WATER

Issue 172. November 2011

Annual Conference & Expo 2011 – Photos Inside

Managing Freshwater Quality: Challenges for Regional Councils

New Future in Recycled Water

water NEW ZEALAND

The New Zealand Water & Wastes Association Waiora Aotearoa

WATER

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The next issue of *WATER* will be published in March 2012.

On the Cover

Water New Zealand News

Features and Articles

Cover photo: Tracey Robinson Photography

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.

Clive Rundle

Another Successful Annual Conference & Expo

Rotorua once again hosted our Annual Conference this year. And once again it was a great success, justifying its position as the highlight in Water New Zealand's annual calendar of events. This year we trialled a different format that concentrated all paper presentations into the first two days, and reserved the final day for the AGM and a forum discussion. Feedback I have received suggests this worked well. More formal evaluation will take place over the next month.

We had fascinating keynote speakers, high quality papers, an entertaining conference dinner with the Topp Twins and the largest trade expo ever. Our thanks in particular go to our premier sponsors City Care, Downer, Hynds, Streat Control, ITT Water and Wastewater and Veolia Water, as well as all the other sponsors and trade exhibitors who support this event each year.

The final day of the Conference featured a forum discussion on the 'Future Face of Water Services'. Reform of the local government sector and water management is currently on the public policy agenda and this forum was held to encourage debate on the issues and options on water services. To stimulate debate the Water New Zealand Board emailed a 'straw-man' for reform to all members on 2 November. A large gathering of delegates listened to the views of four panel members then shared their thoughts in a healthy and constructive debate.

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I thank David Hill, the chair of the forum and all participants from both the panel and the floor for the constructive way in which they debated the subject. Consensus on these issues will be difficult to achieve, however there was almost universal agreement that Water New Zealand should take a position and seek to influence the reform. This is the course your Board is taking.

At the Annual General Meeting the Board reported that Water New Zealand is in good shape. Our finances are strong and our membership continues to grow. We were pleased to announce that Brent Manning was elected to the Board and Steve Couper was re-elected for a second term. Our thanks go to retiring board member Onno Mulder, whose experience and contribution has been invaluable.

The year ahead is an exciting one, with the opportunity to promote changes that will enhance our ability to provide excellent water services for New Zealand. I encourage you to read the 'straw-man' and begin discussing the issues and options with your colleagues so that we are ready to contribute to the reform process as it unfolds. ■

Clive Rundle
President, Water New Zealand

AGM Notices

2011 – 2012
***Water New Zealand* Board**

Congratulations to Brent Manning for his election on to the Board and to Steve Couper for his re-election.

The 2011/2012 Board are:

Clive Rundle - President
Hugh Blake-Manson
Rob Blakemore
Mark Bourne
Steve Couper
Brent Manning

new members

Water New Zealand welcomes the following new members:

ANDREW HILTON
ZHUO CHEN
KELVIN MCCLINTOCK
DAVID SORENSEN
AL DORRIS
RICA SALAMAT
VICTOR ROMERO
TIM PRESTON
TOM PARSONS
KATIE BEECROFT
KEITH WOOLLEY
TRISTAN JAMIESON
JUDITH CARSTENS
NICOLA BROWN
HELEN SHAW
GAVIN LACK
MIKE JONES
CHRISTOPHER ULYATT
NIKOLAI VAKHROUSHEV


Murray Gibb

Diffuse Pollution – Not Just a New Zealand Problem

The biennial conference of The International Water Association's Diffuse Pollution Specialist Groups was held in Rotorua in September. The event brought together specialists from across the globe to share information on management of what is deemed by some to be a 'wicked' problem.

It is certainly a problem in New Zealand. Intensification of land use, particularly over the past 20 years, has brought water pollution to public attention. When asked about their environmental concerns, degradation of water quality is uppermost in people's minds here. For our government policy makers, this environmental issue ranks second behind climate change.

There are a number of misconceptions around water pollution.

There is a widely held view that with the advent of the Resource Management Act regime and a requirement for consenting of point source discharges to water, we have fixed these sources of freshwater pollution.

This is not the case.

It has been 20 years since the Resource Management Act was enacted. Despite good progress made to date, there are still municipal and industrial effluent discharges that are of poor quality. The substandard effluent treatment of these discharges often does not match the scale and environmental risks of waste flows. In many cases regional councils are reluctant to impose stringent consent requirements due to financial constraints. Many local authority sewage discharges to water still require lengthy mixing zones.

A significant percentage of the low flow nutrient loading in the lower reaches of the much maligned Manawatu River still comes from point sources of pollution, including sewage treatment plants.

A further misconception is that freshwater degradation is all due to 'dirty' dairying. In the last 20 odd years the national dairy herd increased from 2.4 to 4.6 million. Certainly the significant increase in the dairy herd over this period has been accompanied by declining water quality.

But urban dwellers cannot righteously point the bone at farming practices. We still use waterways to flush away much of the detritus of urban lifestyles. As a consequence the most polluted streams in the country are those running through our towns and cities.

Although pastoral streams are not as polluted as urban waterways, the much greater pastoral land area does mean that these sources of diffuse pollution dominate at the national scale.

Another misconception is that this is a uniquely New Zealand problem.

New Zealand is no worse or better in its performance on this count than most other countries. Loss of water clarity and algal blooms are common features of degraded waterways across the globe, including the marine environment. For example the Baltic Sea is now regularly afflicted with these blooms.

In increasing its environmental footprint, agriculture is responding to market forces requiring more food to feed a burgeoning, wealthier and more urbanised population. The pressure will increase because further intensification of agriculture is inevitable in order to satisfy increased demand.

This is well illustrated by trends in the amount of available land on a per capita basis. It is decreasing rapidly with population growth increasing at an exponential rate. In 1995 there was 0.4 hectare of agricultural land per person across the globe. By 2030 this figure will have reduced to 0.17 hectare per person, when the total human population exceeds 8 billion.

Internationally policies aimed at fixing diffuse pollution have generally fallen short of need. Exceptions amongst the OECD countries include the Scandinavian countries where there has been progress. Not surprisingly these countries have taken an innovative approach using a mixture of regulatory and non-regulatory tools. There is also growing international interest in innovative policies such as water quality trading.

In New Zealand, with the exception of the Taranaki region, public policy initiatives to date have been unsuccessful in dealing with the problem. The Office of the Auditor General recently released a report on the performance of four regional councils in managing their obligations under the Resource Management Act.

"Internationally policies aimed at fixing diffuse pollution have generally fallen short of need. Exceptions amongst the OECD countries include the Scandinavian countries where there has been progress."

To quote the Auditor, "*… I conclude that Waikato Regional Council and Environment Southland are not adequately managing the causes of non-point source discharges in their regions. In both regions, significant intensification of land use (dairy farming) has meant more pressure on freshwater quality.*

The current regulatory and non-regulatory methods, and how they are being implemented in these regions, are not enough to reduce the known risks to freshwater quality. Both councils are trying to tackle the challenges of non-point source discharges and their cumulative effects, and there are some signs of improvement, but there is still significant work to be done."

Following the successful Scandinavian collaborative model, the Government has established the Land and Water Forum to provide advice on setting and managing limits on water quality and quantity. A mixture of regulatory and non-regulatory tools will be recommended.

What is clear is that using some basic tools will assist in addressing the problem over time. There is abundant evidence on the efficacy of fencing off waterways, planting riparian strips, good pasture management, using wetlands wisely and the proper management of nitrogen and phosphate inputs and outputs.

Wicked problems do require innovative solutions, but tried and true measures can be part of that mix.

For more on the report from the Office of the Auditor General see page 20. ■

Murray Gibb
Chief Executive, Water New Zealand

2011

advancing water reform

WATER NEW ZEALAND'S ANNUAL CONFERENCE & EXPO
ENERGY EVENTS CENTRE ROTORUA 09–11 NOVEMBER

This year's conference opened with a powhiri from members of local iwi, Te Arawa, followed by welcoming addresses from the Mayor of Rotorua, Kevin Winters, and Water New Zealand's President, Clive Rundle.

The electioneering season meant that Minister for the Environment, the Hon Dr Nick Smith was unable to attend but his planned keynote address was delivered by his Rotorua colleague, Rotorua MP Hon Todd McClay.

The opening day of the Conference featured six streams, including policy matters, two full streams of technical topics, a further stream with a focus on operational matters, and dedicated Modelling and IWA/Science streams (the IWA/Science stream was replaced on Thursday with a SWANS stream). The Conference also featured a specialised small water systems seminar on Thursday morning and a well supported poster exhibition.

The policy stream featured a range of speakers addressing challenges for water governance and delivery including the Hon Fran Wilde, Chair of Greater Wellington Regional Council, Kate Miles and Joel Byrnes from AECOM in Australia, who discussed the work they had done for that country's Productivity Commission on water management at the regional level, and Alastair Bisley, Chairman of the Land & Water Forum.

Adam Jeffrey briefed delegates on the project Siemens had done, Picture the Future Water NZ, and members of the National Infrastructure Unit gave a similar briefing on the 2011 National Infrastructure Plan.

Of special note was the presence of Mark Christison from Christchurch City Council who was presented with a special award from the US-based Water Environment Federation for a paper he had written on the Christchurch earthquakes. In a subsequent session Mark, Dave Brunsdon and Tim Ure delivered three separate presentations on Canterbury earthquake related issues.

On Thursday morning a plenary keynote was delivered by Professor David Bibby of Victoria University. This was a thought provoking address offering a global picture of extreme events, their impacts and the societal response. Later that morning Julian Williams of Waikato-Tainui gave a similarly thoughtful presentation on the history and future outlook for the new co-management regime for the Waikato River.

For many, the highlight of the conference proceedings was the panel discussion, The Future Face of Water Services, on the Friday morning. This was very well attended and several spirited exchanges took place.

On the social and networking front Wednesday's AECOM Welcome Reception was followed by the well-attended INNOVYZE Modelling Dinner and Applied Instruments Operations Dinner. The highlight was Thursday night's Hynds-sponsored Conference Dinner and Awards Presentation, which included entertainment from the exuberant and highly talented, Topp Twins.

The Conference, Operations Dinner and Conference Dinner were ably and amusingly MC'ed by Jim Hopkins, who also efficiently dealt with announcements in the expo hall. This year the expo featured some 171 stands and there were examples aplenty of the latest in cutting edge equipment and processes. Congratulations go to Filtration Technology who this year received the best stand prize.

Congratulations to all our award recipients (see full list on page 6) and a very special thanks to our premier sponsors, our dinner sponsors, and the sponsors of the welcome reception and the once again very well attended internet café and coffee cart. ■

Peter Whitehouse
Manager Advocacy & Learning, Water New Zealand

THANK YOU

We would like to thank the six premier sponsors for their continued support for *Water New Zealand's* Annual Conference & Expo.

Represented in the photo above are: (Left – Right) Chris Wrathall – City Care, Jeremy Holman – Downer, Steve Warne – ITT, Ian Cathcart – Veolia Water, Greg Sampson – Hynds and Brian Bennett – Streat Control.

Water New Zealand is grateful for their tangible support, advice and input into planning the Conference and Expo.

We are also appreciative of the generous support from the sponsors of our awards and social functions. AECOM again supported the Welcome Function, Hynds the Conference Dinner and Paper of the Year Award, INNOVYZE supported the Modelling Dinner and similarly Applied Instruments Group the Operations Dinner and Coffee Cart & Internet Café. Our Awards enjoyed the support of CH2M Beca for the Young Water Professional of the Year Award, Opus for the Trainee of the Year Award, Orica Chemnet for the Operations Prize and AWT Water Limited for the Poster Competition.

"For many, the highlight of the conference proceedings was the panel discussion, The Future Face of Water Services, on the Friday morning. This was very well attended and several spirited exchanges took place."

WATER New Zealand Awards 2011

Congratulations to All Award Winners for 2011

Orica Chemnet Operations Prize

Ian Loffhagen – Water Unit Manager, Waimakariri District Council

AWT Water Limited Poster of the Year Award

First: Jo-Anne Cavanagh – *Predicting and Managing Water Quality Impacts of Mining on Streams in New Zealand*
Second: Coral-Lee Ertel – *Asset Management 101 – A graduate Engineer's perspective of entering the world of Asset Management*
Third: Zhuo Chen – NDMA – *A Disinfection By-Product from Chloramination*

Ronald Hicks Memorial Award

Chris Tanner, James Sukias and Charlotte Yates – NIWA Hamilton for their authorship of *Multiyear Nutrient Removal Performance of Three Constructed Wetlands, Intercepting Tile Drain Flows from Grazed Pastures and NZ Guidelines: Constructed Wetland Treatment of Tile Drainage*

Technical Committee

Dukessa Blackburn-Huettner, Rebecca Fox, Steve Apeldoorn, Rob Blakemore, Neal Borrie, Ashish Deshpande, Louis Du Preez, Ian Garside, Roly Hayes, Kelvin Hill, Margaret Leonard, Rob Murray, Victor Mthamo, Kees Swanink, Chris Taylor and Chris Wium

Opus Trainee of the Year Award

Brendon Richards – Wastewater Treatment Plant Operator, Inghams Enterprises (NZ) Pty Ltd

CH2M Beca Young Water Professional of the Year Award

Caleb Clarke – Morphum Environmental Limited

Hynds Paper of the Year Award

Gold: Paul Webber et al – Solid Energy – *Addressing the Environmental Effects of Mining on the Ngakawau River*
Silver: Paul van den Berg – *Water metering in a Rural district*
Bronze: Hugh Chapman – *Development of a Successful Untethered Leak Detection and Pipe Wall Condition Assessment Technology for Large Diameter Pipelines*








Exhibitors – Best Stand Award

Best Stand: Filtration Technology
Highly Commended: Marley and Tyco Flow Control

Other Awards

Modelling SIG Best Paper Award

First: Stewart Sargent – *How Often Will Sewage Spill*
Second: Simon Pearce and Marcel Bear – *Melbourne Water Model Validation*

Modelling SIG Best Presentation Award

First: Stewart Sargent – *How Often Will Sewage Spill*
Second: Simon Pearce and Marcel Bear – *Melbourne Water Model Validation*

President Clive Rundle (centre), looks on as Garry Macdonald (right) presents Mark Christison (left) with the award from WEF

New Zealanders' Leadership and Expertise Recognised on World Stage

Simone Olsen – Editor, WATER

Water New Zealand's WEF delegate, and Water Market Segment Leader for Beca, Garry Macdonald, was recently appointed to the Water Environment Federation (WEF) Board of Trustees by the new WEF President Matt Bond for a term of three years.

Garry's appointment was confirmed in October by the WEF House of Delegates in Los Angeles at WEFTEC 2011.

Garry is the first New Zealander to be appointed to the WEF Board, and joins three other new members, nine existing members and six officers on the 19-person Board which governs WEF.

WEF is a not-for-profit association based in Washington DC with more than 36,000 members worldwide. It includes a large number of member associations including *Water New Zealand*. Its mission is to preserve and enhance the global water environment through technical leadership, innovation, best-practice publications, training and public education.

Garry has been involved with WEF for almost 20 years and, along with Rob Green, GHD, Palmerston North, served two years on the former WEF Executive Committee which later became the Board of Trustees following a major shift in governance arrangements and a rewriting of their Constitution.

While attending WEFTEC this year, Garry presented a special keynote address on behalf of Mark Christison, General Manager, Water and Wastes for Christchurch City Council who was at the last minute unable to attend. The keynote session was on Disaster Resiliency and featured papers from the USA – EPA, Japan – Ministry of Land, Infrastructure, Transport and Tourism, and New Zealand – Christchurch City Council.

The latter presentation entitled *"Water and Wastewater Interdependencies, Christchurch, NZ"* talked about the Christchurch earthquakes and the impacts they've had on the city's water, wastewater and stormwater infrastructure. The presentation was a resounding success with some in the audience moved to tears by the video and pictures shown of the devastation and personal grief in Christchurch.

WEF has awarded Mark a plaque in recognition of his leadership through the response and into the recovery phases of the three major earthquakes. The plaque was given to Garry to bring home to New Zealand and was kept secret until it was presented to Mark at *Water New Zealand's* Annual Conference earlier this month. ■

2011 – 2012 WEF Board of Trustees – Back row from left: Rick Werner, Reno, Nev.; Fran Burlington, Walnut Creek, Calif.; Charles Bott, Hampton Roads, Va.; John Hart, Saco, ME.; Scott Trotter, St Charles, Ill.; Kartik Chandran, New York, NY.; Garry Macdonald, Auckland, New Zealand; Scott Cummings, Auburn, Ala.; Terry Krause, Chicago, Ill.; Karen Pallansch, Alexandria, Va.; Paul Bowen, Atlanta, Ga.; Paul Schuler, Portland, Ore. Front row from left: Executive Director Jeff Eger, Alexandria, Va.; Vice President Sandra Ralston, Charleston, SC.; Past President Jeanette Brown, Stamford, Conn.; President Matt Bond, Kansas City, Mo.; President Elect Cordell Samuels, Pickering, Ontario, Canada; Treasurer Chris Browning, Canton, Ga.

WEFTEC 2011 Report Back

Garry Macdonald – Water New Zealand's WEF Director

A good contingent of Kiwis and *Water New Zealand* members attended WEFTEC 2011, with technical papers presented by Rob Fullerton – Beca and Past President of *Water New Zealand*, John Mackie – Dunedin City Council and Garry Macdonald. Other compatriots spotted amongst the 17,000 attendees were Graeme Thacker, Craig Freeman, Matt Ewen – all of FILTEC, John Crawford – Opus, Phil Read – Reaman Industries, Clint Cantrell – AECOM and there may have been others hiding in the crowd! The attractions of WEFTEC and LA were obviously greater than the Rugby World Cup as these New Zealanders missed the two semi-finals played during the first two days of WEFTEC!

"The annual event brought together almost 17,000 water professionals and more than 900 exhibiting companies from around the world."

The annual event brought together almost 17,000 water professionals and more than 900 exhibiting companies from around the world. Across the 900 presentations were key sessions and workshops featuring in-depth topics such as private sewer system management, innovative applications of recycled water, water infrastructure investment, recent developments in membrane bioreactor technology and improved energy efficiency for wastewater treatment plants and processes.

Stormwater2012

10 & 11 may, wellington

Stormwater Conference – First Time in Wellington

The Conference Committee is currently in the planning stages of the Stormwater Conference for 2012. It is the first time the conference will be held in Wellington. The programme will be published in December at www.waternz.org.nz.

Objectives

In 2012 the objective of the Water New Zealand Stormwater Conference is to provide delegates with an opportunity to:

- Upskill in various areas of stormwater science and management
- Network with peers
- Hear new and cutting-edge stormwater information

The 2012 conference will feature three streams, one of which will be devoted to stormwater modelling and another to the Rivers Group. These groups are excited to bring you this two day conference.

Registration

Registration opens on Wednesday 1 February – register and book your accommodation before Friday 16 March to receive the discounted earlybird registration and accommodation rates.

Sponsorship and Trade Exhibition

The Stormwater Conference is a prime opportunity to promote your organisation through sponsorship and the trade exhibition.

Sponsorship Opportunites

PREMIER SPONSORSHIP

One opportunity available
Total Investment Required – **$10,000 + GST**

CONFERENCE PARTNER

Two opportunities available
Total Investment Required – **$5,000 + GST**

INDUSTRY SUPPORTER

Four opportunities available
Total Investment Required – **$2,500 + GST**

ADDITIONAL SPONSORSHIP OPPORTUNITIES

- **Conference social function sponsorship**
  $5,000 – Conference Dinner
  $2,000 – Welcome Cocktail Function
- **Internet Café & Coffee Cart**
  $2,500 plus coffee costs
- **Keynote sponsorship**
  $2,500

Visit www.waternz.org.nz for further details on sponsorship and exhibition opportunities or contact Bronwyn Carson, Event Co-ordinator at bronwyn@avenues.co.nz

Water *New Zealand* Staff News

Cherish Low

Cherish joined *Water New Zealand* in September as Membership and Business Support. After completing University studies in 2010, she moved into the healthcare field before deciding to follow an administration path. Cherish sees her role at *Water New Zealand* as a good stepping stone to her future goals. Cherish replaces Jan Lang in this role.

Become a Member of *Water New Zealand* Today

For a membership application form please contact: **Cherish Low**
P: +64 4 472 8925
E: cherish.low@waternz.org.nz

Last Issue of WATER for 2011!

This is the last issue of *WATER* for the year. On behalf of the editor, Simone Olsen, the Advertising Salesperson, Noeline Strange and the staff of *Water New Zealand* we would like to thank all those who have taken time to contribute, articles, images and ideas over the five issues published throughout the year.

Enjoy the holiday season!

The next issue of *WATER* will be with readers in March 2012

If you would like to contribute please contact Simone Olsen, simone@avenues.co.nz.

Contributing to this industry publication is a valuable way to share knowledge across the wider water infrastructure sector.

The themes and deadlines for the issues for 2012 will be confirmed in December.

Water Industry Training Develops Environmental Monitoring Qualifications

Water Industry Training

New qualifications for those working in environmental monitoring are being designed at Water Industry Training.

"Environmental monitoring is the collection of environmental data for resource management and design purposes," Annie Yeates, Water Industry Training Manager, says.

"Environmental data includes hydrological, meteorological, air quality and freshwater quality data. The first area we are developing qualifications for is hydrology."

The qualifications are being designed to meet the needs of key players in the environmental monitoring industry such as district and regional councils, research organisations, energy generating companies and the primary production industry.

"Industry based qualifications are going to have many benefits for the field," Annie says. "It will allow the industry to own its own talent and provide a career pathway for school leavers and new science graduates. Graduates of the qualifications will have interdisciplinary skills and an industry recognised level of certification."

Marlborough District Council's Mike Ede agrees. Mike has 27 years' experience in the industry and has had a key role in the development of the qualifications as Chair of the Hydrology Working Group.

"The qualifications will allow those with an existing skill base and no formal qualification to be recognised for those skills," he says. "It also gives those entering the industry something to work towards and attain."

There will initially be two environment monitoring qualifications available, the working titles are:

- New Zealand Certificate in Environmental Monitoring (Core) (Level 3)
- New Zealand Certificate in Environmental Monitoring (Hydrology) (Level 4)

The Level 3 qualification will cover core skills and knowledge related to the wider environmental monitoring industry and graduates of this qualification will be able to collect environmental data under supervision. It is expected that holders of this certificate may be qualified to work as trainee technicians or in similar entry level roles in all sectors of the environmental monitoring industry.

The Level 4 qualification will allow specialisation in hydrology and will cover the application of skills in the field and the manipulation of data. Graduates of the Level 4 qualification will be able to install and manage a hydrometric monitoring network, collect, measure, process and analyse hydrometric data and display knowledge of environmental concepts and principles.

"Industry based qualifications are going to have many benefits for the field," Annie says. "It will allow the industry to own its own talent and provide a career pathway for school leavers and new science graduates. Graduates of the qualifications will have interdisciplinary skills and an industry recognised level of certification."

The qualifications will ensure an industry standard is achieved throughout New Zealand.

"There are currently no quality standards or consistency for hydrology training across New Zealand. These qualifications will fill that vacuum and provide industry best practice training that will help vital hydrological data to be protected for future generations," Annie says.

Hydrology is just the first of several environmental monitoring sectors to be developed into a qualification. The Environmental Monitoring qualifications are expected to be available in 2012. For more information about the new qualifications, please contact Water Industry Training on 0800 691 111.

Focusing on Completion of Qualifications

Water Industry Training has spent 2011 focusing on improving the way they assist their trainees to complete their qualifications.

"The world is changing which means we must change the way we do business," Water Industry Training Manager, Annie Yeates, says. "Funding changes by the Tertiary Education Commission (TEC) for industry training organisations have impacted our annual budget meaning we have had to reassess some areas of our training. We are making a number of positive changes that we anticipate will help trainees to complete their qualifications.

"We have been working hard to address barriers to completion, including making new resources available to assessors and looking at new approaches to assessments. We have also created useful reports for employers that help track their employees' progress towards their qualifications," Annie says.

There are four key areas to these changes that may influence someone's training:

Only 70 credits per trainee per year will be funded – qualifications have varying lengths and numbers of credits, which means training may have to be prioritised each year. This also means trainees are able to focus on completing their qualifications without taking on too much.

Every trainee must earn credits – TEC may recover funding if no credits are earned by a trainee. Failure to demonstrate progress by achieving credits throughout the duration of the qualification will lead to termination of the training agreement. Water Industry Training is working with training providers and assessors to make sure unit standards are achieved more regularly.

Qualifications must be completed within duration – Every qualification has a timeframe in which it should be completed under normal learning conditions (duration). TEC funding may not continue past a qualification's duration, meaning assessments must be completed inside duration or the training agreement may be terminated.

Durations for Water Industry Training qualifications are:

- National Certificate in Water Reticulation (Service Person) (Level 3) – 15 months
- National Certificate in Water Reticulation (Supervisor) (Level 4) – 22 months
- National Certificate in Water Treatment (Level 4) – 18 months
- National Certificate in Wastewater Treatment (Level 4) – 18 months
- National Diploma in Drinking-Water (Level 5) – 2 years
- National Diploma in Wastewater Treatment (Level 5) – 2 years
- National Certificate in Irrigation (Design) (Level 5) – 20 months

More trainees must complete their qualifications – at present around 40% of trainees are completing. If this does not improve TEC funding will reduce, meaning less training may be available.

"There is much that can be done by employers in the workplace to encourage and support trainees through their qualifications," Annie says. "This includes helping them to practice and implement their learning on the job, which in turn helps to achieve better performance and motivation at work – and trainees benefit by achieving a sought after qualification.

"Our training advisers are available to support trainees and their employers through training – please don't hesitate to contact us should you need any help," Annie says. "We look forward to the positive effects these changes will have on our trainees' ability to complete their qualifications and we will continue to work hard to ensure people are achieving."

Water Industry Training

Water Industry Training is part of Agriculture ITO (AgITO). Water Industry Training provides leadership in education and training, develops national qualifications, maintains national standards and provides ongoing support for their trainees and employers. For more information about qualifications, please visit www.waterit.ac.nz.

Water: Wrap Up for 2011

Helen Atkins – Partner & Vicki Morrison – Senior Associate, Atkins Holm Majurey

Introduction

As this article is the last one for the year, we commence with a recap of the matters covered in earlier articles this year. We then move on to discuss matters currently making the news, including the audit report on the management of freshwater and the measuring up discussion document put out by the Ministry for the Environment. We also outline a few other recent developments in brief and provide a summary of two recent cases of interest. We conclude by outlining a number of water related matters where developments which are expected to occur next year.

Recap of 2011 Year to Date

This year has seen a number of changes and proposed changes to the legislative and policy framework affecting water. In particular:

- The Land and Water Forum's Report on the framework for freshwater management reform was released
- The Government's 'Fresh Start for Fresh Water' reforms were announced and the National Policy Statement on Freshwater Management was introduced
- The National Infrastructure Plan (which includes a number of goals for water infrastructure) was released
- The Environmental Protection Authority was established as a standalone entity and given statutory hearing responsibilities under the Resource Management Act 1991 (RMA), the Hazardous Substances and New Organisms Act 1996, and other environmental legislation
- The newly formed Auckland Council settled in and strove to achieve a 'business as usual' approach
- Canterbury specific legislation, which included broad powers to suspend or override parts of the normal RMA process, was introduced to assist with and speed up the earthquake recovery efforts
- The application of the Water Measurement Regulations were expanded to include all renewal and replacement consents as well as new consent applications
- The report of the Waitangi Tribunal on Wai 262 was released which noted the shortcomings of some of the RMA processes and made a number of recommendations for improvement – such as greater involvement of kaitiaki in decision making processes
- The Human Rights Commission released a draft paper for consultation in relation to Human Rights and Water
- Decisions on a number of cases of relevance to the water sector were released including:
  - *Bay of Plenty Regional Council v Fonterra Co-operative Group Limited*[1], an Environment Court case in relation to priority between applications for renewal of resource consents; and
  - *Down v R*[2], a Court of Appeal case regarding prosecutions.

What is Currently Making News

The management of freshwater quality, the proposal for an Environmental Reporting Act, the Whanganui River negotiations, the Freshwater Clean-up and Irrigation Lands, the Transmission Gully Plan Change and the Easton Agriculture and Canterbury Readymix cases are all making news this month.

Managing Freshwater Quality: Challenges for Regional Councils

In September 2011 the Controller and Auditor General released a performance audit report which looked at the management of freshwater quality in four regions – Southland, Manawatu/Wanganui, Taranaki, and Waikato[3]. The purpose of the audit was to review how effective regional councils were in maintaining and enhancing freshwater quality in their regions.

The Audit Report indicated that while internationally New Zealand's overall freshwater quality rates well, there is deterioration in some areas which is of concern and should be addressed. In terms of the particular challenges experienced by regional councils the Audit Report found that these included[4]:

- Regulating 'non-point source discharges' (ie nutrients, chemicals, sediment and bacteria that run off land or leach through soil into water)
- Collaborating with other government agencies and key stakeholders
- Balancing the rural sector's economic needs with the desire for clean lakes and rivers
- Delays arising from the statutory requirement to go through a plan change process in order to implement new or amended water quality policies and programmes
- Separation of decision making in relation to enforcement and prosecutions from elected officials (i.e. councillors)

The Audit Report concluded with some recommendations on how management of freshwater quality could be improved. The overall recommendation was that a more integrated approach should be adopted. In particular, the Audit Report called for[5]:

- Collaboration at all levels – government, dairy, stakeholders, farmers and communities
- Sharing of knowledge and information
- A holistic approach to managing freshwater that integrates land use with freshwater management and effects on the coastal marine environment
- Strong links between freshwater management planning and monitoring to measure the effectiveness of the policies being implemented

For more information on the report see page 20.

In a recent media statement from the Minister for the Environment, the Hon Dr Nick Smith[6], the Government acknowledged the challenges facing regional councils and outlined the steps it had put in place to address these issues (the Freshwater National Policy Statement, the next phase of work by the Land and Water Forum, the increase in fines for non-compliance with resource consents, the introduction of water metering regulations and the increase in funding to clean up lakes and rivers). The Government also indicated that it intended to progress the recommendations in the Audit Report and urged regional councils to do the same.

Proposal for a New Environmental Reporting Act

The Ministry for the Environment released a discussion document in August 2011 about the state of environmental reporting. The Discussion Document sets out the current state of environment reporting and monitoring that occurs, the issues with this reporting and monitoring, objectives and options for improvement, the matters the Environmental Reporting Bill could cover and the costs and benefits of the proposed Bill.

In terms of issues, the document notes that environmental reporting is not currently a statutory requirement in New Zealand (unlike the vast majority of OECD[7] countries) and that as a result there is a lack of consistency in terms of what is measured, how it is measured, when it is measured, and who does the measuring.

To address these issues, the Government is proposing to introduce an Environmental Reporting Bill which would ensure that reporting occurred on a regular basis and was independent and consistent.

The Bill would require the Parliamentary Commissioner for the Environment to:

- Prepare a state of the environment report every five years
- Present the report before the House of Representatives on or before 1 July following the end of the five year period
- Report on freshwater, land, oceans, air and biodiversity

Submissions on the discussion document closed on 18 October 2011 and it is understood that a summary of submissions is currently being prepared. A symposium to discuss the Bill and any consequential changes to the RMA is scheduled for February 2012.

In Brief

Whanganui River Negotiations

A Record of Understanding has recently been signed by the Crown and Whanganui iwi. This record provides a framework for negotiating a settlement of grievances relating to the river. It is expected that the settlement will cover matters such as how iwi will be involved in management of the river, how the health and wellbeing of the river as an integrated whole can be promoted and protected, as well as guidance and strategies for managing the river. Negotiations proper are due to commence early next year.

Fresh Start for Freshwater Clean-up Fund

The Clean-up Fund, which was introduced as part of the Government's Fresh Start for Fresh Water Reforms, has been allocated $15 million to assist in the clean-up of lakes and rivers over two years. Applications for both years opened on 14 September 2011 and close on 31 October 2011 with funding announcements due in February 2012. $6.1 million of this fund has

"A Record of Understanding has recently been signed by the Crown and Whanganui iwi. This record provides a framework for negotiating a settlement of grievances relating to the river. It is expected that the settlement will cover matters such as how iwi will be involved in management of the river, how the health and wellbeing of the river as an integrated whole can be promoted and protected, as well as guidance and strategies for managing the river."

however already been allocated to the cleanup of Te Waihora/ Lake Ellesmere, which is New Zealand's most polluted lake[8].

Irrigation Acceleration Fund

The Irrigation Acceleration Fund was included in the 2011 budget to assist in contributing to sustainable economic growth. The fund provides $35 million over a five year period for support of regional water infrastructure, strategic water management studies, and community irrigation schemes. Up to 50% of the cost of the proposed development is eligible for funding. Applications are now open.

Transmission Gully Plan Change

The final decision of the Board of Inquiry into the Transmission Gully Plan Change was released in October 2011. The Board approved the Plan Change request from the New Zealand Transport Agency as it recognised that:

- The Transmission Gully roading project was a project of national and regional significance;
- That the Freshwater Plan in its current form would potentially preclude consideration of the project due to the lack of flexibility in the relevant policies
- That providing for a wider range of management methods then just avoidance of adverse effects (i.e. remedying and mitigation measures) was an appropriate method to achieve sustainable management of affected water bodies

Recent Cases

Easton Agriculture Ltd v Manawatu-Wanganui Regional Council

The recent High Court case of *Easton Agriculture Ltd v Manawatu-Wanganui Regional Council*[9] is interesting as the plaintiff in that case sought to recover the costs of crop losses from the Council when a stop-bank breached and flooded the plaintiff's land.

The plaintiffs argued that the Council was liable on the basis of negligence, private nuisance, the *Rylands v Fletcher* principle (i.e. owner responsible for losses caused by water "escaping" from their land), and breach of statutory duty.

The Court found that as a result of the provisions of the Soil Conservation and Rivers Control Act 1961 only negligence could be argued. In relation to negligence, the Court found that while the Council had a duty of care to maintain its stop-banks, and while that duty had been breached, the claim failed as the plaintiffs had not been able to establish that that failure had actually caused their loss:

[224] "For the foregoing reasons, I find:

a. The effect of s 148(1) of the Soil Conservation and Rivers Control Act 1941 is that claims against the Council arising from breach of the Moutoa floodway stopbank can be maintained only in negligence.
b. Reinforced by that same provision, the Council owed the plaintiffs a duty of care in monitoring and maintaining the floodway stopbanks.
c. The central and overwhelming focus of the plaintiffs' case was that the Council had breached that duty of care by failing to identify and repair a gap above the cement bags topping the stopbank crest, under the trestle bridge on the southern side of the floodway.
d. As a matter of fact there was indeed a gap of approximately 150 millimetres in that location.
e. The failure of the Council to identify and remedy that gap, in the course of its routine monitoring and maintenance of the stopbanks, was in breach of its duty of care to the plaintiffs.
f. In that respect, alone, I find the Council to have acted negligently.
g. The plaintiffs however failed to prove on the balance of probabilities that the presence of the gap caused the catastrophic failures that occurred to the stopbank. Those failures, both upstream and downstream of the bridge, were more probably caused by factors independent of the gap.
h. Accordingly, it is more probable than not that the floods that damaged the plaintiffs' crops would have occurred to exactly the same extent had the gap not been there."

Christchurch Readymix Concrete v Canterbury Regional Council

In our article published in the June 2011 issue of *WATER* we provided comment on a recent Environment Court case regarding priority between applications for renewals of water take consents under s.124 of the RMA. A recent High Court case, *Christchurch Readymix Concrete v Canterbury Regional Council*[10] has provided some further clarification on priority and in particular on the application of sections 124, and 124A – C of the RMA to riverbed gravel extraction.

This case started life as an application for a declaration in the Environment Court. In its decision the Environment Court found that sections 124A – 124C did not apply to applications to extract gravel from riverbeds essentially because gravel was not an 'allocatable' resource. On appeal to the High Court this finding was overturned. In short the High Court found that sections 124A – C did apply to gravel extraction.

In coming to its decision the High Court set out its view of the appropriate approach to interpreting these sections as follows:

> "[14] The starting point for analysis is Parliamentary sovereignty. Parliament makes law. The Courts apply it — whether the Courts think it is sensible or not. The Courts do not evaluate whether statute law is good policy. The political system deals with accountability for policy.
>
> [15] Where a Court finds what is a mistake or gap, which is obviously contrary to Parliament's intention, the Court can rectify it."
>
> "[16] Second, where there is a procedural gap in a process the Courts may assist to make the legislation work by provision of judicial remedies."
>
> "[37] For the reasons that I have already given I see no difficulty in gravel being viewed as a natural resource and as a public resource. In reality, it is a public resource. To repeat, this is because the ordinary incidents of ownership do not in fact apply, because of the environmental functions of gravels in the riverbed of an active river.
>
> [38] Once we can see that the word "allocate" in s 124A need not be confined to allocation by rules then immediately there is a practical explanation for the inclusion of s 13. It is no longer possible to argue that s 124A is incoherent. That argument was never possible anyway as, to return to my opening remarks, it is simply not possible for a Court to find that a statutory provision in whole or in part makes no sense."

The High Court also found that the Environment Court was incorrect to conclude that the reference to section 13 in sections 124B and C was a mistake and that the taking of gravel was not solely a matter of property rights.

The High Court therefore issued a declaration on the following terms[11]:

1. Section 124B of the Resource Management Act 1991 applies where:
   (a) a person hold an existing resource consent pursuant to section 13 of the Act and the activity consented includes both the disturbance of the bed of the river and all aspects of the extraction of gravel; storage; stockpile and traffic movements associated with the removal of the aggregate resource; and
   (b) the person makes an application affected by section 124; and
   (c) the consent authority receives one or more other applications for a resource consent that:
      (i) are to undertake the same activity within the same area to which the existing consent relates; and
      (ii) could not be fully exercised until the expiry of the existing consent, in that the volume of material available is insufficient to supply the volume sought in the application affection

by section 124, and the other application for the same resource."

Looking Ahead to 2012

In terms of what is on the horizon for next year, there are RMA reforms, additional recommendations from the Land and Water Forum and the Environment Court decisions of Variation 6 appeals.

RMA Amendments: Phase II

Working groups have been convened for Phase II of the amendments including a working group which will review sections 6 (matters of national importance) and 7 (other matters), which are contained within Part 2 of the RMA. As Part 2 is the engine room of the RMA any changes to this Part will potentially have implications for all sectors, including water. A report on these matters is due early 2012.

Land and Water Forum

The Land and Water Forum has two sets of recommendations due in 2012[12]. In March 2012 it will release recommendations on the limit setting aspects of the Freshwater National Policy Statement and what it considers are better processes for making decisions on limits; and in September 2012 it will release recommendations on how to appropriately manage freshwater within limits.

Variation 6 Environment Court Decision

The Environment Court's decision on Variation 6 to the Waikato Regional Plan is due later this year or early next year. This decision is of interest as issues raised included proposals for grand-parenting of water rights and allocation methods where there rivers and water bodies are currently over-allocated.

We will report on these and other matters of interest in our first article next year. Until then, we wish everyone a happy, relaxed and safe festive season. ■

Footnotes

[1]Unreported, Environment Court Auckland, 28 March 2011, Smith J.

[2][2011] NZCA 119.

[3]Controller and Auditor General, *Managing Freshwater Quality: Challenges for Regional Councils*, September 2011, Office of the Auditor General, Wellington.

[4]Audit Report, at pages 4 – 5.

[5]Audit Report, at page 6.

[6]Hon Dr Nick Smith, Minister for the Environment, Media Statement, *Auditor-General's water report backs Govt action*, 27 September 2011.

[7]OECD stands for the organization for Economic Co-operation and Development.

[8]Refer Nick Smith, Press Release, *$11.6 million cleanup plan for NZ's most polluted lake*, 25 August 2011; and *Ministry for the Environment, Fresh Start for Fresh water Clean-up Fund*, www.mfe.govt.nz/issues/water/freshwater/fresh-start-for-freshwater/cleanup-fund.

[9]Unreported, High Court Palmerston North, CIV-2008-454-31, 7 September 2011, Kos J.

[10]Unreported, High Court Christchurch, CIV-2011-409-001501, 13 September 2011, Fogarty J.

[11]Refer paragraph [40] of the decision.

[12]Refer http://www.mfe.govt.nz/issues/water/freshwater/fresh-start-for fresh-water/.


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Managing Freshwater Quality: Challenges for Regional Councils

Deborah Mills – Senior Performance Auditor, Office of the Auditor General

"We have reason to be concerned about freshwater quality in some parts of the country, particularly in lowland areas that are mainly used for farming". This is the conclusion drawn by New Zealand's Auditor-General, Lyn Provost, in a performance audit report released in September 2011.[1] This article, provided by the Office of the Auditor-General (OAG), summarises aspects of this report. For more information, you can find a copy of the report on the Auditor-General's website www.oag.govt.nz.

The Auditor-General's Role and Involvement with Environmental Issues

The Auditor-General audits all central and local government entities, and carries out about 20 performance audits and inquiries each year. She is independent of central and local government and can audit any aspect of government performance. Usually, her work focuses on whether taxpayers' and ratepayers' dollars are spent effectively and efficiently.

Over the past 10 years, the Office of the Auditor-General has done a number of performance audits with an environmental focus, and in 2005 released its first report on freshwater management.[2]

The OAG also contributes to environmental auditing at international forums and is involved in building the capability for environmental auditing in Pacific Island countries. The first two audits by Pacific Island nations dealt with solid waste management and access to safe drinking water. A third environmental audit, on sustainable management of tuna fisheries, is just getting underway.

The OAG's Recent Freshwater Quality Report

Regional councils are responsible for managing the activities that affect freshwater quality. The OAG's recent performance audit involved four regional councils – Waikato Regional Council, Taranaki Regional Council, Horizons Regional Council and Environment Southland. These councils make up approximately one-third of New Zealand's land area, and represent regions where there are significant pressures on freshwater quality.

The four regional council boundaries

Although people often cite other causes of declining water quality, many scientists are sure that freshwater quality is declining because land is being used more intensively – for example, the number of dairy cows on farms has increased. The aim of the OAG audit was to provide an independent view of how effectively regional councils are managing land use (and the resulting pollution that runs off the land, or 'non-point source' pollution) so that freshwater quality in their regions is maintained and enhanced.

Non-point source pollution is arguably the most difficult challenge for regional councils in managing freshwater quality. Adding to this is the challenge of balancing the rural sector's economic contribution alongside the community's desire for clean lakes and rivers.

Having Our Cake and Eating It

Healthy streams, rivers and lakes are important to our way of life. We want them to be clean enough to swim, play and fish in, and to remain clean and healthy enough for our grandchildren to enjoy in years to come. We have an obligation to protect ecosystems regardless of our own interests in them. We also need economic growth and development for our long-term wellbeing. Balancing these important matters is the essence of our report.

How our freshwater should be managed is characterised by many strongly held and potentially conflicting opinions. We came across a range of opinions and research results on whether we can "have our cake

> "Healthy streams, rivers and lakes are important to our way of life. We want them to be clean enough to swim, play and fish in, and to remain clean and healthy enough for our grandchildren to enjoy in years to come. We have an obligation to protect ecosystems regardless of our own interests in them. We also need economic growth and development for our long-term wellbeing. Balancing these important matters is the essence of our report."

and eat it" – that is, whether we can maintain freshwater quality at a level expected by communities and increase the productivity of the agricultural sector. Some regional council staff we spoke to considered that we were driving the land too hard, and that we could not continue to intensify land use without better managing nutrient losses. Others felt that market-based instruments can drive efficiency in the dairy sector and reduce impacts on freshwater quality, and that careful management of contaminants can ensure they do not overwhelm the water systems they enter.

The range of views presented reflects the differing environments within which the regional councils operate. We concluded that the economic viability of farming sustainably, while protecting ecosystems and allowing communities to enjoy freshwater recreational activities is more achievable in some parts of the country than in others.

Our Audit Findings

Our audit involved looking at the state of, and trends in, freshwater quality in each of the four regions, and how the regional councils were responding to any decline in freshwater quality. We asked the National Institute of Water and Atmospheric Research Limited (NIWA) to analyse the four councils' monitoring networks and the state of, and trends in, freshwater quality in the four regions.

This work found that each of the four regional councils we audited had adequate systems for collecting data on, and had a good understanding of, freshwater quality in its region. Each region had areas of poor water quality (high nutrients and faecal pollution, and low visual clarity), particularly in pastoral land use areas. Overall trends in water quality showed a decline in freshwater quality between 2000 and 2009 in pastoral land and some hill areas.

Based on our detailed audit findings and analysis of scientific monitoring data, we concluded that Waikato Regional Council and Environment Southland were not adequately managing the causes of non-point source discharges in their regions. In both regions, significant intensification of land use (dairy farming) has meant more pressure on freshwater quality. The current regulatory and non-regulatory methods, and how they are being implemented in these regions, are not enough to reduce the known risks to freshwater quality. Both councils are trying to tackle the challenges of non-point source discharges and their cumulative effects – while there are signs of improvement, there is still significant work to be done.

> "Managing freshwater quality needs an integrated approach and regional councils cannot manage freshwater quality alone."

Horizons Regional Council was maintaining and enhancing freshwater quality in the Rangitikei and Whanganui river catchments, but not for the Manawatu River catchment. The overall state of water quality remains undesirable in a number of places. Horizons Regional Council has a well-designed set of regulatory and non-regulatory programmes targeted at reducing the known risks to freshwater quality. These programmes should support future improvements in freshwater quality in the region.

Overall, Taranaki Regional Council was maintaining and, in places, improving freshwater quality in its region. Several aspects of Taranaki Regional Council's management of freshwater are effective. However, negative trends in freshwater quality in low-elevation areas suggest that there is vulnerability in the region. We consider that Taranaki Regional Council is well positioned to address these risks to freshwater quality by adapting its existing methods.

With this in mind, we were encouraged to see that all four regional councils were implementing programmes or policies to respond to areas of poor or declining freshwater quality. Although it can take many years to make changes to regional plans, some regional councils are starting to implement innovative, scientifically based policies that seek to manage freshwater quality within limits.

The Government's new National Policy Statement for Freshwater Management now requires regional councils to set freshwater quality limits for all bodies of freshwater in their region. Non-regulatory approaches and permitted activity rules are not likely to be sufficient to manage freshwater quality within limits.

Some regional councils are starting to take a more regulatory approach to managing non-point source discharges. For example, Waikato Regional Council has taken a "whole farm" approach to managing nutrient emissions within limits in the Taupo catchment. Some of the activities and land uses that regional councils are regulating are the same activities that the dairy sector has set targets for improving – for example, keeping cattle out of streams and managing nutrient inputs from land.

Our audit also looked at how regional councils were enforcing compliance with regional rules and resource consent conditions. We were concerned to note that councillors in all the regional councils had some involvement either in deciding whether the council should prosecute or investigating a case once the decision to prosecute had been made. There are strong and longstanding conventions against elected officials becoming involved in prosecution decisions. All investigation and enforcement decisions on individual matters should be delegated to council staff for an independent decision.

Managing freshwater quality needs an integrated approach and regional councils cannot manage freshwater quality alone. We were pleased to note strong collaboration in the sector – from high-level policy at the central government level to regional councils and dairy sector representatives working together at a strategic and on-farm level.

Our Recommendations

We made eight recommendations for improvement, six aimed at all regional councils and unitary authorities and two for the Ministry for the Environment. The recommendations covered:

- Ensuring that regional councils have the information they need to set freshwater quality limits and manage freshwater quality within them
- Providing a stronger basis for reporting on whether regional council policies are having the desired effect
- Ensuring that any decision about prosecution is free from actual or perceived political bias
- Clearer reporting of freshwater quality monitoring results. We also support the development of nationally comparable freshwater quality reporting

Overall, there is still some way to go if we are to halt and reverse New Zealand's declining trends in freshwater quality. Changes are needed sooner rather than later, because it takes time before improved policies result in improved freshwater quality.

Within the next 18 months, OAG will be contacting regional councils and the Ministry for the Environment to ask what progress has been made towards implementing these recommendations. We will provide an update report to Parliament on this progress in April 2013. At this time, we hope to report that regional councils have a stronger framework for ensuring that the quality of freshwater in our lakes, rivers, and streams is being maintained and enhanced. ■

Footnotes

[1]Controller and Auditor-General (2011) Managing freshwater quality: Challenges for regional councils, Wellington. Available at: www.oag.govt.nz.

[2]Controller and Auditor-General (2005) Horizons and Otago Regional Councils: Management of freshwater resources, Wellington. Available at: www.oag.govt.nz.

Creating a New Future in Recycled Water

Richard Irwin – Technical Director – Wastewater, Kirsten Newnham – Principal Process Engineer, AECOM & Paul Hansen – Manager – Treatment Systems, South East Water Limited, Australia

Introduction

The Victorian State Government has set ambitious targets for potable water substitution by recycling and stormwater reuse. Specifically, the Victorian Government's Central Region Sustainable Water Strategy aims to achieve 10 billion litres of potable water substitution by 2030. South East Water Limited provides water, sewerage, recycled water and trade waste services for a population of approximately 1.5 million people located in Melbourne's south (see Figure 1), and must comply with a Statement of Obligations issued by the Minister for Water. In order to achieve these targets, South East Water identified three key wastewater treatment plant upgrades and water reuse schemes. These plants are located at Pakenham, Somers and Mt Martha, as shown in Figure 1.

"The alliance team, named South East Recycled Water Alliance (SERWA), comprises AECOM as the designers, Transfield Services as the contractors and South East Water as the client. SERWA is tasked to design, construct and operate the recycled water treatment plants until the operation is handed over to South East Water. The programme is expected to deliver all these schemes by 2013."

Figure 1 – South East Water service area

Programme Delivery

The programme is being implemented in the form of an alliance with three partners. South East Water opted for the alliance approach for a number of reasons:

- Capital and whole of life cost efficiencies across the entire programme
- Operational and maintenance efficiencies
- Applications of lessons learnt from project to project
- A challenging timeline to meet the delivery timeframe agreed with the recycled water customers

The alliance team, named South East Recycled Water Alliance (SERWA), comprises AECOM as the designers, Transfield Services as the contractors and South East Water as the client. SERWA is tasked to design, construct and operate the recycled water treatment plants until the operation is handed over to South East Water.

The programme is expected to deliver all these schemes by 2013. Pakenham Recycled Water Treatment Plant (RWTP) is currently undergoing validation testing, Somers RWTP is being commissioned, and Mt Martha Tertiary Treatment Plant (TTP) is being designed, with construction expected to start towards the end of this year.

Regulatory Requirements

The regulatory requirements for water recycling in Victoria are described in the Victorian Environment Protection Authority (EPA Victoria) *Guidelines for Environmental Management: Use of Reclaimed Water* (Publication 464.2, 2003), and the *Guidelines for Environmental Management: Dual Pipe Water Recycling Schemes* (Publication 1015, 2005).

A key part of Class A recycled water schemes is the management and protection of public health. All Class A water recycling schemes in Victoria require endorsement from the Victorian Department of Health, in addition to approval from EPA Victoria.

The Class A water quality objectives described in the EPA guidelines are shown in Table 1. In addition, a Hazard Analysis and Critical Control Point (HACCP) management plan for the treatment plant is required, together with validation of the treatment processes to ascertain whether the targeted pathogen reduction is being achieved.

HACCP management is widely practised in the food and pharmaceutical industries to prevent any out-of-specification or non-compliant product being released to customers. Setting of critical control limits for unit process operation is a direct result of the scientific testing or validation of the treatment processes utilised.

Table 1 – Water Quality Requirements for Class A Water[a]

Quality parameters	Unit	Criterion
E-coli	/100 mL	< 10 (median)
Turbidity	NTU	< 2 (24-hr median)
BOD	mg/L	< 10 (median)
SS	mg/L	< 5 (median)
pH	pH unit	6 – 9 (90th percentile)
Cl2 residual	mg/L	1 (or equivalent disinfection)
Pathogen reduction requirements	**Median**	**Lower (critical) limit**
Bacteria	< 10 E. coli/100 mL	
Viruses	7-log[b]	6-log[b]
Protozoa	6-log[b]	5-log[b]

[a]From EPA Victoria, Guidelines 464.2 (2003), and Guidelines 1015 (2005).
[b]Reduction from raw sewage to recycled water.

Plant Descriptions

The design basis for each treatment plant is site specific with respect to water reuse applications, water quality requirements and delivery of reclaimed water. These requirements are described below for each site.

Pakenham Recycled Water Treatment Plant

The Pakenham Sewage Treatment Plant (STP) receives approximately 6ML/d of wastewater, comprising domestic wastewater and trade waste primarily from food industry. Treated STP effluent currently passes through polishing lagoons to achieve Class C quality before being discharged to the local waterway or pumped to a Class C winter storage reservoir for use by local farmers during the irrigation season. The RWTP receives effluent from the existing lagoons and will provide 4ML/d of Class A water to a new residential development approximately 9 kilometres northwest of the works, via a dual-pipe scheme.

Water quality requirements for the Pakenham RWTP are primarily related to compliance with pathogen reduction. In addition, colour reduction was considered a necessary objective as this can affect public acceptance of recycled water. Previous customer research undertaken by South East Water had revealed issues with an earlier dual pipe water reuse scheme where recycled water colour regularly exceeded 80Pt/Co units. Accordingly, a target colour of 25Pt/Co with a maximum acceptable limit of 40Pt/Co was adopted for household uses, to prevent toilet bowl discolouration and similar aesthetic issues.

Various process alternatives for the scheme were evaluated, with the selected process train comprising microscreening, ultrafiltration (UF), ultraviolet (UV) disinfection and chlorination. Bench-scale tests were conducted to assess the effectiveness of chlorination to lower the colour below 40Pt/Co units. These demonstrated that the chlorine dose required to maintain a free chlorine residual downstream of the chlorine contact tank was sufficient to lower the colour to the target levels. The required pathogen reduction will be achieved through the selected process train as per Table 2.

Table 2 – Expected log_{10} reduction of pathogens through treatment processes

Unit process	Viruses	Protozoa
Ultrafiltration (UF):	4-log	4-log
Ultraviolet (UV):	–	2-log
Chlorination:	3-log	–
Total	**7-log**	**6-log**

The UF system will be operated with daily pressure decay testing to monitor the integrity of the membranes. The UV system will be operated with online UV transmittance monitoring according to the Victorian Validation Guidelines (draft, Department of Health Victoria, 2010), to ensure the plant operates within the validated operating range for the required pathogen reduction. The chlorination system is operated with an online chlorine residual monitoring. The product water is diverted to an 'off-spec' diversion pipe (see Figure 2) when monitoring of any of the critical control points is lower than the set point, constituting a key element in the Hazard Analysis and Critical Control Point (HACCP) management of the treatment plant.

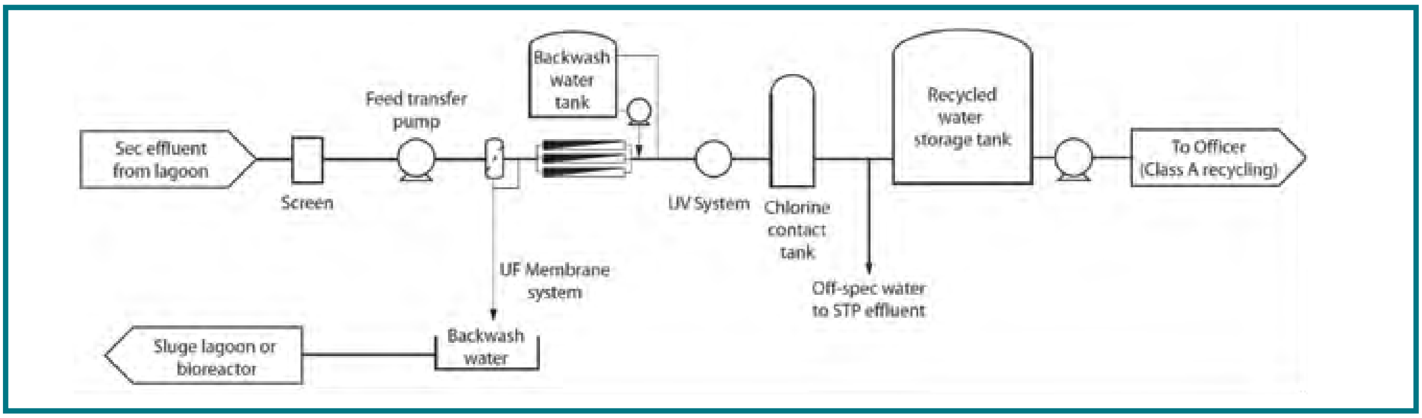


Figure 2 – Pakenham RWTP treatment process

Somers Recycled Water Treatment Plant

At Somers, a potable water substitution agreement has been made between South East Water and a local, large industrial user which will substitute recycled water for potable water in a number of plant processes. This customer has been treating its industrial wastewater and discharging the treated effluent to the Western Port Bay (see Figure 1).

Once the RWTP is commissioned, it will pump most of its waste to Somers STP in order to maximise reuse potential. As well as the construction of the RWTP to provide reclaimed water, the scheme includes the expansion of the existing STP. This is designed for approximately 5.0ML/d and the new works will increase the capacity to 7.5ML/d to accommodate the new trade waste inflow, domestic growth in the region and new sewer connections. Somers STP has been producing Class C recycled water that is pumped via a transfer pipeline to Mt Martha. This water is abstracted from the pipeline by a number of farmers for restricted irrigation use. At Mt Martha, the effluent is combined with Mt Martha effluent and pumped into the South Eastern Outfall (SEO) for discharge to Boags Rocks in the Bass Strait.

Upon commissioning of the RWTP, STP effluent will be distributed between the existing Class C users and the industrial customer, after additional treatment at the RWTP to upgrade the water. The design capacity for the RWTP is 2.4ML/d.

An extensive quantitative microbial risk assessment (QMRA) was carried out on the workers' operational exposure to recycled water and this confirmed that Class A quality water is appropriate for the health and wellbeing of the workforce. In addition, the product water is required to meet agreed quality criteria for specific processes that are susceptible to certain constituents in water. Some of the quality criteria that were critical for the process selection are shown in Table 3.

Table 3 – Selected parameters from the product water quality requirements

Parameter	Unit	Average	90th percentile
pH	pH unit	6.5 to 7.5	8.5
Chloride	mg/L	12	30
Total Hardness as $CaCO^3$	mg/L	15	20
Total Dissolved Solids (TDS)	mg/L	30	65
Total Sodium	mg/L	12	20
Silica	mg/L	0.2	5
Ammoniacal Nitrogen as N	mg/L	0.1	0.5
Total Phosphorus	mg/L	0.05	0.2
Sulphate	mg/L	0.4	2

Extensive evaluation of a number of processes was carried out to select an appropriate treatment stream that would meet the health objectives for Class A water as well as the quality requirements of the industrial customer. Factors such as STP performance, membrane rejection of specific parameters, reliability and impurities from chemical additions (i.e. disinfectants) were considered in the review. The selected treatment process includes high-rate lamella clarifier with a coagulant addition for chemical phosphorus removal, micro-strainer, UF, RO, UV and chlorination. In order to meet the limits on TDS and other constituents, the RO system employs two passes, with membrane gas transfer (MGT) to remove carbon dioxide, and pH adjustment (see Figure 3).

Product Water Storage Tank – Somers RWTP

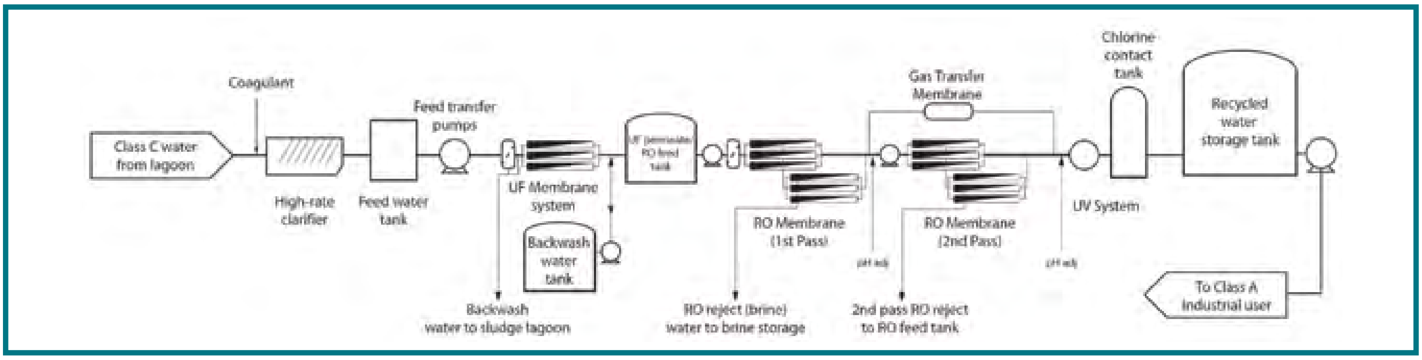


Figure 3 – Somers RWTP treatment process

As for Pakenham, the treatment process was designed to meet pathogen reduction requirements through UF, UV and chlorination. Pathogen reduction through the RO process was not counted for the purpose of process validation due to the difficulties of monitoring the integrity of the RO membranes and thus detecting pathogen breakthrough from the RO units.

The brine (concentrate) from the RWTP RO plant is stored onsite and periodically discharged to the Mt Martha site using the Class C reclaimed water discharge line. Due to high salinity, the brine cannot be used by the Class C customers, and water remaining in the pipeline must be flushed before the Class C customers can resume the use from the discharge main.

Mt Martha Tertiary Treatment Plant

Mt Martha STP is one of three South East Water works that discharge to Boags Rocks via the SEO; the other two being Somers STP and Boneo STP. Melbourne Water is currently constructing tertiary treatment facilities at the Eastern Treatment Plant (ETP) to ensure that effluent discharging to the SEO has negligible environmental or social impact. As such, South East Water is required to increase the quality of effluent discharged into the outfall so as not to compromise the improvements that will be achieved by the ETP tertiary upgrade.

To achieve this, a new tertiary treatment facility will be constructed at Mt Martha to treat all discharges from Mt Martha and Somers sites, namely Mt Martha secondary effluent, Somers Class C effluent, and brine from the new Somers RWTP. The existing Somers Class C customers will continue to be supplied from the transfer pipeline and only surplus Class C effluent will undergo tertiary treatment at Mt Martha.

A number of tertiary effluent qualities were considered, of which two were shortlisted:

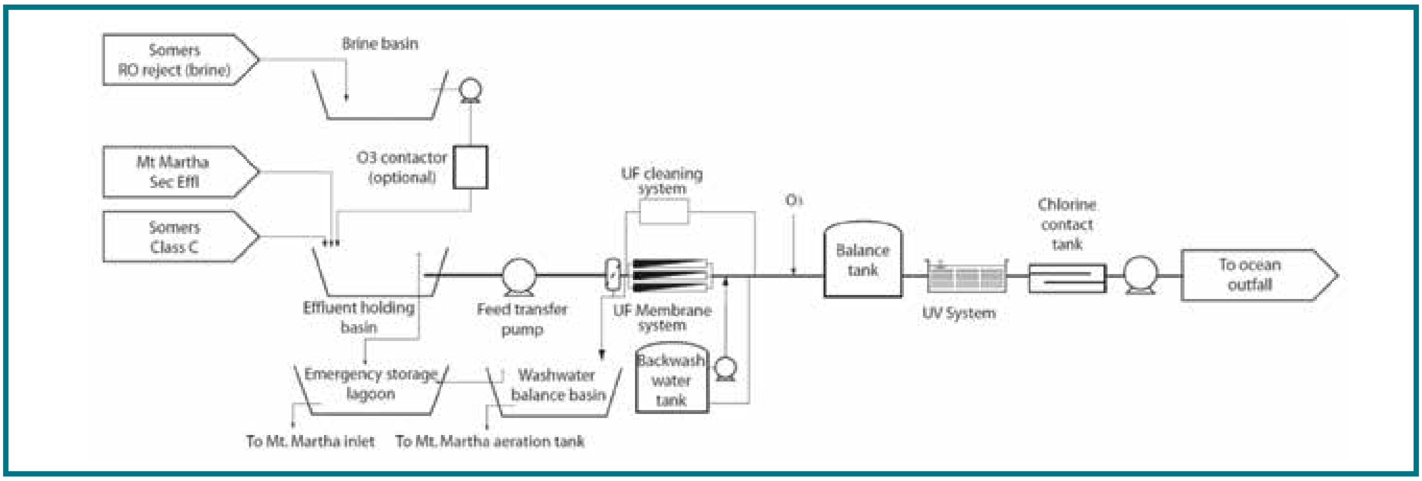
- Matching ETP effluent quality (including colour removal) for all streams discharged to the SEO (including Somers brine)
- Class A only for all streams discharged to the SEO (including Somers brine)

Targeting Class A effluent only was shown to be the most financially and environmentally favourable, although this would not meet the anticipated minimum water quality standard expectations of Melbourne Water, EPA and other key community stakeholders, namely; to match ETP discharge water quality. Accordingly, targeting Class A with colour removal for all streams discharged to the SEO was selected by South East Water as the preferred option.

Various treatment combinations were evaluated to identify the most appropriate treatment stream to achieve both the log reduction and aesthetic quality requirements. The most significant challenge to meet the quality requirements was the uncertainty surrounding the incoming wastewater characteristics, especially from the trade waste and Somers RO reject (brine) which will not be available until around the time of the plant commissioning. An extensive series of bench-scale and pilot scale tests were conducted to evaluate the effectiveness of ozonation, coagulation/flocculation, and chlorination on colour removal and UV transmittance (UVT) improvements for the various incoming streams. Surrogate samples were used for the waste streams that were not available at the time of testing. These were collected from similar process plants operating elsewhere in Australia. Unfortunately, some uncertainty remains regarding feedwater quality as the surrogate processes were not identical to those at Mt Martha, and consecutive samples collected showed significant variability.

Based on the results from the tests, the preferred process train was determined as UF, ozonation of the blend water, UV, and chlorination (see Figure 4). Ozone treatment of the brine stream from Somers prior to UF is an optional inclusion to the process. The anticipated treated water quality is shown in Table 4.

Figure 4 – Mt Martha TTP treatment process



Left – Ultrafiltration Plant – Somers RWTP, Right – Reverse Osmosis Plant – Somers RWTP

Table 4 – Expected treated water quality from Mt Martha TTP

Parameter	Unit	Median	90%ile
Colour (True)	Pt/Co	<15	<25
Ammonia as N	mg/L	<0.5	<2
Total Nitrogen as N	mg/L	16	20
Suspended Solids	mg/L	<2	<5

Treatment Unit	Protozoa (Log reduction)	Virus (Log reduction)
Mt Martha ASP	0.5	0.5
UF	4	4
UV	2	–
Chlorine	–	3
Total log reduction	**6.5**	**7.5**

Status of Water Reuse Projects

Pakenham and Somers RWTPs are scheduled to start delivering recycled water in 2011. Once complete, the SERWA programme will deliver fit-for-purpose recycled water for the dual- pipe scheme and the industrial user. Mt Martha TTP is expected to be commissioned in 2012–13, and the product water is mixed with tertiary-treated effluent from Melbourne Water's ETP for ocean discharge via the SEO. The Mt Martha treatment process will provide opportunities for the communities along the SEO to utilise the water for non-potable purposes. The challenge for SERWA is to design the TTP with the process reliability required by potential customers. This includes significant plant redundancy and the use of sophisticated SCADA and telemetry systems. ■

Adaptive Management – The Answer for Your Next Big Water Project?

Christina Sheard – Associate, Russell McVeagh

Adaptive management conditions were once the sole domain of the aquaculture industry. However, over the past 10 years adaptive management has gained popularity in a variety of contexts, including the management of freshwater resources.

In simple terms, adaptive management effectively allows developments to proceed where there is a degree of scientific uncertainty about the exact nature and extent of the adverse effects which might occur. At the same time, it ensures that the environmental bottom line is not compromised.

This article looks at the Environment Court's requirements for adaptive management conditions, how adaptive management might be used in the water quality context and the potential pitfalls of using this type of condition. First, it examines exactly what is adaptive management.

What is Adaptive Management?

The New Zealand Biodiversity Strategy 2000 was the first policy document in New Zealand to embrace the concept of adaptive management. The Biodiversity Strategy contains the following definition:

> "Adaptive Management: An experimental approach to management, or 'structural learning by doing'. It is based on developing dynamic models that attempt to make predictions or hypotheses about the impacts of alternative management policies. Management learning then proceeds by systematic testing of these models, rather than by random trial and error. Adaptive management is most useful when large complex ecological systems are being managed and management decisions cannot wait for final research results."[1]

The inclusion of the concept of adaptive management in the Biodiversity Strategy was seen as somewhat cutting edge, particularly given that it predated any of the aquaculture adaptive management caselaw which was to come several years later. The aquaculture caselaw was in direct response to opposing tensions between the pressure to develop the coast (and in particular marine farming potential) versus the need to protect the sensitive coastal environment.

Adaptive management is closely tied to the concept of adopting a "precautionary approach". The precautionary approach made its first appearance in caselaw as early as 1994.[2] Adopting a precautionary approach involves taking a cautious approach when faced with scientific uncertainty about the level of risk. The Environment Court has, over the years, grappled with the issue of how to apply the precautionary principle under the Resource Management Act 1991 ("RMA"). The Court has stressed that the RMA does not support a no-risk regime.[3] The RMA is inherently precautionary: there is no need for a further overlay in terms of requiring an additional layer of conservatism.[4] In other words, the Environment Court does not take an overly precautionary approach.[5] It is within this context that the concept of adaptive management evolved.

As outlined above, adaptive management found its first real footing in a lengthy line of more than a dozen aquaculture cases. The Environment Court's first detailed analysis of the concept was in *Golden Bay Marine Farmers v Tasman District Council*.[6] The Court adopted the definition of adaptive management from the Biodiversity Strategy and endorsed an adaptive management regime involving the use of management plans, condition review provisions, monitoring programmes and staged development controlled by enforceable resource consent conditions to manage the effects of a proposed mussel farm. Later in the same year, in *Clifford Bay Marine Farms Ltd v Marlborough District Council*,[7] the Court approved an "adaptive management" approach in relation to the risk marine farming posed to Hectors dolphins. The Court noted that the best approach was to "cautiously to test the waters of Clifford Bay, by permitting a marine farm to be established but on conditions that allow hypotheses to be tested in a scientific way with controls to check for false positives".[8]

> "The concept of adaptive management is now well established in New Zealand law and has been applied in a variety of contexts including geothermal energy, hydro projects, mining, quarrying, land filling and nutrient management. Moreover, the concept is not unique to New Zealand, but has also been adopted internationally."

In general terms, the key components of adaptive management normally involve:

- Uncertainty about the magnitude or nature of an effect
- Good baseline knowledge about the existing environment in which that effect may occur
- The setting of triggers which define the point at which action needs to be taken to reverse the effect if it occurs
- The identification of appropriate remedial action which will reverse the effect back to below the trigger level
- Effective monitoring of the potential effect
- Implementation of the remedial action
- Monitoring of the remedial action to ensure the effects have been reduced to below the trigger levels
- Continued monitoring and remedial action until the effects have been reduced to below the trigger levels

The concept of adaptive management is now well established in New Zealand law and has been applied in a variety of contexts including geothermal energy, hydro projects, mining, quarrying, land filling and nutrient management. Moreover, the concept is not unique to New Zealand, but has also been adopted internationally.[9]

Key Thresholds for Adaptive Management

The leading, and most recent, major decision involving adaptive management is *Crest Energy Kaipara Ltd v Northland Regional Council*.[10] That case involved the installation and operation of 200 tide turbines on the seabed near the mouth of the Kaipara Harbour. The Court, in the interim decision set out some stringent key requirements for adaptive management (which were endorsed in the final decision):

- **Baseline knowledge**: the collection of baseline knowledge through research and monitoring of the existing environment.
- **Triggers**: identifying evaluation criteria which if "triggered" through monitoring, reporting and checking systems, will initiate

the adaptive management process before significant adverse effects eventuate.

- **Appropriate reaction**: these mechanisms must be supported by enforceable resource consent conditions which require certain criteria to be met before the next stage can proceed. Importantly, any adverse effects which exceed the trigger levels must be able to be reversed.
- **Further monitoring**: there must be an ability to reorganise and adjust a development if the monitoring results warrant it. The process may even start again at the design and planning level.

This case highlights the need to ensure that management plans contain sufficient detail to ensure that the regime is certain and enforceable. As the Environment Court noted in *Royal Forest and Bird v Gisborne District Council* adaptive management plans do not alter the requirement for resource consent conditions to be sufficiently certain: [11]

> We appreciated the need for so-called adaptive management informed by ongoing monitoring …However, we do not consider that this approach justifies an open-ended consent with no certainty on the outcomes to be achieved.

The Court set out the test for conditions derived from *Newbury District Council v Secretary of State for the Environment*[12] and endorsed under the RMA in Housing New Zealand v Waitakere City Council.[13] That test requires that conditions must be imposed for a resource management purpose and not for some ulterior purpose, the condition must fairly and reasonably relate to the development in question, and the condition must not be so unreasonable that no reasonable consenting authority could have imposed it. The Court then went on to add:[14]

> A condition must also be certain. It can leave the certifying detail to a delegate, using that person's skill and experience, but cannot delegate the making of substantive decisions.

Adaptive Management in the Freshwater Context

While there are not as many adaptive management cases concerning water quality as, for example, aquaculture, the concept has clear potential for freshwater management, particularly in the context of water quality. Recent adaptive management cases relating to freshwater resources include:

- Meridian's North Bank Tunnel project[15]
- TrustPower's Wairau hydro-electric power scheme[16]
- the Lake Taupo nutrient management case[17]

Designing adaptive management conditions in relation to water quality is relatively simple given that there are well accepted standards which apply to water quality parameters such as temperature, dissolved oxygen and water clarity. These standards are normally adopted as the trigger points which define when remedial action needs to be taken. Designing monitoring regimes to detect changes in water quality is also normally relatively straightforward.

Designing adaptive management regimes for the protection of instream health can be somewhat more challenging. For example, defining trigger points for reductions in native fish, trout, salmon, and macroinvertebrates is much more complex. Detecting changes in aquatic populations is problematic given the naturally high variability in population densities and limits to sampling techniques. Therefore, defining and detecting a statistically significant change in a particular population is difficult in terms of identifying an appropriate trigger. The input of an experienced aquatic biologist will be critical.

Similarly, defining the contingency or remedial action required if trigger levels are breached can be difficult. There must be confidence that the contingency actions will be effective. If ultimately the contingency actions are not sufficient to manage effects, then the only option left to reverse the adverse effects will be remove the development or cease the activity (although it should be noted that while a condition to cease the activity can be offered up by the applicant as part of an adaptive management plan such a condition cannot be imposed by the Court). Critically, the adverse effects arising from the development must be able to be reversed. In order to reduce this risk, adaptive management often involves the staging of projects. Staging allows the effects of a project to be assessed incrementally providing the confidence that key triggers are not being compromised before the next stage is implemented.

Many of the first aquaculture cases involved staging, and consequently it is sometimes argued that staging is required for any adaptive management proposal. However, there is no indication in the caselaw that staging is required but rather the emphasis is on ensuring that adverse effects can be managed and are ultimately reversible if they do occur. However, any applicant proposing a development which is not staged, but involves adaptive management, will want to have a high degree of confidence that adverse effects can be effectively managed given the potential costs associated with baseline monitoring, the resource consent hearing process and infrastructure development.

Any adaptive management proposal must be based on a good understanding of the baseline environment. Baseline monitoring can be an extremely costly exercise. Despite the Government's latest attempts to improve the quality and quantity of baseline data through the National Policy Statement (NPS) for Freshwater Management 2011 and a new national environmental reporting system, the current reality is that there is a dearth of baseline monitoring information for many waterbodies. Proponents of projects often spend millions of dollars over several years establishing a robust baseline of information. Furthermore, consent holders will face additional monitoring costs once the scheme is implemented. Importantly, the consent conditions need to define a date at which monitoring will end.

Look Before You Leap

Adaptive management mechanisms have the potential to assist you in getting your next big water project 'over the line' where there is some scientific uncertainty about the nature or scale of the potential adverse effects. However, the costs associated with putting an adaptive management plan in place should not be underestimated given the requirements for robust baseline information, ongoing monitoring and, potentially, the implementation of remedial action. The key to successfully designing and implementing an adaptive management plan lies in instructing an experienced expert team early on in the project to craft an adaptive management plan which not only meets the requirements set out in caselaw but is practical and cost effective in terms of its implementation. ■

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Footnotes

[1]New Zealand Biodiversity Strategy 2000, page 137.

[2]See for example, *Transpower New Zealand Ltd and Power New Zealand Ltd v Rodney District Council* A85/94, *Shirley Primary School v Telecom Mobile Communications Ltd* [1999] NZRMA 66 and *McIntyre v Christchurch City Council* [1996] NZRMA 289.

[3]See for example, *Land Air Water Association v Waikato Regional Council* A110/01 and *Sawmill Workers against Poisons Inc v Whakatane District Council (No 2)* [2006] NZRMA 500 (HC).

[4]*Shirley Primary School v Telecom Mobile Communications Ltd* [1999] NZRMA 66 and *Jackson Bay Mussels Ltd v West Coast Regional Council* C77/04.

[5]*Jackson Bay Mussels Ltd v West Coast Regional Council* C77/04, para 132.

[6]W19/2003.

[7]C131/03.

[8]Ibid at paragraph 147.

[9]See the European Union Report on Integrated Coastal Zone Management, "Report to Congress on the Potential Environmental Effects of Marine and Hydrokinetic Energy Technologies December 2009" and the Report by the US Department of Energy under the Wind and Hydropower Technologies Program, prepared in response to the Energy Independence and Security Act of 2007.

[10]Interim decision A 132/09 and final decision [2011] NZEnvC 26.

[11]W026/09 at [85].

[12][1980] 1 All ER 7312 (HL).

[13][2001] NZRMA 202 (CA).

[14]Ibid at [88].

[15]*Lower Waitaki River Management Society Inc v Canterbury Regional Council* C80/2009.

[16]*Director-General of Conservation (Nelson-Marlborough Conservancy) v Marlborough District Council* [2010] NZEnvC 403.

[17]*Carter Holt Harvey Limited v Waikato Regional Council* A123/08. The approach to nutrient management in the Waikato region is an example of adaptive management, with clear thresholds identified and mechanisms established for responding according to the environmental conditions.

Consent Process to Effect Changes in Wastewater Discharges – A Review of the Past Decade of Consent Process of Key Wastewater Discharges in the Otago Region

Selva Selvarajah – Director Resource Management, Otago Regional Council

Introduction

Based on the origin, wastewater is widely classified as farm, septic tank, municipal and industrial. Since the enactment of the Resource Management Act (RMA) 1991 there has been an increased focus on wastewater discharges (i.e. point source discharges). It has been nearly two decades since the RMA was enacted. Despite the good progress made by the Otago Regional Council in the first decade, there were still many consented municipal and several consented industrial wastewater discharges that were of poor quality. The treatment of these discharges was substandard and often did not match the scale and environmental risks that arose from the discharges. In many cases the Council was reluctant to impose stringent consent requirements due to financial constraints.

> "Without sound policies, technical knowledge and common sense, the resource consent process may not always yield the desired environmental outcomes."

The resource consent process provides an ideal opportunity to address poor wastewater discharges. A resource consent process has to comply with the RMA requirements, otherwise expensive judicial reviews may occur or the community faith in the resource consent process may diminish. It is equally important to also focus on the environmental outcomes of the resource consent decisions. Without sound policies, technical knowledge and common sense, the resource consent process may not always yield the desired environmental outcomes. The exception to this is where a consent applicant voluntarily adopts best practice and promotes high environmental outcomes. This article describes how an outcome based consent process had been used in the past decade in the Otago region to improve discharge quality and provides a collation of key consents granted during this period.

RMA Process to Deal with Consented Effluent Discharges

What is an acceptable consented wastewater discharge under the Act? This section of the article provides some guidance on acceptable discharges.

The guidance is based on technical information, legal requirement and cultural sensitivity. For example, it is culturally offensive to Maori to discharge municipal or human effluent into waterways because the mauri of the water will be affected by this discharge. Under legal requirements for consent processing, compliance with any national environmental standards (NES), regional policies and rules and s15 (in cases where there is no regional rule) and s107 of the RMA ensures all relevant provisions are followed as per Part 6 (Resource Consents) of the Act. Technical information enables a decision making process on the nature of the receiving environment, allowable contaminant levels, choice of treatment system or discharge medium, i.e. land or water. Processes for land and water discharges are provided separately in the proceeding sections of the article.

Discharges to Water

To meet the cultural requirements of the iwi, ideally a zero discharge to water is preferred particularly with regard to municipal wastewater, otherwise the discharge can be either direct (through pipes or diffusers) or indirect (to trenches). A discharge application will consist of an Assessment of Environmental Effects (AEE). The AEE will describe the discharge quality and any potential adverse effects on the receiving environment. The consent process will ensure compliance with the s107 of the RMA:

S107 (1) Except as provided in subsection (2), a consent authority shall not grant a discharge permit [or a coastal permit to do something that would otherwise contravene section 15] [or section 15A] allowing –

a) The discharge of a contaminant or water into water; or
[b) A discharge of a contaminant onto or into land in circumstances which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water; or]
[ba) The dumping in the coastal marine area from any ship, aircraft, or offshore installation of any waste or other matter that is a contaminant]

if, after reasonable mixing, the contaminant or water discharged (either by itself or in combination with the same, similar or other contaminants or water), is likely to give rise to all or any of the following effects in the receiving waters:

c) The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials;
d) Any conspicuous change in the colour or visual clarity;
e) Any emission of objectionable odour;
f) The rendering of fresh water unsuitable for consumption by farm animals;
g) Any significant adverse effects on aquatic life…

S107 must be complied with hence the requirement is bottom line. It is easy to misinterpret the above RMA provision, particularly the issue of 'reasonable mixing'. It has been perceived by most RMA practitioners that a mixing zone shall always be provided as a 'non-compliance zone'. In the past, in New Zealand, there have been attempts made by technocrats and bureaucrats to define an acceptable mixing zone. Many consultants still require or recommend that regional councils grant long mixing zones (several hundred metres).

The Otago Regional Council's (ORC) Regional Plan: Water (Water Plan) has a good policy on mixing zone. The Water Plan Policy 7.7.6 states, "…where mixing zone is required for the discharge of contaminants to water, to ensure that it is limited to the extent necessary to take account of:

a. The sensitivity of the receiving environment;
b. The natural and human use values identified in Schedule 1;
c. The natural character of the water body;
d. The amenity values supported by the water body;
e. The physical process acting on the area of discharge; and
f. The particular discharge, including contaminant type, concentration, and volume…"

Notwithstanding the Water Plan policy on mixing zone, the legal advice obtained on reasonable mixing by the Council emphasises that a consent authority could set higher discharge requirements than provided in s107 of the RMA. In other words, if the Council chooses to provide no zone of non-compliance in a consent, such a practice will not breach s107. Furthermore, if a Water Plan policy requires a waterway to be managed for a particular use (e.g. contact recreation which may result in some form of contact with water such as swimming, fishing or boating) it is assumed that the whole of the waterway is accessible to the community for contact recreation rather than only some parts. For example, Water Plan Policy 7.6.1 – To enhance water quality in the following water bodies so that they become suitable to support primary contact recreation: (a) Mill Creek and Lake Hayes…(f) Koau Branch of the Clutha River/Mata-Au…).

The debate on the length of mixing zone often causes a 'friction' between the applicants and the consent authority. The focus should be on the extent of the treatment of a wastewater including the best practicable options and alternatives. The next step is to assess any adverse effects of the discharge including the effects on contaminant assimilation. Poor proposals are easily noticeable and will be based on a philosophy of 'dilution as a solution' and use the available dilution to design a treatment system. If such poor practices are not tackled, it could be argued that a primary treatment system may simply satisfy the requirements of a sewage discharge to a large water body.

Land Discharges

Wastewater discharge to land is the preferred option for ORC (Water Plan Policy 7.7.1 – To promote discharges of contaminants to land in preference to water, where appropriate). Discharges to land face more challenges in the Otago region for the following key reasons:

- Applicants' and consultants' lack of knowledge
- Freezing weather conditions
- Poor soil infiltration rates

Land discharges could be classified as land disposal and land treatment. Often land treatment is confused with land disposal. A typical land treatment system is defined in this report as that applies pre-treated or raw wastewater to soil to aid bio-chemical processes in soil along with crop/plant uptake of nutrients to minimise or to avoid onsite or offsite contamination. Therefore, land treatment of wastewater requires consideration to the extent of pre-treatment of wastewater, application methods (e.g. sprinklers versus drips), effects of aerosols (where applicable), contaminant bio-chemical reactions in soil, plant uptake, nutrient budgets, contaminant leaching to groundwater and effects, and any surface water contamination.

In contrast to land treatment systems, in most cases land disposal does not require any complex technical expertise. Key information required is infiltration rate which will dictate the rate of wastewater discharge. Wastewater treatment prior to discharge may require primary or secondary treatment. Often trenches are used to dispose wastewater with sufficient rotation available to avoid clogging. Council does not promote this 'trench technology' because the technology is crude with several uncertainties. However, it may be argued correctly that such a discharge option is still superior to a well treated discharge to water. Land disposal should be assessed on a case by case basis giving particular regard to depth to or distance to groundwater and surface water respectively, and contaminant plumes and their effects on aquifers and surface water. Clearly, land treatment is the preferred option.

One of the key advantages of a land treatment system that utilises any crops or trees for productive purposes is that a substantial income could be generated from a properly designed and managed system. Sewage wastewater application to non-food crops or trees is a straightforward process. Wastewater without any human or animal pathogens could be utilised by pasture, viticulture, food crops or orchards. Some industries (e.g. dairy) may restrict the use of human wastewater on food or beverage based crops.

Key Wastewater Discharge Consents Granted in the Past Decade by the Council

Appendix 1 shows a list of 20 discharge consents granted in the past decade. The list also shows the quality and quantity of historical and newly consented discharges, discharge medium (land or water) and cost of upgrading. There are 12 discharge consents from the city and district councils and eight from industries including ski-fields, airport and subdivisions. In most cases the quantity of discharge has increased with the renewal of consents because of actual or anticipated population growth (e.g. sewage) or increased activity (e.g. industry). There are two new major discharges (Jacks Point and Mt Cardrona Station Ltd), both of which are to land, with the remainder of those historical. Of the total consents granted, half of the discharges were to land (either land treatment or disposal).

Discharge Quality

Overall there has been a major improvement in discharge quality. Where land based systems are used as alternatives to water discharge, the discharge quality was not expected to improve because of land treatment efficiency. With the exception of the Dunedin City Council Tahuna Waste Treatment Plant discharge to the Pacific Ocean and the Clutha District Council Milton discharge to Tokomairiro River, all other water discharges have been consented at or below the in-pipe contact recreational water quality limit of 260 E.coli/100mL.

Treatment Systems

A range of treatment options has been deployed to achieve discharge quality limits. Council preference for land discharge has always been considered by the applicants in detail. Only in cases where land discharge was considered as not practical, water discharges were used. Treatment options such as sequencing batch reactor (SBR), trickling filter, membrane bioreactor (MBR), dissolved air flotation (DAF) and Biofiltro (worm treatment) were used to discharge to water, whilst discharges to land utilised MBR, SBR, packed bed reactor (PBR) and pond treatment systems. After the successful trial of the Biofiltro system at Kaka Point, Clutha District Council decided to install this system at Tapanui, Lawrence, Stirling and Owaka to meet the Council contact recreation in pipe limits. Land discharges were delivered into/onto trenches, subsurface (drippers) and surface (sprinklers). Subsurface irrigation systems are designed for freezing conditions.

Cost of Upgrade

The total estimated cost of upgrade or waste treatment system installation has been $232 million. Of this, in excess of 50% (i.e. $120m) is for the upgrade of the DCC Tahuna Waste Treatment Plant to install a new ocean outfall and provide a secondary treatment system. Other significant capital expenditure has been from Queenstown ($42m long-term), Wanaka-Albert Town ($19.5m already committed), Fonterra ($12.4m already committed), Silver Fern Farms Ltd ($11.67m already committed), Jacks Point ($7.5m long-term) and Hawea ($6.5m long-term). Such investments are long-term based and are designed to meet the requirements of the existing and future national and regional water quality regulations and community expectations.

Methods, Policies and Principles of Achieving Desirable Discharge Qualities

In most cases a substantial amount of staff time has been spent on liaising with the applicant on preferred options pre-application. The following principles/preferences/processes were relayed to the applicants during the process:

- Whilst good consent process is adhered to, the process would be outcome focused by upholding Council policies
- Allow applicant to understand Council policies at the outset and work closely with the applicant towards a non-adversarial and productive consent process
- In the absence of information on adverse effects of new and significant discharges on sensitive catchments, a conservative approach is taken
- Where there are opportunities for effecting changes, use these to bring about desired outcomes

- Where possible provide technical advice within limits without involving in-design details
- Land based systems are preferred over discharges to water
- No mixing zone will be allowed for water discharges particularly on faecal bacteria discharge and that contact recreational water quality on faecal bacteria has to be met in-pipe
- A full 35 year term would be recommended to be granted for substantial amounts of discharge quality improvement that would meet Council policies
- Applications with excellent discharge qualities could be processed non-notified since adverse effects are less than minor
- A reasonable period (2–4 years) would be granted for the transition from existing discharge to commissioning the upgraded discharge
- Open and without prejudice discussions during pre-application and post-application periods

The following examples provide additional methods used to achieve desirable discharge qualities:

If Necessary Resist Poor Practices Approach

Where there is a significant difference between applicants' and Council staff preference for discharge qualities and there are fundamental differences in approaches, a consent process could become adversarial, time consuming and costly. In such situations Council policies could not be allowed to be compromised hence finding a middle ground was not possible.

Silver Fern Farms Ltd – Finegand

Pre-application the applicant approached Council for direction regarding discharge quality. Staff drew attention to Policy 7.6.1 requiring Koau Branch of the Clutha River to meet recreational water quality limits. The applicant was not satisfied with the response and wanted more detailed information on discharge quality. Unfortunately during the consent process there was a considerable amount of effort spent to argue our no mixing zone policy. The panel with two independent commissioners and a Councillor commissioner granted consent with a mixing zone. Despite this the applicant appealed the decision. Later with permission from the Court and the Council, the applicant engaged Council's external expert to trial a pilot DAF system at Belfast. Since the trial was successful the appeal was resolved with a consent memorandum. Since this process the relationship between the applicant and Council staff improved substantially which resulted in resolving other consent discharges including substantial upgrade of the boiler discharges.

> "Wastewater without any human or animal pathogens could be utilised by pasture, viticulture, food crops or orchards."

Clutha District Council (CDC) – Milton Discharge

Considerable amount of time and effort had been spent to achieve Policy 7.6.1 outcome to improve Tokomairiro River water quality. Unfortunately the process became adversarial and the Director Resource Management had to co-author the staff recommending report and take up the role of a recommending officer at the hearing to emphasise the Council's Water Plan policies. The outcome was not satisfactory to the Council which resulted in a high faecal bacteria discharge. Whilst the process was adversarial it provided a platform to work with CDC on other consents, all of which yielded successful and win-win outcomes (see below).

Work With the Applicant For a Solution

When the applicants are making a full attempt to effect the desired outcomes but are struggling to find a solution, working with the applicant is the best way of progressing on an outcome.

CDC – Kaka Point, Lawrence, Stirling, Owaka and Tapanui Discharges

Council staff worked with CDC staff to find options that would be cost effective whilst achieving council discharge quality limits. Eventually it was decided to trial the Biofiltro system at Kaka Point. Council staff agreed to hold all applications until the Kaka Point Biofiltro treatment system was built, commissioned and monitored. Since it was found that the Biofiltro system was affordable by the respective local communities and Council discharge quality limits could be met, long-term consents were granted to all five discharges.

Waitaki District Council (WDC) – Palmerston Discharge

The original application in 2003 was for a stay-on for the historical flood irrigation system by the Shag River. By keeping the application on hold, a considerable amount of effort had been made by the applicant and Council staff to secure a proper land based system. As a result a consent for a proper land treatment system has been granted this year after waiting for eight years.

Identify Issues/Opportunities and Effect Changes

Where there is an opportunity to effect changes such opportunities have to be seized and used to bring about better outcomes.

Fonterra – Stirling Discharge

Through routine auditing of the historical Stirling cheese factory discharge, staff identified a high amount of faecal bacteria discharge for which there was no provision in the consent. This event triggered ongoing liaison with the consent holder to identify and eliminate or treat the sources of faecal contamination. During this process there was also discussion to improve the historical and consented heavy BOD discharge (in excess of 5 tonnes per day) to the Clutha Mata-Au Branch. Following a reporting of this issue to the Council committee, the consent holder proposed a Memorandum of Understanding (MoU) approach to improve water quality in a collaborative way. The entire process did away with a formal and costly consent review process and a new consent with high discharge qualities was granted under non-notified consent process. Consequently the consent holder installed the first membrane bioreactor system in the region with zero faecal bacteria discharge and BOD discharge reducing from 5 tonnes to <100 kg per day.

Treble Cone and Coronet Peak Discharges

There has been a history of poor treatment systems in the ski-fields in the Otago region. In early 2000 there was an outbreak of Norovirus at one of the region's ski-fields which resulted in a large number of ski-field staff and clients contracting the virus. Cross contamination of water supply by wastewater was found to be the cause. The opportunity allowed Council staff to liaise with two ski-fields during their consent renewal process to install a packed bed reactor system to avoid any long-term impacts of ski-field effluent discharges.

Consider Long-Term Conservative Solutions In Cases Where There is Absence of Information

In the case of new and significant discharges in sensitive catchments it is difficult to assess any future adverse effects. Under the circumstances a conservative approach is the way forward.

Jacks Point – Land Discharge

The large scale 400ha subdivision in Queenstown required a sewage discharge consent. The applicant was well aware that a discharge to water would not be granted by the Council. The applicant proposed decentralised (several discharges) land based discharges. The focus was on total indirect nitrate discharge into Lake Wakatipu. The applicant wanted a direction on the maximum annual amount discharged. Since there was no information on how Lake Wakatipu could react to increased nutrient input and the fact that the water quality was in excellent condition, the approach was to maintain the historical nutrient output from the historical sheep farming from the same land parcel. Using a nutrient model approach a discharge limit of 3.6 tonnes of nitrate-N/year was set based on a historical sheep farming land use (9kg N/ha/year).

If Appropriate Provide Technical Advice Within Limits

Sometimes there is opportunity for Council staff to provide technical solutions without involving design details of treatment systems. Such opportunities are a catalyst in resolving some discharge quality issues.

Dunedin International Airport Ltd – Effluent Discharge

The discharge was to the main drain and since the discharge was human origin there were concerns about pathogens. Whilst the applicant's consultants' proposal satisfied nutrient discharge quality the amount of faecal bacteria discharge in the discharge was still unresolved. Council staff suggested filtration process to alleviate the bacteria issue and provided contact details for filtration technology. Subsequently the applicant adopted this technology to treat faecal bacteria to secure a 20 year consent.

Queenstown-Lakes District Council – Hawea Discharge

The historical discharge was to trenches located by the Hawea River. Through ongoing liaison with Council staff, QLDC originally proposed a full (all year) land treatment system at the cost of $6.5 million. This proposal was based on an anticipated additional large number of subdivisions being in place. When the additional subdivisions were not forthcoming QLDC staff requested a status quo short to medium term consent. Since this was not acceptable to Council staff there was a site meeting to discuss the issue.

Following the site visit Council staff concluded that there was sufficient land onsite for an eight month 'cut & carry' system with winter discharge to historical trenches. The estimated cost of $1.5 million was affordable for a short to medium term with an outcome of removing large amounts of nutrients that would otherwise have been discharged indirectly into the Hawea River.

Conclusions

In the past decade the Council has been very successful in dealing with historical and new water and land point discharges through the consent process. The success is attributed to: (a) the Water Plan policy directions; (b) consent holders' or applicants' co-operation and foresight to improve discharge quality or the medium of discharge; (c) high technical and practical knowledge on treatment systems and their limitations held by parties involved in the process; (d) an outcome and principle based approach by Council staff using a range of approaches to achieve the outcomes and (e) ORC Councillors' recognition of poor quality discharges and the upholding of the Water Plan policies. ■

See following pages for: *Appendix 1. Key wastewater discharge consents granted that required upgrades within the past 10 years.*

Appendix 1. Key wastewater discharge consents granted that required upgrades within the past 10 years

Consent Holder With Consent Number	Site	Treatment System	Historical Discharge Type	Historical or Consented Discharge Quality (90th–95th %ile or Maximum) Volume in m³/d Unless Stated		New Discharge Type	New Discharge Quality (90th–95th %ile or Maximum)		Special Condition	Date of Granting	Capital Cost
District Councils											
DCC 2002.621	Tahuna waste treatment	Sequencing batch reactor	Water – Pacific Ocean	Vol BOD SS Amm FC	600L/s 600 250 40 2,200,000	Water – Pacific Ocean	Vol BOD SS Amm FC	600L/s 140 140 40 12,000	Secondary and UV treatment	October 2004	$120 million (ocean outfall $40M + secondary treatment $80M)
CDC 2007.090	Milton	Trickling filter	Water – Tokomairiro River	Vol BOD SS TN TP E.coli	800 30 40 30 14 150,000	Water – Tokomairiro River	Vol BOD SS TN TP E.coli	1625 30 40 22 14 2,100	UV	May 2009	$2.60 million
CDC 2008.690	Kaka Point	Biofiltro	Water – Pacific Ocean	Vol BOD SS Amm TP Ent	120 87 110 29 11 29,000	Water – Pacific Ocean	Vol BOD SS Amm TP Ent	120 12 30 20 10 140	Contact recreation in pipe	January 2011	$0.30 million
CDC 2003.680	Owaka	Biofiltro	Water – Owaka River	Vol BOD SS Amm TP E.coli	436 60 120 25 12 100,000	Water – Owaka River	Vol BOD SS Amm TP E.coli	360 12 30 20 10 260	Contact recreation in pipe	January 2011	$0.74 million
CDC 2005.246	Tapanui	Biofiltro	Water – Pomahaka River	Vol BOD SS Amm TP E.coli	200 80 120 30 12 250,000	Water – Pomahaka River	Vol BOD SS Amm TP E.coli	465 12 30 20 10 260	Contact recreation in pipe	December 2010	$0.69 million
CDC 2005.193	Stirling	Biofiltro	Water – Clutha River Matau Branch	Vol BOD SS Amm TP E.coli	130 100 200 35 12 500,000	Water – Clutha River Matau Branch	Vol BOD SS Amm TP E.coli	140 12 30 20 10 260	Contact recreation in pipe	January 2011	$0.42 million
CDC 2008.308	Lawrence	Biofiltro	Water – Tuapeka Creek	Vol BOD SS Amm TP E.coli	190 80 120 30 15 550,000	Water – Tuapeka Creek	Vol BOD SS Amm TP E.coli	250 12 30 20 10 260	Contact recreation in pipe	January 2011	$0.58 million
QLDC 2005.484	Wanaka–Albert Town	Sequencing batch reactor	Water – Clutha River	Vol BOD SS Amm FC	5,010 100 150 30 150,000	Land disposal	Vol BOD SS TN E.coli	26,400 35 35 12 1,000	TN shall not exceed 12mg/L	July 2007	$19.50 million
QLDC 2008.238	Queenstown	Not determined yet	Water – Shotover River	Vol BOD SS TN TP FC	14,000 100 130 40 10 100,000	Land disposal (gravel beds)	Vol BOD SS TN TP FC	45,000 20 20 15 10 100		May 2010	$42 million

Consent Holder With Consent Number	Site	Treatment System	Historical Discharge Type	Historical or Consented Discharge Quality (90th–95th %ile or Maximum) Volume in m³/d Unless Stated		New Discharge Type	New Discharge Quality (90th–95th %ile or Maximum)		Special Condition	Date of Granting	Capital Cost
QLDC RM10.308.02	Hawea	Cut & carry and land disposal	Land disposal	Vol TN TP E.coli	440 40 9.5 250,000	Land treatment (cut & carry) and disposal	Vol TN TP E.coli	775 40 10 250,000	8 months cut and carry	November 2010	$1.50 million ($6 million long-term)
WDC RM.11.096.01	Palmerston	Cut & carry	Flood irrigation adjacent to Shag River	Vol BOD SS TN DRP FC	300 60 90 33 9 10,000	Land treatment	Vol BOD SS TN TP E.coli	420 40 60 40 12 5000		April 2011	$0.45 million
CODC RM10.306.01	Roxburgh	Maturation ponds	Water – Clutha River	Vol BOD SS TN TP E.coli	300 100 150 35 15 500,000	Land disposal	Vol BOD SS TN TP E.coli	470 100 150 35 15 500,000		October 2010	Not available
Industry											
Silver Fern Farms Ltd 2004.353 2004.312H	Finegand	DAF	Water – Clutha River (Koau Branch)	Vol BOD SS Amm DRP E.coli	20,000 1500 1200 50 12 Unlimited	Water – Clutha River (Koau Branch)	Vol BOD SS Amm DRP E.coli	20,000 210 70 63 15 15,000		May 2006	$11.67 million ($2.6 million additional for composting and sludge incineration)
Fonterra 2007.636	Stirling	Membrane bioreactor	Water – Clutha River (Mata-Au Branch)	Vol BOD SS TN TP E.coli	3,000 1800 450 180 72 No limits	Water – Clutha River (Matau Branch)	Vol BOD SS TN TP E.coli	3,700 30 200 25 20 10		June 2008	$12.50 million
Dunedin Intnl Airport Ltd 2004.309	Dunedin	Trickling filter with filtration	Water – Main Drain	Vol BOD SS Amm TP FC	153 80 150 50 15 60,000	Water – Main Drain	Vol BOD SS TN TP E.coli	153 10 (GM) 10 (GM) 10 (GM) 8 (GM) 260		October 2006	$0.70 million
Jacks Point 2009.312	Queenstown	Packed bed reactors	New discharge	New discharge		Land treatment	Vol BOD SS TN TP E.coli	1374 15 20 5 12 10,000	Total-N leaching shall not exceed the historical leaching of 3600kg/year	Granted in October 2005 and re-granted in March 2010	$7.50 million
Dunstan Hospital 2009.474	Dunstan	Packed bed reactor	Clutha River	Vol BOD SS TN TP FC	10 96 45 55 12 73,000	Land treatment	Vol BOD SS TN TP E.coli	20 40 40 30 No limit 1000		February 2010	$0.30 million

Consent Holder With Consent Number	Site	Treatment System	Historical Discharge Type	Historical or Consented Discharge Quality (90th–95th %ile or Maximum) Volume in m³/d Unless Stated		New Discharge Type	New Discharge Quality (90th–95th %ile or Maximum)		Special Condition	Date of Granting	Capital Cost
Mt Cardrona Station Ltd 2009.348	Cardrona	Membrane bioreactor	New discharge	New discharge		Land treatment (cut & carry)	Vol BOD SS TN TP E.coli	2164 20 (mean) 30 (mean) 10 (mean) 8 (mean) 1,000 (GM)	<1mg/L nitrate during winter	July 2010	$3.50 million
Treble Cone 2008.004	Queenstown	Packed bed reactor	Land disposal	Vol BOD SS TN TP FC	60 30 60 50 15 10,000	Land treatment	Vol BOD SS TN TP E.coli	72 20 20 25 12 200		August 2009	$0.90 million
NZ Ski Ltd 2009.458	Coronet Peak	Packed bed reactor	Land disposal	Vol BOD SS TN E.coli	111 180 50 74 200,000	Land treatment	Vol BOD SS TN E.coli	65 20 20 30 200		July 2010	$0.70 million
Grand Total (Rounded)											**$231 million**

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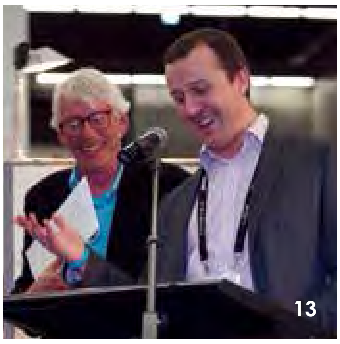
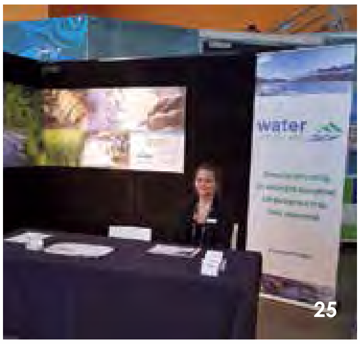
1) President Clive Rundle speaks on the opening morning of the conference, 2) Members of the all volunteer Conference Technical Committee are acknowledged at the dinner by President Clive Rundle for their contribution, 3) Rotorua MP Hon Todd McClay delivers the keynote address on behalf of Minister for the Environment Hon Nick Smith, 4) Delegates listen to presentations in the breakout rooms, 5) The Topp Twins pose for a photo during their act at the Conference Dinner & Awards Presentation, 6) Bruce Porteous of Orica Chemnet presents the Orica Chemnet Operations Prize to Ian Loffhagen, 7) The audience at the Conference Dinner & Awards Presentation dance along to with the Topp Twins, 8) Rotorua Mayor Kevin Winters welcomes delegates at the conference opening, 9) A member of Te Arawa iwi at the powhiri, 10) Representatives of the six Premier Sponsors at the entrance to the Energy Events Centre, 11) A bird's eye view of the expo hall, 12) Charlotte Yates, Chris Tanner and James Sukias receive the Ronald Hicks Memorial Award from President Clive Rundle, 13) Left, Conference MC Jim Hopkins with Jeff Milsom at the AECOM Welcome Reception, 14) Guests enjoy the chance to catch up at the Conference Dinner & Awards Presentation, 15) Chief Executive Murray Gibb speaks at the Conference Dinner & Awards Presentation, 16) (L–R) Murray Gibb, Clive Rundle, Rob Alloway holding the Hynds Paper of the Year Award with MC Jim Hopkins, given in absentia to Hugh Chapman, 17) (L–R) Clive Rundle, Rob Blakemore and Opus Trainee of the Year Award winner Brendon Richards, 18) Delegates listening to a presentation in the





Bay Trust Forum, 19) The Applied Instruments Coffee Cart & Internet Café keep delegates refueled during the Conference, 20) Clive Rundle presents Caleb Clarke with the CH2M Beca Young Water Professional of the Year Award, 21) Topp Twins call Steve Martin of Hynds up to dance with them, 22) Professor David Bibby gives his keynote address, 23) Poster presentations are displayed in the Energy Events Centre, 24) Steve Couper and MC Jim Hopkins with the AWT Water Limited Poster of the Year Award given to Jo Cavanagh in absentia, 25) Cherish Low at the *Water New Zealand* stand, 26) Filtration Technology's stand – Best Expo Stand winner

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An Overview of Urban Stormwater Quality: Perspectives from Auckland

Rajika Jayaratne – Stormwater Technical Specialist, Matthew D Davis – Manager Stormwater Development and Technical Services, Judy-Ann Ansen – Team Leader Stormwater Technical Services, and Grant Ockleston – Manager Stormwater Unit, all of Auckland Council.

Introduction

The Auckland region is the largest population centre in New Zealand and with significant commercial and industrial activity. The region is characterised by harbours (i.e. Waitemata, Manukau and the Kaipara), estuaries and a myriad of streams and waterways, all of which are highly valued.

Urbanisation has been in process for more than 150 years, and in this relatively short time, has placed significant pressure on land and water resources in the Auckland region resulting in:

- Loss of land and streams to urbanisation
- Degraded water quality and ecological health in most rivers and lakes
- Ongoing sedimentation leading to slow and irreversible degradation of the marine environment, especially in sheltered harbours and estuaries
- Increasing concentrations of zinc, copper and other metals in sheltered harbour and estuary marine sediments, and in organic contaminants which are emerging as potential concern (ARC, 2010)

Of particular concern in the Auckland region is urban stormwater quality. A synopsis of urban stormwater quality issues is given below.

Contaminant Sources and Observations

Over the last decade several investigations were undertaken to better understand contaminant runoff, sources and fate (ARC, 2010; Gadd et al, 2009; Green, 2010; Griffith and Timperley 2005; Kingett Mitchel Ltd. and Diffuse Sources Ltd., 2003; Kennedy and Gadd, 2003; Moore et al, 2008, 2009; Pandey, 2007; Pennington and Webster-Brown, 2007; Timperley and Reed, 2010).

Stormwater quality runoff is highly variable and depends upon many factors including catchment characteristics, land use, building materials, vehicle traffic, dry weather periods and rainfall intensity. Several observations can be made from these factors.

Monitoring of eight different sub-catchment types are reported in Figure 1. The monitoring is compared to Australian and New Zealand Environment and Conservation Council water and sediment quality guidelines (ANZECC, 2000), and United States Environmental Protection Agency standards (USEPA, 2002) (Figure 1). These guidelines provide trigger levels at which chronic exposure to aquatic life is expected to be toxic, resulting in changes in species population, abundance and/or functioning. Copper and zinc concentrations were measured in most locations at levels that exceed ANZECC (2000) and USEPA (2002) trigger values.

Monitoring was utilised to derive yields and annual contaminant loads for three different land use categories (Tables 1 and 2; Griffith and Timperley, 2005). Concentrations of zinc and copper have been found at levels that exceed those at which ecological impacts are expected (ARC, 2010). Further investigation was undertaken to ascertain the sources of zinc, copper and lead, and a mass balance and percentage breakdown of sources estimated (Figure 2). Yields for land uses and activities have been incorporated into a spreadsheet model that computes annual stormwater contaminant loads (Timperley et al, in press).

Sediment

Sediment discharge is greatest as land development occurs and decreases as an urban catchment matures and becomes impervious surface ratios increase. Roads and roofs generally make up 70 to 80% of the impervious surface in typical highly urbanised catchments. However, they typically generate a small proportion of the total suspended solids (TSS) carried in urban stormwater. Some evidence exists that the major sources of sediment in urban catchments are open stream channel erosion and erosion of bare earth on construction sites (which can be small, localised sites). In general, industrial and commercial land uses generate lower TSS loads than residential land use (Griffith and Timperley, 2005).

Metals

No direct relationship between metal loads and impervious surface area was discerned. However, there is a noticeable relationship between land use type and road activity. Moreover, it was found that roofing material used in industrial zones is a main contributor of zinc in stormwater in urban areas, with road activity as another principal contributor. Zinc contaminant loads are largely related to the quantum of galvanised roof material, which increases from residential to commercial to industrial. Copper contaminant load is related to the area of roads carrying high numbers of vehicles per day, which generally increases from residential to commercial and industrial. Copper discharge can also be influenced significantly by the use of architectural copper (Pennington and Kennedy, 2008).

While much focus has been on copper and zinc, marine sediment monitoring reveals that a range of other metals are accumulating. There is a strong correlation between increase in zinc and, for example, antimony, cadmium, tin and mercury (ARC, 2010).

Discussion

Characterisation of urban stormwater runoff can assist in the identification, development and implementation of targeted and cost-effective improvements of the quality of stormwater discharge. Auckland Council uses the Contaminant Load Model to identify contaminant loads and contaminant hot spots that can be targeted for intervention.

For example, in the Central Waitemata Harbour contaminant study, it was found that significant TSS and metals that discharge to the Waitemata Harbour originate from Henderson Creek (Project Twin Streams area) (Timperley and Reed, 2010). Moreover, the contaminants from this catchment impact not only the immediate Henderson Creek area but also the middle Waitemata Harbour and Shoal Bay on the North Shore (Green, 2010). Consequently, Henderson Creek is an area to target. Optioneering is underway to mitigate sediment and contaminant discharge from Henderson Creek.

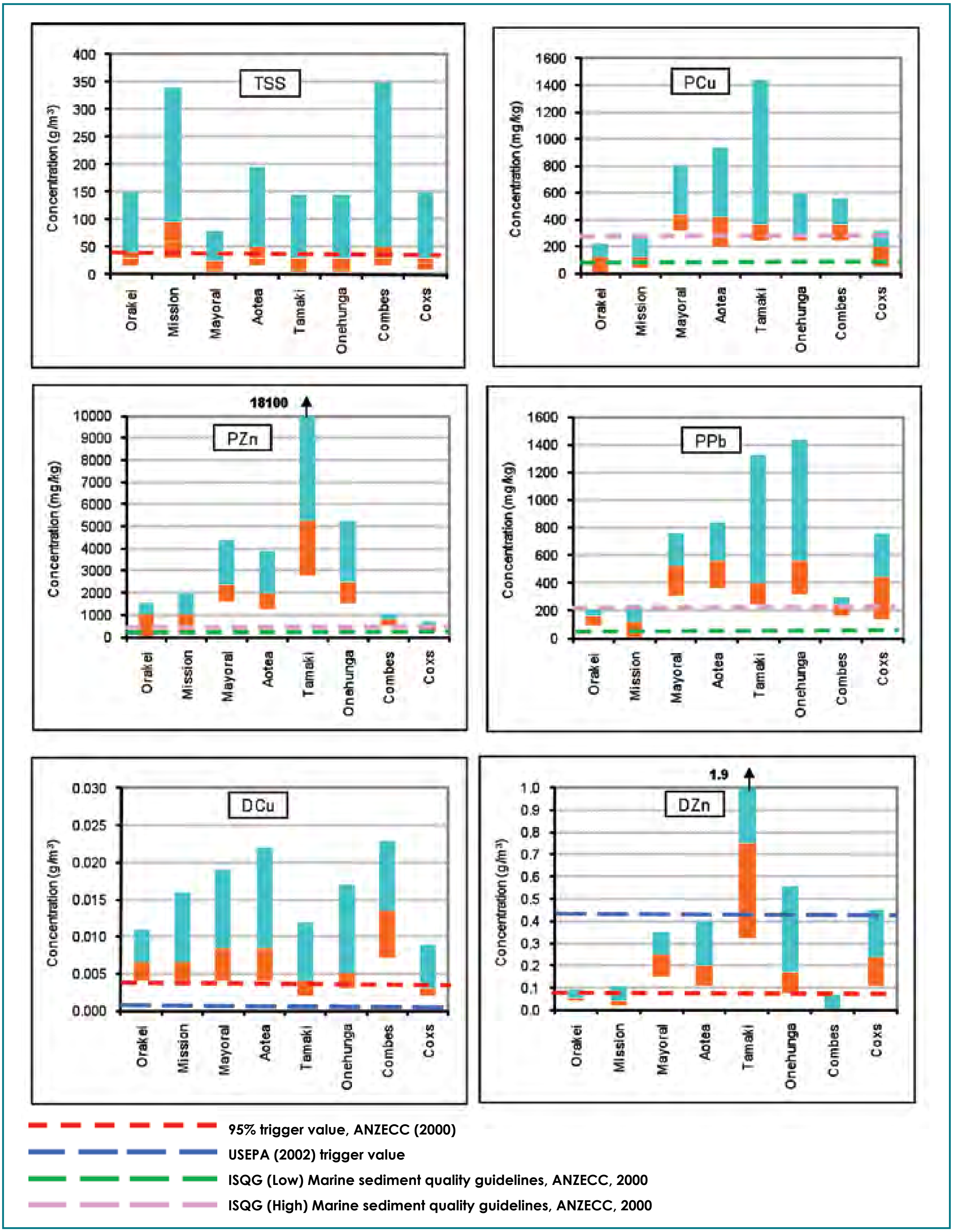
While a significant amount of urban stormwater quality research has taken place in Auckland, investigations in other urban centres in New Zealand have revealed similar findings about urban runoff (Stansfield et al, 2010).

Disclaimer

The opinions expressed in this paper are those of the authors and do not reflect policy or otherwise of the Auckland Council.

For more information about stormwater research work and publications contact Matthew Robertson, Stormwater External Liaison Advisor, Stormwater Unit, Auckland Council. matthew.robertson@aucklandcouncil.govt.nz. ■

Figure 1 – Comparison of total suspended solids, zinc, copper and lead concentrations in Auckland City monitoring (Griffith and Timperley, 2005)



NOTE: 10th percentile is the bottom of the orange bar, the 50th percentile (median) is the top of the orange bar and the 90th percentile is the top of the blue bar. TSS – Total Suspended Solids; PZn – zinc attached to suspended solids; PCu - copper attached to suspended solids; PPb - lead attached to suspended solids; DCu – dissolved copper; DZn – dissolved zinc

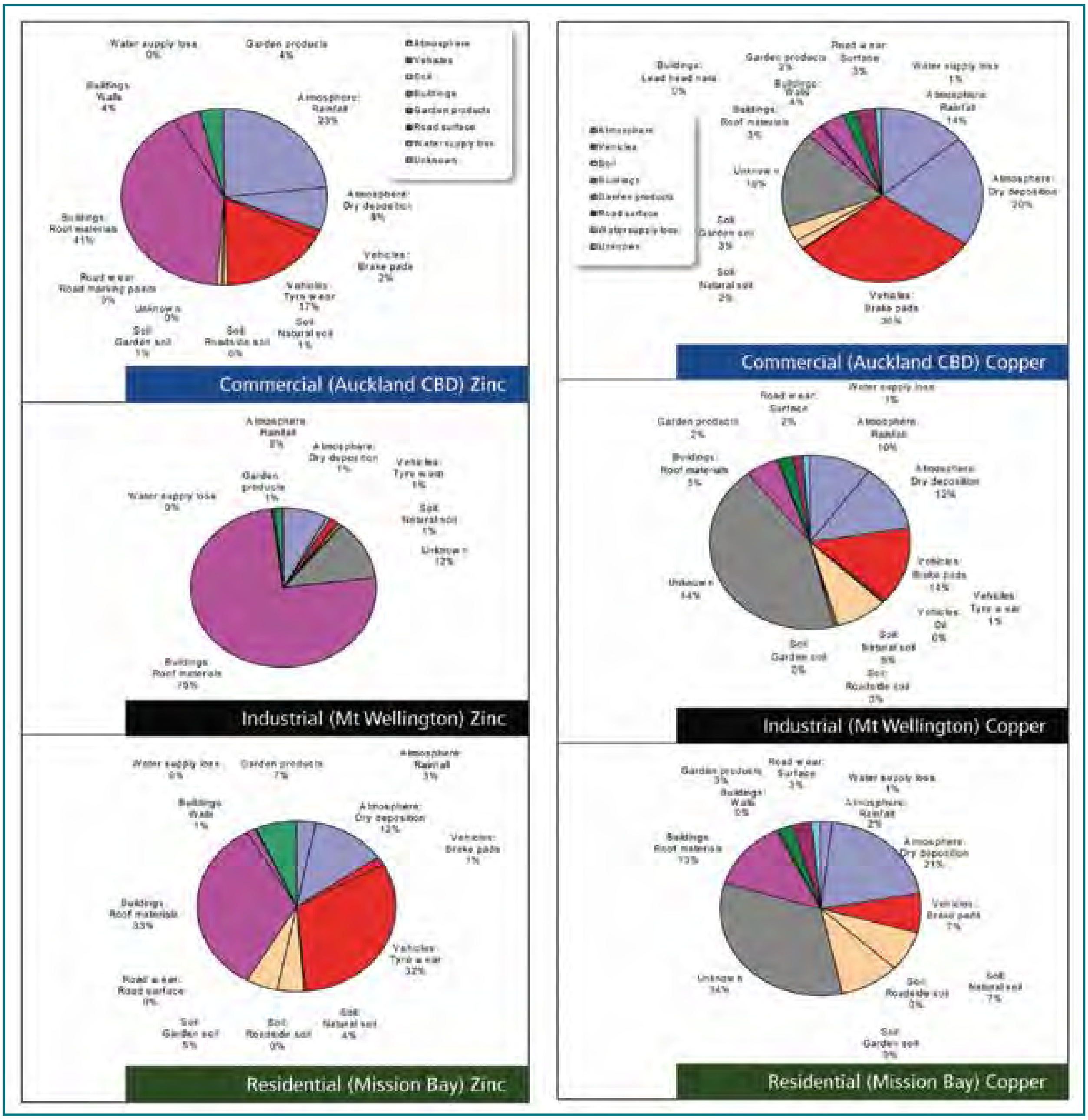


Figure 2 – Sources of zinc and copper runoff in urban sub-catchments (Kennedy and Pennington 2008)

Table 1 – Auckland City stormwater quality control monitoring sites (Griffith and Timperley, 2005)

Sub-catchment	Landuse	Catchment area (ha)	Impervious area (%)
Central Business District (CBD)	Commercial	30.1	85.3
Mission Bay	Residential	45.2	47.7 (MPD 69.3)
Mt Wellington	Industrial	34.0	56.2 (MPD 70.6)

Table 2 – Yields and annual loads of metals and total suspended solids (Griffith and Timperley, 2005)

Sub-catchment	Yield				Annual loads			
	TZn [a]	TCu [a]	TPb [a]	TSS [a]	TZn	TCu	TPb	TSS
	g ha^{-1} a^{-1} [b]	g ha^{-1} a^{-1}	g ha^{-1} a^{-1}	kg ha^{-1} a^{-1} [c]	kg a^{-1} [d]	kg a^{-1}	kg a^{-1}	t a^{-1} [e]
CBD	1630	140	124	310	47.0	4.21	3.73	9.33
Mission Bay	573	79	60	620	26.0	3.57	2.71	28.0
Mt Wellington	5170	135	135	252	176	4.59	4.59	8.57

Notes: [a] TZn = total zinc; TCu = total copper; TPb = total lead and TSS = total suspended sediments.
[b] g ha^{-1} a^{-1} = gram per hectare per annum.
[c] kg ha^{-1} a^{-1} = kilogram per hectare per annum.
[d] kg a^{-1} = kilogram per annum.
[e] t a^{-1} = tonnes per annum.

"Characterisation of urban stormwater runoff can assist in the identification, development and implementation of targeted and cost-effective improvements of the quality of stormwater discharge. Auckland Council uses the Contaminant Load Model to identify contaminant loads and contaminant hot spots that can be targeted for intervention."

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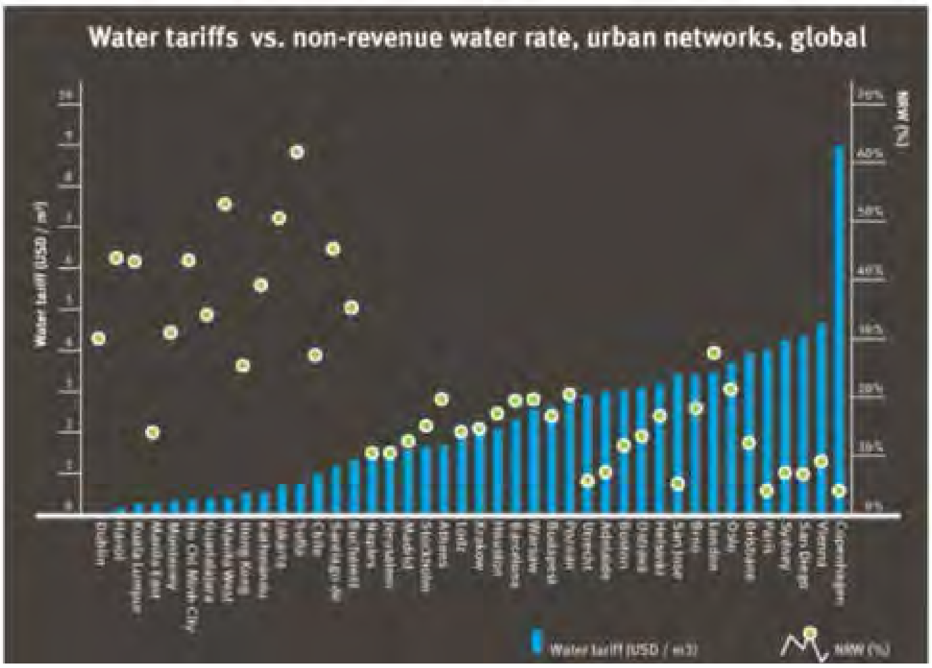
The Relationship Between Water Price, Water Loss and Network Management

Richard Taylor – Thomas Civil and Environmental Consultants

I recently read an article published by TaKaDu, an international company specialising in analysing water network flow and pressure data to facilitate water loss reduction, on the connection between water prices and water network efficiency (Ref 1). The article was particularly interesting because it presented international data on water price and Non-Revenue Water and highlighted some very strong correlations between the two factors. Figure 1 shows one of the key graphs included in the TaKaDu article (reproduced with permission). It should be noted that the water tariff shown includes water and wastewater fixed and variable costs and the total sales tax, if any.

Non-Revenue Water (NRW) can be described as follows. With reference to the Water Balance Diagram in Figure 2, Non-Revenue Water (NRW) comprises unbilled authorised consumption (for example use by Fire Service and maintenance staff), apparent losses (unauthorised consumption and customer metering under-registration) and real water losses. In developed countries, real losses generally comprise over 90% of NRW. It should also be noted that where customers are unmetered, there is a high level of uncertainty with NRW calculations.

Figure 1 – Relationship between Water Tariffs and Non-Revenue Water



"In many cities and towns in New Zealand the cost of water production is low. Often the variable cost of water is 10 cents/m³ or less. In my opinion, this fact tends to undervalue what the real cost of water should be, and provides an inherent justification for under-investment in water systems. When the cost of water production is low, there is not the financial incentive to manage water losses at a low level, and unwittingly, many of the systems, processes and programmes above which are required to manage water networks well, are either overlooked or not recognised from the perspective of managing a resource."

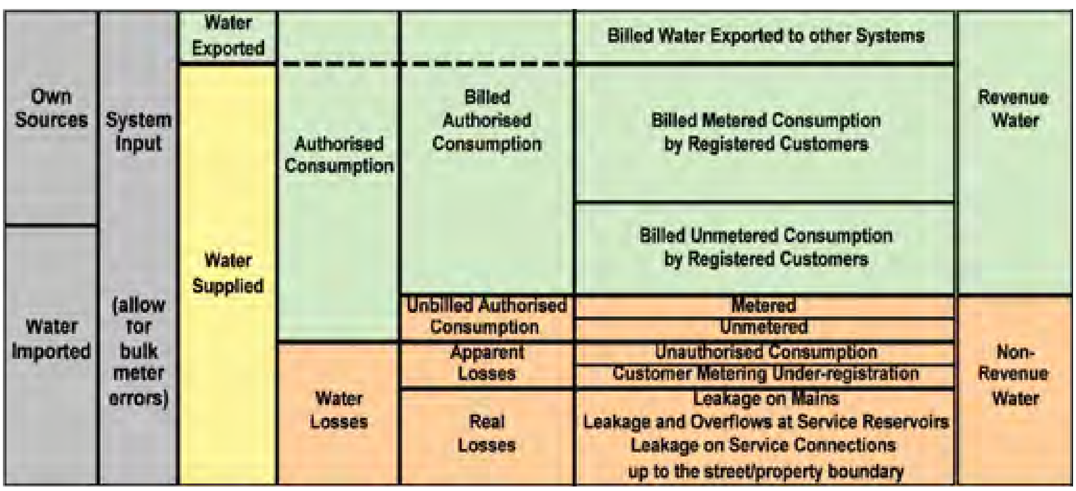


Figure 2 – Standard Water Balance Diagram

Referring back to Figure 1, it is apparent that there is a strong inverse relationship between NRW rates and water price. From a strategic point of view simple conclusions can be made; low water prices mean that due to underfunding of network maintenance and renewals there are high water losses from the network. But is there more to it than this?

Figure 3 shows the 'Four Complementary Leakage Management Activities', recognised worldwide by water loss personnel.

At a first order level, the leakage management activities above require investment in the following areas:

Speed and Quality of Repairs

- Systems and processes to receive and dispatch reported water fault information.
- Maintenance resources (staff, plant and materials) to respond in a timely manner and carry out effective repairs.

Pipe Materials

- Ongoing network renewal programme targeting old and leaky pipelines and service connections.
- Suitable selection of materials and quality control during construction and commissioning.

Active Leakage Control

- Ongoing leak detection programme to locate and fix water leaks, either using in-house resources or leak detection contractors.

Pressure Management

- The design and installation of pressure reducing valves to manage water pressures at adequate (and not excessive) pressures.

However, a deeper analysis of what is required to manage water losses to a low level identifies many more systems and processes that must be in place to be successful. Some of these are outlined below:

Speed and Quality of Repairs

- Systems and processes to identify the presence of unreported leaks. In areas with porous soils, or where unreported leaks enter stormwater or wastewater lines, unreported leaks can be left for extended periods of time resulting in high water loss. Hence, monitoring systems to identify unreported leaks (or high levels of leaks generally) are essential for a well-managed network. This typically requires effective network metering of supply areas, telemetry systems (or regular datalogging) to monitor flows, and human resources to analyse the data.
- Accurate as-built plans and ready access to these plans are necessary if maintenance staff are to isolate and repair watermain faults in a timely manner.

Pipe Materials

- For understanding the condition of the network, and for developing and planning network renewal programmes, an asset management system which holds relevant asset data and maintenance records is necessary. A system which can report on those sections of main comprising a certain pipe material, age and/or maintenance history is required. An advanced system may also hold information on soil type, risk and critical assets. This requires investment in GIS, asset management and human resources.

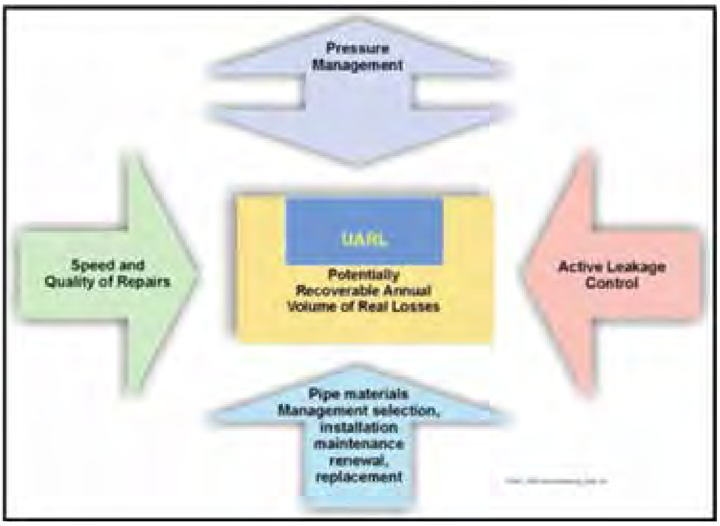


Figure 3 – Four Complementary Leakage Management Activities

Active Leakage Control

- In order to be efficient with active leakage control, real-time monitoring of flows into supply areas and effective reporting systems are required. For greater efficiency, investment in network sectorisation is required so that smaller areas can be monitored giving better outcomes.

Pressure Management

- Network sectorisation will provide opportunities for managing water pressures at efficient levels.
- Network models are often required in the design of network sectorisation.
- More sophisticated pressure management techniques can be utilised (as appropriate) to achieve lower levels of water loss.

In addition to the above, in order to measure and report on the level of water loss effectively, investment in bulk metering, customer metering, water billing reporting and NRW reporting is required.

The systems, processes and activities outlined above essentially comprise the fundamentals of operating a water distribution network efficiently (excluding water quality considerations), and hence water loss, while often ignored or considered as a one-dimensional attribute, is actually a very good indicator of overall network management. With reference again to Figure 1, the cliché rings true 'you get what you pay for!' Figure 4 (next page) shows recent New Zealand data for the major centres. The inverse relationship between price and NRW is not apparent, however note that the price of water is over \$1.20/m³ for most of the supplies and the level of NRW is generally between 10% and 20%. This is reasonably consistent with the group of data points plotted in the centre third of the graph in Figure 1, noting that the water tariff in Figure 1 includes for water and wastewater. I am sure if a graph was produced for all water supplies in New Zealand the overall trend as in Figure 1 would be similar, and the relationship between low levels of NRW, and having good management practices, processes and systems in place (and vice versa) would also be true.

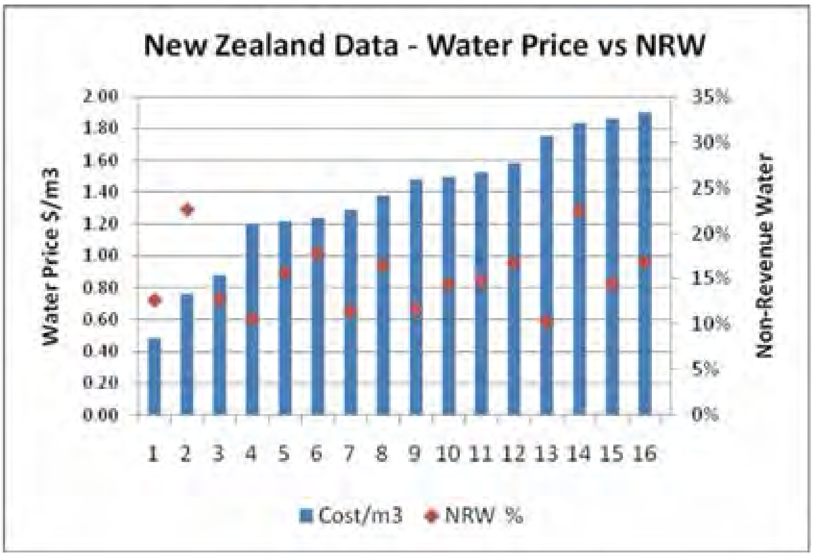


Figure 4 – New Zealand Data for the Major Centres – Water Price vs Non-Revenue Water

In relation to this however, there are some unique factors in New Zealand which are relevant, and unfortunately unhelpful.

In many cities and towns in New Zealand the cost of water production is low. Often the variable cost of water is 10 cents/m³ or less. In my opinion, this fact tends to undervalue what the real cost of water should be, and provides an inherent justification for under-investment in water systems. When the cost of water production is low, there is not the financial incentive to manage water losses at a low level, and unwittingly, many of the systems, processes and programmes above which are required to manage water networks well, are either overlooked or not recognised from the perspective of managing a resource. I would suggest where investment in GIS, metering and asset management systems has been undertaken, it has been for customer service, political or legislative reasons rather than efficient resource management reasons.

But does the low cost of water production present a problem, or not? The world is driven by economic, social, cultural, political and environmental considerations. If the cost of water production is very low, should high levels of water loss be accepted? Some would say yes, as from an economic perspective it may be justifiable. But what is often not understood is that high water loss is typically a symptom of poor overall management of water networks; where there is no bulk metering or monitoring systems, no metering of large customers, unsatisfactory reporting from billing systems, poor as-built records and GIS, no asset management system, little knowledge of network condition, no consideration of supply pressure, no understanding of the level of water loss, no active leak detection programme, minimal renewal programmes etc.

Unfortunately (or fortunately for customers) water supply systems will generally still deliver water to customers, even where there is an absence of these systems and programmes mentioned above. The water networks have generally been designed to operate with minimum intervention. Hence, water suppliers can often successfully manage to operate networks at a low cost, with very little investment in the water supply network, providing there is sufficient water supply. The issues come to light when there is a loss of supply due to significant network failure, excessive leakage, or a water shortage due to drought or under-average rainfall; when questions are raised during the water take resource consent renewal process, and high overall demand cannot be explained; when growth in demand brings a new focus on demand management (including water loss management) and the comparative cost of increasing supply.

Then the hard questions start being asked as to how well the system is being managed. Also, without good systems in place, there is often a low level of efficiency with human resources; a high proportion of staff time is spent obtaining and processing information which if readily available using smart systems and good reporting, would allow issues to be dealt with quickly; therefore staff would have more time for carrying out important planning tasks.

In my experience in talking to and working with a number of water suppliers around New Zealand, there are those who have good systems in place and those who are making progress in bringing the management of their networks up to an acceptable standard. For others there is a lot to be done. Often I suspect, the political realities of increasing water prices to fund necessary improvements mean that underfunding of water supplies is a 'way of life' in many parts of New Zealand.

Unfortunately, as mentioned above, water networks will generally continue to operate in delivering water to customers even with under-investment. But, for a developed country like New Zealand, our water supply networks should be managed and operated well. To make better progress towards this goal, the hold on artificially low water prices needs to be released. This point of view is in line with that expressed in the recent article by Hon Rodney Hide – Minister of Local Government entitled 'The Future Framework for Water Infrastructure' (September 2011 issue of *WATER*) where it states "Councils have been reluctant to fully charge for the full costs providing potable water services and this reluctance has led to an inefficient use of water and poor asset management".

In my opinion the Local Government Act (LGA) 2002 Amendment Act 2010 provides some hope in this regard for two reasons.

Firstly, the definition of *Community Outcomes* has been changed from:

- *The outcomes for that district or region that are identified as priorities for the time being through a process…; to*
- *The outcomes that a local authority aims to achieve in order to promote the social, economic, environmental, and cultural well-being of its district or region, in the present and the future.*

Under the old LGA 2002, communities generally requested a 'clean, safe and reliable' water supply, and in many cases, the old existing water networks were able to provide this adequately (as they were designed to do) and the community was probably totally unaware of the actual lack of investment in their water network there was a water supply crisis. In my opinion, without a crisis situation, senior council management were somewhat restricted by the process, and unless they were particularly proactive in communicating the real

> "Often I suspect, the political realities of increasing water prices to fund necessary improvements mean that underfunding of water supplies is a 'way of life' in many parts of New Zealand."

issues, the status quo remained, and only minor changes occurred. Under the new amendments, Council management have the opportunity to lead the process by stating aims for the local authority. In this regard, NRW (and/or water loss targets) are an opportunity for water suppliers to promote system metering, monitoring, renewal work and other important programmes which besides addressing water loss issues, will provide excellent management tools for staff.

Secondly, the LGA 2002 Amendment Act 2010 requires that national performance measures are specified for water supplies (along with other key services) for reporting nationally. NRW (expressed as a percentage of water supplied) and 'Real Water Losses' (in litres/connection/day for urban systems or m³/km main for rural systems) should be included in these measures as they are good indicators of overall network management as outlined above, and the results should assist in justifying future investment in water supplies. Of course, a perverse outcome could possibly occur whereby economic indicators outweigh non-economic indicators, and low water prices are championed. Let's hope not.

To summarise, international data confirms the link between low water prices and high levels of NRW (and hence high levels of water loss), and this trend I am sure, applies also in New Zealand. I have described above why investment across a broad range of activities associated with water supplies is required to achieve low levels of water loss; because there are so many systems, processes and programmes associated with successfully managing water losses to low levels. There is therefore significant investment needed to bring all water supplies up to an acceptable standard for a first world country such as New Zealand, and to make progress towards this goal, the hold on artificially low water prices needs to be released. The LGA 2002 Amendment Act 2010 provides some opportunities to deal with this issue. Perhaps restructuring of the water industry in New Zealand could also provide a way of efficiently implementing systems (such as asset management systems) at an economic scale. As mentioned above, unfortunately (or fortunately) water networks can often operate for many years without new investment and the community is likely to be unaware of this fact until something goes wrong with the supply. I believe change is required, both in terms of perception of service and water price. The introduction of universal metering where customers are unmetered could be an important catalyst in changing the way water supply is perceived and valued in those areas. However, any change will need to be well communicated, as for the average New Zealander, I suspect they think there is nothing wrong with their water service and what they have been paying for; the water still comes out of the taps! ■

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International Conference on Diffuse Water Pollution Hosted by New Zealand

Rob Davies-Colley – Co-Chair, Technical Programme, International Conference on Diffuse Water Pollution

Introduction

New Zealand recently hosted two international conferences on aspects of water pollution. The International Water Association (IWA) conferences on 'Diffuse pollution and eutrophication' (DIPCON2011, www.dipcon2011.org) and 'Health-related water microbiology' (HRWM2011; www.hrwm2011.org) were held simultaneously from 19–23 September 2011 at the Energy Events Centre, Rotorua. These events were and are particularly important to New Zealand given that water quality in this country, including microbial quality, is generally worsening and is overwhelmingly diffuse in nature (Davies-Colley 2009; Howard-Williams et al. 2010) – reproduced in this issue, see page 56). This article is an overview of DIPCON2011 – which overlapped by design with HRWM2011 in a joint special session on "Diffuse microbial pollution". A future article will report on the HRWM2011 conference.

The importance of diffuse pollution, particularly from agriculture, for water quality in New Zealand, has long been recognised by water quality scientists here. The paradigm shift can probably be traced back at least to a landmark paper by Wilcock (1986) entitled "Agricultural runoff: a source of water pollution in New Zealand?". The question-mark in the title now seems jarringly redundant, and it is sobering to be reminded that, a generation ago, there was by no means universal acceptance of the potential for agriculture to pollute waters, even among scientists. How things have changed! The popular view of the New Zealand public, at least until relatively recently, seems to have been that pollution came from pipes (Davies-Colley 2009). But public perceptions are now also changing.

Professor Ken Hughey and associates at Lincoln University have surveyed public perceptions of the environment in New Zealand for a decade, and found that water quality is consistently rated as the number one issue – ahead even of climate change (to which it is, of course, related). That finding is not particularly surprising in a country that hugely values its waters, but what is perhaps more interesting, at least to those of us who work on water science and management in New Zealand, is that the Lincoln surveys show that, over those ten years the public have steadily becoming more aware that water quality degradation in this country is mainly attributable to agriculture – that is to diffuse pollution from livestock farming (http://www.lincoln.ac.nz/Research-Centres/LEaP/Environmental-Management-Planning/Projects/Public-Perceptions-of-NZs-Environment/).

Diffuse Pollution of Waters

Diffuse water pollution is pollution from land use that is generated (diffusely) over the land surface, in contrast to point source pollution by wastewater from city sewage or factories. The IWA specialist group on diffuse pollution and eutrophication defines diffuse pollution as follows: "Pollution arising from land-use activities (urban and rural) that are dispersed across a catchment, or subcatchment, and do not arise as a process effluent, municipal sewage effluent, or farm effluent discharge" (Campbell et al. 2004). So the definition is a little wider than the complement of point pollution (i.e. non-point pollution – the term used most commonly in North America) and encompasses multiple small point sources distributed over the catchment such as silage heaps and sewer leaks.

In New Zealand water pollution has generally increased over several decades despite massive expenditure on wastewater treatment – because the gains from point source control have been outweighed by increases in diffuse pollution loads (Ballantine & Davies-Colley 2009; Davies-Colley 2009; Ballantine et al. 2010; Howard-Williams et al. 2010; Verburg et al. 2010). It follows then, that if water pollution is to be controlled, New Zealand must increasingly turn its attention from the 'pipes and pumps' area of the wastewater sector to how we use our land. It follows then, that if water pollution is to be controlled, New Zealand must increasingly focus on how we use our land. Managing diffuse source pollution is inherently more demanding than managing point source pollution, because of the need to control and manage land use.

Conference Planning

The New Zealand diffuse pollution conference has been a fairly long time in the genesis. The concept was first suggested at the IWA diffuse pollution conference in Istanbul, Turkey, in 2006 (DIPCON2006) by Dr Jim Cooke, then based at NIWA-Hamilton. Jim has since been treasurer of the IWA Specialist group on diffuse pollution and eutrophication, and was co-chair of the organising committee for the New Zealand conference. The concept was advanced a year later at DIPCON2007 in Belo Horizonte, Brazil, when the other DIPCON2011 co-chair, Dr Rob Davies-Colley from NIWA, presented plans for a New Zealand conference and also raised the possibility of a back-to-back meeting with the IWA Health-related Water Microbiology (HRWM) specialist group. That concept was almost simultaneously proposed by scientists in ESR (Dr Marion Savill) and NIWA (Graham McBride and Dr Rebecca Stott) at HRWM2007 in Japan. Since then, planning has accelerated in the count-down to the joint event, when the two specialist groups of IWA on health-related water microbiology and diffuse pollution and eutrophication met in Rotorua.

NIWA agreed to act as major sponsor of DIPCON2011 early in the planning, with recognition by NIWA Chief Scientist (Freshwater and Coasts) Dr Clive Howard-Williams and other senior NIWA staff, that diffuse pollution dominates water quality issues in New Zealand and may be expected to be a major and growing preoccupation for the institute and for New Zealand. An outcome of the sponsorship agreement was the invitation to Clive to present a keynote address at DIPCON2010 in Quebec, Canada – by way of introduction for international delegates to water quality issues in this country one year out from the New Zealand conference. The resulting paper overviewing diffuse pollution in New Zealand is reproduced in this issue (Howard-Williams et al. 2010). Other sponsors of DIPCON2011 included: the Waikato, Bay of Plenty and Auckland Councils, Diffuse Sources, the University of Waikato (Lake Ecosystem Research NZ), Cawthron Institute, Ravensdown, Ballance, Fonterra and DairyNZ. NIWA also sponsored the HRWM2011 conference.

DIPCON2011 Themes

Table 1 lists the themes of DIPCON2011, starting with the 'overlap' theme of 'diffuse microbial pollution' which was joint with HRWM2011. Most of the other themes would be fairly traditional for recent DIPCON events, with the exception of Theme I on 'Indigeneous knowledge and diffuse pollution in small island states'. This was an attempt both to engage Maori for their concerns with water pollution (and aspirations, ultimately, for co-management), and also raise awareness of diffuse pollution in small developing island nations, particularly in the Pacific.

Table 1 gives total numbers of contributions (oral and poster presentations) in different theme areas. By running three parallel streams we were able to accommodate 107 technical oral presentations. In contrast to previous DIPCONs, we did not have



"We have also begun to see that what we do or do not do about our freshwater in New Zealand impacts both on our standard of living and our quality of life, on the economy and the environment. One way of thinking about this point is in terms of our brand, which is based on a promise about the environment but is important not only for tourism but also increasingly for the perception – and reception – of our primary exports abroad."

a theme explicitly on modelling and monitoring, although a fairly large number of papers could have been clustered into such a 'cross-theme' topic area. Consistent with the relative importance of diffuse pollution concerns in New Zealand, Theme C on nutrients and eutrophication, and Theme B on Agriculture were the largest areas of interest as judged by conference contributions (Table 1). A special issue of the journal *Marine and Freshwater Research*, guest edited by Professor David Hamilton (University of Waikato) and Dr Rich McDowell (AgResearch), is to be based on contributions to the conference in these two dominant themes.

Plenary Speakers

We wished to give international delegates some of the flavour of environmental problems and water quality issues in New Zealand. With that in mind, we invited the Parliamentary Commissioner for the Environment, Dr Jan Wright, to address delegates in the opening plenary on the morning of Monday 19 September. The PCE will be ultimately responsible for national environmental reporting in New Zealand if proposed legislation proceeds (http://www.mfe.govt.nz/publications/ser/measuring-up-environmental-reporting/index.html). Jan gave a potted history (her words!) of environmental issues in New Zealand. Then on Tuesday 20 September, Greens co-leader, Dr Russel Norman gave a plenary address on the need for action in New Zealand to address declining environmental quality, notably water quality.

Four high-profile international guests spoke in the remaining plenary sessions. In the special combined (with HRWM2011) plenary on Tuesday 20 September, Professor David Kay (University of Wales) observed that more stream kilometers in Europe are limited by microbial pollution than by any other category of pollutant, which may be expected to change the focus of the EU's Water Framework Directive. David sees this as a huge opportunity for researchers and policy-makers working on microbial pollution. On Thursday 22 September, Dr Eva Abal, University of Queensland and Chief Scientist for the Great Barrier Reef Foundation, conveyed her passion for communicating scientific findings on water condition to policy-makers and the public, in a talk on "Environmental report cards" – with interesting case studies from around the world including New Zealand. On Friday 23 September, Dr Kevin Parris, an economist with OECD in France, outlined "Opportunities for reducing diffuse pollution from agriculture" – including economic instruments. In his opinion, agricultural water pollution must be regulated rather than relying entirely on voluntary action by the sector. Kevin's address gave rise to a Radio NZ "Nine-to-Noon" interview that can be heard at http://www.radionz.co.nz/national/programmes/ninetonoon/20110928. Finally, in the closing plenary on the afternoon of Friday 23 September, Dr Eric van Bochove, the current chair of the IWA Diffuse Pollution Specialist Group, gave his perspectives on future initiatives and directions for controlling diffuse pollution.

Workshops (including Catchment Microbial Modelling)

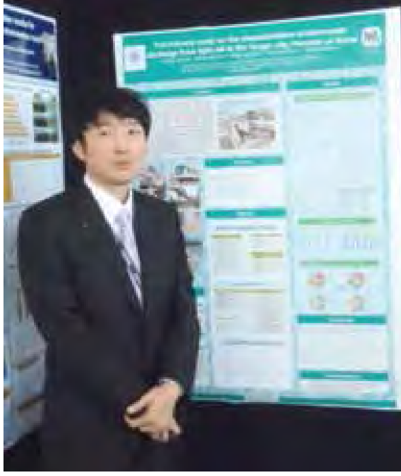
Workshops are a special feature of DIPCON events and promote lively discussions on a range of global issues. The workshops convened at DIPCON2011 were no exception in this regard. Each workshop had chairs who are acknowledged leaders in their fields, and two invited speakers who spoke for 30 minutes each on issues of international relevance. This was followed by a general discussion led by the chairs, for about one hour. In some cases there will be follow-up papers expressing the consensus views of the workshop to be published in the IWA journal, Water21. The workshop on water quality trading will produce a position statement to be sent to the European Union. Table 2 lists workshop titles held at this conference and key speakers and chairs.

Graham McBride chaired a pre-conference workshop (as part of HRWM2001) on "Catchment Microbial Modelling" on the afternoon of Sunday 18 September. This was attended by 57 delegates from both specialist groups who heard presentations on the state-of-the-art models and on how these models can inform policy (and what policy-makers need). This workshop culminated in the 'Rotorua Declaration'– about which more in an article in the next *WATER* issue (meanwhile, see the opening page at www.hrwm2011.org).

The OECD Sponsored Symposium on Wetlands in Agriculture

An OECD-sponsored symposium entitled "Bringing Together Science and Policy to Protect and Enhance Wetland Ecosystem Services in Agricultural Landscapes" was nested within DIPCON2011. Wetlands provide a critical suite of ecosystem services to regulate and stabilise stream flow, intercept and attenuate diffuse pollutants, enhance biodiversity and nutrient cycling, sequester carbon, and





Left to right – Max Gibbs (NIWA) speaking on efforts to restore Lake Okaro on the Rotorua Lakes field trip; Professor David Hamilton (University of Waikato) discussing the diversion wall protecting Lake Rotoiti from nutrient in (inflowing) waters from eutrophic Lake Rotorua; Andy Bruere (BoPRC), organiser of the Rotorua Lakes field trip, speaking near Lake Rotoehu; Poster session at DIPCON2011; Winner of the Young Water Professional (YWP) best poster award at DIPCON2011, Kyoung Jin Kim (Korea)

provide aesthetic, spiritual, and recreational benefits for humans. However, agricultural development has often led to the drainage, degradation and loss of wetlands that were once part of agricultural landscapes across the globe. Co-convenors Dr Chris Tanner and Dr Clive Howard-Williams led presentations and discussion sessions with a team of renowned wetland experts from nine different countries overviewing the scientific understanding of ecosystem services accruing from wetlands in agricultural landscapes, and the policy approaches that support appropriate wetland creation, restoration and protection. The results will be published in a special issue of the journal Ecological Engineering.

Field Trips

Field trips at DIPCON2011 were deliberately scheduled mid-week to build in a refreshing break from the conference. The field trips seemed to be enjoyed greatly by the many international delegates, including DIPCON board members. Those who participated in the Rotorua Lakes field trip experienced the cultural highlight of a mihi provided by local iwi (Ngati Rangiwewehi) at Hamurana Springs as well as a well-deserved bathe in Soda Springs (Photos 1–3) at the end of the day. On the Upper Waikato field trip, Huka Falls and geothermal features were scenic highlights. Special thanks to Professor David Hamilton (Field trip co-ordinator) and the rest of the conference organising committee to Andy Bruere (Bay of Plenty Regional Council) and Bala Tikkisetty (Waikato Regional Council) for leading the very enjoyable and informative field tours to the Rotorua Lakes District (photos) and upper Waikato Basin respectively (and to their councils for sponsorship). Thanks also to Jonathan Abell and Rebecca Eivers (PhD students at Waikato University) for assistance with field trips, Alison Lowe (Rotorua District Council) for explanation of the land-based wastewater treatment for Rotorua City, Mike Barton (Taupo sheep and beef farmer), Willie Emery (manager of Soda Springs) and John Patterson (Bay of Plenty Regional Council). An 'alternative' field trip targeted at, but not limited to, students and young water professionals (YWPs), featured white-water rafting on the Kaituna River, which seemed to have been enjoyed by all those who participated.

Posters

Posters are sometimes seen as 'poor relations' of oral presentations at scientific and technical conferences, and traditionally DIPCONs have been no exception. In contrast, posters have always featured strongly at HRWM conferences – probably because they have deliberately kept to one stream of (plenary) talks so time for oral presentations is always very limited. We believe posters contribute equivalently to a successful conference, so we attempted to increase the profile and relative status of posters at DIPCON2011 by a number of measures including: issuing poster guidelines on the website (and highlighting advantages of posters such as greater net 'exposure'), ensuring posters were prominently displayed in the Grand Hall off the entrance to the Energy Events Centre (where morning and afternoon teas were served), and scheduling two special poster sessions (Photo 5) into the programme. These poster sessions commenced with (3min) 'flash presentations'(chaired by Poster Co-ordinator, James Sukias and Rob Davies-Colley) from authors of designated 'keynote' posters. Our impression is that there is still some way to go before posters are valued as much as they should be in events of this kind. A number of posters were assigned to the 'overlap' theme of diffuse microbial pollution and displayed prominently near the registration desk at the Energy Events Centre.

YWPs and Students

The IWA has a special category of membership, 'young water professionals' (YWPs; essentially people under 35 years) to support young professionals early in their careers and encourage promising

"Diffuse pollution, including microbial pollution, of waters in New Zealand will continue to be a major environmental issue. That agriculture is the source of most water pollution in this country is increasingly recognised by the general public of Aotearoa."

graduate students into a career in water. Inspired by initiatives at the Quebec conference (DIPCN2010), and with assistance from IWA YWP representative on the DIPCON Board, Katerina Rusicka (Austria), Dr Deborah Ballantine organised a broad range of events specifically targeted at YWPs and students for DIPCON2011. These included: a mentoring scheme, targeted social events (notably a very well-patronised and enjoyable quiz evening), and prizes for contributions of YWPs to the conference programme (Photo 5). Young people are the future of the water sector – in diffuse pollution as much as other fields.

Next DIPCON – 2013 in China

In a break from the annual meeting tradition over many years, the DIPCON board has decided to move to two-yearly events from now on, so there is now a two-year gap before the next DIPCON – which will be held in Beijing, China in 2013. In the closing plenary session on Friday 23 September, Professor Xiaoyan Wang of Capital Normal University, Beijing, outlined plans from the DIPCON2013 organising committee – which will include some logical extensions of initiatives at the New Zealand conference, such as an active YWP programme.

Concluding Remarks

Diffuse pollution, including microbial pollution, of waters in New Zealand will continue to be a major environmental issue. That agriculture is the source of most water pollution in this country is increasingly recognised by the general public of Aotearoa. A paradigm shift among policy-makers and politicians seems needed to respond to this increasing public awareness – that to control water pollution, overwhelmingly from land use, implies increased control of land use. DIPCON2011 will have met its organisers' aim if the science and management of diffuse pollution in this country is advanced.

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DIPCON2011 Organising Committee:
Rob Davies-Colley (NIWA; Co-Chair – Technical Programme), Jim Cooke (Diffuse Sources; Co-Chair – Promotion and Budgeting), David Hamilton (University of Waikato; Plenary Speakers Organising and Field Trips), Graham McBride (NIWA; HRWM Liaison and co-chair of the Special Joint Session on "Diffuse Microbial Pollution"), Bruce Williamson (Diffuse Sources; Plenary speakers organiser and Guest Editor for Water Science and Technology), Deborah Ballantine (NIWA; YWP Programme and Technical Programme), Bob Wilcock (NIWA; Workshop Co-ordinator and Technical Programme), James Sukias (NIWA; Poster Co-ordinator), Clive Howard-Williams (NIWA; Symposium on Wetlands in Agriculture), Chris Tanner (NIWA; Symposium on Wetlands in Agriculture); Rich McDowell (AgResearch; Guest Editor for Marine and Freshwater Research special issue) and Lea Boodee (OnCue Conferences; Conference Manager).

Table 1 – Themes at DIPCON2011, with international and New Zealand chairs indicated along with numbers of oral and poster contributions

	Theme	International Co-chair	New Zealand Co-chair	Oral papers	Posters
A	Microbial diffuse pollution (joint with HRWM)	Eric van Bochove (Canada)	Graham McBride (NIWA)	8	28
B	Agriculture	Fiona Napier (Scotland)	Rich McDowell (AgRes)	21	5
C	Nutrients and eutrophication	Shigeo Fuji* (Japan)	Clive Howard-Williams (NIWA)	27	12
D	Urban and transport	Lee-Hyung Kim (Korea)	Bruce Williamson (Diffuse Sources)	11	8
E	Sediment pollution	Wanpen Wirojanagud (Thailand)	Sandy Elliott (NIWA)	6	3
F	Groundwater (and surface water interactions)	Peter Schipper (Netherlands)	Chris Daughney (GNS)	6	1
G	Economics, policies and education	Xiaoyan Wang (China)	Justine Young (Waikato Regional Council)	9	2
H	Integrated Catchment Management (ICM)	Ralf Kunkle (Germany)	Andrew Fenemor (LCR)	10	3
I	Indigenous knowledge and diffuse pollution in small island states		Garth Harmsworth (LCR)	5	0
J	Mining, heavy metals and emerging pollutants	Ralph Heath (South Africa)	Ian Boothroyd (Golders)	4	4
			TOTALS	**107**	**66**

Table 2 – Workshops at DIPCON2011

Workshop Name	Contact Person	Chairs	Invited Speakers	Notes
Report cards	Bruce Williamson (Diffuse Sources, NZ)	Eva Abal (Australia)	Bruce Williamson (Diffuse Sources, NZ); Eva Abal (Australia)	The workshop enabled a lively discussion on the use of report cards for ecosystem health and society values and stressed the integrative nature of this technique.
Water quality trading	Ray Earle (Ireland) & Sean Blacklocke (Ireland)	Ray Earle (Ireland); Sean Blacklocke (Eire)	Suzi Kerr (Motu Foundation); Kevin Parris (OECD)	This was the 3rd and last in series that will produce a position statement from the Diffuse Pollution Specialty Group stating that water quality trading, alongside other market-oriented approaches (e.g., competitive BMP grants, mitigation banking, sole-source offsets, etc.) should be further studied and pilot-tested where applicable throughout the EU.
Mining	Ralph Heath (South Africa)	Prof. Wanpen Wirojanagud (Thailand); Dr Ralph Heath (South Africa)	Dr Ralph Heath (Golder SA.); Jo Cavanagh (Landcare Research); Dr Ian Boothroyd (Golder, NZ)	The workshop looked carefully at diffuse impacts originating from mines, and how can these be quantified and reduced throughout the life of mine especially in closure.
Stormwater from industrial estates	Brian D'Arcy (UK)	Prof. Wanpen Wirojanagud (Thailand) and Dr Ralph Heath	Prof Lee-Hyung Kim (Korea); Dr. Zorica Todorovic (Atkins Global, UK); Matthew Davis (Auckland Council, NZ)	Coordinated by Brian D'Arcy. This workshop was to initiate contributions to upcoming workshops on urban runoff to be held in Seoul (2012) and Beijing (2013).
Agricultural intensification	Bob Wilcock (NIWA)	Prof. Hong Di (Lincoln University)	Mark Tomer (USDA, USA); Fiona Napier (SEPA, Scotland)	The workshop initially dealt with two themes before being opened up to a panel discussion on agricultural diffuse pollution issues and solutions. The first talk dealt with different approaches by EU Member States to monitoring programmes, including types of measurements, cost effectiveness, indicator parameters, role of modelling, issues of scale and the role of land-based monitoring. The second talk dealt with responses of farmers in the US to climatic change and the demand for biofuel production, particularly corn-grain ethanol and increased maize production and the resulting changes to N pollution of waterways.
Nutrient loads on lakes	David Hamilton (University of Waikato) & Max Gibbs (NIWA)	David Hamilton & Max Gibbs	Dr Marie-Laure De Boutray (Canada) Dr Linda May (Scotland)	The workshop addressed a number of modelling issues, and the minimum data requirements, facing lake managers and researchers. Special consideration was given to *in situ* monitoring of lakes.

Diffuse Pollution and Freshwater Degradation: New Zealand Perspectives

Clive Howard-Williams – Chief Scientist, Freshwater and Coasts, Rob Davies-Colley – Principal Scientist, Aquatic Pollution, Kit Rutherford – Principal Scientist, Catchment Processes & Bob Wilcock – Principal Scientist, Aquatic Chemistry & Eco-toxicology; all of the National Institute of Water and Atmospheric Research

An edited version of a presentation for the 14th International Conference, IWA Diffuse Pollution Specialist Group. For a full version of the paper please contact r.davies-colley@niwa.co.nz.

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Introduction

New Zealand has much natural landscape with mountains and natural forest occupying ca.43% of the land surface. These areas contain near-pristine rivers, lakes and wetlands. The remaining land area comprises planted forest (5%) and pastoral and arable land (52%) and the country's lowlands are almost devoid of natural landscape (Elliott, 2005; Davies-Colley, 2009). Given the large area of pastoral farming, it is not surprising that New Zealand suffers considerable diffuse water pollution, and the link between pastoral intensification and declining water quality is increasingly acknowledged by the Government (New Start for Freshwater, 2009). This decline has been rated the country's number one environmental problem in several opinion surveys. Water pollution, now overwhelmingly from diffuse sources, has been well documented and the management of diffuse pollutants is currently receiving considerable attention (Ministry for the Environment, 2009; Land and Water Forum, 2010). There has been government recognition of the 'strong link' between land use intensification and water quality decline (Ministry for the Environment, 2009). The reasons for this attention relate to public pressure and changing perceptions of the value of natural waters. Behind these are the continuing drives by international primary commodity markets for the documentation of sustainability practices. A significant pressure for cleaner waters has come from the indigenous Maori (Polynesian) people of Aotearoa, New Zealand. Maori recognise freshwater as a taonga (treasure) and have an obligation of guardianship of the landscape including waters (Land and Water Forum, 2010).

The challenge facing New Zealand is how to cope with the economic drive for increased pastoral production while demonstrably minimising contaminant loss to both freshwater and the coastal zone. Detailed reviews of the extent of, and impacts of, diffuse pollutants on the New Zealand aquatic environment have appeared frequently over the last decade as concern has increased over the impacts of pastoral agriculture on them (McDowell, 2009; Quinn et al., 2009). This challenge is significant. The most recent OECD Environmental Review of New Zealand (OECD, 2007) highlights that water quality in lakes and rivers has declined in those areas dominated by pastoral farming and the OECD has recorded the following changes in the 15 year period, 1990–2005:

- Change in agricultural production: New Zealand ranked 1st out of 28 OECD countries, with the highest % increase in agricultural production
- Change in total phosphate fertiliser use: New Zealand had the 2nd highest % increase in phosphate fertiliser use out of 29 OECD countries, while 23 countries decreased their P-fertiliser use
- Change in total nitrogenous fertiliser use: New Zealand had the highest % increase out of 29 OECD countries, while 21 countries decreased N-fertiliser use. (The actual net application of N-fertiliser (2.1 tonnes/km^2 of agricultural land) in New Zealand is now close to the OECD average of 2.2 tonnes/km^2 of agricultural land.)

International and New Zealand-specific experience shows that such changes are likely to be accompanied by increases in diffuse pollution (Wilcock, 2009). The New Zealand Office of the Parliamentary Commissioner for the Environment has argued for "a paradigm shift in farming practices for New Zealand to become environmentally sustainable".

Here we outline five major aspects of the diffuse pollution issue that have wide international relevance:

1. Characterisation of diffuse pollution and the shift from point to diffuse sources
2. Pollutant pathways
3. Attenuation of diffuse pollutants
4. Modelling
5. Managing diffuse pollution

Characterisation of Diffuse Pollution

Urban and mining-impacted streams are typically of lowest 'ecological health' in New Zealand, as elsewhere, owing to severe physical changes, gross sedimentation, and toxic pollution, but a far greater total length of streams in pastoral agriculture are moderately to severely impacted. The 'universal' diffuse pollutants – fine sediments, pathogens and nutrients – all of which are mobilised by livestock, predominate in waters draining the New Zealand landscape.

Fine sediment mostly affects (i) rivers by reducing water clarity and impacting on primary producers and consumers in aquatic food webs, and (ii) coastal areas by reducing water clarity, shoaling by sedimentation and smothering shellfish beds.

Faecal matter (and associated pathogens) affects contact recreation, water supplies and coastal shellfish harvesting from commercial, recreational and traditional harvest sites. In a national study of freshwater swimming sites collated by the Ministry for the Environment 40% of 280 river sites were found to be non-compliant with guideline values for recreation in terms of E. coli (http://www.mfe.govt.nz/environmental-reporting/freshwater/recreational/snapshot/freshwater.html#results). Although microbial pollution is of major concern for contact recreation, application of a water quality index for contact recreation to 77 sites in the National Rivers Water Quality Network (NRWQN; Davies-Colley and Ballantine, 2010) suggests that low visual clarity limits contact recreation in New Zealand rivers more commonly than microbial pollution (high E. coli).

In terms of nutrients, New Zealand has a long history of documentation and research on freshwater eutrophication that has affected rivers, wetlands, lakes and estuaries (Burns, 1991; Winterbourn, 1991) with significant deviations from OECD trends (White, 1983). SPARROW modelling calibrated to the NRWQN dataset (Elliott et al., 2005) suggests that point sources account for only 3.2% of the Total N, and 1.8% of the Total P flux to the sea from the New Zealand landmass. Diffuse pollution has probably been present since widespread land clearance for grazing started in the 19th Century in (originally 80% forested) New Zealand, but has gone largely unrecognised until recently. Over the past four decades or so, New Zealand has been preoccupied with controlling point pollution, with water pollution from diffuse pastoral sources only acknowledged fairly recently – particularly since publication of a landmark paper by Wilcock (1986). Now the gains made from investment in wastewater treatment risk being negated by increasing diffuse pollution from expansion and intensification of pastoral agriculture (Ballantine and Davies-Colley, 2009; Wilcock, 2009; Quinn, 2009). Diffuse pollution (with a few exceptions) seems less amenable than point pollution to control under New Zealand's (effects-based) environmental legislation, the Resource Management Act of 1991.

Correlations between land use and river water quality consistently quantify the relationships between water quality and land use as shown in Table 1. Visual clarity is negatively impacted by land use and is positively related to the percentage of native forest in the catchment. Nutrients and E. coli concentrations are all positively related to the percentage pastoral land use in the catchment, and negatively to the percentage of native forest.

Table 1 – Correlation of river water quality variables (medians for the period 2005-08 from NRWQN) and percent of catchment in pastoral, arable and native forest land use types. All correlations are significant at $P<0.05$. (From Davies-Colley, 2009.)

Parameter	% Pastoral	% Arable + Hort.	% Native Forest
Visual clarity	- 0.45	- 0.24	0.30
Total Nitrogen	0.85	0.45	- 0.39
Total Phosphorus	0.70	0.24	- 0.32
E. coli	0.80	(0.17)	- 0.34

Of the pastoral land use category, which makes up 42% of New Zealand's land cover, dairy farming has the highest diffuse pollution footprint with 36.7% of the Total Nitrogen load entering the sea originating from the 6.8% of the land area occupied by dairy farming (Table 2), while 'other pasture' (sheep, beef, deer etc) provides 38.9% of the Total Nitrogen from 31.9% of the land area (Elliott et al., 2005). This is not surprising given that the nitrogen loss rates from dairy farms are four times higher than from other pasture (cf. 39kg/ha/yr compared with 8kg/ha/yr from sheep and beef farms, and 5kg/ha/yr from forest (MAF, 2008; Quinn et al., 2009).

Table 2 – Land use area (%) and Total Nitrogen load to the sea as a % of the national total load (after Elliott et al., 2005).NA = Not Applicable. Total area of NZ = 263 500km^2; total N load to the coast = 167 700 t/yr.

Pollution Source	Land use area %	Load to Coast %
Point sources	NA	3.2
Dairy	6.8	36.7
Other pasture	31.9	33.3
Trees (Native and plantation forest)	39.2	24.8
Other non pasture (mountains, scrub)	22.1	2.1

A recent study of 112 currently monitored New Zealand lakes (Verburg et al., 2010) found that 49 were eutrophic or worse and 29 were oligotrophic or better. However, bias in the distribution of the monitored lakes was acknowledged in that many lakes in natural areas were not monitored. Statistical extrapolation, accounting for this bias, indicated that 32% of all 3820 New Zealand lakes of >1ha in area are eutrophic or worse, while 43% are oligotrophic or better. Of the monitored lakes, 73% of those in the eutrophic or worse category were located in predominantly pastoral land use catchments (Verburg et al., 2010).

Diffuse sources have thus now comprehensively supplanted point sources across the country. For example, at (nitrogen-limited) Lake Rotorua a sewage discharge was diverted in 1991 with an immediate decline in Total N in the lake, but Total Nitrogen levels are now higher than they were in 1991 due to steadily increasing nitrogen loads from catchment streams draining pastoral land (Figure 1).

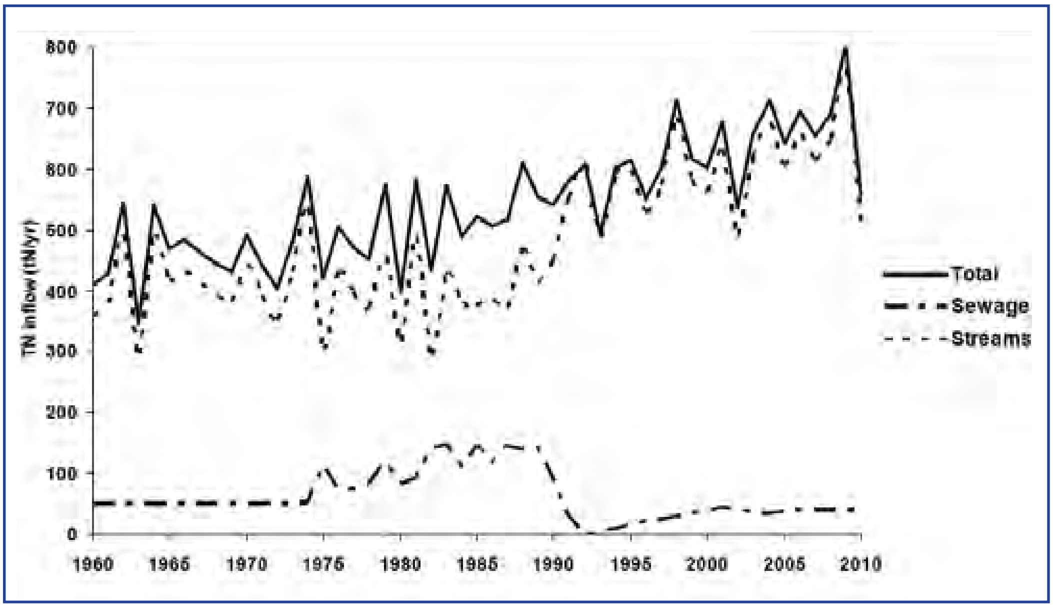

Figure 1 – Diffuse pollutants continue to increase as point sources decline. At (N-limited) Lake Rotorua the sewage discharge was diverted in 1991 (Data from Rutherford, 2003 and unpublished) but diffuse inputs from streams continued to increase.

Management of diffuse pollution relies on the estimation for each catchment of the load that has arisen from human activity and is additional to the natural load. We estimate that 75% of diffuse source N & P flux to the sea is from modified landscapes, mostly pastoral and, as such, is theoretically manageable while 25% would be 'natural'. Lake Taupo, New Zealand's largest lake has a mixed land use catchment with 22% pastoral, 27% as plantation forest and the remaining 51% as native forest, scrub and mountain vegetation. The manageable loads there of Total N and P are only 40% of the natural load as modelled for pre-European times. Nutrient management in the Lake Taupo catchment has been focussed only on that 40%.

New Zealand catchment modelling indicates that the manageable load, as a proportion of the total load, varies not only with time but with distance downstream in rivers. In the case of the Waikato River, the manageable nitrogen load gradually diverges from the 'natural' load as the river progresses downstream to a distance of ca. 225km, and then doubles in the next 50km while the 'natural' load increases by only 16% (Table 3). The manageable load increase is due to the inflows from a major tributary, the Waipa River. The situation for phosphorus is not as clear-cut because the Waipa would have provided a significant natural phosphorus load. In this case the manageable P load doubled below the Waipa junction and the 'natural' load also doubled by 0.5t P/day (Table 3).

"In two sensitive lake catchments deemed to be of national significance, Lakes Taupo and Rotorua, the last decade has seen national government intervention to assist with lake restoration initiatives that have established nutrient load limits. These have been set following extensive scientific consultation advice and modelling in conjunction with broad community consultation."

Distance downstream (km)	Total Nitrogen load		Total Phosphorus load	
	1920 'Natural'	2010 Manageable	1920 'Natural'	2010 Manageable
0	1.2	–	0.09	–
75	1.5	3.0	0.2	0.3
170	4.2	6.4	0.4	0.7
225	6.1	9.2	0.51	0.9
Waipa River inflow here				
250	7.1	18.4	1.1	1.8
300	10.5	23.1	1.5	2.5

Table 3 – Waikato River natural nutrient loads and anthropogenic (manageable) loads (tonnes/day) vary with distance downstream from Lake Taupo (0km). The 'natural load' figures are the modelled load for the 1920s before hydropower development but after some limited land use change. 225km is upstream and 250km is downstream of the Waipa River inflow.

Pathways of Diffuse Pollutants

Diffuse pollutants move into waters through three main processes:

i. surface runoff as overland from land to water
ii. livestock direct access to waters (including wetlands and lake margins)
iii. leaching to groundwaters and subsequent re-emergence as springs

i. **Overland flow** is probably the largest source of diffuse pollution in New Zealand and comprises mostly particulate diffuse pollutants (fine sediment, microbes and particulate N and P). It is highly flow-dependent as described above, and is mostly derived from critical source areas (CSAs) for runoff representing often only a small proportion of a catchment (Pionke et al., 2000; McDowell et al., 2004). Because surface runoff mainly occurs during and immediately after rainstorms, diffuse pollution from this pathway tends to correlate positively with stream flow – in sharp contrast to livestock access and groundwater seepage (and point source pollution) that tend to be diluted with increasing stream flow. In New Zealand rivers water clarity (inversely related to fine sediment) tends to decline with increase in discharge, while microbes, and total nitrogen and phosphorus concentrations increase with discharge – broadly consistent with the inference that overland flow is the dominant source of diffuse pollution in this country (Smith et al. 1996, Davies-Colley, 2009).

In a comparative study of pasture, pine and native forest catchments, Cooper and Thompsen (1988) found that on an areal basis, the pasture catchment exported about 15 times more P than either of the forested catchments and about 3 and 10 times more N than the native and pine catchments respectively. The proportion of TN export that occurred during stormflow in the pasture, pine, and native catchments was 90%, 52%, and 20%, respectively and similar proportions occurred for TP exports.

In any catchment or farm, identification of Critical Source Areas for priority attention to mitigate or ameliorate pollution in runoff is a necessary first step in diffuse pollution control. These areas can then be set aside for management actions that reduce pollutant runoff such as minimising fertiliser application or livestock exclusion or reduction. Beneficial Management Practices (BMPs) that are most appropriate to overland flow are those that act as 'filters' to intercept diffuse pollutants in the surface runoff. These include contour tilling and planting, grassy strips, wetlands and stream-bank vegetation. Other BMPs include the use of slow release fertiliser such as rock phosphate that minimises soluble fertiliser loss in rains (Hart et al., 2004), and livestock stand-off pads that prevent soil damage from treading compaction during wet weather (Table 4).

ii. **Livestock direct access**. This widespread pollution source is important in New Zealand and is a significant area for management attention. Direct livestock access to waters or wetlands adversely affects water quality by:

» Physical damage by livestock treading and browsing to the vegetation, soils and substrates in and on the edges of lakes, wetlands and streams, increasing their susceptibility to erosion, sediment loss and pollutant runoff
» Direct dung and urine deposits in waters, which add nitrogen, phosphorus and faecal microbes

A study in the Sherry River (http://icm.landcareresearch.co.nz/) has shown that river crossings of dairy herds between milking parlour and pasture up to four times daily approximately doubles average faecal pollution levels (Davies-Colley et al., 2004). The microbial quality of the Sherry River has greatly improved since the fords used for dairy crossings were all replaced by bridges, although the river still falls well short of contact recreation guidelines – mainly because dairy cattle continue to access unfenced channels from pasture.

Studies of direct pollution by sporadic access of cattle to streams have been conducted in New Zealand. Bagshaw et al. (2008) found that beef cattle in hill land spent about 2% of their time in stream channels to which they had unrestricted access, and inferred that a proportional amount of faecal deposition would go directly into stream water, with a further 2% deposited in the 'immediate' riparian zone (from which any rise in stream stage would readily entrain faecal matter). Bagshaw and co-workers also studied dairy cow access to unfenced streams (15 separate observational experiments on 5 different farms) and found that cows spent only about 0.1% of time in the channels, but deposited about 0.5% of faeces (Collins et al., 2007). Monitoring of stream water quality upstream and downstream of the dairy paddocks in 10 of the 15 experiments (Davies-Colley and Nagels, 2008) showed that the stream water was highly polluted with E. coli concentrations up to 30,000 cfu/100mL. The faecal bacterial yield agreed well with observations that 0.5% of faecal deposits directly enter stream water, suggesting a 5-fold amplification of defecation rate water versus land.

Thus, fencing of stream banks in pastoral landscapes, ideally with a set-back to create a riparian buffer, is increasingly recognised as the most important BMP to arrest this pollutant pathway, with bridged stream crossings also important on dairy farms where cows move usually twice-daily to milking sheds, often crossing streams.

iii. **Nutrients leaching to groundwater** and their subsequent emergence in seeps and springs, is a particular issue in New Zealand's alluvial soils and porous volcanic soils where groundwater resources are often significant. This is a particular problem for nitrate entering aquifers in aerobic conditions al-though microbial pollution of groundwaters can also be significant in the near-field. In the intensively-farmed Waikato region 16% of bores exceed this guideline (Quinn et al., 2009). Recently, Hickey and Martin (2009) analysed acute (short-term) chronic (long-term) nitrate toxicity data in order to recommend freshwater guidelines for nitrate concentrations in natural waters. As a result of this analysis recommended guideline values for chronic toxicity were: a) 1.0mg NO_3-N L^{-1} in pristine environments with high biodiversity values; b) 1.7mg NO_3-N L^{-1} in slightly or moderately disturbed systems; and c) 2.4–3.6mg NO_3-N L^{-1} in highly disturbed systems (i.e. with measurable degradation).

Of special note in relation to the management of nitrate pollution are the legacy issues that relate to extended residence times of polluted groundwater. In the Central North Island, nitrate from groundwater-fed springs and seeps is a major contributor to the total nitrogen load of large (nitrogen-limited) lakes. In the Lake Taupo catchment groundwater ages vary from 2.5 to 80 years (Morgenstern, 2007) with a mean age of water of 9 streams being 37 years, so the lake now receives nitrate from farming activities several decades in the past. The effects of current farming will not show up for several decades into the future. The policy response to this legacy of nitrogen in groundwater has been termed 'the load to come' (Vant and Smith, 2004). Lake protection and remediation programmes in the central North Island have been required to account for the load to come when calculating nutrient input budgets and time scales of change.

Attenuation of Diffuse Pollutants

Attenuation of pollutants with distance downstream from the source of flow is an important consideration for modelling (Rutherford, 1987; Elliott et al., 2005) and management.

"In the first case, 'Lateral Attenuation', particulate and dissolved inorganic nutrients are removed when surface and subsurface water flows through riparian vegetation before reaching the stream channel. In the second case 'Instream Attenuation', processes such as plant and microbial uptake (denitrification in the case of nitrate) can remove nutrients from waters within the stream channel itself."

Attenuation of overland flow takes place on land through natural interception mechanisms (and BMPs) as mentioned above and it takes place adjacent to, and in, streams where different nutrient attenuating systems have been identified (Downes et al., 1997). These were:

i. streams receiving lateral flow where nutrient processing occurred in groundwater and in surface runoff adjacent to the stream
ii. Streams with spring sources where nutrients were attenuated in the stream channel

In the first case, 'Lateral Attenuation', particulate and dissolved inorganic nutrients are removed when surface and subsurface water flows through riparian vegetation before reaching the stream channel. In the second case 'Instream Attenuation', processes such as plant and microbial uptake (denitrification in the case of nitrate) can remove nutrients from waters within the stream channel itself. Other Instream Attenuation processes such as hyporheic exchange, sediment exchange, microbial pollutant die-off in sunlit channels, long-term storage of sediments (infilling) and nutrient transformations (i.e. from dissolved inorganic nutrients to particulate nutrients and vice versa) have also been demonstrated as important. These processes combined reduce fluxes and the concentrations that would otherwise be encountered in downstream water bodies.

i. **Lateral attenuation**: Attenuation of runoff through riparian vegetation on stream edges has been the subject of long study in New Zealand with one of the seminal works being that of McColl (1978). He showed then the value of riparian vegetation along pasture streams as nutrient traps for overland flow of phosphorus to stream channels during rain storms. The study provided 'strong support for the use of buffer strips of vegetation along stream channels as a means of protecting streams from phosphorus losses'.

In a study of faecal coliform attenuation in pasture lands, Collins et al. (2004) found that during large runoff events, and where preferential flowpaths occur, buffer strips need to exceed 5m in length in order to markedly reduce the delivery of faecal microbes to waterways, but during low-rates of water application to pastures, riparian buffers trapped >95% of E. coli in the runoff. Cooper et al. (1995) provided a note of caution in the long-term sustainability of riparian strips for lateral attenuation, suggestion that riparian soils can become saturated with P. The results imply that riparian set-asides may lead to the development of a zone likely to supply runoff to the adjacent stream that is depleted in sediment-bound nutrients and dissolved N but enriched in dissolved P.

ii. **Instream Attenuation** of pollutants has been modelled as a first order decay process (see Cooper and Botcher, 1993; Hearne and Howard-Williams, 1988; Elliott, 2005) so that downstream concentration $C_z = C_0 e^{-Kz}$, where C_0 is the source concentration, K is the attenuation coefficient (m^{-1}) and z is distance downstream (m). In the case of nutrients, the downstream attenuation coefficient for dissolved nutrients in water (K_w) may also be calculated from $K_w = R_w / F_w$ where R_w is the mass of nutrient removed per unit time per meter of stream length and F_w is the nutrient flux (mass per unit time) in the suite of equations describing nutrient spiralling (Newbold et al., 1981). Most diffuse pollution occurs in small (low order) streams that have the greatest attenuation capability. This is demonstrated by the strong dependence of K_w on stream and river discharge (Rutherford et al., 1987; Figure 2). The information suggests that for optimising nutrient attenuation, attention should be paid to streams that have a K_w of greater than 0.0001/m or >10% loss of nutrient per km of stream length. These conditions are found in streams with a flow rate of <0.5 m^3/s (Figure 2).

The nutrient attenuation coefficient (K_w) for mid summer periods in the Whangamata Stream in the central North Island was shown to vary fifty-fold, in a cyclical manner, from 0.03/m to 1.5/m over a 30 year period. This reflected changes in discharge, in-stream vegetation biomass, stream shade by riparian vegetation, and in-stream plant species composition (Howard-Williams and Pickmere, 2010).

In addition to stream attenuation of nutrients there is increasing evidence of high variability in attenuation processes operating in groundwaters particularly for nitrate-N. For instance at Lake Rotorua groundwater appears to be well oxygenated (viz., little denitrification) so attenuation of groundwater N is unlikely. By comparison, at Lake Taupo many groundwaters are anoxic (Hadfield, 2007) and have low nitrate concentrations with an assumption of high denitrification rates on organic-rich layers in the aquifers (Stenger et al., 2009).

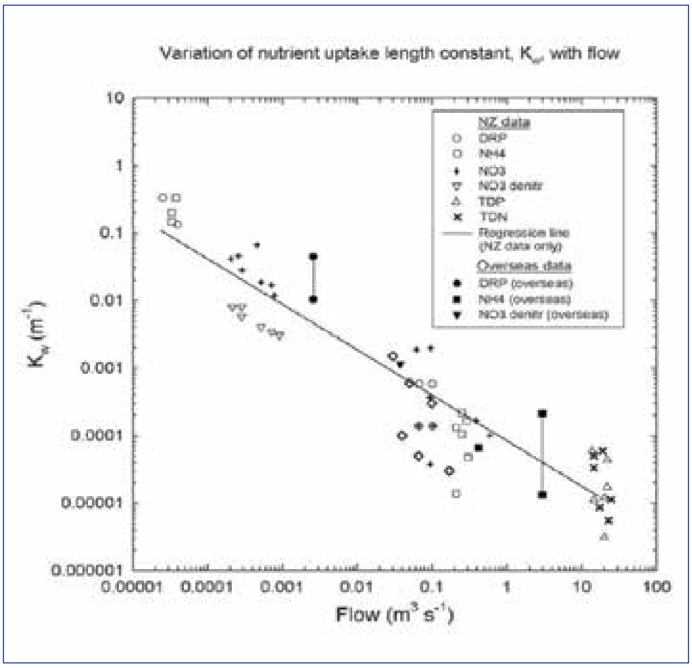

Figure 2 – (After Rutherford et al., 1987). Variation in the downstream attenuation coefficient for dissolved nutrients (K_w) with stream flow.

A number of factors affect attenuation (Table 4) and in addition to managing these for nutrient removal, considerable advances can be made by maximising attenuation at diffuse pollution source sites on farms. A comprehensive statement on the effectiveness of on-farm mitigation strategies for managing contaminant sources was provided by Quinn et al. (2009).

Enhancing attenuation in and near waters	Reducing nutrient loss from farms
Riparian strips	Riparian and farm drain management
Wetland and seep protection	Slow release fertilisers
Maximising aerobic-anaerobic interface for denitrification	Nitrification inhibitors
Constructed wetlands	Constructed wetlands
In-channel vegetation	Nutrient budgets, nutrient mapping
	Feed pads, herd homes, wintering off-site
	Improved weather and climate forecasting
	Nutrient trading/capping

Table 4 – Mechanisms that enhance attenuation in streams and prevent nutrient loss from farm soils to waters

Modelling

Diffuse pollution modelling in New Zealand has been done through statistical, mechanistic, stochastic and conceptual approaches (e.g. Decision Support Systems and Bayesian Belief Networks) and includes several of the models reviewed for the EU Water Framework Directive (Yang and Wang, 2009). Statistical modelling includes SPARROW (Alexander et al., 2002) which accounts for in-stream attenuation. This has been used to define pollutant loads to the sea across the New Zealand landmass (Elliott et al., 2005) and to focus on more detailed catchment understanding. SPARROW forms the core of a recent model package (Catchment Land Use for Environmental Sustainability – CLUES); which was specifically designed to be used by water managers and combines underlying land use pollutant spreadsheet approaches such as OVERSEER™ with SPARROW to relate catchment pollutant loads on a GIS framework (McBride et al., 2008). The resulting package allows for a map-based delineation of land uses and provides GIS images of seasonal or annual loads of pollutants through the stream network.

Other catchment models that have been used with success are GLEAMS (and GLEAMSHELL) (Cooper and Bottcher, 1993). Catchment nutrient modelling with GLEAMSHELL provided the nutrient inputs to New Zealand's largest lake, Lake Taupo for scenarios that investigated proposals for increased dairy farming in this nitrogen sensitive area. The model, together with an in-lake dynamic ecosystem model (Spigel et al., 2001; Hamilton and Wilkins, 2004), resulted in a Policy Response (Variation 5 to the Waikato Regional Plan) that limits future land-use intensification in the catchment. This includes a nitrogen capping policy that limits inputs to the lake and accounts for 'the load to come' of nitrate in groundwater.

Recently the statistical ROTAN model (Rutherford et al., 2009) has been developed to quantify the role of groundwater lags in delaying the response to land use changes of nitrogen inputs to lakes Rotorua and Taupo. ROTAN is currently being used to calculate how quickly lake inputs will decrease if nitrogen exports from land are reduced in different parts of the Lake Rotorua catchment – so that the mitigations including land purchase and retirement can be targeted where they will be most cost-effective and timely. An empirical approach to modelling diffuse pollution is that of Unwin et al. (2010) who make use of the spatial framework tool, the 'River Environment Classification' (Snelder and Hughey, 2005) to model water quality.

Mechanistic models for exploring microbial diffuse pollution have been reported by Collins and Rutherford (2004). These have highlighted the very different 'microbial regime' of baseflows compared to (microbially polluted) stormflows when microbes are entrained by flood currents and washed into waters with overland flow – resulting in polluted storm plumes affecting downstream waters and coasts. A stochastic approach of increasing interest in New Zealand is quantitative microbial risk assessment (QMRA) to investigate health risks to humans of microbial pollution of recreational or drinking waters or bivalve shellfish under different pollution scenarios (McBride, 2007).

Managing Diffuse Pollution

Management of diffuse pollution involves approaches at several levels: reductions of nutrients at source (i.e. by reducing animal stocking rates); retiring, or not permitting certain activities on, sensitive land in sensitive catchments and by widespread application of mitigation methods. It is widely accepted that there is no single mitigation option for diffuse pollution reduction (e.g. Stevens and Quinton, 2009 and Quinn et al., 2009 for arable and pastoral systems respectively). Diffuse pollution management is receiving attention at four levels: i). national government; ii). regional government; iii). rural industry promoted standards and iv). community-led initiatives. Several management instruments are currently being evaluated involving combinations of the above. Regulating for diffuse pollution is not the single answer, even if this were (to become) politically tenable. In the UK, the National Farmers Union rejected regulation as an answer to diffuse pollution stressing the need for advice-based voluntary approaches (Whyte, 2004), a sentiment also strongly expressed by the various agricultural sector groups in New Zealand where a recent Government panel has recommended a matrix of governance and management approaches to the problem (Land and Water Forum, 2010). These approaches range in scale from national to local in the following sequence:

- Defining national objectives based on values setting for water quality
- Establishing limits and standards at regional scales but based on spatial frameworks to account for natural landscape and waterway variability
- Collaborative processes at catchment scales ("integrated catchment management") that involve both industry and local stakeholder

Key to this last point is strong rural industry engagement to provide credibility, advice and incentives, as well as the introduction of adaptive management and audited self management as tools for promotion and validation of BMPs. Across all these scales in New Zealand are the interests of the indigenous Maori ('first nation') people who have traditional obligations to protect freshwater so as to 'leave a worthy inheritance for future generations' (Land and Water Forum, 2010). Negotiations on the role of Maori in freshwater management up to and including full co-management of water bodies (e.g. Collier et al. 2010) are currently underway.

Regional governments in New Zealand have been increasingly active in the last decade in promoting water protection. In Taranaki the Regional Council provides a riparian planning service 'to maintain water quality in the region'.

Since the late 1990s it has:

- Prepared (free of charge) more than 2,000 farm riparian management plans, focussed mainly on fencing and planting
- Promoted 500km of stream fencing and 425km of stream bank re-vegetation which, when added to existing fencing and planting means that 60% of stream bank, on the lowland 'ring' plain under a riparian plan, is fenced, and 43% is vegetated
- Supplied 1.5×10^6 plants (300,000 plants in 2010 alone) at cost
- Detected a 30% improvement in stream ecological health using a Stream health Monitoring and Assessment Kit (SCHMAK), and in this time no negative trends have been detected in the monitored streams

In two sensitive lake catchments deemed to be of national significance, Lakes Taupo and Rotorua, the last decade has seen national government intervention to assist with lake restoration initiatives that have established nutrient load limits. These have been set following extensive scientific consultation advice and modelling in conjunction with broad community consultation. Thus, in the case of Lake Taupo, the legislated 'Regional Plan Variation 5 (Lake Taupo)' imposes a cap (a Nitrogen Discharge Allowance or NDA) on nutrient loads leached from individual farms which is based on the load in their 'best' recent farming year. A NDA can be traded between farmers. A 20% reduction in the manageable loads is to be achieved over a 10 year period to accommodate the 'load to come' through the purchase and retirement of farms by the Lake Taupo Protection Trust (www.laketaupoprotectiontrust.org.nz).

In the case of Lake Rotorua, a target of 435t N/yr has been set for the nitrogen input to the lake – the input during the 1960s before there was widespread concern about algal blooms in the lake. Currently nitrogen export within the catchment totals 825t N/yr, of which >80% originates from pastoral farming. Streams have a large groundwater component and the mean 'age' of groundwater ranges from 15 to 110 years which means that even if nitrogen leaching losses from pasture were reduced immediately, it would take several decades for the input to the lake to reduce. Internal releases of nutrient from the lakebed during summer stratification are also likely to delay lake recovery. Measures are currently being considered to reduce nitrogen exports and to reduce internal lake loads.

Significant approaches to water governance at regional and local levels and combining regulation and voluntary action have been proposed in the last few years; Regional government initiatives include the Horizons council's *'One Plan'* that will see the establishment of Water Management Zones with specific controls over land use intensification of farming activities at catchment and sub-catchment scales, and a mix of 'persuasion, advice and rules to manage water quality within the Management Zones'.

"In two sensitive lake catchments deemed to be of national significance, Lakes Taupo and Rotorua, the last decade has seen national government intervention to assist with lake restoration initiatives that have established nutrient load limits."

Using a similar approach, the Canterbury Regional Council's recent approval of the *Canterbury Water Management Strategy* will see a combination of regulatory action set at regional level, to deal with environmental problems complemented with incentive mechanisms that progressively drive efficiency in the use of water and responsible land management practices. This will be done through ten Water Management Zones sufficiently large to enable the management of surface and groundwater systems to be integrated with the management of the areas where the water is used but also small enough to avoid becoming remote from local catchment issues. Water management zones are seen as spanning the divide at the right scale between regulation and community and industry voluntary action.

As detailed in the water planning frameworks for many countries, catchments are usually the best spatial management unit. In New Zealand, Beneficial Management Practises in dairy farming areas have been quantitatively evaluated over the last decade through a set of five 'Best Practise Dairy Monitor Catchments', which demonstrate the efficacy of BMPs (Wilcock et al., 2007) in different dairy-dominated catchments in five regions of the country with varied climate and soils. In the Whatawhata Hill Country experimental farm, retirement of much riparian and steepland in the Mangaotama Catchment has improved water quality and aquatic ecological health in less than a decade (Dodd et al., 2008), although some expected benefits are expected to take longer owing to 'legacy' effects to do with nitrogen in groundwater and stored sediment in streambanks.

As part of the Primary Sector Growth Partnership in New Zealand, "the fertiliser industry is responsible for meeting its commitments to ensuring the sustainable use of freshwater resources in the primary sector. These commitments include: by 2013 80% or nutrients applied to land nationally are managed through quality assured nutrient budgets and nutrient management plans…" (Land and Water Forum, 2010). The dairy industry has signed the voluntary 2003 *'Dairying and Clean Streams Accord'* that had achieved the following by 2008–09: 1. Dairy cattle are excluded from streams, rivers and lakes – 80%; 2. Regular race crossing points have bridges or culverts – 97%; 3. All dairy farms have in place systems to manage nutrient inputs and outputs – 97%; 4. All dairy farm effluent discharge complies with resource consents and regional plans – 60%. These data need to be treated with some circumspection as one influential report disputes industry claims about the percentage compliance with the 'Accord' (Deans and Hackwell, 2008). Whatever the final numbers, the industry intervention is producing positive environmental outcomes from existing dairy farms. However, of ongoing concern is continuing degradation as a result of conversions from sheep and beef farming to dairying (Environment Waikato, 2008).

Managing diffuse nutrient loads through regulation by setting load limits (nutrient caps) on catchments, and through identified nutrient concentration targets (regional planning standards) in downstream waters needs to be directed by government (central and regional) regulatory agencies. This should be combined with co-operative approaches with the rural industry sectors and rural communities to work through voluntary mechanisms (Codes of Conduct, Audited Self Management (ASM) schemes, adaptive management) to implement good management practise.

Future Directions

Further improvement in management of diffuse pollution needs attention by science and by government agencies at several scales of policy and regulation, by industry and by communities in catchments.

Science attention should focus on:

- Definition of pollutant pathways
- Understanding of attenuation mechanisms (including for targeting BMPs)
- Modelling spatial extent, levels and sources of 'manageable loads', with user accessibility to models fostered to maximise information transfer
- Assess effectiveness of BMPs, taking natural spatial variability into account

Policy, Regulation, incentives and community actions in relation to water resources in New Zealand are currently being re-examined by several agencies (Land and Water Forum, 2010).

These include:

- National objective setting, including national environmental standards, is needed to ensure consistency of values and approaches.
- Setting of regional standards based on values of receiving waters in a spatial context, and on system time lags. Setting limits (and targets if there is a need to claw back diffuse pollution) is currently a mechanism that regulators have to reduce cumulative impacts of land use and prevent further diffuse pollution at catchment scales.
- Work with industry landowners and catchment stakeholders, increasingly in ICM-type frameworks, to promote mitigation methods and local-scale management (incentives, BMPs, audited self management, community restoration schemes). ■

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World Water Monitoring Day

Susannah Peddie – Policy & Projects Advisor, Water New Zealand

Based on the premise that clean water is everyone's right, and also everyone's responsibility, World Water Monitoring Day (WWMD) is an international education and outreach programme that aims to build public awareness and involvement in protection of water resources around the world. It does this by encouraging groups and communities to conduct basic monitoring of their local water bodies, and then report their findings back to the WWMD database.

The first World Water Monitoring Day was created by the Clean Water Foundation in America to mark the 30th anniversary of the Clean Water Act. The event included monitoring and education programmes, and was so successful it prompted the Foundation to partner with the International Water Association (IWA) to create a global monitoring event. The programme is now coordinated by the IWA and the Water Environment Federation. While World Water Monitoring Day is officially celebrated on 18 September each year, the programme encourages monitoring anytime from 22 March until 31 December.

> "The WWMD programme is beneficial for education and awareness, but is also useful in that results are helping to create a comprehensive data set for water bodies around the globe."

Simple water sampling kits can be ordered from WWMD and enable participants to sample their local water bodies for four key water quality indicators: dissolved oxygen, pH, temperature and turbidity. Some groups also monitor for the presence of macroinvertebrates. Last year 212,502 participants from 85 countries contributed WWMD data, and the programme continues to grow from year to year.

In 2009 WWMD started an annual Water Champion Award Competition, to honour participants in each region around the globe who have boosted awareness of water quality issues via the programme.

The WWMD programme is beneficial for education and awareness, but is also useful in that results are helping to create a comprehensive data set for water bodies around the globe. On the WWMD website it is possible to view the data collection sites, and view and compare monitoring data.

Water New Zealand has been a partner for World Water Monitoring Day since 2008, actively promoting the programme in New Zealand. If you would like to learn more about WWMD and how you or any individuals or groups you know can get involved, please contact *Water New Zealand* or see the WWMD website (www.wwmd.org) for more information.

Auckland Supercity – One Year On

Hon Rodney Hide – Minister of Local Government

Rodney Hide

The first of November marks the one year anniversary of one council for Auckland – an important milestone. It was the largest local amalgamation ever attempted in Australasia and I'm happy to be taking a look back at what has been achieved.

When I became Minister of Local Government, I knew that designing and implementing a single local government structure for the whole of Auckland would be a big job. In my early days in the portfolio, I spoke with many of Auckland's councils, community groups, businesses and interest groups, setting out what I loved about Auckland and what I wanted the Auckland governance reforms to achieve.

I'm as passionate today about Auckland as I was then. Auckland's natural beauty, diversity and get up and go is amazing. It's a great place to live and work. My commitment to Auckland drove my mission to enable Auckland to reach its full potential. I approached the work on Auckland with one simple goal: making Auckland even better.

The reforms were critical for Auckland's future and for New Zealand's future.

Auckland is the only city in New Zealand positioned to take on a globally-connected city role. Already it is showing a number of characteristics of a strong international city. It is New Zealand's international gateway, with our main port and airport. But the Government has always believed Auckland has strong potential to significantly improve its productivity and rate of productivity growth.

A country's international competitiveness increasingly relies on the competitiveness of its major cities. Cities have to attract businesses and investment which in turn support innovation, growth and the specialised skill sets that underpin the export of goods and services. Cities must also offer an attractive lifestyle, not only to attract the skilled international workers we need, but also to ensure talented Kiwis choose to stay here and drive our economy. The future success of New Zealand – its economy, its people, and its international reputation – are dependent on the success of Auckland – more so than ever before.

For more than 50 years, Auckland's ability to develop and prosper had been hindered by duplicated services, competing leadership, complex and fragmented decision-making processes, factionalism and weak accountability. The fragmented governance structure was responsible for an abundance of red tape, which impacted adversely on both business and Auckland's diverse communities. Auckland lacked a vision which united the whole region and brought out the best from it.

A Royal Commission spent 18 months considering what was wrong with Auckland governance and how to fix it. It received a large number of submissions from Aucklanders expressing their frustration over the sheer amount of regulatory red tape, the cost of complying with different district plans across the region, poor services and high costs.

The Commission's report boiled down to two key points: the system of governance was weak and fragmented; and its structure resulted in poor engagement between local authorities and communities. The eight councils lacked a collective sense of purpose and did not have the ability to effectively implement solutions for the wellbeing of greater Auckland.

The Commission laid out the challenges: address the inefficiencies; ensure effective service delivery through a united governance structure; address the poor history of Auckland's infrastructure development; and get greater community involvement.

Addressing these was an enormous task, but one that excited me as Minister of Local Government.

We had the opportunity to finally get the regional governance arrangements, and the relationship between Auckland and Wellington, right and working well. And to make changes which would create the environment for future improvements, regardless of who was actually holding the reigns of power, locally or centrally. With a system in place that allowed local government in Auckland to represent the interests of the entire Auckland region and foster a common identity and purpose across the region, the city could make great bounds forward.

Planning and delivering the Auckland Council took enormous effort and cooperation from Ministers, council staff, officials in both central and local government and from Mark Ford and the Auckland Transition Agency. It was clear to the Government that Auckland's future depended on critical decisions being taken at a regional level. We had to get it right and we had to have a transition process that ensured there would be no loss of service.

The whole thing was only possible because of the good will and hard work of all those involved – council staff and elected representatives, government officials, and Ministers.

I am very proud of what has been accomplished. The Government delivered – on time and under budget. We now have one Mayor and one council, where previously there were eight. There were eight long-term plans, five water and wastewater companies and seven district plans. Now we have just one of each.

I wanted the Auckland Council to focus on providing a service culture for the people of Auckland, and from day one the Council delivered. Training and induction processes during the transition concentrated on ensuring staff were well prepared to meet customer needs. That's a credit to the ability and commitment of the Auckland Council staff, which shouldn't be underestimated. Running a city the size of Auckland is a busy job, and in its first year, the Auckland Council has been very busy.

In the first six months, the Council issued over 8.5 million library items, took 1.5 million customer service calls and made 55,000 building inspections. $144 million has been delivered in savings, with a rates increase of only 3.94 per cent.

I'm very pleased that resource consent forms have been streamlined and reduced from around 850 to 120 and that they are available online. The first rates notices have recently gone out and ratepayers will have noticed that they only have one rates bill instead of two. The Council has also standardised fees at the lowest level and halved the previous 60 different categories of dog licence.

The Council now has the largest library group in Australasia, giving Aucklanders access to 3.5 million items. Aucklanders can now use their library cards at any of the 55 libraries and four mobile libraries in the region.

In a period of enormous change the Council maintained all critical services for Aucklanders and kept the quality high.

Among the most critical services are those relating to the three waters. This was an area we spent a lot of time and care to get right.

The Royal Commission on Auckland Governance had recommended that all water supply and sewage treatment services for Auckland should be provided by Watercare Services Ltd, as a

> "The Government has taken an active interest in the Auckland Plan, as it is very committed to Auckland and its development."

council-controlled organisation. That recommendation was based on Watercare's already existing regional functions across Auckland and its high level of operation.

After reviewing the options and the rationale for the Royal Commission's recommendation the Government decided to accept it and Watercare became responsible for the integrated water supply and wastewater services to the Auckland region on 1 November 2010.

Watercare is required by the Local Government (Auckland Council) Act 2009 to manage its operations efficiently with a view to keeping water costs to its customers at minimum levels.

After 2015 the Auckland Council, in consultation with its communities, will be able to decide how water supply and sewage treatment services are provided.

The benefits of those decisions for Aucklanders are already becoming evident.

Beginning 1 July 2011, the price of drinking water across metropolitan Auckland dropped on average 20 per cent. Watercare has assured me they will be ever mindful of their requirement to be a low cost provider that cannot return dividends or surpluses to its shareholder.

But the savings and efficiencies, though certainly welcome, weren't the point of the reform. The purpose of the reform was to substantially improve the governance of our largest city. With the help of Aucklanders, the Council is now poised to make real, lasting improvements, which never would have been possible before. For example, the work on the waterfront and on the CBD has been needed for some time, but had to wait till there was a council sufficiently empowered to do the job.

These changes will result in a strengthened and integrated governance structure for Auckland. As a unitary authority, the Council will now be able to make critical regional decisions to move Auckland forward and foster common regional identity and purpose.

For example, transport has always been a major challenge for Auckland and is the most significant area of shared expenditure between the Government and the Auckland Council. Auckland Transport has replaced the previous nine transport entities and we have, for the first time, a coherent, region-wide approach to solving Auckland's transport issues.

No more endless disagreements about the location and funding of regional amenities and the provision of necessary infrastructure. These issues were stuck in the mire of competing local agendas, but are now moving forward and being resolved.

Local decision-making on transport now rests with a single body. There will be no more costly duplication of functions with eight rating authorities and a multitude of differing bylaws. When Auckland needs to act as one, it will be able to.

I'm excited about Auckland's potential, and admire the Council's determination to make a positive difference. Mayor Len Brown deserves enormous credit for his leadership, positivity and focus on Auckland's future. Auckland governance needed fixing and Len has not shied away from the challenge. Len and his Council have presented a bold vision for Auckland's future and I greatly look forward to seeing how Auckland develops under their watch.

Recently, the Council released four draft plans for public consultation: the Auckland Plan, Economic Development Strategy, City Centre Masterplan and Waterfront Plan. Together they set out the Council's long-term vision for the city's and the region's future. I hope Aucklanders take the time to look at the plans and make a submission.

The Auckland Plan is the first plan of its type in New Zealand – a spatial plan. The Auckland Plan sets out the Council's vision for developing Auckland over the next 20 to 30 years. Spatial planning, although new to New Zealand, is a key strategic planning tool used by governments and local governments across Europe, North America, Australia and Asia.

The Plan will guide the location and sequencing of major infrastructure, listing the major infrastructure projects planned for the next 30 years to identify the existing and future location and mix of critical infrastructure, services and investment within Auckland, including those services relating to water supply, wastewater and stormwater.

The Government has taken an active interest in the Auckland Plan, as it is very committed to Auckland and its development. The decisions made in the Plan will have implications for both the Council and the Government, and the prosperity of Auckland will contribute to the potential of the country as a whole. The spatial plan process has the potential to improve Auckland's economic performance, urban form, liveability and affordability of housing, and to contribute to New Zealand's economic, environmental, social and cultural prosperity.

The Auckland Plan, and the other plans released alongside it, mark the first time that local government has been able to plan effectively for the whole of Auckland. The fact that they were produced in 10 months, and to such a high standard, is extraordinary. Nowhere in the world has this been achieved. I'm also very pleased with how the Government, the Council and officials have worked together throughout the process.

The advent of a single Auckland Council also marks a new chapter in Auckland's relationship with central government. While respecting Auckland Council's autonomy, the Government has a strong interest in Auckland's success and its contribution to New Zealand's success. The Government won't always agree with the Council, but has welcomed the opportunity to discuss, and make progress on, issues of shared interest.

Having seen the leadership and enthusiasm of Len and his Council, the commitment and dedication of Council staff, and the vision evident in the draft Auckland Plan, it's already clear to me that Auckland Council is operating at a level of confidence, cohesion and cooperation not possible under the previous governance structure.

Auckland, we got it right. ■

Scientific and Engineering Applications of Weather Radar in New Zealand

Luke Sutherland-Stacey, Paul Shucksmith & Geoff Austin – Physics Department, University of Auckland

Introduction

Accurate measurement of rainfall is important in a diverse range of civil engineering fields. In New Zealand, best practice for most engineering hydrological and hydraulic application involves use of rain gauge measurements, possibly from an existing network (or single gauge) or a temporary network deployed for a particular project. These rain gauge measurements might be used to drive a complex surface hydrological model coupled to a hydraulic pipe or channel model, or simply used to derive a time to concentration relationship for a catchment where the outflow is also monitored.

A major source of engineering risk associated with designs based rain gauge networks stems from uncertainty in the representivity of rain gauge derived accumulations. It is well understood that a short gauge record may not sample a long enough period of meteorological events to capture infrequent high intensity storms, and considerable engineering margins are usually added to designs to account for 50, 100 or 500 year return period events which are unlikely to have been directly observed.

A less well understood source of representivity error in rain gauge measurements is the uncertainty associated with the spatial separation between gauges usually being very large compared to the characteristic length scales of meteorological systems. Relatively small scale precipitating systems such as individual convective cells or structures imbedded in large scale rain fields can easily fit between even the densest rain gauge networks and deliver significant precipitation which may go unrecorded.

In large catchments this spatial sampling effect can be somewhat mitigated by averaging over long enough time periods, however in catchments with short time to concentration characteristics there is not enough time for this to be practicable. Small steep catchments often also experience significant orographic enhancement of precipitation (whereby air masses forced up and over terrain dump their moisture faster than over flat terrain). In the most extreme cases a catchment may flood due to a rapid and localised intense precipitation from a thunderstorm but not record any accumulation in a rain gauge.

One approach to alleviate the uncertainty introduced by the coarse spatial sampling characteristics of rain gauges is to simply populate a catchment with additional gauges. However this can have prohibitive cost, particularly as each gauge must be maintained regularly. In the case of steep or forested catchments it may also be difficult to distribute gauges uniformly over a catchment (World Meteorological Organisation guidelines recommend gauges be deployed to flat sites far away from trees to overcome wind shear and shadowing effects).

Alternatively, other sources of precipitation measurements can be sought. The most widely used remote-sensing technique for precipitation is weather radar technology. As the term 'radio detection and ranging' suggests radar systems use an electromagnetic signal to determine spatial distribution of fields.

At a conceptual level a weather radar can be described as electromagnetic resonator which can periodically deliver a brief pulse of centimetre wavelength microwave energy to a parabolic dish. The dish in turn focuses the pulse into a 'pencil beam' along a particular path through the atmosphere. As the pulse of radiation travels outwards it is scattered strongly by anything with comparable or greater size to the radiation wavelength, including rain droplets. A fraction of this scattered radiation returns to the dish and based on dish pointing information and the time between the initial pulse and returned signal a map of 'reflectors' near the radar can be constructed.

The reflectivity signal (Z) is a volume sample of all the rain drops within a radar beam's volume, so conversion to rainfall rate (R) is accomplished with the so-called Z-R relationship which makes assumptions about the size distribution of small and large raindrops. A Z-R relationship of $Z=200R^{1.6}$ was first proposed by Marshal and Palmer (1948) and is still in wide use today.

Weather Radars in New Zealand

New Zealand is well served by a national radar network run by the Meteorological Service (NZ MetService Ltd). The radar network comprises of (at the time of publication) seven Doppler C-band (wavelengths ranging between 5.34–5.40cm) radars, which provide coverage of the majority of the populated areas in the country (Figure 2). A notable exception to the coverage of the radar network is the West Coast of the South Island. The intervening Southern Alps (some 3000m high) block line of sight for the two radars on the East Coast of the South Island. The lack of radar observations on the West Coast is of scientific and meteorological concern, as this region experiences the highest annual rainfall accumulations in New Zealand, due to strong orographic forcing (Henderson M. 1999). The situation is also not ideal for support of weather forecasting in the South Island as the majority of precipitating weather systems approach from the west, so lead time of radar observations is reduced in the South Island compared to the North Island. An eighth radar, scheduled to be commissioned near Greymouth in late 2011, is expected to ameliorate this shortcoming.

Each radar in the national radar network records reflectivity data at up to 300km range. Because the path followed by a radar beam is nearly a straight line (it is bent slightly by variations in the refractive index of the atmosphere) and the earth is spherical, the radar beam climbs as it travels and at maximum range is incident on a region of the atmosphere many kilometres above the ground. This beam overshooting effect means that the maximum effective range of any radar is actually limited by the curvature of the earth and the variation in precipitation structure with height. As a rule of thumb even very powerful radars have trouble generating quantitative precipitation estimates beyond about 125km in range. Figure 1 is a typical cross-section of a convective cell and is indicative of the representivity problems when attempting to relate precipitation images aloft to that arriving at the ground.

If a particular catchment of interest is outside of the QPE range of a conventional weather radar then a small portable radar, like those constructed and run by the University of Auckland Atmospheric Physics Group (UOAAPG), can be utilised instead. The radars have much lower power than their larger fixed-in-place counterparts (and a maximum range of only 20km) but have the advantage that they can be relocated easily to observe catchments or events of interest. For example the group deployed to Mount Ruapehu in 1996 to make radar observations of the erupting plume. Photographs of two different University of Auckland portable radar designs are given in Figure 3.

National Radar Example: TC Wilma

The national radar network is particularly well suited for the observation of large scale severe weather. At the end of January 2011 a tropical cyclone was predicted to pass close to and possibly

"At a conceptual level a weather radar can be described as electromagnetic resonator which can periodically deliver a brief pulse of centimetre wavelength microwave energy to a parabolic dish. The dish in turn focuses the pulse into a 'pencil beam' along a particular path through the atmosphere."

make landfall over the northern and eastern parts of New Zealand, although the cyclone lost power and was downgraded to a severe depression before ultimately only glancing the East Coast (Figure 2).

Nonetheless a significant amount of precipitation fell in only a short space of time. The national radars imaged the passage of the remnants of Wilma and an accumulation map can be generated to indicate the ability of the radars to measure the accumulation delivered to the eastern region of the North Island (Figure 4). For a comparison, rain gauge accumulations from the national climate database (CliFlo) run by the National Institute of Water and Atmospheric Research have also been plotted and indicate a good agreement between radar and in-situ measurements. The radar measurements however provide a better estimate of the spatial distribution of precipitation.

Real-time data of severe weather is an important and useful tool for civil defence managers as it allows for the flood risk situation to be constantly assessed. Spatially resolved data from radars, if suitably quality controlled in real time, can also be ingested into regional flood models to provide additional decision making support. Retrospectively, the data is useful for assessing hydrological risks and understanding the meteorological situation.

Portable Radar Example: Waipapa Catchment

Small portable rain-radars represent an easily accessible data collection resource for engineering end-users who for a variety of reasons may not have access to adequate rainfall information. Deployment of a small radar can be useful to characterise the hydrological behaviour of catchments with short time to concentration. Often such catchments appear to behave unpredictably when observed with coarser rainfall measurement techniques.

In the winters of 2008 and 2009 the UOAAPG undertook a one month *proof of principle* field study, followed by a three month extended study, near the Waipapa Catchment in the central North Island. The aim of the project was to collect data to aid in the understanding of the catchment behaviour.

The catchment is hilly of some 15x10km in physical extent and drains into the Waikato River. Indicative recession times after modest rain events (~10mm/hr) are some 12 hours during which the Waipapa river flow can double from a base of about 6cumec. The catchment is gauged at its outlet, and the installation also includes a rain gauge, the only one nearby, which has been used operationally as indicative of rain falling into the catchment. There are clearly representivity problems associated with this assumption, and the installation of a temporary radar was used to test the validity of using a sparse gauge network for this application.

The radar was sited overlooking the catchment and operated in a high resolution rapid update scanning mode. A new image was available every 30 seconds and disseminated in real time via a web interface. The accuracy of the radar for measurement of surface rainfall rates was tested by first converting the radar reflectivity signal into rainfall rate and then making point wise comparisons to local rain gauges. The matchup was at times excellent (Figure 6). The uncertainties arising when converting between an electromagnetic response like radar reflectivity and an engineering unit like accumulation should not be understated. As discussed earlier, difficulties arise due to the variability in reflector shape and composition – review of the statistical comparison for this field work can be found in Sutherland-Stacey (2011).

It is immediately apparent from the data that significant spatial and temporal variability exists in the rain fields. In the example in Figure 5, heavy showers traverse the study area from the north west and deliver significant accumulations to localised areas of the catchment. These intense localised features are the origin of the apparent unpredictability of the catchment – the single observing rain gauge is unable to form a representative sample of the rainfall amount within the time to concentration of the catchment. In the case of Figure 5, for example, the gauge at the catchment outlet measures initially very little rain despite the showers in the upper reaches of the catchment, so modelling based on the rain gauge measurements results in too little outflow, too late.

Concluding Remarks

End users of rainfall data in New Zealand are well served by the existing National radar network in addition to access to mobile radars for specialised research projects or case studies. However even with computer driven design and modelling becoming increasingly ubiquitous in modern engineering practice, it still remains something of an unsolved problem to make use of large radar datasets to supplement or replace conventional observations from rain gauges in everyday engineering. ■

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Marshall, J. S. & W. M. Palmer (1948) The Distribution Of Raindrops With Size. Journal of Meteorology, 5, 165–166.

Sutherland-Stacey, L., G. Austin & P. Shucksmith (2011) A mobile rain radar for high resolution hydrological observations in New Zealand. New Zealand Journal of Hydrology, 50, 339–360.

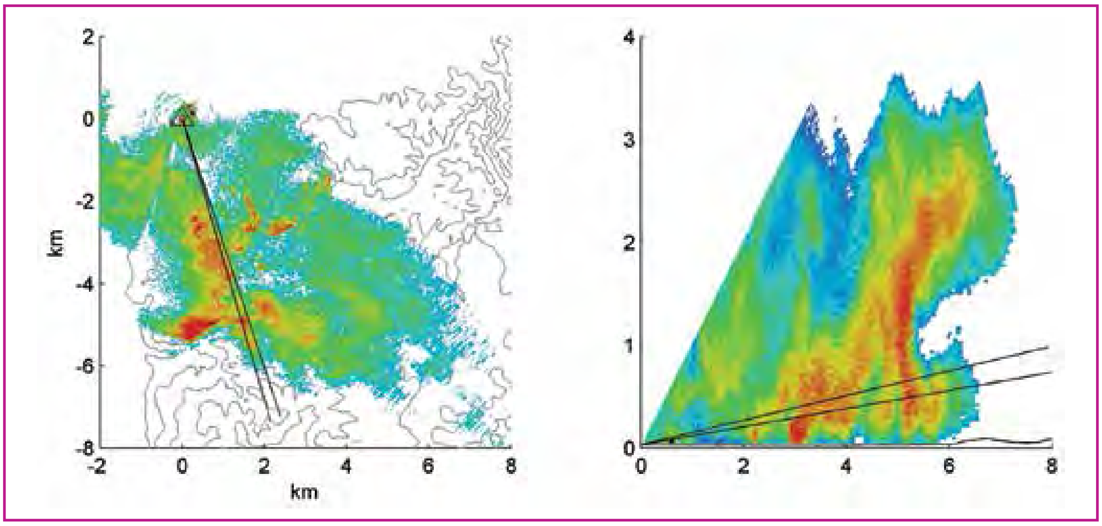


Figure 1 – (left) Example of a plan position indicator (PPI) scan. The radar location is indicated (Δ) along with a wedge (solid lines) along which a vertical profile, known as a range height indicator (RHI), scan has been made (right). An equivalent wedge in the RHI image indicates the slice through which the PPI passes. Note the significant variability in the vertical, particularly above 1km altitude.

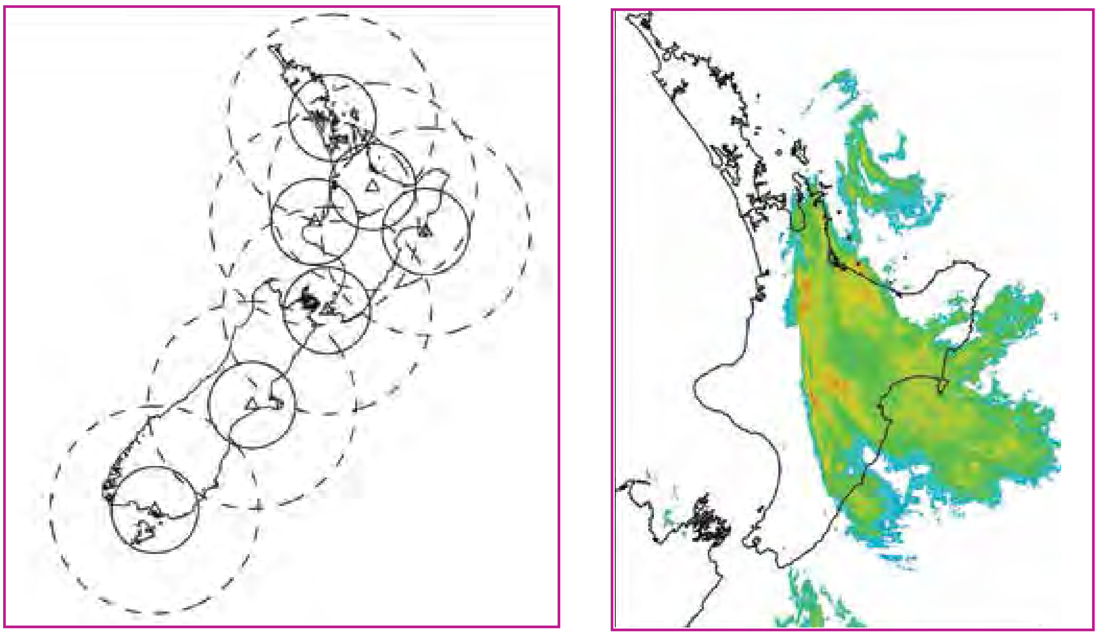


Figure 2 – (left) Location of the existing C-band weather radars (Δ), range for quantitative precipitation estimation (solid lines) and the maximum range for which the radars collect data (dashed lines) is also indicated. (Right) Composite radar reflectivity image obtained during the passage of ex-TC Wilma, 2011/01/28 16:15. The vortex is resolved as a circular structure off the Coromandel peninsula.]

Figure 3 – University of Auckland radars. (Top) Constructed in a shipping container and sited overlooking a hydro power catchment in the Snowy Mountains of Australia (photo courtesy Andrew Peace). (Above) A towable trailer mounted radar overlooking the Waipapa catchment near the Waikato River.

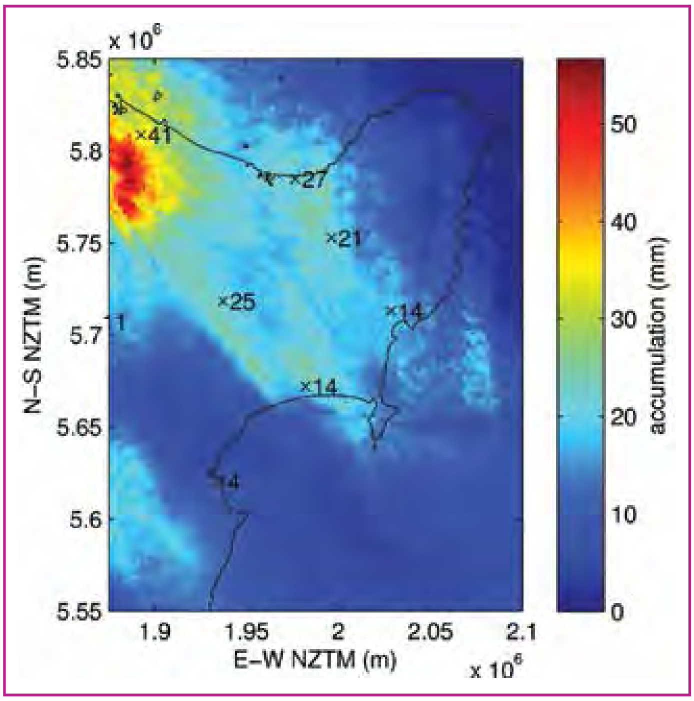


Figure 4 – Two hour rainfall accumulation generated from a national radar network reflectivity composite during the passage of ex-TC Wilma valid 2011/01/28 1200–1400 UTC. Rainfall accumulations for the same period recorded by rain gauges in the national climate database are also indicated.

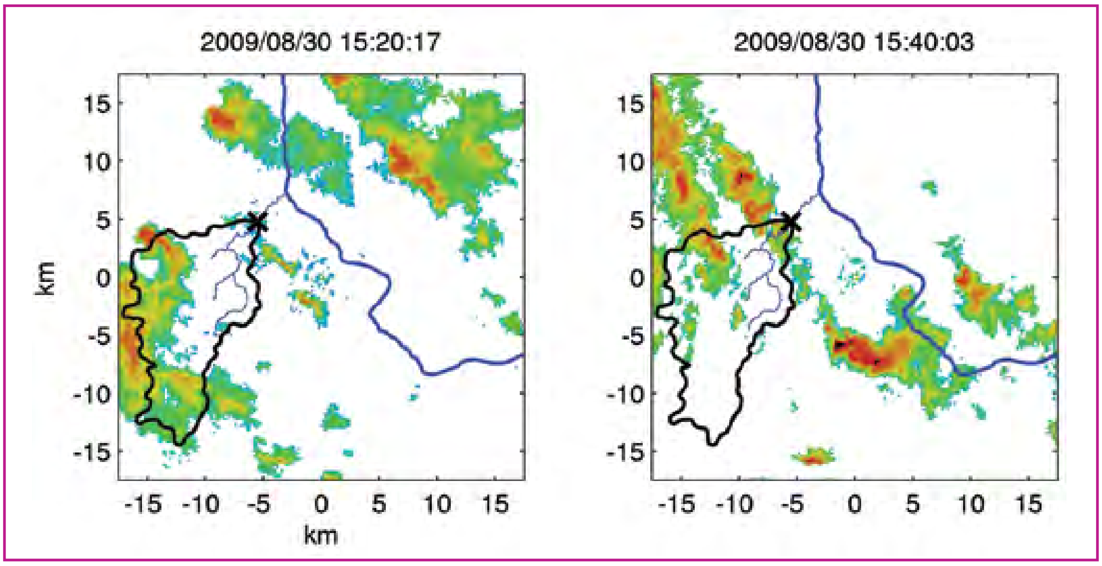


Figure 5 – Two radar reflectivity images generated with the UOAAPG trailer radar. The Waipapa catchment is indicated with solid black line, the Waikato river solid blue and the Wapiapa tributary in a weaker line. The location of the catchment rain gauge is indicated (×).

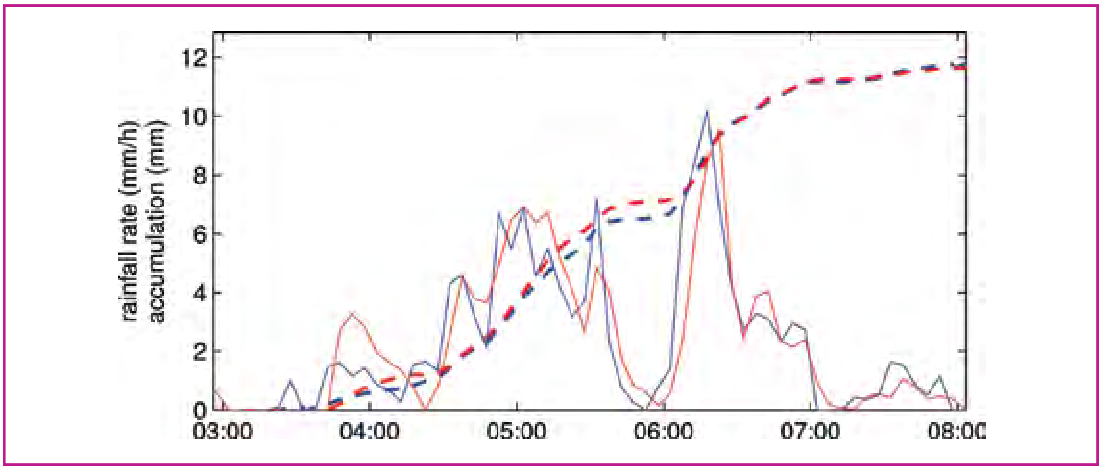


Figure 6 – Comparison between radar derived (solid blue) and drop counting gauge (solid red) rainfall rates and accumulations (dashed).

Earthquake Proof Polyethylene Pipe to Replace Pressure Mains for Christchurch

Shaun Cawood – CEO, RX Plastics

Dealing with the challenges of repairing and replacing large parts of Christchurch's drinking water, wastewater and stormwater systems following the devastating earthquakes in September 2010, February 2011 and June 2011 has been the highest priority of Christchurch City Council infrastructure arm, CCHL.

When priorities shifted from emergency repairs after the September quake, to longer term replacing and rebuilding of the largely PVC pressure mains, sewage pipes and stormwater, it became apparent that newer technologies and materials needed to be employed.

With the far more devastating earthquake of 22 February, much of the repair work included re-fixing areas of pipe that had already been repaired following September's event.

Of Christchurch's 1858km of street sewer pipes, approximately 300km suffered earthquake damage. Ten of the city's 97 pumping stations tasked with pushing wastewater through to the treatment plant were damaged and pressure pipes from 13 of the pumping stations were so badly damaged they are being completely replaced.

According to Phil Gatehouse, Sales and Marketing Manager of Ashburton based pipe manufacturer, RX Plastics, CCHL managed contractor City Care and its consultants have spent a significant amount of time researching internationally, to come up with the best materials and technologies to 'earthquake proof' the city's pressure water systems.

"North American research demonstrates that polyethylene (PE) piping is the most effective material for underground infrastructure, due to the fact that it will stretch and move with the ground. PE is ideally laid in long lengths with the minimum number of joins, and is restrained from end to end, but totally elastic in between. If the valves move, the pipe will take it, whereas PVC pipe will break rather than move."

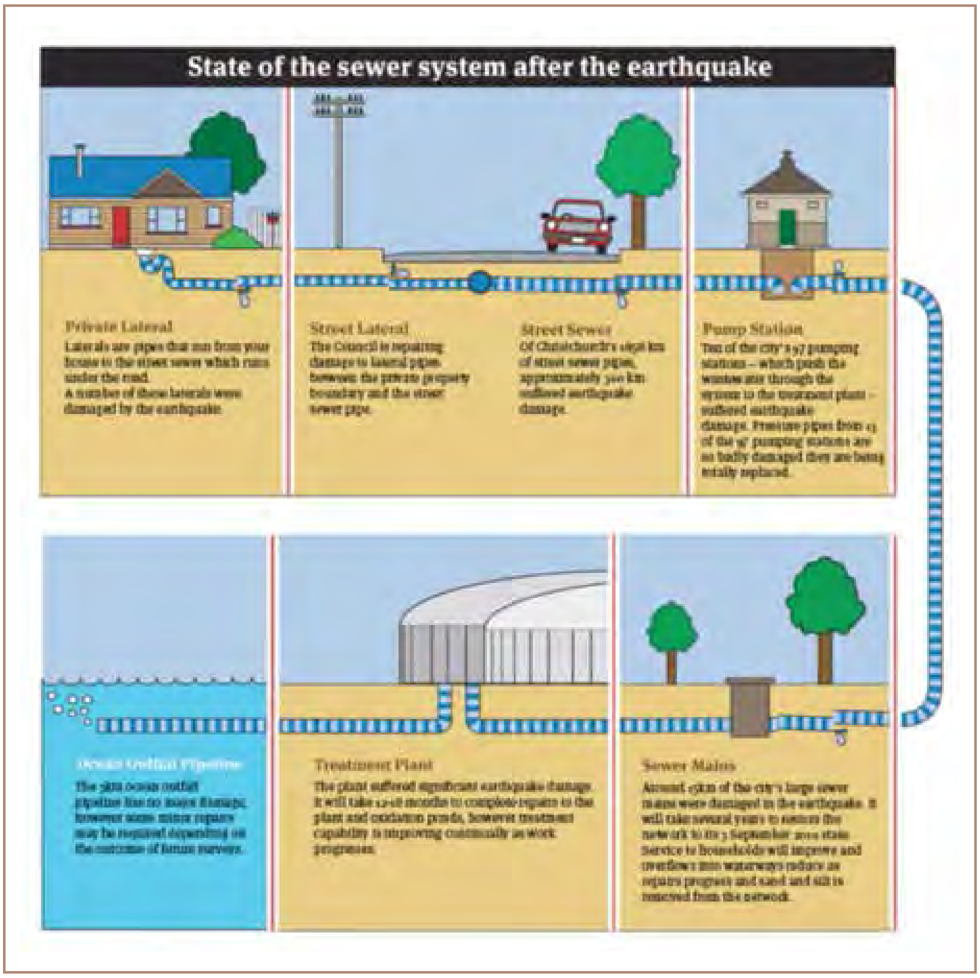
> "Of Christchurch's 1858km of street sewer pipes, approximately 300km suffered earthquake damage."

PVC pipe or the older asbestos cement pipe is very brittle, and so ends up cracking or breaking when the earth moves.

"A large percentage of the existing Christchurch infrastructure is PVC pipe, and contractors here have more than 30 years' experience laying PVC pipe," Gatehouse comments.

The biggest challenge faced by contractors experienced in working with PVC, when they started laying PE pipe as part of the repair work, was the inexperience of their staff in doing electrofusion and buttwelding to ensure perfectly formed PE joints.

"Cleanliness is next to godliness when it comes to PE joints," Gatehouse says. "If the joints are clean and properly welded, then PE can give an excellent result that will last for up to 100 years of asset life. If the joints are not clean, then often there will be no successful result at all."



Following on from further damage on 22 February to areas that had already been repaired, a stringent set of standards was issued by the Council, specifying the materials to be used as well as the requirements for training of contractor's staff laying the pipe.

"RX is one of a number of companies supplying the PE pipe for the rebuild, and we have invested a significant amount of time and resource into complying with the Council's standards.

"The standards include ISO certification, independent auditing of standards around the manufacture of the pipe and use of virgin raw materials.

"Manufacturers are also expected to prove that our product is suitable for electrofusion and buttwelding. The council has recognised that PE is a far better earthquake proof material, and they are looking for surety as they rebuild the city's infrastructure."

With the change in Council requirements, contractors are now more than ever before being asked to use PE as a pipe solution rather than traditional PVC for many subdivisions, and that is placing a fresh set of challenges onto those contractors.

Given that manufacturers are all complying with the Council's standards and the potential for installation issues, "Major repair work is now starting in parts of Halswell and in many other parts of Christchurch, repairing the most significantly damaged areas from the September earthquake. A large PE pipeline was also laid in Redcliffs to get water supplies back online for residents following the 22 February event, but Gatehouse says the majority of the infrastructure rebuilding work is expected to gain momentum over the next six months."

the Council is now requiring their contractors to have certification in buttwelding and electrofusion.

Major repair work is now starting in parts of Halswell and in many other parts of Christchurch, repairing the most significantly damaged areas from the September earthquake. A large PE pipeline was also laid in Redcliffs to get water supplies back online for residents following the 22 February event, but Gatehouse says the majority of the infrastructure rebuilding work is expected to gain momentum over the next six months.

PE will be used for all pressure mains supplying drinking water and large size PE will be used for pressure sewer pipe, which will be pumped rather than gravity fed as it is at present. The stormwater system will remain in PVC pipe.

Lessons from earthquakes elsewhere in the world have helped to inform decisions in Christchurch. The frequently quoted Kobe earthquake was also used as a benchmark for Christchurch. One of the major issues in relation to earthquakes is the high incidence of fire, which makes failure of water mains a major issue.

Once again, the ability of PE pipe to move in the ground means that emergency services would still have access to vital water supplies to control post-quake fires resulting from gas leaks and sparks from above ground power lines.

Gatehouse says RX is working closely with its resellers who are organising contracts and tenders for different aspects of the projects.

Overall, management of the infrastructure rebuild has been placed in the hands of a public private alliance, which will contract the work out to five contracting companies – Fulton Hogan, Downer Construction, Fletcher Construction, McConnell Dowell and City Care.

The process of permanently rebuilding roads, sewerage and water infrastructure, is expected to take up to five years and has a budget of $2.5 billion, funded by the Council, the NZ Transport Agency, insurers and the Government.

In addition to the supply of PE and PVC piping, RX has been working with the Council around the supply of individual wastewater units in the form of pump chambers, now that some properties have dropped below the depth of the sewage pipes.

The pump chambers take sewage from the house, then pump to the nearest sewage pump station. There is also need to provide septic tank solutions for homes inside the city's red zone which don't currently have working wastewater systems. ■

Water New Zealand Conferences & Events

2012 *Water New Zealand* Stormwater Conference

10 – 11 November 2011

Amora Hotel, Wellington, New Zealand

The Stormwater Special Interest Group in conjunction with the Modelling Special Interest group of *Water New Zealand* and the Rivers group are in the planning stages for the *Water New Zealand* Stormwater Conference 2012.For more information visit www.waternz.org.nz/stormwater_conference.html

Other Conferences

Asia Water 2012 – 7th ASIAWATER Expo & Forum

27 – 29 March 2012

Kuala Lumpur Convention Centre, Malaysia

For more information visit www.asiawater.merebo.com

Australian Water Association – OzWater Association

8 – 10 May 2012

Sydney Convention and Exhibition Centre, Darling Harbour, Sydney, Australia

For more information visit www.awa.org

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