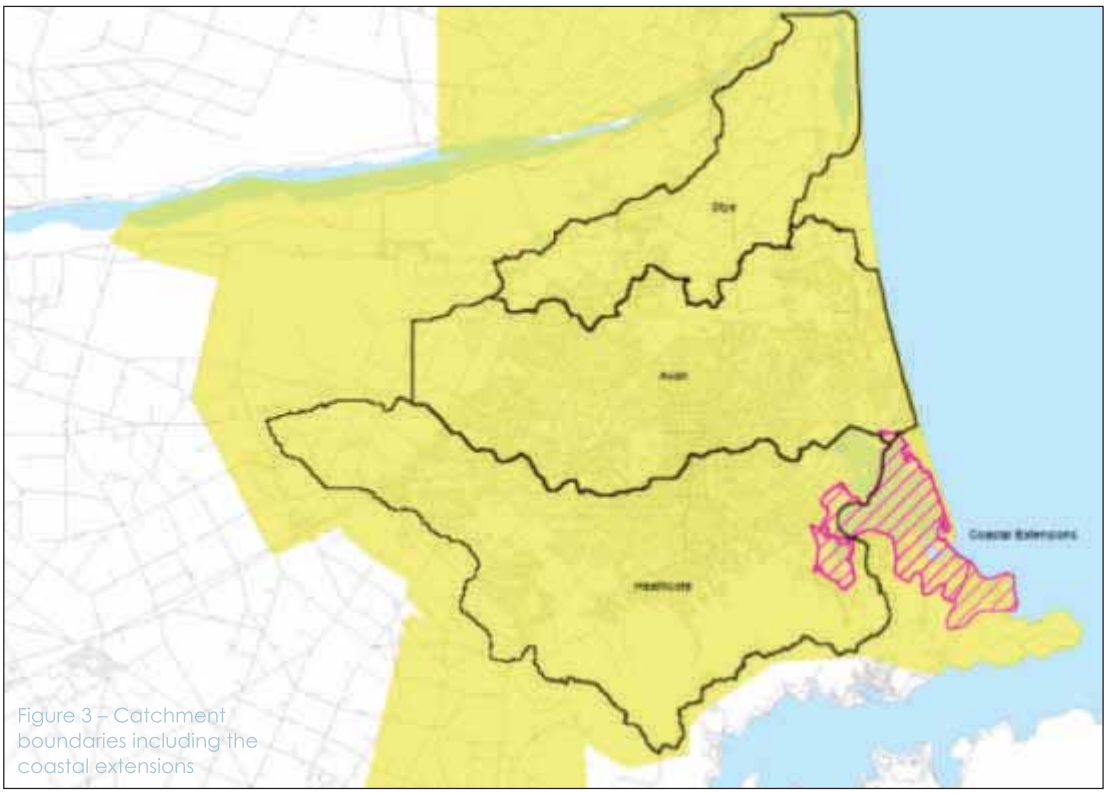


Figure 3 – Catchment boundaries including the coastal extensions

areas, and the Heathcote River towards the south (refer Figure 3). There are also minor catchments draining directly to the sea or Avon-Heathcote estuary.

5. Changes to Rivers/Drainage and Flooding as a Result of the Earthquake

The earthquake sequence in Canterbury has caused changes to the topography of the land in Christchurch. This has changed the flood vulnerability for a large number of properties due to on-site changes in ground levels and the extent of the changes in ground levels are shown in Figure 2. Flood vulnerability may also have changed due the off-site changes to streams/rivers and floodplains affecting the predicted flood levels.

The three flooding mechanisms that cause flooding are listed below with explanations of how the earthquake has modified these mechanisms:

- Pluvial flooding is caused by runoff that is in excess of the capacity of the stormwater systems and causes overland flow. It can be exacerbated in situations where settlement has occurred, as this settlement can change overland flow paths or reduce hydraulic gradients to stream/rivers.
- Fluvial flooding is caused by flow in streams/rivers that exceeds the capacity of the channel and causes flooding of the adjacent land. The earthquakes have reduced the capacity of some stream/river due to lateral spreading, which has reduced widths and increased bed levels. Ground subsidence (particularly along stream banks) can increase the overflow from streams/rivers onto flood prone land, and can also result in inundation of previously flood-free land.
- Tidal flooding is caused by extreme sea levels in coastal areas and lower rivers that cause flooding of adjacent land. Land settlement can make areas more prone to tidal flooding where the land settles to a level below tide levels if not protected.

What this means at a property level is that some individual residential properties that previously were only exposed to infrequent flooding now have the potential to flood more regularly, whereas properties which had some existing flood vulnerability may have an increased area with potential to flood, or an increased flood depth due to this subsidence.

6. Flood Models Used in Determining IFV

The IFV methodology (refer Section 7) uses the maximum flood depths determined from modelling. Three types of flood model were used to determine these maximum predicted flood depths. In summary these are:

1. River flood models: The river flood models are computer models developed by Christchurch City Council (CCC). They are used for flood hazard assessment by CCC. These were developed using DHI's MIKE FLOOD suite of software. There is a river flood model for each of the Avon, Heathcote and Styx river catchments developed by DHI, NIWA and GHD, respectively. The river flood models are used to assess "fluvial and tidal" flooding in the main floodplains in close proximity to rivers, stream and main drains. The models for the Avon-Heathcote Estuary coastal areas also consider extreme tide levels when assessing flood hazard.
2. Overland flow model: The overland flow model was developed by T&T and BMT WBM using the 2D software package TUFLOW GPU. The model simulates the flow of runoff across land using the rain-

on-grid method with allowances for hydrological losses. This model also includes hydraulic representations of all stormwater pipes of diameter 600mm and greater, and all surface waterways over the city. The TUFLOW overland flow model covered all of Christchurch including the Avon, Heathcote, and Styx catchments. The overland flow model was used to assess "pluvial" flooding outside the main floodplains that is not assessed by the river flood models, plus it also simulates "fluvial and tidal" flooding.

3. Coastal extensions: This model was developed for areas that are not covered by either the river models or the overland flow models. The coastal areas around Southshore, Ferrymead, Bromley and South New Brighton are at additional risk to flooding due to high sea levels. A study by Goring (2011) found that the maximum 1% AEP tide level is 10.894 m above the Christchurch Drainage Datum. For the Sumner area, the level from Goring (2011) is 10.856 m above the Christchurch Drainage Datum. In some places, the coastal extensions overlap the Avon and Heathcote models. Where this is the case, the maximum flood depth of the two overlapping points is adopted.

The models were run for pre and post each of the four significant earthquake events. The five scenarios are pre-September 2010, post-September 2010, post-February 2011, post-June 2011 and post-December 2011.

7. Increased Flooding Vulnerability

The process for making the engineering assessment as to whether a property has potential IFV is described in the following text.

1. The flood depth is the maximum flood depth for the 1% annual exceedance probability (AEP) rainfall event for each scenario. The change in flood depth is determined overall across the earthquake sequence and for each of the four significant earthquakes.
2. The exacerbated flood depth is defined as the increase in flood depth due to onsite land subsidence. The increase in flood depth due to onsite land subsidence is the portion of the increase in flood depth that is caused directly by the ground surface subsiding. In some cases, the increase in flood depth is greater than the ground surface subsidence, due to off-site issues causing the flood level to rise. In this case, the exacerbated flood depth is the depth of ground surface subsidence. In other cases, the increase in flood depth is less than the ground surface subsidence, due to the flood level dropping. In this case, the exacerbated flood depth is the limited to the increase in flood depth. Thus, in all cases, the exacerbated flood depth is the minimum of the increase in flood depth, or the depth of ground surface subsidence.

Figure 4 – a) Observed flooding and b) modelled flooding for 4/5 March flooding in Flockton Basin

3. Potential IFV properties are those with exacerbated flooding in areas with observed land damage.
4. Onsite assessment is the final part of the engineering assessment for IFV to check that the flood mapping used to determine the IFV is providing sensible outcomes. The onsite assessment includes checking that no barriers exist which may block flow, or that there are any other reasons why the flood mapping may not reflect reality.

After the engineering assessment of properties is complete, the properties with potential IFV are passed to the EQC's valuers who undertake a valuation assessment in order to confirm that a property should be recognised as damaged due to IFV.

8. Issues in Determining IFV

8.1 LiDAR

The primary data source used in the assessment is the LiDAR. The LiDAR is used as the basis for Digital Elevation Model (DEM) that are used for each scenario modelled using river flood models and overland flow path models.

The LiDAR was commissioned by various agencies at different times and for different purposes. Extensive verification by T&T and SCIRT has been undertaken to understand the limitations of its use.

A key limitation was the differing extents for each LiDAR run. Where LiDAR coverage was not available a composite DEM was developed

substituting data from earlier LiDAR runs. A second limitation is that the pre-earthquake LiDAR was of a lower quality than more recent LiDAR surveys.

8.2 4 and 5 March 2014 Flood Event

During 4 and 5 March 2014 Christchurch experienced a rainfall event that caused extensive flooding across the city. The event highlighted flooding issues, some of which did not exist prior to the earthquakes or have been worsened by the earthquake sequence. This flooding event was used to calibrate the TUFLOW overland flow model. Figure 4 shows the observed and modelled flooding in the Flockton Basin area. Where flooding was observed it can be used to confirm the modelled flood. However, observations of flooding are incomplete, so the absence of flooding in observed map does not necessarily indicate absence of flooding.

9. Conclusions

The process of developing a comprehensive framework, policy, methodology and modelling ensures that a fair, reasonable and consistent approach has been achieved. This enables EQC's customers to be appropriately compensated for their loss. The identification of potential properties was completed at the start of May 2014 and will be followed by on engineering onsite assessments and valuation assessments.

It is important to note that many Christchurch properties were at risk of flooding pre-earthquake, but the severity (depth and/or extent) has increased. EQC is only able to compensate customers for the increase of vulnerability (not any pre-earthquake effects of flooding). More information on IFV is available from the EQC http://www.eqc.govt.nz/canterbury-earthquakes/land-claims/flat-land/increased-risk-of-flooding

Acknowledgements

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NB: This paper was presented at the recent Water New Zealand Stormwater 2014 Conference in Chirstchurch.

Avon River Stormwater Quality Treatment – An Innovative GIS Design Approach

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Abstract

The Stormwater Management Plan (SMP) for the Avon River catchment in Christchurch considers retrofit of stormwater quality treatment devices throughout the highly urbanised catchment of 8,862ha. The concept design for treatment utilised traditional and innovative GIS approaches and proposes a range of water quality devices and mitigation scenarios.

This paper describes the GIS identification of stormwater quality device retrofit locations which form the basis of the mitigation options. An engineering constraints approach informed a complex GIS analysis across the entire catchment. The analysis extended to sizing and costing the devices within the GIS model for two types of treatment device with the overall goal of informing a benefit-cost analysis. The GIS approach enabled easy modification and validation of the proposed retrofit locations as well as visualisation of potential options for future of stormwater management within the catchment.

Keywords

Stormwater treatment, specimen / concept design, global stormwater discharge consent, GIS.

1. Introduction

Christchurch City Council ('council') is currently preparing a Stormwater Management Plan (SMP) to support a global stormwater discharge consent for the Avon River. The Avon River runs through the heart of Christchurch and is an integral part of the fabric of the city. The SMP considers the effects of existing and proposed development within the catchment (8,862ha), the nature of discharges into the river and the effects of urbanisation on the water quality (Bartram and Ritchie 2013) and sediment quality (Gadd and Sykes 2014) in the river. The SMP also proposes modifications to the existing stormwater infrastructure (the 'Avon SMP Blueprint', Couling (2014)) within the catchment to better manage both stormwater quality and quantity over the next 35 years.

The Avon SMP Blueprint will form a chapter of the SMP and will present the options, costs and benefits of new stormwater quality infrastructure within the catchment. This paper discusses in detail a part of the method used to derive the stormwater quality infrastructure options.

2. Background

Council has previously applied for two global stormwater discharge consents; the Styx River (Golder Associates 2012) and the South West Area Plan (Golder Associates 2011). These two consents were focused on the community's aspirations for the waterway, achieving policy directives (CCC 2009) and the effects of proposed greenfield development discharging into waterways. These earlier consents could rely on large water quality devices, such as ponds and wetlands, situated in the greenfield development areas to mitigate the effects of proposed urbanisation (Couling 2012, Golder Associates 2011a). The Avon SMP blueprint had to consider a dramatically different environment; consisting of approximately 50% existing impervious coverage (Golder Associates 2014), 550 km of existing pipework, 1,200 stormwater outfalls and very few possibilities for constructing large communal treatment devices. A different approach to the concept design for stormwater infrastructure was required; one which relied heavily on a dispersed treatment approach with a multitude of small treatment devices located across the catchment.

The concept design for the dispersed treatment device solution relied on existing guidance (CCC 2005) but also required significant effort in selecting appropriate devices (Couling 2014), establishing appropriate design criteria for them (Christensen (2014), Stone (2014), Parsons (2014)), considering specimen designs at an individual sites, across sub-catchments and the application of the site specific specimen designs across the whole catchment to provide the 'catchment wide picture'. This paper focuses solely on part of the method used to inform options for the catchment wide picture using data models within a Geographic Information System (GIS) platform.

The Avon SMP Blueprint Concept design provides realistic and robust solutions so that the community can have confidence in the proposed befits and costs. The robustness of the design will be tested in the resource consent process where the costs of the proposed scheme are likely to be scrutinised. Council also required a design method which was both auditable and flexible so that it could easily be modified for changes in the other design elements (i.e. the specimen designs).

3. The Challenge

As described above the Avon SMP presented new challenges with the nature of the catchment, resulting in mitigation options which significantly varied from previous SMP blueprint documents (Section 2). The density of existing development, with high utilisation of existing open spaces and tight engineering constraints limited the scope for large devices. High environmental protection aspirations (CCC 2009), in conjunction with this, meant a new approach was required The resulting design approach had to focus on the existing stormwater infrastructure, and identifying locations for retrofit of many, small, stormwater quality devices, i.e. a dispersed treatment system.

The specimen designs considered a number of case studies for the implementation of a dispersed treatment solution but a number of questions arose:

- How do you take a specimen designs and 'roll it out' over a large catchment?
- How much of the catchment could realistically be treated in this manner and how much would they cost?
- What does the retrofit picture look like?

These questions condensed into a goal to establish a concept for potential retrofit locations for various stormwater treatment devices. The objectives required to meet this goal were to:

1. Determine potential stormwater treatment device retrofit locations (Rain Gardens and Proprietary Filtration Devices);
2. Establish approximate catchment areas, device sizes and rough order cost estimates; and
3. Inform potential spatial combinations of treatment types to derive 'mitigation scenarios' for testing within a Contaminant Load Model.

An overarching aim was to enable the community and decision makers to engage with the proposed solution through clear representations of the scale and breadth of the proposal.

4. Solution

A solution was identified to meet the goal which involved utilisation of the existing GIS data and current GIS tools to 'roll out' engineering

design concepts in the form of data models. These data models would attempt to replicate the specimen design across the whole catchment which could inform the identification of a mix of potential treatment mitigation scenarios.

The same approach was then extended to develop cost estimates based upon the findings of the specimen design for each proposed treatment device. Two treatment devices were considered within the 6 values context of the Waterways, Wetlands and Drainage Guide (CCC 2003).

The GIS approach provides a clear audit trail, replicable results, adaptation to changing design and policy criteria and also provides an excellent tool for displaying results.

5. Methodology

The methodology was delivered in stages:

1. Start up and data collection: project briefing, planning, and sourcing up to date GIS data from a range of sources.
2. Model development: building the data model (GIS) from a range of input data, criteria, design constraints, and calculations. Development of cost estimates for each retrofit location.
3. Model validation: comparison of the model results of device locations and contributing catchments against the specimen designs done for Shirley and Addington.
4. Reporting: drafting, review, and finalisation of a report.

The output from the study informed the development of potential combined treatment scenarios. These are spatial combinations of a range of treatment methods and devices into potential catchment wide mitigation scenarios. The following stage also considered development of total cost estimates for the scenarios, calculation of treated and untreated areas and the 'big picture'.

5.1 Data Collection

Georeferenced data was required to inform the identification of retrofit locations. As with any concept design a wide range in data is required. In particular information such as stormwater network and road network data / geometry, parcel boundaries, surface elevation, groundwater depths, and land use. The majority of the data was available within existing council GIS datasets but some additional data was required from other custodians, such as LINZ and ECan.

5.2 Model Development

The model builder feature of ArcGIS 10.0 was used to apply the design rules to the existing datasets. This involved development of a series of inter-related models to:

1. Establish potential retrofit sites based upon design parameters and constraints;
2. Establish the catchment areas draining to the sites (allowing for bubble up sumps);
3. Calculate the dimensions of the devices based upon the contributing area; and
4. Derive cost estimates for each site.

5.2.1 Potential Retrofit Sites

Potential retrofit sites were identified from existing stormwater network feature datasets. Rain Gardens were based upon stormwater inlets

and filtration devices were based upon stormwater outlets. These full datasets were then narrowed down based upon design constraints and device specific rules.

A number of constraints limited the placement of all types of stormwater treatment devices, such as; location within the road reserve or adjacent to a waterway (e.g. not within schools, parks or heritage sites), ground levels must be greater than 11.85m RL (to account for future sea level rise and the impacts on the stormwater drainage network), and median groundwater depths must be greater than 0.6m (Thomas 2013) were applied. Areas outside of the constraints were considered for potential retrofit locations through the application of device specific rules. These rules were based upon the thinking applied when developing the specimen designs, i.e. the data model attempted to replicate, at least in part, a traditional design approach. For example, rules were used to identify relevant assets within the datasets, test proximity to other features, and consider topography and network geometry. The design rules applied for the identification of Rain Garden sites included:

- Established in service sumps, owned by council and suitable inlet types
- Merged close proximity sumps located on the same side of the same street
- Established if there were sufficient width in the road reserve to site a device depending on the hierarchy of the road
- Were based upon a bubble up sump feature

The design rules applied for the identification of filtration device sites included:

- Outlets with a connected pipe greater than 600mm in diameter; to target larger catchments
- Outlet within 30m of a waterway to identify pipes discharging to the receiving waterway and not an internal network connection
- Re-routing of the network for pipes along one bank of a watercourse for pipe delivering equivalent flow as a 600mm pipe and within approximately 30 m of each other
- Outlets not connected to arch culverts

For the filtration devices some manual correction (typically, removal of devices working in series) was required at the end of the automated processing to produce a realistic result.

5.2.2 Catchment Areas

In order to calculate the size of the treatment devices the contributing catchment areas needed to be established. Typically the catchment for a small treatment device, such as a Rain Garden, in a smaller event (i.e. up to the water quality storm (Christensen 2014)) is controlled by road and curb geometry, roof connections and general topography. Utilising a tool based upon the terrain would require a very detailed resolution of the terrain to represent fine features, (e.g. road curbs), with consequential computational effort. In order to avoid this, a data model was developed. This model utilised the road boundaries, sump locations, parcel boundaries, and a coarse topographic model (based on LiDAR data) as base data. A series of catchment delineation rules were applied, but in principle involved:

1. Dividing the road into very small segments;
2. Associating the small segments with the closest, lower sump;
3. Associating parcels with the closest road; and finally
4. Merging all segments and parcels draining to common sumps.

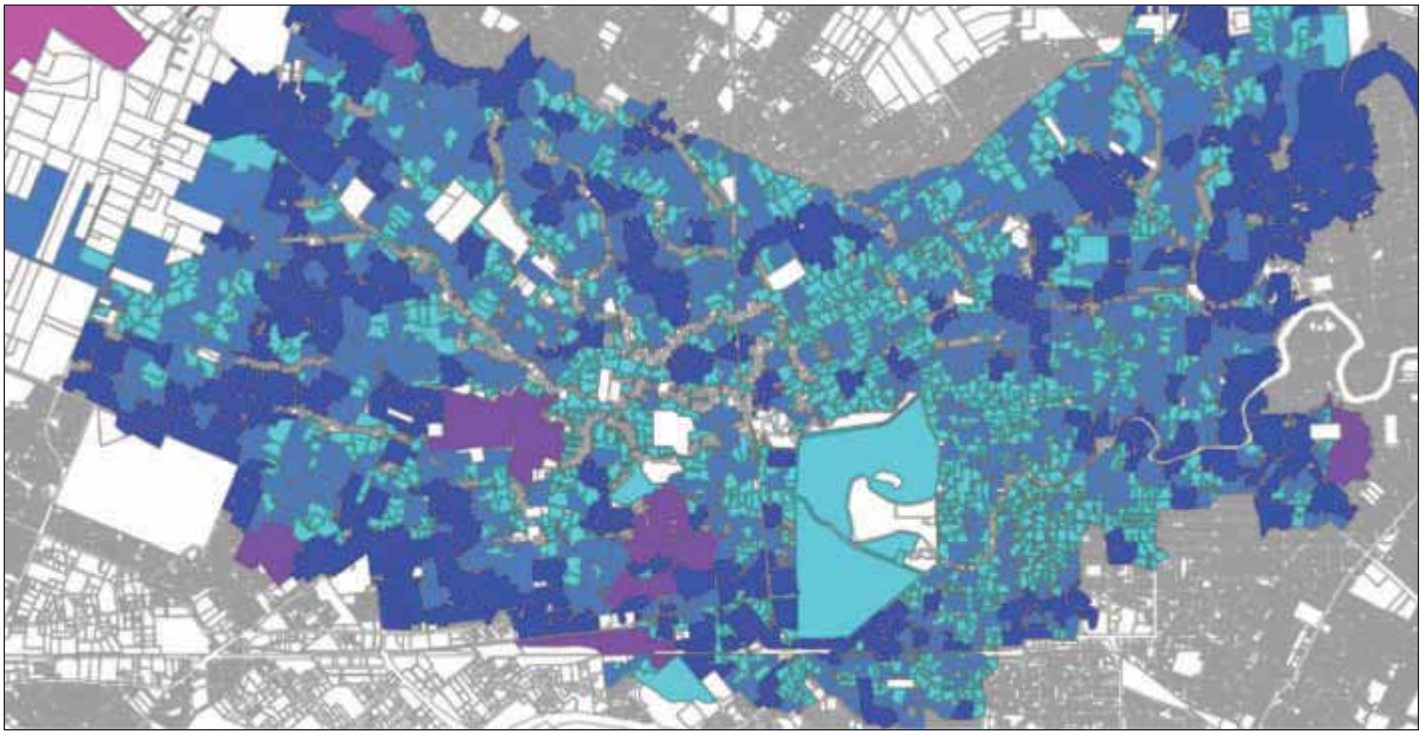
Other rules included testing:

- Parcel proximity to a waterway; to identify parcels which may drain directly to a watercourse or open channel, but not piped waterways
- Sump function; identifying bubble up sumps which will drain to other network sumps
- Sump status; identifying sumps in service

The catchment delineation relied on a number of key assumptions:

1. Houses/parcels connect to the closest road; this may be inaccurate as topography and stormwater connections will dictate the actual discharge location.
2. Thiessian polygons have been used as one of the ways to divide the road segments. This infers a proximity based relationship independent of topography. In reality topography will dictate and catchments may be inaccurate.

Figure 3 – Rain Garden catchment with device footprint



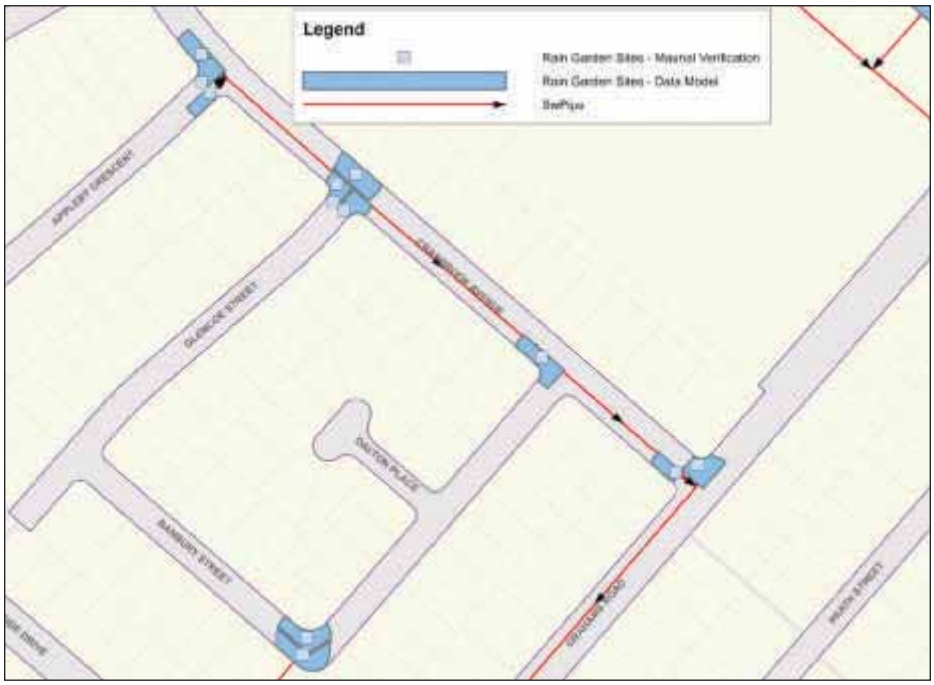


Figure 4 – Grahams Road Design Validation

3. Sumps within the divided road segments drain the segment, with similar consequences to item 2 above.
4. If there is no sump within a road segment then topography is considered in a simplified form, i.e. the closest sump which is lower than the level set by equation (1), where The 250mm allowance is for the averaging effects of the LiDAR grid development (i.e. curb height and road cross fall).

(The maximum level within the road segment + the minimum level within the road segment) / 2 + 250mm (1)

5.2.3 Device Dimensioning and Cost Estimation

Utilising the contributing catchment characteristics for each device location permitted the estimation of the device size and also the presentation of the treatment coverage. The sizing of the device relied upon the design guidance and cost curves prepared by Christensen (2014). Effectively the data model was used as a spreadsheet to calculate the foot print and consequential cost of each device. The contributing catchments could then be mapped by size of the device (Figure 3), where lighter colours are smaller devices.

5.3 Model Validation

The results of the analysis were compared against a number of sites throughout the city, including, Grahams Road and the Shirley and Antigua Catchment specimen designs (that were undertaken to inform the Avon SMP Blueprint). There were some differences in catchment boundary, size and device location at the individual treatment device level, overall however, there was a reasonable correlation between the two methods (Figure 4).

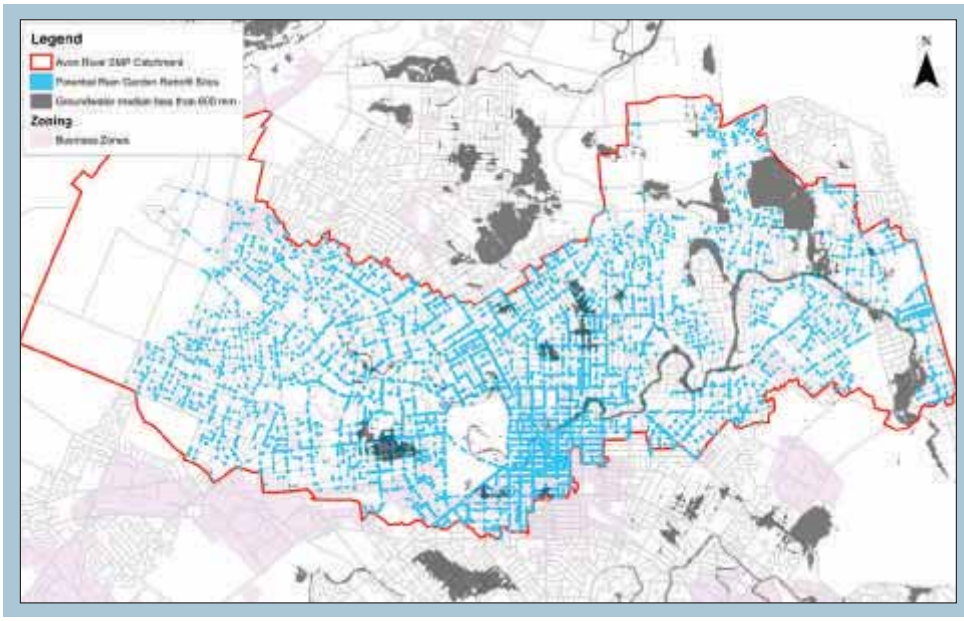


Figure 5 – Potential Rain Garden retrofit locations

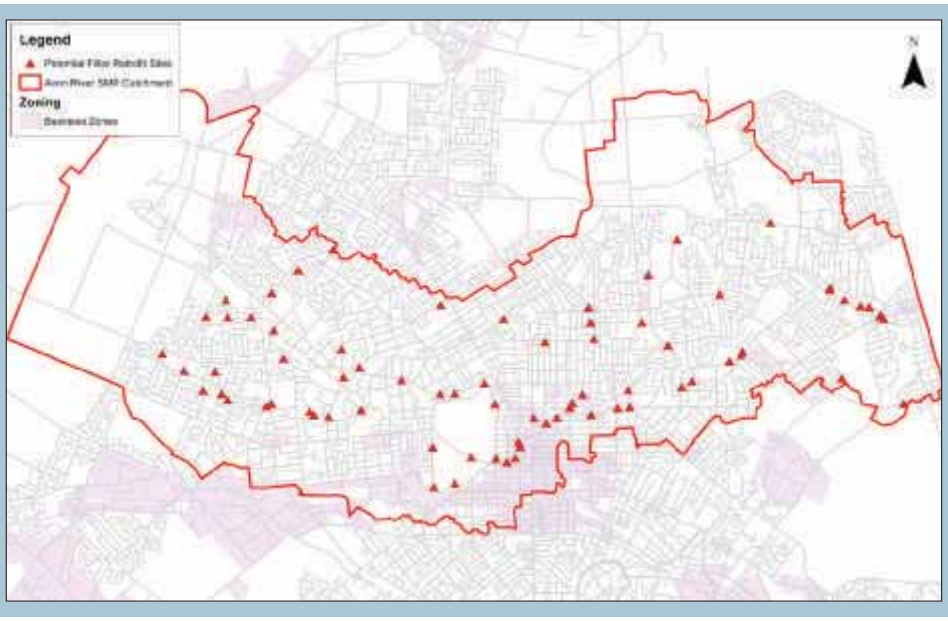


Figure 6 – Potential filtration device retrofit locations

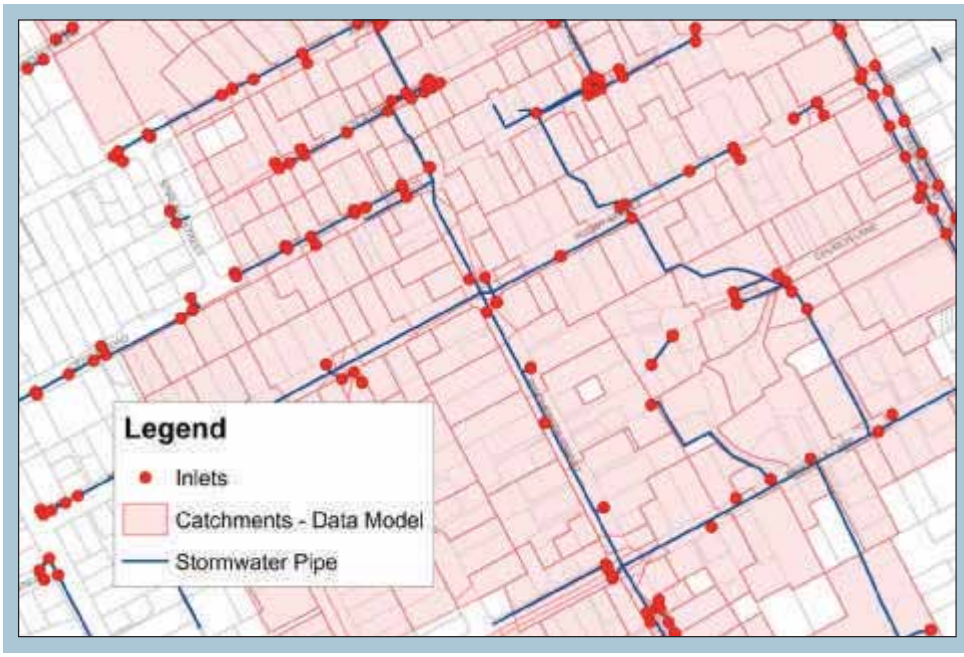


Figure 7 – Catchment Generation

6. Results

Figure 5 shows the results of the data model for Rain Gardens which identified approximately 5,000 potential retrofit sites across the catchment. Figure 6 presents a similar figure for the 78 potential filtration device locations identified. The catchment delineation model produced a large number of small catchments (Figure 7) which were suitable for approximate sizing of devices and the identification of treated areas.

7. Discussion

7.1 Meeting the Goal

The goal to establish potential locations for retrofit stormwater treatment devices at a concept level was achieved through meeting the project objectives (Section 3). Locations were identified for both Rain Gardens and Filtration Devices and these were validated against other design processes. The proposed locations could be used to develop catchment wide mitigation strategies.

The delivery of the project relied on a mix of engineering and GIS skills. The project goal could not have been achieved without an understanding of the data (and its limitations), knowledge of the capability of GIS, knowledge of the full design process, and what a realistic outcome could be. A considerable amount of 'trial and error' was required in development of the models as not all the parameters within the traditional design process could be automated and other techniques were required. The trial and error highlighted the benefits of the approach as initial design parameters could be altered, and the models re-run without the need to repeat intermediate processing steps manually.

In application, the design parameter selection requires careful consideration, with testing of appropriateness and effectiveness, i.e. constantly asking the question: does this analysis approach produce realistic locations? The practicality of individual retrofit site selections accumulates to the practicality of the whole concept design. The practicality of the overall concept design was a key driver. What is proposed has to be achievable or else the SMP could potentially fail, with time, through either the establishment of overly restrictive consent conditions (as a result of an optimistic evaluation of potential retrofit sites) or by limiting the potential benefits of the receiving waterway (as a result of a pessimistic evaluation of potential retrofit sites or an overestimate in costs).

7.1.1 Accuracy

The model validation did provide some certainty in the derivation of the sites and the overall cost estimates. The estimates for each individual site were not considered accurate given the dependence on the catchment area as the primary factor for device sizing (which were generated with only partial consideration of topography). However, the overall cost estimates were in the same magnitude as preliminary estimates undertaken by the design team.

The models are also reliant on the input data accuracy. If the built network is not accurately represented by the GIS datasets either through inclusions or exclusions (e.g. new infrastructure being built and not included or old infrastructure being abandoned or unsurveyed), then the accuracy of estimates of treatment coverage could be affected. For example, if a length of existing pipework was not in the GIS data then a portion of the catchment could drain to a river without passing though a treatment device and the number of treatment devices could be underestimated.

Sampling of the accuracy of the base data sets was not undertaken during the project. However, the method does permit 're-running' of the models as new data emerges, if required.

7.1.2 Advantages

There are significant benefits with the approach, including:

- The data model provides an audit trail, repeatability, and consistency. A traditional design approach relies on the individual designer and their interpretation of the data provided. This approach clearly identifies the process for which sites were selected, rightly or wrongly, and allows third parties to see how the output was derived.
- The development of the retrofit site location data models could occur in parallel with the specimen design work, so that if the specimen design changed then the big picture could respond without significant rework.
- The facilitation of sensitivity testing. Given that the based design rules could be altered and models re-run, the designers could gain an appreciation of how their rules affected costs or treated areas.
- Future flexibility. The models developed for the Avon could easily be modified for other catchments with similar datasets or as more up to date datasets are supplied/derived.

These benefits were obtained in applying this method, which took a similar quantum of effort to deliver as estimates for the traditional design approach.

"The trial and error highlighted the benefits of the approach as initial design parameters could be altered, and the models re-run without the need to repeat intermediate processing steps manually."

A very similar approach could be used for any number of applications where GIS data is available.

7.1.3 Disadvantages

There are disadvantages with utilising a data model approach, including:

- More specific skill sets are required to develop the data models. The models require a reasonable level of GIS competence in parallel with engineering knowledge. This makes the approach less accessible to engineers and harder to review (i.e. both the model and the

output require review, potentially by different people).

- The models need accurate and extensive electronic spatial data (not just hardcopy plans). The models require greater complexity as the reliability of the data decreases. More 'data cleaning' steps are required in poor data, which is both time consuming and adds risk of model failure.
- The initial startup time is longer. A detailed understanding of the data is required to develop a model, and in conjunction with any data cleaning leads to longer periods before first delivery of output. Also, the progress in producing the output is harder to track than a traditional design as the design does not progress geographically.

8. Next Steps

The potential retrofit locations will be used to establish catchment wide treatment solutions based upon a spatial mix of devices. Retrofit locations included in these catchment wide options will then be prioritised and programmed so that more detailed cost estimation can occur.

At the next stage of design the feasibility of each site will be considered with consideration given to services. The specimen design work (Christensen 2014) found that services tended to add complexity and cost to the design but did not exclude them completely. Services were not tested in the methodology due to the complexity in the analysis.

> "Software and hardware tools ... can be used to analyse large spatial datasets with (relative) ease. The software tools are both powerful and flexible and are only constrained by the imagination of the designer and operator."

9. Conclusions

Software and hardware tools are now widely available, which can be used to analyse large spatial datasets with (relative) ease. The software tools are both powerful and flexible and are only constrained by the imagination of the designer and operator. These tools permitted the identification of potential retrofit sites for a distributed treatment scheme within a large catchment. However, these tools could be used for any number of purposes.

GIS data is typically available in urban areas for topography and infrastructure so the approach outlined in this paper could readily be adapted to other cities.

Acknowledgements

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Tom Parsons is a Stormwater Engineer for Innovate Consulting Ltd. He specialises in concept design, stormwater modelling, project management, and programme management. Tom has focused recently on work for Christchurch City Council and investigations into earthquake effects on the drainage network and the Avon River SMP. ■

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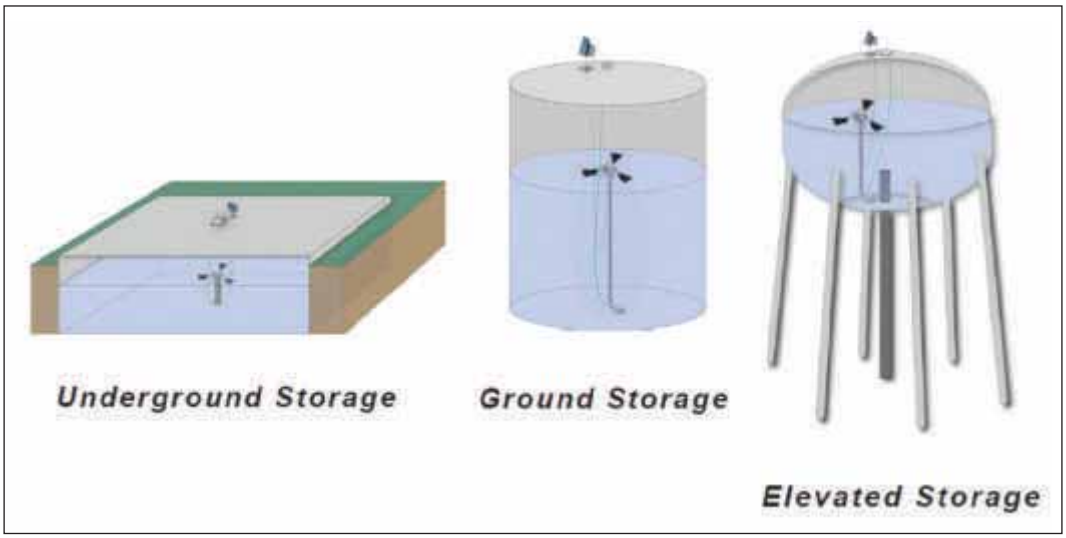
Features of SolarBee Mixing Equipment

SolaBee mixing equipment operates day and night on solar power or low energy grid power. Its collapsible design allows for customer or factory installation and it will fit through hatches as small as 18" in diameter. With an injection system for boosting, the equipment has just one moving part and a life expectancy of 25 years. It self-adjusts for varying water levels and produces SCADA outputs for monitoring as well as a safe low voltage.

Medora Corporation's mixers' energy-efficient, high-volume flow capabilities can be used to increase the baffle factor and actual T10 (the time at which 90 per cent of the water remains in the CT basin) detention time in treatment plants. Increased detention time allows a lower chlorine level to be used to meet the required CT, or chlorine concentration multiplied by time. A lower chlorine level will lower the total trihalomethane (TTHM) potential.



Mix First, Then Boost

Frequent boosting with small doses of disinfectant is far less costly than having a major problem occur in your distribution system. All of Medora's portable water mixers are equipped with chemical injection capability and the company offers an optional Disinfectant Boost System to dose small amounts of disinfectant (chlorine or chloramine) to maintain the desired residual level.

The Disinfectant Boost System is a portable air-operated injection system designed to be mounted in the back of a pickup truck or ute. It allows a single operator to safely and reliably boost multiple tanks in one day from ground level. With frequent monitoring and this portable boosting unit, customers can give end-users optimal quality water.

Medora Coporation's portable water products are certified to NSF/ANSI Standard 61. ■

Water New Zealand Conferences & Events

Water New Zealand Annual Conference & Expo 2014 – *Implementing Reform*

17 – 19 September 2014

Claudelands Events Centre, Hamilton, New Zealand
For more information visit waternz.org.nz or contact Hannah Smith hannah.smith@waternz.org.nz

Other Conferences:

Australian National Backflow Prevention Conference

Melbourne, Australia 1 August 2014

W: bpaq.org.au

IWA World Water Congress & Exhibition

Lisbon, Portugul 21 – 26 September 2014

W: iwa2014lisbon.org

21st Century Watershed Technology Conference and Workshop

Hamilton, 3 – 6 November 2014

W: watershedtech.org

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