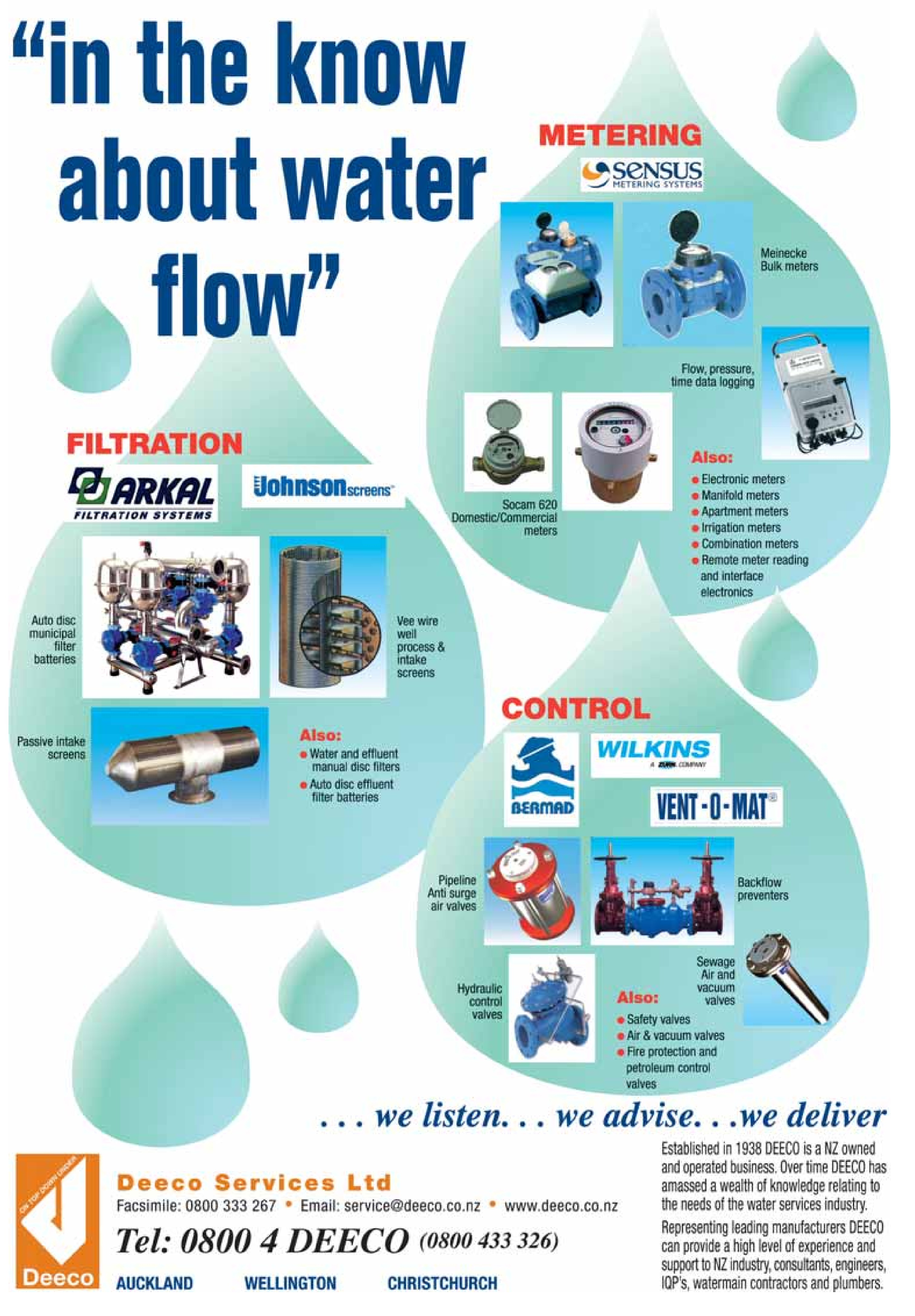
WATER

Issue 175. July 2012

Water New Zealand's Annual Conference & Expo 2012 Update – Register Now!

Turning Wine into Water

water NEW ZEALAND
The New Zealand Water & Wastes Association



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

WATER

On the Cover

Water New Zealand News

Features and Articles

Cover photo: iStock.com

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

Clive Rundle

President's Column

I thought I would use my column this month to share a concern I have about the way we are approaching the development of safe water supplies in New Zealand. I have recently heard speakers describing the work they have been doing with their communities to determine what improvements to make to their water supplies.

The decision whether to invest in capital works to protect public health rests with councilors and community groups and the view that 'our water supply is fine' can sometimes prevail. In simple terms they are saying 'we think that our water is safe enough and we don't think it is worth the cost of meeting the drinking water standards'. I find these outcomes a bit disturbing.

I'm sure this process is consistent with the consultative principles of the LGA, and it seems to be permitted by our rather toothless water legislation, but is this the right way to make such decisions affecting public health? Are these decisions in the right hands?

Those of you that know me, will know that I have worked almost exclusively in the potable water treatment field during my career (I seldom stray to the 'dark side' if you know what I mean!). Despite this, I would not take it upon myself to determine the 'safe' concentration of a contaminant – I refer to the Ministry of Health's drinking water standards and the advisors to the Ministry who have been tasked with determining what an appropriately safe water quality is for New Zealand.

But even the Ministry itself does not rely on its own knowledge to judge such weighty matters. It in turn relies on the guidance of authorities like the World Health Organisation and the USEPA. Even they rely on research organisations whose budgets can often run into millions to determine what a safe concentration of a contaminant is and what is not.

> "Council officers in local government organisations in New Zealand have always impressed me with their strong public service ethos. Their desire to serve the local community is highly commendable and I am confident that they are advocates for effective water treatment and advise their political masters accordingly."

So is it reasonable for these matters to be left to well-intentioned elected representatives and communities to decide for themselves? We don't ask them to set the safe blood alcohol limit or food safety standards. Neither should we expect them to have the knowledge to judge acceptable water quality.

Council officers in local government organisations in New Zealand have always impressed me with their strong public service ethos. Their desire to serve the local community is highly commendable and I am confident that they are advocates for effective water treatment and advise their political masters accordingly. But if we accept the recently released LECG report findings, there are still an estimated 35,000 cases of acute gastrointestinal illness from networked drinking water in New Zealand each year due to non-compliance with the Standards.

Let's hope that in the current local government reform process we can not only preserve that valuable public service ethos, but also provide these fellow water supply professionals with the legislative framework needed to secure the necessary funding for these 'core services' and to enable them to insist on doing the right thing to protect public health in their communities. ■

Clive Rundle
President, Water New Zealand

NEXT ISSUE OF *WATER*

The next issue of *WATER* will be in mailboxes mid-September.

The topics for the September issue will be Urban Metering, Demand Management, Governance and Training and Recruitment.

If you wish to contribute an article or photos please contact the editor, Robert Brewer, on +64 4 473 8054 or email robert@avenues.co.nz

The deadline to submit material is 12 August 2012.

new members

Water New Zealand welcomes the following new members:

CHRISTOPHER MILLER
TREVOR STUTHRIDGE
KRIS KASER
HUGH POPE
DAVID COUTTS
STEVE CUTFIELD
ROBIN GARDENBROEK
RUSSELL BRENTS
MYLES LIND
GARY MEYER
MARION SAVILL
MURRAY WASHINGTON
RICHARD THOMAS
GRAEME WILD
DIANNE QUAN
CAM TOMLIN
BARRY CARTER
MURRAY ENGLAND
KENNY WILLIAMSON
DAVE MACCOLL
IAN FRASER
TIM URE
SAM WANG
FIONA RAYNER

Murray Gibb

Water Quality and Leadership

"As a country we have grappled with appropriate policy responses to declining water quality for the last decade."

The current arrangements for water management in New Zealand were put in place over twenty years ago. In the intervening period we have struggled to meet community expectations round water quality, which has declined in the face of intensification of land use. The scale of rural intensification has meant that its relative contribution to declining water quality has been greater than that from urban land use.

Farmers in New Zealand and elsewhere across the globe have responded to declining commodity prices in a number of ways including increasing rates of fertiliser application. Locally this has been used in dairying, allowing for increased stocking rates, total numbers and production.

It is fashionable to decry the environmental consequences of increasing the national dairy herd without thinking through the alternatives, or considering the global context.

The fact of the matter is that we have to trade with the rest of the world. Cars, cellphones, computers and plasma television sets don't grow on trees. They have to be imported. In order to be able to buy imported goods and services we have to trade with the rest of the world, by selling into the international marketplace.

With the notable exception of the late Sir Paul Callaghan, very few commentators have publicly debated the consequences of not growing the dairy industry in the last two decades. He quite rightly pointed out that the tradable sector's proportionate share of gross domestic production was held flat only through dairying's expansion.

How much less good quality public infrastructure, that we as a nation enjoy today, would we have been able to afford, if the dairy industry hadn't filled the gap left by a relative decline in other traded goods and services?

Beating ourselves up over the consequences is a pointless exercise. Declining water quality is a global phenomenon, and a predictable consequence of policy not keeping pace with an entirely logical response by farmers to demands from consumers for more food at cheaper prices.

When all is said and done there is a finite quantity of natural resources; land and freshwater, from which to feed a burgeoning and increasingly urbanised global population achieving higher living standards.

That is not to say we shouldn't deal with the consequences. We should, and in New Zealand's case we are fortunate that we can. Intensification within sustainable limits is the goal. It is not an oxymoron. Internationally the challenges lie with both water quantity and quality. We are one of the few net food exporters not facing challenges around absolute water availability. New Zealanders abstract only a tiny proportion of annual water runoff quantity. Most of our productive use of water is rain fed.

As a country we have grappled with appropriate policy responses to declining water quality for the last decade. It has only been in the last three years, since the Government introduced its *Fresh Start for Freshwater* policy initiative that signs of progress have emerged.

Competing interests with different objectives for water have put it into the wicked problem category. Wicked problems require innovative solutions. The Land and Water Forum's latest report proposes innovative solutions. It offers a package of recommendations which, if implemented, would provide a circuit breaker to improved management.

Its second report for the year, due for release in September will address water allocation and transfer, and make recommendations around a water strategy. A strategic, rather than the piecemeal approach occurring at present, can do no worse than our performance to date. It is certainly worth trying.

The Land and Water Forum has recommended ways of setting absolute limits on water quality. It is sorely needed, both in making rules at a regional level and in dealing with cumulative effects. The Government has made it clear that it places great store in the Forum and its recommendations.

Urban water infrastructure is also in the spotlight. There is a serious question mark round the ability of some suppliers to upgrade drinking water and wastewater infrastructure to meet regulated standards. In the new policy environment all consent holders for discharges, be they rural or urban, will have to work within absolute limits.

So what has made the difference in the past three years? The single ingredient missing was leadership. Former Minister, the Hon Dr Nick Smith, along with the Minister for Primary Industries, the Hon David Carter, went out on a limb and batted for the *Fresh Start for Freshwater* policy initiative.

Dr Smith can also take credit for the Better Local Government reform package which, amongst other things, will result in a review of the efficiency of local government infrastructure provision. This effectively picks up on recommendations from the original Land and Water Forum report of September 2010.

Reform is in the air. It is long overdue. ■

Murray Gibb
Chief Executive, Water New Zealand

REGISTER NOW!

Conference Registration

Registration is now open for *Water New Zealand's* Annual Conference & Expo 2012 at www.waternz.org.nz

The preliminary Conference programme is now on the website. For a preview of all presentations on offer in 2012 go to www.waternz.org.nz/annualconference_current.html

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

Early Bird Registration

Be sure to register before 3 August to take advantage of the Earlybird discount available on your registration fees.

Corporate Package Registration

Make the most of the substantial discount available for groups of five or more attendees from the same organisation. Register your group early to ensure your organisation receives the great discounts. This offer closes on 3 August 2012.

Conference Theme and Programme

The core theme of the Conference is ***'Water Challenges & Opportunities'***.

There will be on offer over 90 presentations covering every aspect of the water environment and its management.

The conference will have three primary streams plus full Modelling and Operations streams. Also included this year, the ASTT Trenchless Technology stream – on trenchless technology issues, and the IWA Stream – focusing on leading-edge science relevant to the water sector.

This year's Conference will follow the same format as 2011 with two full days of presentations on Wednesday and Thursday. The *Water New Zealand* AGM and panel discussion will be held on Friday morning along with the exhibitor visitor morning, a great opportunity for exhibitor/client meetings.

Poster Presentations

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

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

All completed posters must be sent by Monday 30 July to: Amy Jackson, *Water New Zealand* Conference, c/– Avenues Event Management, PO Box 10-612, Wellington, New Zealand or email: waternz@avenues.co.nz

Networking Opportunities

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

To view the programme and read more about the social functions at the Conference visit: www.waternz.org.nz/annualconference.html

- **Welcome Reception**
  Wednesday 26 September
- **INNOVYZE Modelling Dinner**
  Wednesday 26 September
- **Applied Instruments Group Operations Dinner**
  Wednesday 26 September
- **Conference Dinner and Awards Presentation**
  Thursday 27 September

Water New Zealand Awards 2012

The following awards will be presented at the 2012 conference:

- Hynds Paper of the Year Award
- CH2M Beca Young Water Professional of the Year
- AWT Poster Award
- Ronald Hicks Memorial Award
- Opus Trainee of the Year
- Orica Chemnet Operations Prize

Call for Nominations for 2012 Awards

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

Closing dates for nomination are:

17 August: The Ronald Hicks Memorial Award

24 August: CH2M Beca Young Water Professional of the Year

24 August: Opus, Trainee of the Year

CH2M Beca Young Water Professional of the Year Award

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

To download the CH2M Beca Young Water Professional of the Year nomination form visit the awards page: www.waternz.org.nz/annualconference_awards.html

Orica Chemnet Operations Prize

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

Send nominations and a short explanation of why you think your nominee should be the recipient of the prize to Peter Whitehouse at *Water New Zealand*. Email peter.whitehouse@waternz.org.nz or phone Peter on +64 4 495 0895.

Opus Trainee of the Year Award

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

Send nominations and a short summary of why you think the trainee in question should receive the prize to Peter Whitehouse at *Water New Zealand*. Email peter.whitehouse@waternz.org.nz or phone Peter on +64 4 495 0895.

The definition and scope of each award, the criteria for selection, along with the nomination processes and timelines for submission can be found at www.waternz.org.nz/annualconference_awards.html

Water New Zealand Awards Committee

Call for nominations for Honorary Life Membership of *Water New Zealand* to be presented at the Conference Awards Dinner is now open. Send nominations to Hannah Smith, *Water New Zealand* Board Secretary, hannah.smith@waternz.org.nz by 5.00pm on Wednesday 1 August 2012.

Water New Zealand Annual General Meeting – Early Notification

The *Water New Zealand* 2012 AGM will take place at 9.00am on Friday 28 September 2012 at the Conference venue, Energy Events Centre, Rotorua.

To meet constitutional deadlines any notices of motion for this meeting must be supplied to the Chief Executive by 5.00pm on Friday 24 August 2012.

Water New Zealand Board Election – Call for Nominations

Nominations for election to the Board of *Water New Zealand* will be called on Friday 20 July 2012. The closing date for nominations is Thursday 9 August at 5.00pm. The Board comprises six elected members and may include two co-opted members. Members are elected for three-year terms. This year two positions are available. Sitting members Clive Rundle and Mark Bourne retire by rotation.

Members contemplating standing for the Board may wish to discuss the role and responsibilities of directors with sitting members of the Board.

If you have any queries please contact the association secretary, Hannah Smith on +64 4 495 0897 or email hannah.smith@waternz.org.nz

KEY DATES FOR YOUR DIARY

3 August	Earlybird and Corporate Package Registrations Close

KEY DIARY DATES FOR PRESENTERS

30 July	Poster Abstracts Due
2 August	Authors/Presenters – Final Papers Due
14 September	Authors/Presenters – Powerpoint Presentations Due

Keynote Speaker Profiles

Hon Amy Adams

Minister for the Environment

Minister Adams became a Member of Parliament at the 2008 General Election and represents the large Canterbury electorate of Selwyn. She has served as Chairperson of both the Finance and Expenditure and Electoral Legislation select committees and as a member of the Justice and Electoral and Regulations Review Committees

Minister Adams was appointed Minister for the Environment following the resignation of Nick Smith earlier this year. She is a qualified lawyer having graduated from Canterbury University with first class honours.

Before being elected to Parliament Minister Adams was a partner with Mortlock McCormack Law in Christchurch specialising in commercial and property law. She is a previous member of the CDLS Property Law committee and the NZ Law Society's Women's Consultative Group and the Institute of Directors.

Minister Adams lives in Aylesbury, with her husband Don and their two children, on their 600 acre sheep and crop farm. She was re-elected in 2011 with a majority of 19,450 votes.

Professor Torkil Clausen

Water Policy Adviser to the DHI Group; Chair of the Scientific Programme Committee for the World Water Week, Stockholm; Senior Adviser to the Global Water Partnership and Advisor to the Water Resources Department of Lao PDR

Professor Clausen currently serves on a number of national and international committees and boards, including Chair of the Flood Management Programme of the World Meteorological Organisation, Member of the Asia-Pacific Steering Group on Water and Climate Change, Chair of the World Bank Environmental and Social Panel of Experts for the proposed Rogun Dam in Tajikistan, and Chair of the Expert Panel for the Africa Water and Climate Development Programme.

He received the King Hassan II Great World Water Prize at the 4th World Water Forum in Mexico 2006. The Prize was used to create the "Women's Water Fund" to promote women's careers in water management.

Previously he has been Deputy CEO of the DHI Group, Founding Chair of Danish Water Forum, Senior Adviser to UNEP, Founding Chair of the GWP Technical Committee, CEO of the Danish Water Quality Institute, and Counsellor in the Danish Ministry of Foreign Affairs/Danida. He has degrees in hydrology (MSc) and water resources (PhD).

Invited Speaker Profiles

Nigel Broomhall

Energy & Utilities Industry Solution Executive – IBM New Zealand

Nigel is tasked with bringing relevant global IBM solutions into the New Zealand market, to challenge current thinking, share work already underway around the world, and provide thought leadership to the energy and utilities industries. With a science background from Canterbury, and a passion for innovation and creativity, he likes to take on large challenges. It was this attitude that led him to merge water and electricity data together in Canterbury to provide farmers with a cost per litre for water, and to lead the carboNZero certification of the Meridian Energy Group of companies.

Dr Joel Byrnes

Associate Director – AECOM

Dr Byrnes holds a PhD in economics and specialises in providing advice to clients on policy and regulatory issues relating to the urban water sector in Australia.

Prior to commencing his consulting career Joel was an academic economist, teaching a wide range of economic subjects, and publishing widely on water resource and local government matters. His PhD thesis examined the relative economic efficiency of water and wastewater utilities in regional NSW and Victoria, and proposed a number of reforms to improve the performance of utilities serving communities in regional Australia.

Joel is currently an adjunct Professor at LaTrobe University in Victoria, where he is an active member of the Centre for Water Management and Policy. He is also a member of the Centre for Local Government at the University of New England, where he sits on the editorial board.

Phil Gurnsey

Associate Planning – Beca

Phil has over 20 years' experience in resource management at both local and central government through his time consulting in Dunedin, with Environment Canterbury, as a policy manager at the Ministry for the Environment, as an adviser in the Office of the Minister for the Environment and Climate Change Issues, and now with Beca in Wellington.

Phil trained as a planner and has led reforms of the Resource Management Act (RMA), the response to Christchurch air pollution and co-ordinated the whole-of-government programme on climate change. He has also worked across many policy areas including water reform.

He was an adviser to the Waikato River Clean Up Trust in the evaluation of funding of applications to the Waikato River Clean Up Fund in 2011/12.

David Hamilton

Professor – Department of Biological Sciences, University of Waikato

David Hamilton was the inaugural appointment to the Bay of Plenty Regional Council Chair in Lake Restoration at Waikato University in 2002 and holds this position today. David obtained his PhD from Otago University, studying a series of South Island lakes, and has expanded his research interests to include algal bloom phenomena, nutrient dynamics and model applications for management of lake ecosystems. He was one of four scientists who initiated the Global Lake Ecological Observatory Network (GLEON) in 2005. He also initiated the ecological model CAEDYM, which has been applied to aquatic systems in more than 70 countries. David spent 12 years at the University of Western Australia where he was involved in lake and reservoir projects in Israel, USA, Malaysia and Italy, as well Australia. In 2010 Hamilton received the New Zealand Freshwater Sciences Society Medal for Excellence for outstanding contributions to freshwater science.

Latu Sauluitoga Kupa

Executive Director – Pacific Water and Wastes Association

A former Managing Director of Samoa Water Authority (SWA), Latu left SWA in 2003 and set up his own engineering consultancy firm called KEW Consult Limited. He currently heads the Pacific Water and Wastes Association Secretariat Office in Apia, which provides capacity building assistance and support to 21 Pacific Island Water and Wastewater Utilities.

Latu has had a lengthy involvement with SPC-SOPAC and more recently, through having established partnerships with UN-Habitat Global Water Operators Association, Australian Water Association and Water New Zealand. Latu gained a Bachelor of Engineering (Mechanical) from Canterbury University in 1989 and is a member of the Institute of Professional Engineers of Samoa as well as the Institute of Professional Engineers of New Zealand.

Mike Paine

CEO – Southern Water

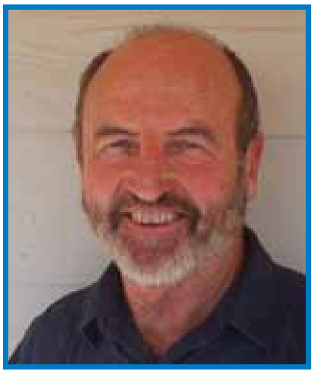
Before being appointed as CEO of Tasmanian organisation Southern Water, Mike was CEO of Cradle Mountain Water from 2008 to 2010.

Before this, Mike was General Manager of Customers and Communication at Geelong-based Barwon Water and before that was CEO of Westernport Regional Water Authority, south east of Melbourne. Mike has a Bachelor of Civil Engineering from the University of Queensland and a Graduate Diploma in Engineering (Municipal Management). He is a Fellow of the Institute of Engineers and a member of the Australian Institute of Company Directors.

Dr Stephen Palmer

Public Health Physician

Dr Palmer graduated from Otago University with a basic medical degree in 1982. He trained in public health medicine in the late 1980s and became vocationally registered in 1990. He became Medical Officer of Health for Greater Wellington in 1993 and works mostly works in environmental health and liquor licensing. For the last five years he has been involved in the Community Water Fluoridation issue and helped set up the National Fluoride Information Service within Hutt Valley DHB.



Steve Posselt

Civil Engineer, Australia

Steve has been a civil engineer in the water industry since 1971, during which time he has been involved in many aspects of the business. In 2007 he started adventuring with his three wheeled kayak after selling his successful manufacturing business that he started from scratch. He was out of the industry for three years but in 2010 he started back in manufacturing with fellow enthusiasts of fabricated flow control equipment, such as penstocks and slide gates.

From the early eighties until 2006 Steve was active in the Australian Water Association and maintains a keen interest in everything water. From time to time he is a climate change activist and occasionally despairs at much of society's rejection of robust science.

Gregory Priest

Project Manager – Sustainability, Australian Water Association (AWA)

Greg is the Australian Water Association's Sustainability Program Manager, managing the delivery of the Australian and New Zealand Biosolids Partnership and AWA's Industry Sustainability Programme. Greg's role is to assist the Australian Water Sector to address corporate sustainability and climate change matters and provides a conduit for the development of membership knowledge and skills development.

Greg has an academic background in Environmental Science and prior to joining AWA, Greg worked in various Australia Commonwealth and State Government roles, advising on sustainability policy and developing industry capacity building resources.

Role for the Trade and Industrial Waste Forum

New Zealand Trade and Industrial Waste Forum's annual conference is being held this year in Wellington from 8–10 August. Details on the programme and registration details can be found at www.confer.co.nz/tiwf

Water New Zealand supports the Forum and what it seeks to achieve. The vision for the Forum is very clear.

Set up in 2011, the NZTIWF aims to provide a focus for discussion on the management of liquid waste streams from the agricultural and processing industries that support New Zealand's economic base.

There are several drivers for doing so.

Firstly, there has been no readily available fit for purpose forum for debate and information exchange on this subject in either New Zealand or Australia. Community expectations round protection of the environment, particularly freshwater, are high. New Zealanders consistently rank freshwater quality as their number one environmental concern, ahead even of climate change. It is water, above all, that nourishes our economy.

Secondly, in an increasingly resource-constrained world, sustainable management of our natural resource capital is becoming more important. What were formerly regarded as waste streams are increasingly being looked on as valuable by-products providing feedstock material for further processing for both trade and industrial use.

Thirdly, for a first world country New Zealand runs on an unusual economic model, based mainly on biological production. Our competitive edge internationally is determined by the success of our tradable sector. Of our twenty top exports over 80 per cent by value are currently derived from primary biological production.

Put differently, without our dairying, forestry, meat, horticultural and fishing providing feed stocks, we would have negligible export processing industrial capacity. All these industries run economically because we have water that is abundant, essentially free and clean. If any one of these factors deteriorate or is lost we lose our competitive edge.

So it is important that we process the waste streams from our primary processing industries cleanly and sustainably. Our international reputation depends on it.

The Board sees the New Zealand Trade and Industrial Waste Forum as providing a vehicle for discussion on improving New Zealand Inc.'s performance in processing our biological industrial output. Effective dialogue between all stake holders is critical. There is much to do. ■

Annual Membership Subscriptions Due Soon

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

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

> 6.2 *All subscriptions shall be payable to the Association on demand. Any member for whom an annual subscription has not been paid within ninety days of demand will automatically be removed from the membership list of the Association, with the loss of rights arising from affiliation with other organisations.*

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

New Software Package for *Water New Zealand*

The office is currently upgrading its operational system and website functionality to Cyberglue Memberconnex. *Water New Zealand* uses a separate membership database, website, and financial package for collating information relating to members and for interacting with members.

At its April meeting the Board approved the purchase of the Member Relationship Management system (MRM) which will combine all our current systems in to one fully operational system and is designed specifically for membership organisations. The new system will allow interaction, from both members and non-members and will allow Staff, Board, and SIG's to remotely access the system.

One advantage of the system for members is the ability to pay membership subscriptions and change contact details online. It is hoped to be up and running shortly and members will be advised when it goes live.

New Staff – Appointment of Technical Coordinator

Dr David Edmonds

Water New Zealand has appointed a senior civil engineer, Dr David Edmonds, to the newly created position of Technical Coordinator. This position has been created in order to boost the technical output from the Association. This is a core objective.

In addition to its events programme and promotion of training, the Association produces and publishes technical guidelines, codes of practice and educational material. It also runs a variety of projects, for example an annual performance review for local network operators and a wastewater information database (the latter in conjunction with the Ministry for the Environment). There is an on-going need to revise and update this technical output and produce new material.

Dr Edmonds spent over 30 years at Opus International Consultants (formerly Ministry of Works and Development) culminating as Manager, Business and Strategic Planning. Earlier roles included Manager, Central Laboratories, Chief Materials Investigating Engineer, and Senior Design Engineer (Materials). His discipline is civil/structural engineering, which he carried through to PhD level. More recently he has been Solid Waste Manager at the Porirua City Council.

Commenting on Dr Edmonds appointment, Chief Executive Murray Gibb said that *Water New Zealand* was delighted to secure a person of his calibre to the position.

"David Edmonds brings a wealth of experience to the role. *Water New Zealand*'s nationwide network of members represent many disciplines including physical and social sciences, public health, engineering, law and management."

"With decision makers and technologists from central and local government, industry, the academic and research communities, consultants and service/equipment supply organisations as members, *Water New Zealand* has a vast pool of expertise from which to gather, collate and publish technical water related information. Marrying this with a person with Dr Edmonds' expertise will boost our output," he said.

Water New Zealand Member Contact Details

Please advise us if you changed contact details recently. An accurate database depends on the supply of timely and accurate information.

Contact: Stephanie Berlips
P: +64 4 472 8925, E: stephanie.berlips@waternz.org.nz

Details can be updated on line at www.waternz.org.nz/forms/changeofdetails/changeofdetails.html

A couple of screen shots from the WEF's WATER'S WORTH IT™ campaign video taken at the Indianapolis Speedway during the Indianapolis 500 in May 2012.

WEF Makes a Splash at the Indy 500

Garry Macdonald – Water New Zealand WEF Director/ WEF Board Member

WEF's WATER'S WORTH IT™ campaign has really taken off – this time at the world-famous Indianapolis Speedway and the 2012 running of the Indy 500. In May this year, WEF had the opportunity to deliver the WATER'S WORTH IT™ message to the hundreds of thousands of race fans attending the Indianapolis 500, the world's largest single-day spectator sporting event.

The 30-second public service announcement, which was shown on a large screen at the entrance of the Indianapolis Motor Speedway, can be viewed at www.WatersWorthIt.org

A growing number of utilities, WEF Member Associations, and other water organisations are using the WATER'S WORTH IT™ public messaging campaign with their constituencies. In addition, five new fact sheets – highlighting the campaign's core focus areas of respect, effort, passion, health, and future – have been added to the General Public section of the WATER'S WORTH IT™ website.

"Feedback since the March 22 campaign launch has been overwhelmingly positive," said Lori Harrison, WEF director of public information.

"We're hearing from both large and small organisations how WATER'S WORTH IT™ is making a big difference in their outreach efforts."

"Some Member Associations have also incorporated WATER'S WORTH IT™ into their websites and annual conferences while other creative uses of the messaging include truck decals and postal stamps."

"Since the campaign is designed to either complement existing public information materials or stand on its own, "the sky's really the limit" on how it can be used," Harrison said.

WEF Executive Director, Jeff Eger says that it's time water took its rightful place in the national conversation.

"It's an issue that demands attention, understanding, and support. WATER'S WORTH IT™ was created to address that compelling need and to raise the profile of the water professionals who are on the front lines every day protecting public health and the environment."

"We're hearing from both large and small organisations how WATER'S WORTH IT™ is making a big difference in their outreach efforts."

WEF is taking a proactive stance in making sure that this simple message resounds across the country in local and national political fora, so that elected officials recognise the its fundamental importance to all parts of the national and global economy. This message is equally important in all countries and communities – and Water New Zealand is certainly picking up its own "water's worth it" baton through continued involvement in the Land and Water Forum and interactions with local and central government.

The campaign website www.watersworthit.org – is a one-stop-shop for free, customisable materials such as fact sheets and brochures, as well as preprinted merchandise such as buttons, stickers, and Tshirts. WEF regularly updates the WATER'S WORTH IT™ website with new materials.

I encourage all of you to visit the website. ■

For further information contact Garry Macdonald, Water NZ WEF Director/WEF Board Member, garry.macdonald@beca.com

On-Site Wastewater Systems Maintenance Guidelines for Homeowners – Protecting Your Health, Your Environment, Your Investment

Rob Potts – CPG for SWANS-SIG

In February 2012, Water New Zealand's Small Wastewater and Natural Systems Special Interest Group (SWAN-SIG) released maintenance guidelines to assist homeowners with their individual on-site systems. These on-site systems have commonly and incorrectly been referred to in the past as Septic Tanks.

Modern systems are significantly more advanced than the early primary treatment systems and are now more akin to the type of system you would find at community sewage treatment plants in many towns or cities. These community plants often have full or part-time operators and a fully developed and functional Operating and Maintenance Manual. However, owners of dwellings with their own on-site systems are generally left to their own devices unless a maintenance contract is specified on a building or resource consent condition.

The new maintenance booklet walks the on-site system owner through the following:

- The type of system installed on their property. For those who don't know, it helps them through a detailed methodology to identify what type of treatment system they may have, from older septic tank to advanced activated sludge or filter type system.
- It identifies the places where User Guidelines or information on the system may be found, as well as listing standard Do's and Don'ts.
- It outlines inspection and maintenance requirements based on the type of system identified, i.e. how often inspections and standard maintenance should be undertaken for the treatment unit, the distribution system and the land dispersal system.
- It outlines simple tasks the homeowner can undertake if they are a DYI type person. There are some good photos identifying various components to assist the homeowner.
- It then outlines the tasks that should be performed by a Servicing Agent or Contractor and the sort of certificate they should provide to satisfy compliance with Council maintenance conditions.

"Modern systems are significantly more advanced than the early primary treatment systems and are now more akin to the type of system you would find at community sewage treatment plants in many towns or cities. These community plants often have full or part-time operators and a fully developed and functional Operating and Maintenance Manual."

The guidelines are simple and should be widely distributed. Please access the link below and either print off the guidelines and provide to people in your community with on-site systems or pass on to them the link details.

If you are at a Council, please print out the guidelines and make them available at your reception and provide them along with new building or resource consents. Note the photos are best if you print them in colour.

The new Maintenance Guidelines are supplementary to the "ON-SITE WASTEWATER SYSTEMS Information Booklet for Homeowners Selecting a System for your Property" publication.

Top left – Servicing an advanced wastewater treatment unit, Top right – Checking scum and sludge levels in a septic tank, Above – Maintaining an on-site wastewater system

Both publications can be found on the *Water New Zealand* website: www.waternz.org.nz/swans.html along with other useful information, such as links to:

- Effluent quality trial results of on-site systems (OSET)
- On Site NewZ blog
- Directory of On-site Suppliers
- Past SWAN-SIG newsletters

Letter to the Editor

Optimising Flood Infrastructure Design

In the latest *WATER* issue (May 2012 p.30), the article by Nadia Nitsche and Otto Ursem claims that 2D modelling is superior to 1D modelling because "These 2D models are able to predict the flooding more effectively by removing the subjectivity the modeller needs to apply to 1D models and allows the surface to determine the path the overland flow will take. Another major assumption of all previous 1D modelling is that all the surface water can get into the drainage system if capacity is available."

With respect to overland flow paths, a contour map (technically a 1D terrain model) leaves very little subjectivity for the modeller, as the contours can be placed as accurately as the ground survey allows. In the case of catchpits, placement within 1cm horizontally is supported by most 1D modelling packages.

In contrast, the modeller must make a subjective decision as to which 2D grid the catchpit joins, with consequences as to the grid cell mean elevation which sets the ground surface at the inlet. Grid cells may be as large as 2m x 2m, as used in the paper by Vaakesan et al (2012). In this case the road gutter is poorly resolved, and consequent inlet flow errors may be significant, especially after allowing for wetting and drying levels for flow computation.

"This is obviously a topic of some interest and we encourage the lively debate of 1D modelling vs. 1D/2D modelling."

With respect to the claim about the "major assumption of all previous 1D modelling", clearly the authors are unaware of the 1987 version of Australian Rainfall and Runoff p. 303, in which Section 14.5.4 (iii) is headed "Pit Entry Capacities". This subsection then summarises extensive research into the limitations imposed by catchpit geometry on flows into the primary drainage system, and recommends weir-type structures for modelling the flow links, at least at shallow upstream depths.

Accordingly, in the original model of the Auckland CBD flow (see Barnett and MacMurray (1995)) exchanges through catchpits between primary and secondary flow paths were governed by weirs meeting ARR specifications, and the third Conclusion read "Because secondary flows result from overflow or rejection of inflow at drainage inlets, they must be analysed in combination with the primary flows in the subsurface drainage network."

Further, it would appear from Vaakesan et al. that the catchpit coupling model described had severe limitations, such as an inability to specify separate incoming and outgoing flow regulations. Therefore that model was not even up to the standard recommended by 1987 ARR specifications. Other problems identified were "artificial water generation" and "model instability and large computation times." Run times of hours or even days were quoted, as against complete runs of 1D-based models in a few seconds.

Far from superseding all previous 1D modelling, this evidence does not even support 2D modelling as competent to obtain timely, reliable solutions! ■

Dr Alastair Barnett – FIPENZ

References

Barnett A.G. and MacMurray H.L. "A fundamental new analysis of urban drainage using control element lifetime locus integral theory" Proc. IPENZ Transactions, Vol. 22, No. 1/CE Nov. 1995, pp 17–24

Vaakesan et al. "Hydrodynamically Coupled Stormwater Model of the Auckland Central Business District" Proceedings, Stormwater 2012, Wellington

Nadia Nitsche and Onno Ursem Reply:

This is obviously a topic of some interest and we encourage the lively debate of 1D modelling vs. 1D/2D modelling. Thanks to Dr Barnett for his letter.

It is our view that regardless of 1D or 2D, the model should be built to define the characteristics of a problem and represent the reality. With this in mind, we have used the 1D/2D modelling in our example to understand the issues around the inletting of the overland flow path into the system. The initial historical 1D model applied did not illustrate the problems of inletting issues that the operational staff raised. We found that by using the 1D/2D coupled model we were able to better define these issues in a more efficient manner.

When undertaking this modelling, we took into account recent research of catchpit capacities in Auckland and internationally (Maunsell, 2008). We also considered the recommendations that have been put forward by Vaakesan et al.'s (2012) work on coupled modelling.

A model will always have certain limitations and assumptions associated with it and for that reason it is the user who is ultimately responsible for understanding assumptions and sense-checking results. With this in mind we have found that for the demonstrated example we were able to use the 1D/2D coupled model more effectively than 1D alone.

We do appreciate Dr Barnett's thoughts. From both views it is evident that the consideration of exchanges through catchpits between both primary and secondary flow paths are important and may be the next step forward in urban modelling. ■

Nadia Nitsche and Onno Ursem – Planning and Modelling Team, AECOM

References

Vaakesan et al. "Hydrodynamically Coupled Stormwater Model of the Auckland Central Business District" Proceedings, Stormwater 2012, Wellington

Maunsell "Stormwater Collection Improvements Study" Metrowater, 2008, Auckland

Water – A View from the Beehive

Hon Amy Adams – Minister for the Environment

Hon Amy Adams

***WATER* invited the new Minister for the Environment, Hon Amy Adams, to outline her thoughts and approaches to water, its management and importance to New Zealand. Below is Hon Adam's View from the Beehive.**

Freshwater is what gives our $11 billion a year dairy industry its competitive advantage. It is pivotal to our clean, green brand and our $8 billion a year tourism industry.

Add in the contribution to our meat, horticulture, cropping, freshwater aquaculture and wine industries and we are looking at more than $30 billion per year. Water is to New Zealand what minerals are to Australia. Managed wisely, our freshwater resource is available in perpetuity.

> "New Zealand must be globally competitive, not just in the quality of our products, but for the environmental-integrity of our production systems."

But our freshwater is much more than an economic resource. It is what makes our great kiwi lifestyle – the fishing, swimming, kayaking and rafting. We all have our favourite lake or river.

The realisation, though, that we are not doing as well as we should in managing this resource, has been growing for two decades. Water quality, still amongst the best internationally, is showing signs of deterioration.

The regions and communities that make up this great country are very diverse. But we do have many issues in common, especially around the way we all want to use, enjoy, benefit from and protect our natural resources, today and for future generations.

Fresh water is a key strategic and productive asset for New Zealand. Maintaining and improving our water quality is one of the Government's environmental priorities, and a key objective of the current water reforms.

That's why the Government commissioned the Land and Water Forum to look into these issues.

The Forum brings together a range of industry groups, environmental and recreational, non-governmental organisations, iwi, scientists, and other organisations with a stake in freshwater and land management.

Two reports have been delivered to the Government, the most recent of which on fresh water governance, just last month. This second report will help establish clearer national direction on how councils set objectives and limits for fresh water quality and quantity, in line with the National Policy Statement introduced by the Government last year.

The Forum's report also considers how communities can have more say on setting those objectives through the greater use of collaborative processes. I have been impressed with the way the Forum members, who represent very diverse interests, have worked together to tackle often highly contentious issues.

There is plenty to consider in this report, including how the recommendations could be progressed within the wider work the Government is doing to reform the resource management system.

The Forum will prepare a third report later in the year. The Government will then be in a position to develop durable policies on fresh water management, based on the complete package of recommendations.

The Environment Ministry is also considering how our freshwater reforms fit into the wider reform of the resource management system. The Government wants environmentally-responsible economic progress in a way that supports our future growth.

New Zealand must be globally competitive, not just in the quality of our products, but for the environmental-integrity of our production systems. We need infrastructure that supports this ambition.

To make progress we must work together to develop the best possible solution, and then ensure it is implemented in a cost-effective and timely way.

> "Time and again critical decisions about water – for example, around infrastructure – have been shunted into the too-hard basket, when they require long-term thinking, funding and commitment."

Decisions on who gets access to vital natural resources such as water shouldn't be driven by who got in first, or who has the best lawyer or the most money. Instead, we need to weigh long-term economic and environmental outcomes, as well as community needs.

Time and again critical decisions about water – for example, around infrastructure – have been shunted into the too-hard basket, when they require long-term thinking, funding and commitment.

The Government recognises this. In Budget 2011, we allocated $35 million over five years to support the development of regional-scale rural water infrastructure proposals to an investment-ready stage.

The first successful applicant was the Hawke's Bay Regional Council for $1.67 million to look at whether a water storage project on the Ruataniwha Plains is feasible and affordable.

Another $70,000 will co-fund the design and preparation of a contract for an extension of the Tilverstowe irrigation scheme in North Otago.

For New Zealand to succeed, we can't keep saying no to infrastructure projects because they involve change.

The process should instead focus on fairly balancing all competing interests. To build New Zealand's productivity we need to be more innovative, think beyond personal interests to wider community and national interests, and do it fast.

We are a nation whose prosperity depends on our environment-based industries.

For that reason the Government is committed to providing leadership in finding an appropriate balance between economic and environmental outcomes.

I hope we can all work constructively together to position New Zealand as a global leader where environmental values are intrinsic to economic development. ■

Review Proposes Changes to Water Industry Qualifications Pathway

Stephanie Robertson – Communications Advisor, AgITO

Qualifications in the water sector are currently being reviewed as part of the New Zealand Qualifications Authority's (NZQA) Targeted Review of Qualifications. The purpose of the review is to ensure qualifications meet the needs of their sector and it focuses on reducing duplication of qualifications and ensuring the qualification system is easy to understand, particularly for trainees and employers.

The Water Working Group is being led by Martyn Simpson, with support from Governance Group member Cliff Olsen and Review Co-ordinators Rob McCrone and Fiona Beardslee. It consists of all existing water, wastewater and irrigation qualifications, with water reticulation qualifications to be reviewed in the Civil Works Cluster later this year.

The Water Working Group, made up of 18 people from across the water industry, had its initial meeting in Wellington on 16 March. Martyn Simpson, training adviser for Water Industry Training and Working Group leader, says that as a result of that meeting the group was able to develop a report for NZQA.

"We have completed a water industry overview and report into the industry, existing qualifications and job roles. We have identified the skills and knowledge attributed to these roles and have identified gaps in qualifications and training, the appropriate levels for qualifications suitable for each role and a training pathway for people entering the industry right through to advanced supervisory and management roles."

The water industry was asked for feedback on the report in a consultation period that water working group finished in June.

"We consulted the wider industry to get feedback on report and industry overview. We have saved feedback to collate which will be considered alongside the report," Martyn says. "There may be alterations to the report depending on industry feedback."

The review will ensure that all qualifications are aligned with new rules for listing qualifications on the New Zealand Qualifications Framework (NZQF). This means that no existing qualifications will be retained as they currently exist. Those found well suited to their purpose will be converted to meet the new rules, which include clear descriptions of what a graduate is expected to know and be able to do, and the employment and further education pathways open to them.

"The new qualifications will be known as 'New Zealand' qualifications instead of 'National' qualifications. People currently qualified with National Certificates or Diploma will still be qualified, this is just a name change only."

The new qualifications will be known as 'New Zealand' qualifications instead of 'National' qualifications.

"People currently qualified with National Certificates or Diploma will still be qualified, this is just a name change only," Martyn clarifies.

The report to NZQA details proposed qualifications for the water industry, including two new qualifications at Level 3. The New Zealand Certificate in Water Treatment (Plant Assistant) (Level 3) is aimed at plant assistants with at least six months experience in the industry and a New Zealand Certificate in Water Treatment (Small Scale Operator) (Level 3) has been proposed based on the job role of a small scale water treatment plant such as a community, school or marae.

The existing Level 4 and 5 qualifications in water treatment and wastewater treatment will be fully reviewed at a later stage of the review to better suit job roles and required skills and knowledge and investigate the possibility of elective sections.

Further details on the proposed qualifications pathway will become available as the review progresses.

"We will be seeking industry representatives to be involved in developing what is included in the new qualifications," Annie Yeates, Water Industry Training manager says.

Any feedback or queries about the review can be directed to Martyn Simpson at martyn.simpson@waterit.ac.nz

About 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 our qualifications, please visit www.waterit.ac.nz

Stormwater2012
10 & 11 may, wellington

Stormwater 2012 Conference

In this issue of *WATER* we take some time to review the Stormwater 2012 Conference which was held just as the May issue of *WATER* was being finalised. The conference continues to underpin the significance of stormwater management and, as such, *WATER* has decided to look more closely at some of the aspects of this year's event.

Firstly we carry a report on the conference itself from *Water New Zealand*. Then we get a view of the conference through the eyes of a team of engineering students who attended (and presented) at the event.

And lastly we publish in full the top three papers presented at Stormwater 2012 as voted by the Stormwater Special Interest Group members.

Conference Report

Amy Aldrich – Water New Zealand

The Stormwater 2012 Conference was held 10–11 May at the Amora Hotel, Wellington. This year's conference was held over two days with over 200 delegates attending. Delegates enjoyed a stimulating array of presentations including topics such as Stormwater Design, Stormwater Management, Stormwater Treatment Quality and Monitoring and Asset Management. The Modelling Special Interest Group and the Rivers Group once again teamed up to include a third stream dedicated to their specialties.

After flight delays on Thursday morning the conference kicked off to a great start with Wellington Mayor Celia Wade-Brown welcoming delegates. Celia Wade-Brown's welcome touched on the Porirua catchment plan and the importance of cleaning up the harbour. Celia is passionate about improving the quality of the stormwater flowing into streams and harbours and believes bringing awareness about the waste that goes down the stormwater drains and where this ends up is very important. Celia recommended a book by J G Ballard, *The Drowned World*.

Mayor Wade-Brown's welcome was followed by an opening from Hugh Blake-Manson, *Water New Zealand* Board representative. Fran Wilde, Chairperson Greater Wellington Regional Council gave the opening keynote address on day one.

Fran Wilde has held a number of leadership positions in business and politics. As well as chairing the Regional Council she is also Chair of the Local Government New Zealand Regional Sector Group, which comprises Chairs and CEO's of all regional councils in New Zealand. Fran is a company director and has her own consultancy business, Fran Wilde & Associates Ltd.

Fran spoke about the activity in the central government and the changes coming in to the future. Fran finished her Keynote address by suggesting delegates read the local government document, focusing on the fine print as it is something to be considered.

Day one saw combined efforts from the Modelling Special Interest Group and the Rivers Group introduce a Rainfall Runoff Forum. The Modelling SIG and Rivers Group are working with various groups, including *Water New Zealand*, to develop Rainfall Runoff guidelines.

The purpose of the forum was to update and seek feedback from interested parties and individuals on the options and approaches for the various stages of the Rainfall Runoff Project. Delegates were left with plenty to discuss which had to be marked as a 'to be continued' as the forum was shorter than planned due to the earlier flight delays. Feedback from delegates indicated they found this forum both interesting and beneficial.

Day one concluded with the welcome function in the exhibition area followed by dinner at Macs brew bar. Conference MC and comedian Te Radar kept the delegates entertained with assistance from special guest Eric Rush, former All Black and New Zealand Sevens player.

Day Two began with a Keynote opening from Craig Potton, New Zealand photographer and conservationist. For more than three decades he has documented the New Zealand wilderness, exploring relationships between the concept of artistic beauty and wilderness in the natural world. He has been actively involved in conservation work for more than thirty years.

Craig has recently completed the New Zealand documentaries Rivers (2010) and Wild Coasts (2011) which he conceived, screen-wrote and presented. In 2011 he won an award for the Best Documentary Script for his programme on the Rangitata River.

The conference once again provided delegates with the opportunity to up-skill in various areas of Stormwater, keep up to date with new and cutting edge stormwater projects and to network with their water industry peers.

Special thanks to Stormwater 360, Premier sponsor and Silver Sponsor, Golder Associates, for their continued support helping make this another successful event.

Thanks are also due to Morphum Environmental for their support as an Industry Supporter and MWH for their support to supply the coffee cart and internet stations.

Lastly many thanks to the *Water New Zealand* Stormwater Special Interest Group Conference Committee who contributed so much time to make this conference the success it was.

The Stormwater Conference Sub-committee:

- John Palmer, Consultant, Tauranga
- Peter Hartley, AECOM New Zealand Ltd, Tauranga
- Nick Brown, Auckland Council, Auckland
- Mark Pennington, Pattle Delamore Partners, Tauranga
- Nick Simpson, Aurecon New Zealand Ltd, Wellington
- Bronwyn Rhynd, Stormwater Solutions Consulting Ltd, Auckland

Planning for the 2013 8th South Pacific Conference in Auckland is already underway. We look forward to another stimulating programme, so keep your eye out for conference details and we look forward to seeing you again next year!

Experience at the Stormwater Conference – A Student's Perspective

Karen Stokes and Jason Lim

The student low impact design competition was part of a group project we were required to partake in as part of our Urban Stormwater Management paper at the University of Auckland. Sponsored by Auckland Council and supported by IPENZ, it was a challenge to apply the different aspects of low impact stormwater management learnt throughout the semester to a fictional subdivision development.

As the 2011 winners of the competition, our team was encouraged to submit an abstract for the 2012 *Water New Zealand* Stormwater Conference. Having already spent many late nights and hard work putting our project together, we were up to the challenge and jumped at the opportunity to take it further. After more work our abstract was accepted along with the conference paper, and with industry financial support from SKM and Tonkin & Taylor we were off to Wellington to attend the annual Stormwater Conference.

Upon arriving one of the first things we noted was that we appeared to be among far more experienced engineers. However we were able to relieve our nerves early on as we were scheduled to present our project on the first day. The audience, many of whom had years of experience and knowledge in stormwater issues, showed interest in what we had to say throughout and questions and comments following our presentation were welcomed.

After our presentation some of the audience came and talked to us about our project. It was great to be able to discuss it and also to recognise that there were plenty of others with a keen interest in low impact design.

Having some time, we were then able to focus our attention on many of the other presentations on offer. We learned of existing stormwater problems around the country and the solutions people were using – such as detailed modelling of current stormwater networks to guide future development of the Kapiti Coast; crushed mussel shells as a sustainable filter media to remove contaminants from runoff and of new developments in the field such as the consideration of whole of life requirements in the design process.

The large number of industry professionals with similar interests gave us a great opportunity to network and discuss projects and ideas between the presentation sessions. Attendees representing many of the local and district councils and consulting firms were present giving us a good idea on a variety of stormwater issues and how these issues related to their work.

The exhibitor displays were also an interesting part of the event. We were shown many stormwater-related products available on the market such as a polymer sponge able to filter and adsorb hydrocarbons from even high concentration runoff.

Left to right – Aidan Cooper, Karen Stokes, Ben Fountain – SKM, Jason Lim, Dr Elizabeth Fassman – University of Auckland

At the end of the final day we walked away having had a worthwhile experience. Not only were we able to share our project work with professionals, we also had the opportunity to share and discuss our interests with industry professionals from all across New Zealand.

> "The large number of industry professionals with similar interests gave us a great opportunity to network and discuss projects and ideas between the presentation sessions."

The networking opportunities and the current and the details about future work to be undertaken in the country has helped us set some goals over the next few years for ourselves and we look forward to being a part of many future events.

Soakage Disposal in High Groundwater

K.M. Purton, A.L. Williams and G.J. Levy – Beca

Abstract

The Christchurch Southern Motorway Stage 1 (CSM) is a $140M, 10.5km motorway, currently being constructed between Barrington and Halswell. The stormwater design provides treatment and attenuation of stormwater prior to disposal to soakage or surface water, with the soakage disposal being a consent requirement in areas where soils allow, to enhance groundwater recharge.

This paper describes the design challenges with stormwater disposal to soakage for the CSM, and how these were resolved. Due to high groundwater levels, there is a risk of groundwater levels rising close to the base of the soakage disposal areas in extreme conditions. In these circumstances, conventional assumptions about unconstrained vertical discharge to ground no longer apply, and an understanding of horizontal groundwater movement and groundwater mounding was required. The combined probability of an extreme high groundwater level and a large design storm also needed to be understood, as well as the consequences of such events for design. This led to risk management decisions around the implications of low probability but high consequence events, and design of contingency measures to address these. This paper will examine the issues, the design approach, and the solutions adopted.

Keywords

Soakage, groundwater, high groundwater, groundwater mounding

Presenter Profile

Kate Purton is a Senior Civil Engineer with 12 years' experience in water, wastewater and stormwater. Kate was the lead stormwater designer for the CSM design.

1. Introduction

The 10.5km Christchurch Southern Motorway Stage 1 (CSM) is currently under construction in south-west Christchurch, approximately 5km from the central business district. The stormwater management for the motorway includes conveyance, treatment and attenuation, prior to discharge to ground or surface water.

This paper describes the design process, challenges and solutions for the basins discharging to ground via soakage.

Soakage disposal retains water within the natural hydrological cycle, providing shallow groundwater recharge, which in turn contributes to base flows in waterways. Where ground conditions are suitable, and suitable treatment is provided, soakage disposal is Environment Canterbury's preferred disposal option.

2. CSM Project Background

2.1 CSM Overview

When completed the CSM will duplicate the existing 3km long Southern Motorway, extend the motorway 5km over greenfields, and upgrade 2.5km of Halswell Junction Road to connect to State Highway 1 (SH1). An overview plan of the CSM is included in Figure 1.

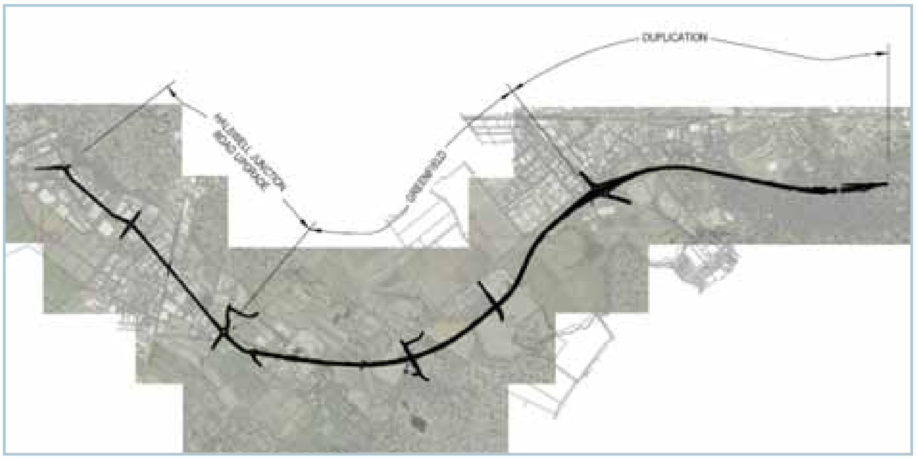


Figure 1 – CSM overview plan

This project is being procured by the New Zealand Transport Agency (NZTA) through a design and construct contract in which Fulton Hogan are the Contractor and Beca Infrastructure Ltd (Beca) the Contractor's designers. Opus International Consultants Ltd (Opus) is the Principal's Agent. Pattle Delamore Partners Ltd (PDP) is the independent peer reviewer for stormwater, while URS New Zealand Ltd is the peer reviewer for the other disciplines (with Tonkin & Taylor its sub-consultant for geotechnical peer review).

2.2 Procurement and Design Process

A Specimen Design for the CSM was carried out for NZTA by Opus in 2007/08. This was used to set the designation boundary and obtain consents from Environment Canterbury (ECan).

In 2009 Fulton Hogan, working with Beca, prepared a Concept Design, which formed the basis of its design-build Tender. Fulton Hogan's tender was successful, and in early 2010 work began on the Detailed Design. Construction of the CSM started in late 2010 and is due to be completed in early 2013.

"This paper describes the design process, challenges and solutions for the basins discharging to ground via soakage."

3. CSM Stormwater Design

3.1 CSM Stormwater System

3.1.1 Overview

The CSM stormwater management system can be considered by motorway section, with a different approach for each section: the Halswell Junction Road Upgrade section, the Greenfields section, and the Duplication section.

In the Halswell Junction Road Upgrade section, stormwater is conveyed by a conventional piped system to the upgraded Halswell Junction Road wet pond where it is treated and attenuated before discharge to surface waters.

In the Greenfields section stormwater is conveyed, treated and attenuated either by conveyance swales and dry basins disposing to ground or surface water, or by attenuation swales discharging to surface water.

In the Duplication section stormwater is conveyed, treated and attenuated by attenuation swales discharging to surface water or the CCC piped stormwater system.

This paper focuses on the dry basins disposing to groundwater (soakage disposal), which are located in the Greenfield section.

3.1.2 Basins Discharging to Soakage

There are four dry basin systems discharging to soakage, each named after adjacent roads or landowners: Mushroom Basin, Lee Basin, Carrs Basin, and Musgroves Basin. The term "dry basin" refers to grassed basins which are dry between events.

Stormwater up to the critical duration 2% Annual Exceedance Probability (AEP) event is conveyed to these basins by swales and pipe reticulation. Secondary flow from the 2% AEP up to the 1% AEP critical duration is conveyed within the designation, and either disposed of to surface water or retained. With the exception of the Lee Basin, the basins have overland flow paths to surface waterways for over-design events.

Each soakage basin system consists of two basins, an infiltration basin which provides treatment of the first flush volume via infiltration through sand infiltration media, and an attenuation basin which provides storage prior to discharge to ground. The exception to this is the Musgroves Basin, where only the first flush basin discharges to ground, while the attenuation basin discharges to the adjacent waterway, Dry Stream.

The discharge to ground occurs via constructed soakage fields or, in areas of high permeability, direct to the underlying gravels as shown in Figure 2.

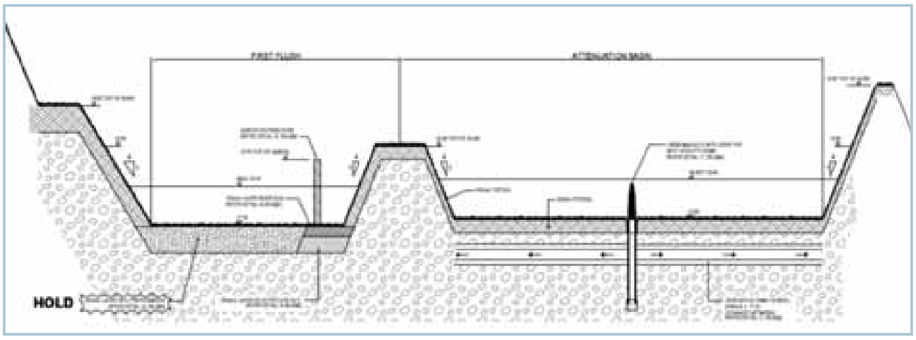


Figure 2 – Cross-section of soakage basin system with attenuation basin discharging direct to ground

The paper focuses on the overall performance of the soakage basins and their ability to discharge to groundwater, rather than the performance of the sand infiltration media in the first flush basins.

3.2 Compliance and Constraints

The consent conditions for the CSM project required that the basins discharging to ground:

- Contain the critical duration 2% AEP event without spilling
- Drain down within 48 hours after a storm event
- Are planted with grass or other vegetation

The design was also constrained in terms of the area of land available, as the NZTA designation for the motorway had already been set.

4. Standard Design Assumptions for Soakage Disposal

4.1 Soakage Testing and Design Soakage Rates

In order to determine the soakage rate for a given location, site soakage testing needs to be carried out. A common test procedure involves a test pit or borehole excavated at the proposed soakage pit location and depth. In advance of the soakage test, water is added to the hole for a minimum of four hours to try to saturate the soil. The hole is then filled with water and the drop in water level is measured over time, and

> "The measured soakage rate is divided by a factor of safety to arrive at a design soakage rate."

plotted (drop in water level versus time) on a graph. The minimum observed soakage rate, or minimum slope of the graph, is the measured soakage rate in mm/hour.

The measured soakage rate is divided by a factor of safety to arrive at a design soakage rate. This is due to the effects of clogging of the soils over time, and the limitations of the test in terms scale and partially unsaturated conditions. The recommended factor of safety varies between guidelines from 1 to 25. The New Zealand Building Code Compliance Document Clause E1 Surface Water recommends a factor of safety of 1, i.e. that this test rate is adopted as the design soakage rate. Auckland Regional Council's TP10 (ARC TP10) recommends a factor of safety of 2. For treated waste-water soakage, the US EPA recommends a factor of 10 to 25. Christchurch City Council (CCC) generally adopts a factor of safety of 3 for soakage systems.

4.2 Gradient to Groundwater

In adopting a design soakage rate based on a small scale soakage test, and using that directly as the disposal rate below the soakage field, there is an underlying assumption that the groundwater level is sufficiently low that the water discharged can be absorbed by the directly underlying unsaturated zone (i.e. the effect of groundwater movement within the saturated zone, which is not measured by the soakage test, is neglected). In other words, a hydraulic gradient of 1 is commonly used. If the water table is high, and volume to be discharged is large, this may not be the case, and the hydraulic gradient can become significantly lower as soakage occurs laterally, reducing the drain-down rate.

To achieve a soakage rate that is not affected by groundwater, the groundwater depth below the basin needs to be sufficient. The depth required depends on the rate and duration of discharge and hydraulic parameters (porosity and hydraulic conductivity). For a porosity of 0.4, neglecting groundwater movement within the unsaturated zone, the groundwater depth below the basin needs to be 2.5 times the depth of the basin. This means that a 1m deep basin needs more than 2.5m of unsaturated soil above the groundwater table.

5. Discoveries During Detailed Design

5.1 Investigations

During the Specimen Design phase, ground investigations were carried out by Opus, including test pits and shallow soakage tests. This information was used to determine soakage rates for the Concept Design. The water levels measured in these test pits, and local groundwater level data, were used to determine groundwater levels at each site.

Early in the detailed design process, a more detailed search of long term local groundwater level data was carried out. Test pits and soakage tests were also carried out at each of the soakage sites, and soil samples taken from each test pit for laboratory grading tests, and two piezometers were installed at each site. These piezometers were then monitored fortnightly to provide site specific data. The results of these investigations are summarised below.

5.2 Long Term Groundwater Records

In searching for available groundwater level data during detailed design, it became apparent that directly relevant long term site specific groundwater monitoring data was not available. In Canterbury, records for deeper groundwater, that is the first to fourth aquifers, are readily available from ECan, however shallow groundwater records are much less common. Shallow groundwater records also tend to be project (site) specific and therefore recorded over shorter periods. Shallow groundwater monitoring from the initial investigations for the CSM covered a period of approximately two years. A number of local historical records were identified from CCC shallow groundwater monitoring wells, however these records were of various lengths and ended in approximately 1995, so were not able to be correlated to the more recent piezometer records.

A margin was added to the measured groundwater level, based on the variation within the historical records available, and a maximum groundwater level was assumed at each basin. The design soakage invert levels at the basin were then set above this level, and it appeared that simple vertical soakage would be achievable.

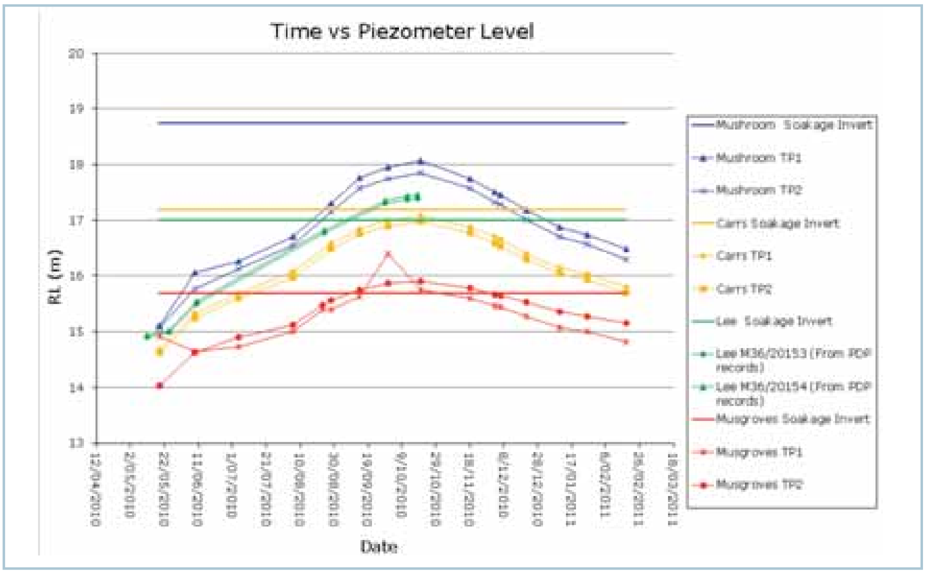
5.3 Soakage Test Results

Generally two soakage tests were carried out per site. The soakage test results, with the exception of Musgroves Basin, provided acceptable soakage rates. A factor of safety of 3 was generally applied to the results to determine design soakage rates, except where very high soakage rates were measured a maximum design soakage rate of 300mm/hr was adopted. The soakage test results and design soakage rates chosen for sizing the basins are summarised in Table 1.

5.4 Groundwater Monitoring Results

As described, piezometers were installed at each of the soakage basin sites, close to the proposed locations of the soakage fields. The initial piezometer monitoring results were in the expected range, however the measured levels rose over time and revealed groundwater levels much higher than expected. The peak level occurred in October 2010. The piezometer monitoring results, and design invert levels of the soakage fields are shown in Figure 3. Where soakage is direct to the underlying gravels, the design invert level shown in Figure 3 is the invert of the subsoil drains (which discharge the water to ground underneath the basin).

Figure 3 – CSM piezometer monitoring results



It can been seen from Figure 3 that as the design was progressing with assumed levels, the measured groundwater levels progressively approached, and in some cases exceeded, the designed soakage invert levels.

With such high groundwater levels, the assumption that the discharged water would be able to be absorbed by the directly underlying unsaturated zone (i.e. a hydraulic gradient of 1) would no longer hold. The standard design approach, assuming simple vertical soakage, would not be suitable.

5.5 Basin Level Changes

The simplest solution to this problem would appear to be to raise the levels of the soakage inverts at the basins. However, the basin levels and soakage invert levels had been arrived at by assessing full hydraulic design gradients from the motorway. Any increase in soakage invert level would require a corresponding increase in motorway level. The motorway levels had been set at the start of detailed design to provide freeboard above 1% AEP flood levels, and geometric design of the motorway was nearly complete. An increase in motorway level would result in the need for additional fill, at a high cost to the project, as well as redesign which would cause delays. Changing the basin levels and motorway levels was therefore a last resort, and a more detailed analysis of the soakage performance was required.

5.6 Potential Effects of High Groundwater

The higher than expected groundwater levels raised a number of significant issues.

With high groundwater levels, the base assumptions of the design regarding soakage rates and ability to discharge into an unsaturated zone beneath the basin would not be valid. This could mean that:

- The basins may not contain the 2% AEP event, spilling to their secondary flow paths more often.

Table 1 – Soakage test results and design soakage rates

Basin	Soakage test	Measured minimum soakage rate (mm/hr)	Design soakage rate adopted (mm/hr)
Mushroom Basin	Mushroom SP1	900	300
	Mushroom SP2	1800	
Lee Basin	Lee Basin SP1	3600	300
Carrs Basin	Carrs SP1	450	150
	Carrs SP2	Soakage rate too high to measure	
Musgroves Basin	Musgroves SP1	96	20
	Musgroves SP2	40	Site not used

- Basin drain-down would occur more slowly. Depending on the time taken to drain, this might cause performance issues with consecutive storms (as the available storage would be reduced by water still in the basins from the previous event). The drain-down could take longer than the 48 hours required by the consents. If prolonged ponding occurred, this might cause issues with grass die-off.

This raised potential issues with consent compliance, with respect to the basins containing the critical duration 2% AEP event, meeting the 48 hour drain-down requirement, and maintaining grass cover.

6. Alternative Approach

6.1 Risk and Effects on Performance

The return period of the measured groundwater levels needed to be assessed, to determine the likelihood of such high levels occurring again in the future.

In addition to this, the analysis to date had been based on a peak groundwater level coinciding with a 2% AEP storm. The combined probability of a 2% AEP rain storm event and a 2% AEP groundwater level occurring together would be less than a 2% AEP. It was agreed with NZTA that the design case should be an event with a combined 2% AEP, in other words the combination of groundwater and rain storm event which together had a 2% AEP. A combined 2% AEP event could consist of a more common groundwater level with a large storm, or a high groundwater level with a smaller storm.

The effects of this overall 2% AEP event (or events) on performance of the basins needed to be determined. Two-dimensional groundwater modelling was identified as the most appropriate method for assessing the effects of the two principal design scenarios.

6.2 Analysis of Risk

A shallow groundwater well with a long term continuous record was identified at Weedons Ross Road, West Melton (M35/0931), some 20km west of the Christchurch airport. With a data set from 1976 to present, this was the closest unconfined monitoring well, with a long term record. Comparison of the records showed that the recent water level variation in this well was very similar to that measured in the CSM piezometers.

An extreme value analysis was carried out on this groundwater level data to determine the return period of the October 2010 groundwater peak. This indicated that the October 2010 peak ground water level at Weedons Ross Road had a return period of approximately 25 years (a 4% AEP event). Further, from the record, the additional rise to a 2% AEP event was determined.

The likelihood of a high groundwater event coinciding with a storm event was then analysed, in order to determine an overall 2% AEP event or events. This analysis was carried out both from a peak annual 24 hour rainfall perspective to determine a likely groundwater level that might occur at the same time, and from a peak annual groundwater level to determine a likely 24 hour rainfall depth that might occur at the same time. For the analysis, three NIWA Lincoln rainfall gauges were used (4881, 4882 and 17603) as these were the closest long term records to the well site.

In Figure 4, the plot shows the groundwater level coinciding with each annual maximum 24 hour rainfall event analysed, with the recommended design groundwater values marked in red squares for each of the 2% and 1% AEP design rainfall events.

Figure 4 – Rainfall ARI vs groundwater level, analysed from an annual maximum storm basis

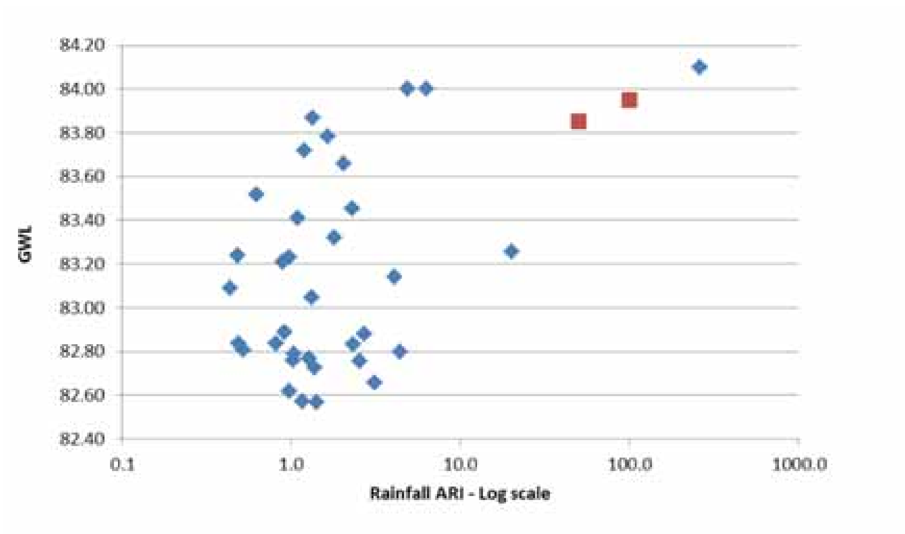
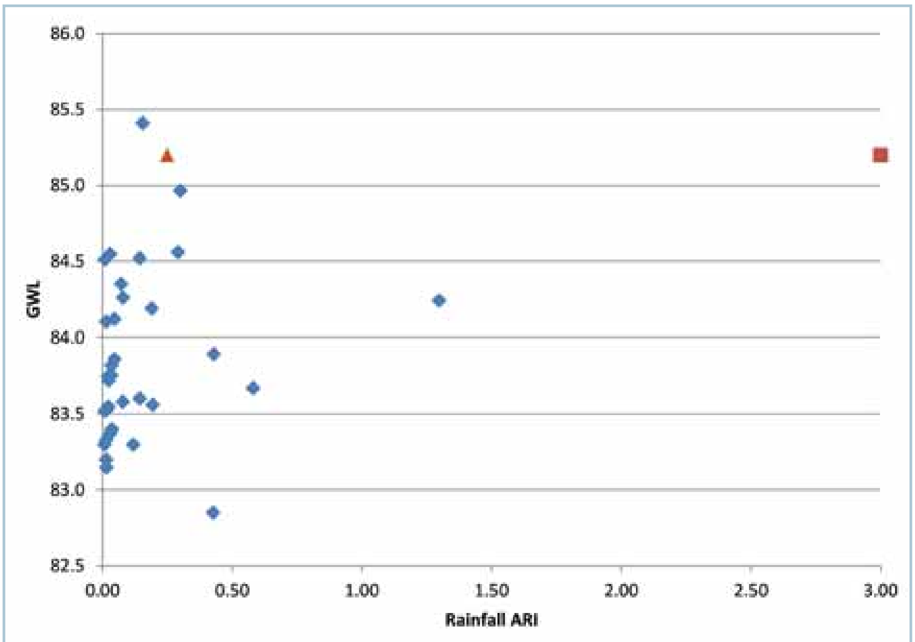


Figure 5 shows the converse plot, with the nearest appropriate 24 hour large rainfall event coinciding with the annual maximum groundwater events. There was less certainty around the most appropriate storm event case to use with the high groundwater level case. Not shown in Figure 5 (due to the altered horizontal scale to give resolution for frequent events) is that there was also one solitary larger rainfall event (60 year ARI) coinciding with a high groundwater level of 84.6m. While a 3 month storm appeared to be appropriate in general, it could be argued that a 3 year ARI storm might be needed as a sensitivity test to reflect the skew imparted by the single larger rainfall event. As a result, it was concluded that two "high groundwater" scenarios were necessary.

"In searching for available groundwater level data during detailed design, it became apparent that directly relevant long term site specific groundwater monitoring data was not available."

Figure 5 – Rainfall ARI vs groundwater level, analysed from an annual maximum groundwater level basis



The groundwater and rainfall analysis therefore concluded that three scenarios needed to be modelled:

- 2% AEP storm with "typical" groundwater level (large storm base case)
- 3 month ARI storm with 2% AEP groundwater (high groundwater base case)
- 3 year ARI (33% AEP) storm with 2% AEP groundwater level (high groundwater sensitivity case)

The three cases were modelled for each basin.

6.3 Two-Dimensional Groundwater Modelling

Two-dimensional groundwater modelling was carried out for each basin, for the critical duration storm, for each of the three cases outlined above. This modelling was carried out using GEO-STUDIO SEEP/W.

Each basin was modelled as a two-dimensional cross-section, typically 1000m long, with constant head boundary conditions applied at the far ends of the section to achieve the assumed underlying groundwater level. The inflows into the model (i.e. runoff into the basins) were calculated in a separate spreadsheet analysis using a Rational Method approach, with a peak inflow of twice the average inflow occurring at time 0.7D. This is consistent with the method to calculate runoff described in CCC (2003). These inflow hydrographs were applied to the model as

"A high permeability sensitivity case was also modelled with the 2% AEP and typical groundwater level to understand the effect of the permeability factors on the basin performance."

a time variable unit flux over the basin areas ($m^3/d/m^2$).

The surface profile of the basin was included in the model, so that where the applied runoff cannot infiltrate (due to the soil being fully saturated) the volume would pond in the basins, with subsequent infiltration as a function of head.

An example model set-up cross-section for the Mushroom Basin is shown in Figure 6. The yellow colour represents Springston Formation gravel, while the thin pink layer (just visible in the figure) represents Springston Formation sand/silt.

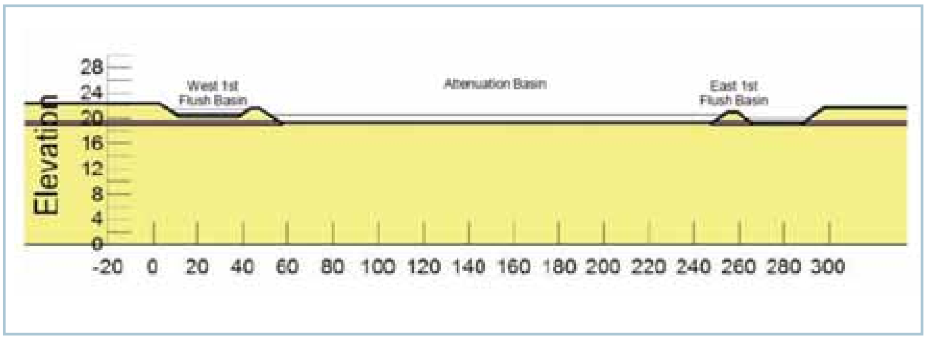


Figure 6 – Mushroom Basin model set-up cross-section

The hydraulic conductivities used in the groundwater modelling were much lower than the soakage rates used in the initial simplified spreadsheet design approach, which had been assumed to apply to vertical permeability above the water table, as discussed in section 4.2. The groundwater modelling takes account of the fact that when the groundwater level is high relative to the level of the soakage field, most of the soakage occurs horizontally into saturated soils, at a much lower hydraulic gradient.

The measured soakage rates were reduced by a factor of 15 to allow for reduction in permeability over time (a factor of 15 had been back-calculated from testing of similar soils in north Canterbury), and then in some cases a further factor of 10 to allow for vertical permeability relative to horizontal (reflecting the interbedded fine soils observed in the test pits, i.e. the anisotropy of the soils). This may be a conservative approach. A high permeability sensitivity case was also modelled with the 2% AEP and typical groundwater level to understand the effect of the permeability factors on the basin performance.

Examples of the groundwater modelling results are shown in Figures 7, 8 and 9.

Figure 7 – Mushroom Basin modelled groundwater levels at end of 3 year ARI (33% AEP) storm event with 2% AEP groundwater level (high groundwater sensitivity case)

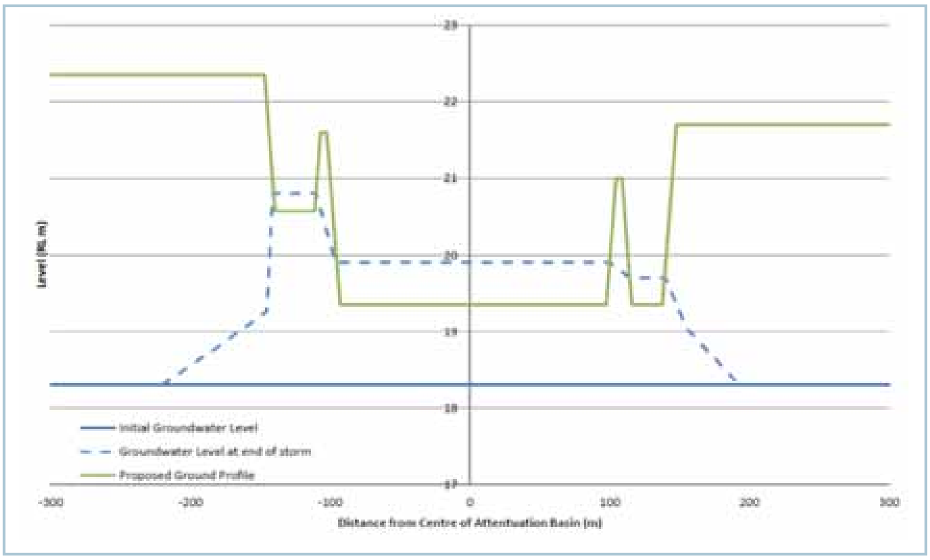
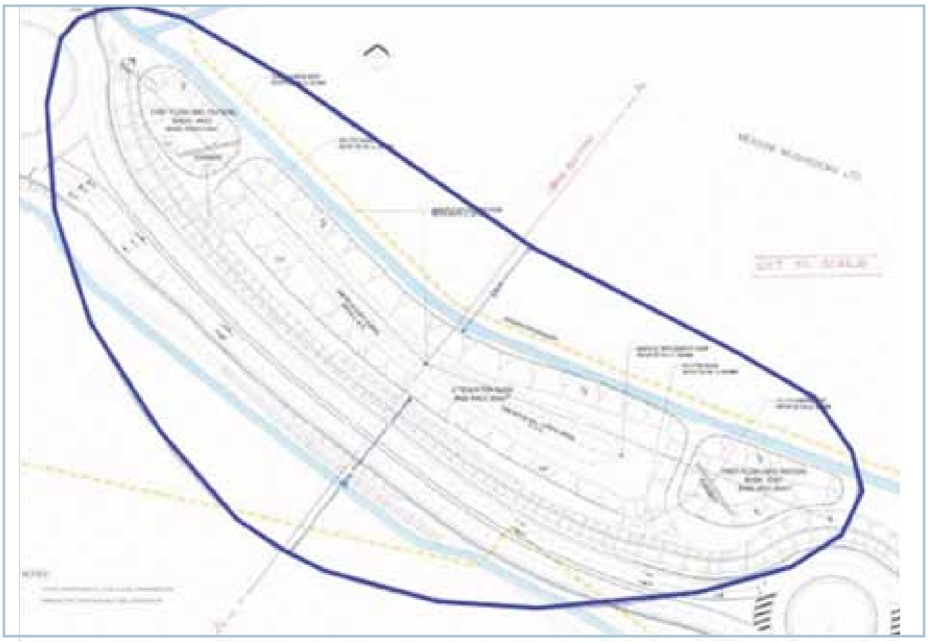


Figure 8 – Mushroom Basin modelled groundwater mounding at end of 3 year ARI (33% AEP) storm event with 2% AEP groundwater level (high groundwater sensitivity case)



The groundwater modelling showed that the principal issue was not containment, but rather the time for basins to drain down:

- The 2% AEP events modelled could be contained within the basins (with minor modifications at Carrs Basin). The modelled groundwater levels for the Carrs Basin for the large storm base case are shown in Figure 9.
- The drain-down time following a storm event could be much longer than the 48 hours required by consents. Drain-down times for the cases modelled varied from less than one day, to up to two months. The shorter drain-down times were generally for the high groundwater base case and the high permeability sensitivity case. The longer drain-down times were generally for the large storm base case and the high groundwater sensitivity case.

As noted above, the parameters used in the model may be conservative. While there are a large number of infiltration and soakage basins used for stormwater management in the Canterbury area, few or any, are already constructed sufficiently close to the proposed CSM basins to confirm whether the model represents actual conditions or is conservative (i.e. results in higher mounding and longer drain down times). The adoption of a conservative approach provides for operation of the basins in all likely conditions. This provides NZTA with information that will not result in any surprises in the future operation and maintenance of the basins.

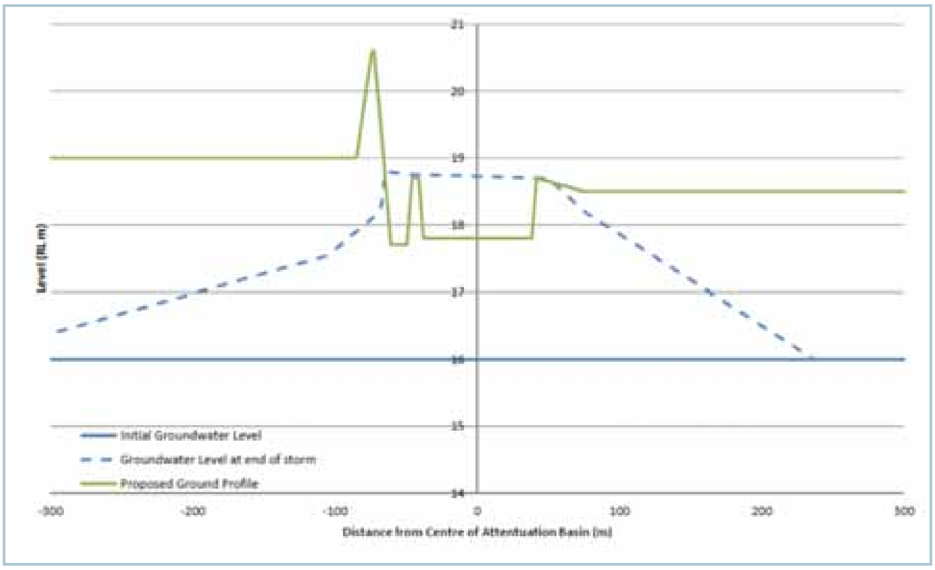


Figure 9 – Carrs Basin modelled groundwater levels at end of 2% AEP storm event with typical groundwater level (large storm base case)

6.4 Design Modifications

As a result of the groundwater modelling the following modifications were made to the design:

- Basin bund levels were increased to provide containment of the design storms. The lowest top of bund level at Carrs Basin was increased by 200mm to contain the 2% AEP event. The 2% AEP event was already contained at the other basins, and therefore no bund modifications were required.
- A soakage field was moved towards a higher permeability subsurface stratum connecting to an adjacent waterway (at a lower level). The Musgroves Basin soakage field was moved towards Dry Stream to improve connectivity between the soakage field and Dry Stream. The location of high permeability material between the soakage field and the stream was confirmed by test pits on site. (If the existing material between the soakage field and stream was found not to have a high permeability it would have been excavated and backfilled with a high permeability material.) This response did not compromise the overall ECan objective of achieving groundwater recharge, as it was only the first flush basin that was disposed to ground, and it would continue to do so unless the groundwater was very high, at which time recharge would not be a requirement.
- Provision to pump out standing water was added. The Mushroom, Carrs and Musgoves Basins all have secondary flow paths to waterways. In the event of prolonged ponding becoming an issue, temporary surface pumps could be set up at the sites to pump water from the basins. The Lee Basin does not have an overland flow path. A rising main from the Lee Basin to the nearest waterway, the future Owaka waterway, was therefore added to the design. In the event of extended ponding in the Lee Basin a temporary surface pump could be set up to pump water from the basin, through the rising main, to the Owaka waterway.

It was noted that if prolonged inundation occurs the grass may die-off. If this became a recurring issue the grass could be replaced with gravel base, with a revised approach to vegetation maintenance.

6.5 Compliance

This information was then provided to Environment Canterbury and the consent was varied to remove the 48 hour drain-down requirement, recognising that there was already a condition requiring maintenance of a good grass sward in the basins.

7. Conclusions

The conventional soakage design approach involves adopting soakage rates based on field soakage test results, reduced by a factor of safety. This is based on the assumption that the groundwater table is sufficiently below the basin that soakage can occur near-vertically, into the unsaturated zone, i.e. with a hydraulic gradient of 1.

The CSM design experience has shown that sufficient investigation needs to be carried out early in the design process to confirm that this assumption is correct. Where groundwater levels may approach close to the basin or soakage field invert such that the hydraulic gradient is less than 1, then a different design approach is required, which can account for the horizontal soakage and reduced hydraulic gradient. This may require groundwater modelling.

In carrying out groundwater modelling a conservative approach should be taken in assessing the groundwater mounding that occurs. A conservative approach means that the long term owner of the basin has a system that should operate successfully in all likely scenarios.

In the event that such modelling shows increased containment is needed, or long drawdown times might eventuate on an infrequent basis as a result of extreme events (particularly unusually high groundwater levels), then it is appropriate to identify contingency plans to address these, and to ensure that these measures are noted in any operation and maintenance plans for the eventual owner of the facilities.

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The Rational Method – Frequently Used, Often Misused

"In this paper the limitations of the method are examined in detail, with the intention of clarifying its use and range of applicability."

Mark Pennington – Engineer, Pattle Delamore Partners Ltd

Abstract

The Rational Method has been in use in some form or another at least since 1889, where its use appeared in a paper by Kuichling titled "The Relation between Rainfall and the Discharge in Sewers in Populous Districts". It is not so much that the method itself is judged as being rational, but more than the method relates to the ratio between rainfall and runoff (which is essentially the runoff coefficient, C).

The method enjoys a prominent place in flow estimation guidelines in New Zealand and internationally. Unfortunately it is frequently misapplied, possibly as a consequence of its apparent simplicity. There are (erroneous) perceptions that the method can be used to estimate discharge for a wide variation in rainfall duration, to estimate total runoff volume and hence for sizing of mitigation works, and for determination of flood hydrographs for unsteady analyses.

In this paper the limitations of the method are examined in detail, with the intention of clarifying its use and range of applicability. Detail into the derivation of runoff coefficients that are applied is given, and some less-widely known applications of the method (including the "probabilistic approach") are described. This paper is intended for a practitioner audience.

Keywords

Rational Method, Rainfall-Runoff, Peak Flow Estimation

Presenter Profile

Mark is a Civil Engineer with some 18 years of post-graduate experience, the majority of which has been spent in hydrological and hydraulic investigations and analyses. He has a Master's degree in hydraulics and his main focus in the last few years has been in urban stormwater management and in flood management for river systems.

1. Introduction

The Rational Method is widely publicised as a simple and effective method for use in hydrological calculations. Published data exist that cover a wide range of applicability, and it appears as a published method in many guideline and regulatory documents.

A "rational" number is defined mathematically as one that can be expressed as a ratio of two integers. For example, the number 3/4 (0.75) is a rational number while √2 (1.4142...) is not a rational number. Considering the antonyms for the word "rational", the terms "absurd", "irrational" and "nonsensical" are given by at least one popular dictionary. Consequently it is hoped and assumed that every method in common use for rainfall-runoff analysis is a "rational method", but not necessarily the Rational Method.

The notion of the term "rational" being a reference to a ratio is described further in this paper.

While many guideline documents give a full description of the Rational Method and its use in peak flow estimation, it is frequently the designer's objective to size mitigation works. The Rational Method can be used to give an indication that changes in land use result in changes to hydrological response, but its application to quantifying these changes is somewhat limited. Many guideline documents miss this.

2. Rational Method Theory

The Rational Method Formula is given as

$$q = F.C.i.A$$

Where

q = peak discharge [L^3/T]

F = units conversion factor

C = dimensionless runoff coefficient

i = rainfall intensity for duration equal to catchment time of concentration [L/T]

A = catchment area [L^2]

In Figure 1 the relationship of variables in the formula with the physical process are shown. In this it can be seen that the runoff coefficient, C, accounts for almost all of the physical processes in place.

Examination of this formula reveals that the product of rainfall intensity and catchment area has unit equivalent to that of peak discharge [L^3/T]. Therefore it can be seen that the rate of "inflow" to the catchment is given by i.A (and is a steady rate over rainfall duration). In response to this, the peak rate of outflow q, is given by the formula. Thus for a consistent set of units (where F = 1), runoff coefficient C, represents a ratio between inflow and outflow.

$$C = \frac{q}{i.A} = \frac{out\_flow}{in\_flow}$$

As an example, a runoff coefficient, C, value of 0.8 can be taken to mean that the peak rate of discharge from a catchment is 80% of the average rate of rainfall accumulation in the catchment. In consideration of this, it may appear odd that peak outflow rate should be linked by a constant to average inflow rate. During a rainfall-runoff process, it would be usual for runoff (i.e. outflow) to begin at zero in response to rainfall (inflow), and gradually increase with continuous rainfall to a point at which outflow equals inflow (i.e. it tends towards a steady state). Given sufficient rainfall, therefore, the runoff coefficient, C, should tend towards a value of unity (unless a steady, continuous loss exists) and not be limited to published C-values.

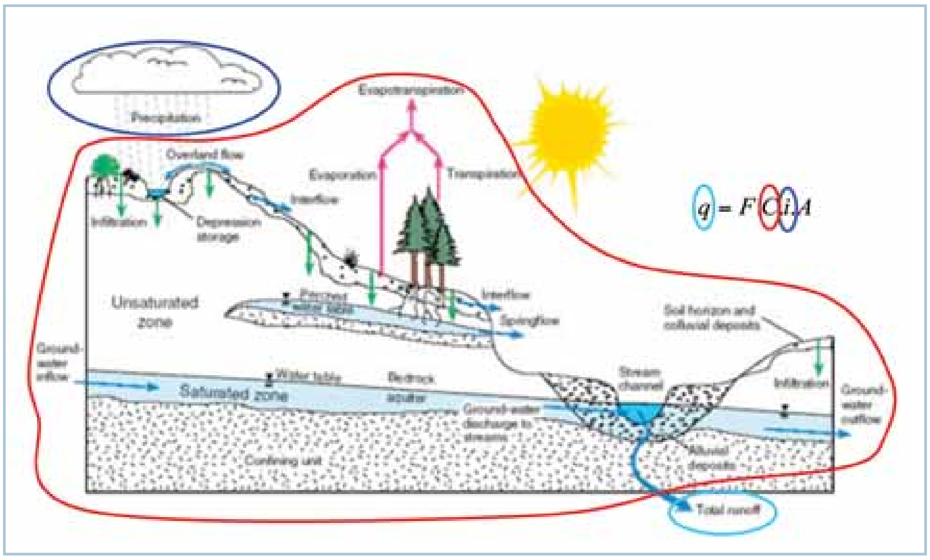
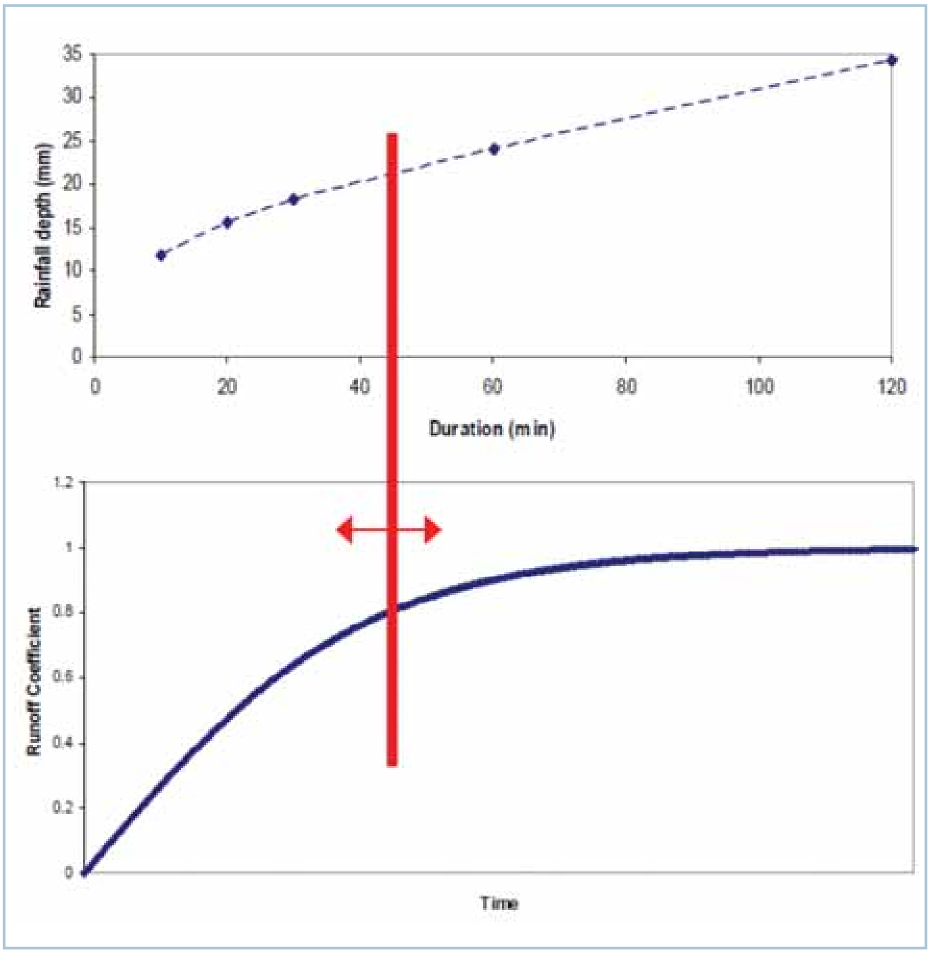


Figure 1 – The Physical Process

In general rainfall depth-duration-frequency data will show decreasing intensity with increasing duration. Selection of a rainfall intensity corresponding to duration greater than time of concentration (even with the same runoff coefficient) will result in a peak discharge estimate that is lower than what would be obtained if using the (higher) intensity that would correspond to duration equal to time of concentration. This is shown diagrammatically in Figure 2, where rainfall depth is shown to increase with duration (with decreasing intensity), and runoff coefficient is shown to approach unity with time.

Figure 2 – Variation in Rainfall Depth and Runoff Coefficient with Time



This emphasises the importance of the duration that is applied to a Rational Method analysis. From a theoretical perspective, prescribed runoff coefficients are generally "calibrated" for use only when rainfall duration exactly equals catchment time of concentration. When duration is less than this, not all of the catchment is able to contribute runoff and the catchment area, A, should be adjusted in the formula to reflect this. When duration exceeds time of concentration the runoff coefficient to be applied should begin to approach a value of 1 with increasing duration. Therefore the runoff coefficient is only applicable to a rainfall duration that is equal to catchment time of concentration.

3. Example Problem

For the purpose of demonstration, an example problem has been set up and will be referred to throughout this paper. The example is a small undeveloped catchment that is set to be developed for residential purposes, shown in Figure 3. The example catchment is rectangular in shape, covering 10 hectares in area with uniform slope of 1:50. A collector channel collects sheet flow runoff and delivers this to the observation point.

The Rational Method has been used to estimate the hydrological response for both the pre- and post-development scenarios, with calculations summarised in Table 1. Time of concentration is calculated by published methods, and the result is used in selection of design rainfall intensity to be applied from depth-duration-frequency tabulated values. The Rational Method "C" value (often termed "runoff coefficient") is selected from standard published data.

Figure 3 – Example Catchment

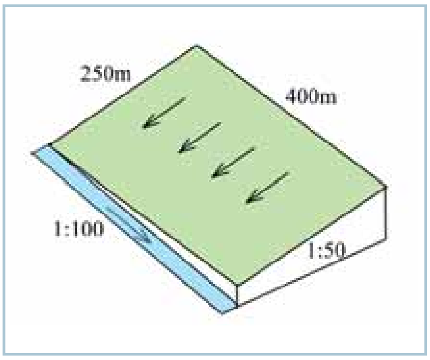


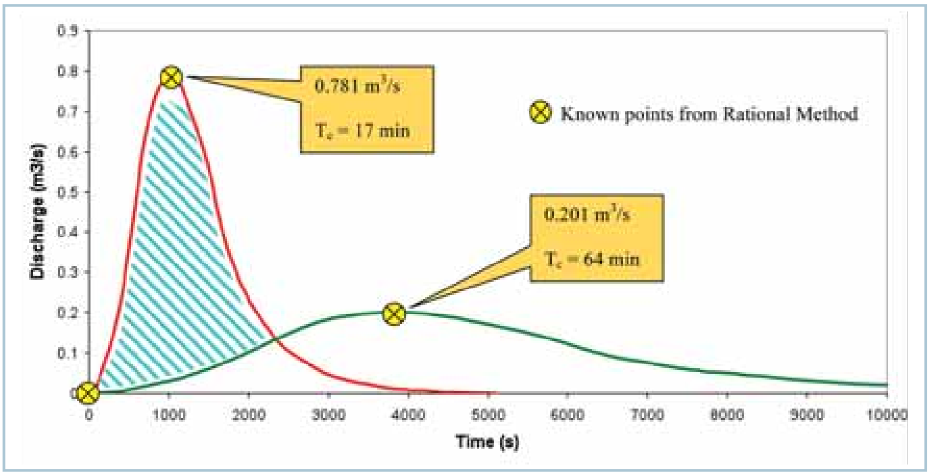
Table 1 – Results of Analysis for Example

Catchment Condition	Time of Concentration (min)	Design Rainfall Intensity (mm/h)	Rational Method "C"	Peak Flow Estimate (m^3/s)
Pre-Development	64	24.1	0.30	0.201
Post-Development	17	51.1	0.55	0.781

From the results shown in Table 1 it can be seen that development of the currently undeveloped catchment will have a notable change on the hydrological response (higher peak discharge and shorter response time). The Rational Method has been appropriately applied in this case to estimate the peak discharge for each case. However the results reveal differences in performance that are difficult to compare directly as the peak discharge estimates apply to two different rainfall durations. These results are sketched schematically in Figure 4. In this the rising and falling limbs of each hydrograph are shown dashed as the analysis does not give any detail on these. Rather, just two points on each hydrograph are given by the Rational Method, these being zero discharge at time equals zero, and peak discharge at time equals time of concentration. Any further information shown in Figure 4 is surmised in this case, and cannot be used for more detailed analysis or optioneering.

"From the results shown in Table 1 it can be seen that development of the currently undeveloped catchment will have a notable change on the hydrological response (higher peak discharge and shorter response time). The Rational Method has been appropriately applied in this case to estimate the peak discharge for each case."

Figure 4 – Analysis Results



The problem frequently facing designers is in what measures should be put in place to mitigate the effects of the development, and this is where use of the Rational Method is frequently stretched, often into misuse. Some common misuses include the following:

1. Use the Rational Method to determine peak discharge estimates for a range of rainfall durations such that a comparison between pre- and post can readily be made. For example, for the pre-development case, find out the peak flow in response to a 17-minute event and compare against the post-development peak flow estimate.
2. Using the "runoff coefficient" (C-value), estimate total runoff volume for the design events and provide storage for the difference to mitigate effects. For example, with C = 0.30 this means that 30% of total rainfall onto the catchment eventually runs off the catchment, and comparison of this volume with a similarly calculated volume for the post-development case yields a storage volume that will adequately mitigate effects of development.
3. As the average rainfall intensity was used in the calculation, this gives average runoff rate over the rainfall duration. Total volume for each catchment condition can therefore be calculated by finding the product of flow rate and

duration, with the difference between these being required as storage for mitigation of effects.

4. By application of an "appropriate" or "generic" hydrograph shape, find the volume represented by the shaded area in Figure 4, provide this while constraining outflow to pre-development peak rate and this represents adequate mitigation of adverse effects resulting from the changed hydrological response.

The above bullet points are all incorrect applications of the Rational Method. Specific investigation into these misuses will is given later in the next section.

4. Application of Theory to the Example

The example referenced above has been used to demonstrate a typical application of the Rational Method where inappropriate analyses are frequently encountered. The problem here is to size mitigation measures to reduce the impact of a change in land use on the rainfall-runoff response from a catchment.

4.1 Changing Rainfall Duration

The first bullet point in Section 3 of this paper indicates use of the Rational Method for rainfall duration being something different to catchment time of concentration. The effects of this are outlined below.

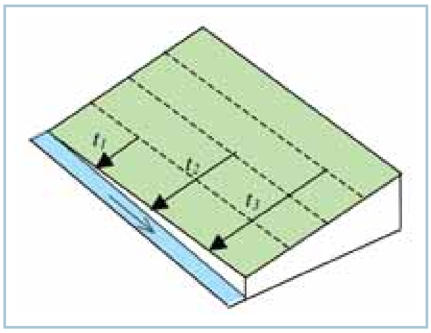
In the pre-development catchment condition, the contributing catchment area for rainfall duration less than time of concentration can be calculated using the Manning equation.

$$t = \frac{100.n.L^{0.33}}{s^{0.2}}$$

Where
t = travel time (minutes) [T]
n = Manning roughness coefficient [$L^{-1/3}$.T]
L = up-slope length of contributing catchment (m) [L]
s = catchment slope in %

Knowing time t the above equation may be solved for L which can be used to calculate contributing catchment area A. In this way the catchment may be split into sub-areas by isochrones, along which overland travel time is constant (as shown in Figure 5). Thus for each rainfall duration that is less than catchment time of concentration, a different contributing area (that is less than total area) should be used.

Figure 5 – Isochrones in Example Catchment



For t = 17 minutes, this equation may be solved for L to yield L = 7.45m, which gives a catchment area A = 2,980m^2.

Using this in the Rational Method Formula yields q = 0.013m^3/s.

This number may be compared to the post-development rate of 0.781m^3/s, but as these are for rainfall events of vastly different contributing catchment area, such a comparison is not meaningful for the purpose of sizing mitigation works. Should consistent catchment areas be used then runoff coefficient should not be the same if duration is kept constant, rendering use of the Rational Method here for direct comparison to be somewhat meaningless.

4.2 Using the Runoff Coefficient to Find Runoff Volume

As has been explained above, the runoff coefficient, C, represents a simple ratio between inflow and outflow that has been observed to occur over various surface types when rainfall duration and catchment time of concentration are equal. During the period of time between the onset of rainfall and the catchment time of concentration, the accumulation of runoff volume is very unlikely to be linear, meaning that a constant runoff coefficient over this time does not apply. Loss models used in hydrological simulation generally all agree with this, where hydrological losses tend to decay with time.

Using the runoff coefficient as a volumetric runoff coefficient as alluded to in bullet point 2 above, results using the example referenced above yields the runoff volumes given in Table 2.

Table 2 – Runoff Volume Estimates

Catchment Condition	Rainfall Duration (min)	Design Rainfall Intensity (mm/h)	Rational Method "C"	Runoff Volume Estimate (m^3)
Pre-Development	64	24.1	0.30	771.2
Post-Development	17	51.1	0.55	796.3

"Instead of attempting to use the runoff coefficient for volume estimation, total runoff volume can be given by the integration of discharge with time."

The above volume estimates appear to reveal no great change to runoff volume resulting from development of the example catchment. While such comparisons are frequently encountered, it is not meaningful to compare runoff volumes from rainfall events of such differing duration. However, as mentioned previously, the Rational Method cannot be used for duration that is different from catchment time of concentration. Furthermore, the above calculation is based on the assumption that Rational Method runoff coefficient represents a volumetric runoff coefficient, which is clearly false.

4.3 Product of Discharge and Duration to Find Runoff Volume

Instead of attempting to use the runoff coefficient for volume estimation, total runoff volume can be given by the integration of discharge with time. Where discharge is steady, this can be simplified to the product of discharge and time. However, application of the Rational Method Formula only gives just two points on the runoff hydrograph. These points are plotted at zero discharge for time equals zero, and peak discharge at time equals catchment time of concentration. The Rational Method does not provide any further information on hydrograph shape.

In Figure 6 a series of runoff hydrographs are shown. All of these have the same peak discharge at the same time of concentration, but clearly different total runoff volume (area under the curve). One hydrograph has equal time for rising and recession limbs, and is represented by an isosceles triangle. Another shows the shape if the recession time is twice that of the time

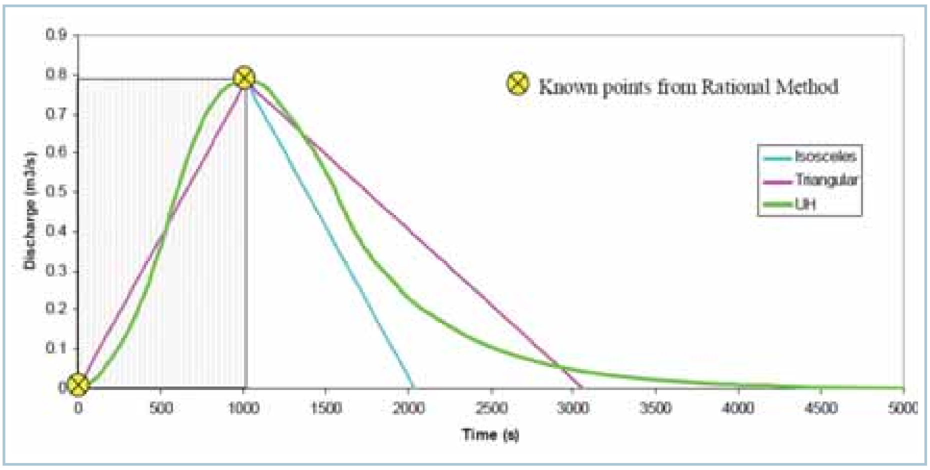
"From inspection it can be seen that if the isosceles triangle hydrograph shape is correct (i.e. representative of the true catchment response), then the volume estimate given by the product of peak discharge and catchment time of concentration is exactly correct. However for the other hydrograph shapes shown, volume estimates will be low."

to peak, making a triangular shape, and lastly the SCS Unit Hydrograph shape has been fitted to the data (curvilinear plot). Also shown (shaded) is the result that would occur if volume we calculated by finding the product of peak discharge as given by the Rational method Formula and time of concentration.

From inspection it can be seen that if the isosceles triangle hydrograph shape is correct (i.e. representative of the true catchment response), then the volume estimate given by the product of peak discharge and catchment time of concentration is exactly correct. However for the other hydrograph shapes shown, volume estimates will be low.

The Rational Method only provides two data points on each hydrograph, as shown in Figure 6, and therefore its use for estimation of total runoff volume is limited.

Figure 6 – Hydrograph Shapes



In the above case, the product of discharge and duration (or catchment time of concentration) yields a volume estimate of 796.6m³/s. A larger volume would result if one of the other hydrographs plotted in Figure 6 was used, and it is likely that the volume estimate of 796.6m³/s would be close to a lower bound. A similar calculation for the pre-development case yields a total runoff volume of 771.8m³/s, with the difference between these two (some 25m³) being largely meaningless as it has been calculated by comparison between results from two very different scenarios.

To generate an accurate runoff hydrograph for volume estimation a temporal rainfall distribution, or hyetograph, is required, the use of which is outside of the range of applicability of the Rational Method.

4.4 Hydrograph Volume Differential

Bullet point 4 in Section 3 suggests an approach whereby mitigation volume is estimated by integration of discharge hydrographs with time and differencing the pre- and post-development values. This is a valid approach, but difficulty lies in its dependence on assumed hydrograph shape. Examination of Figure 6 suggests that a reasonable approximation may be possible by making an assumption of triangular hydrographs to find this difference. The assumption of the rising limb being linear on each of the pre- and post-development hydrographs is likely to be reasonably representative, however the falling limb slope is strongly dependent on individual catchment characteristics. The differencing approach using triangular hydrographs relies, in this case, on the falling limb of the post-development hydrograph and the rising limb of the pre-development hydrograph both being linear.

Furthermore, the recession time assumed in plotting triangular hydrographs becomes relevant to this calculation.

For the purpose of comparison, an isosceles triangle hydrograph shape approximation for both pre- and post-development hydrographs will result in a required detention volume of some 695m³ for the example in this paper. It is reasonably plain to see that if recession time for the post-development hydrograph in Figure 6 were extended out to be greater than time to peak, a greater volume estimate would result from application of this method.

4.5 Typical Solutions Using the Rational Method to Determine Detention Volume

In the example described above, it is often assumed (sometimes incorrectly) that adequate mitigation has been provided if the post-development peak discharge is constrained to no more than that for the pre-development case. The reason that mitigation sized in this way is not necessarily adequate is because differing downstream flood mechanisms and conditions may be present that are not all peak discharge sensitive. In many instances, prolonging the duration over which a threshold discharge is attained may increase stream erosion, or may exacerbate flooding where capacity constraints exist.

However, these effects are ignored in this paper for the purpose of demonstration. Three different hydrograph shapes have been used in determination of required detention volume if post-development peak discharge is to be constrained to no more than the pre-development rate. These three shapes are those shown in Figure 6. In each case required detention volume has been calculated by an algorithm that allows maximum flow (at pre-development rate) to occur at all times, with the difference between inflow and maximum allowable outflow being taken to storage. Storage volume is released such that the maximum outflow never exceeds the pre-development peak discharge. This is not entirely realistic as the outflow configuration and detention structure shape will result in different performance in reality, but this analysis represents a lower bound and a basis on which to conduct comparisons. In most cases outflow rate will not be able to be kept constant over a range in detained volume due to changes in hydrostatic head through an outlet structure.

In Figure 7 the results are shown if both pre- and post-development hydrograph shapes, with peak and time-to-peak determined using the Rational Method, are assumed to be representative of the catchment response.

Figure 7 – Results Assuming Isosceles Hydrographs

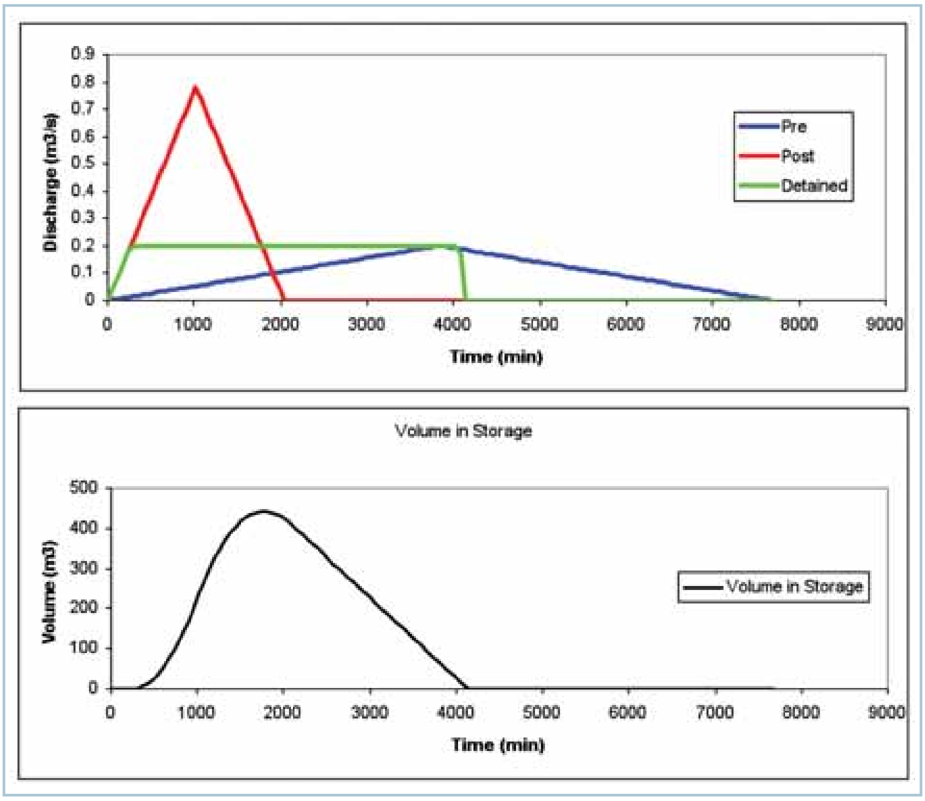
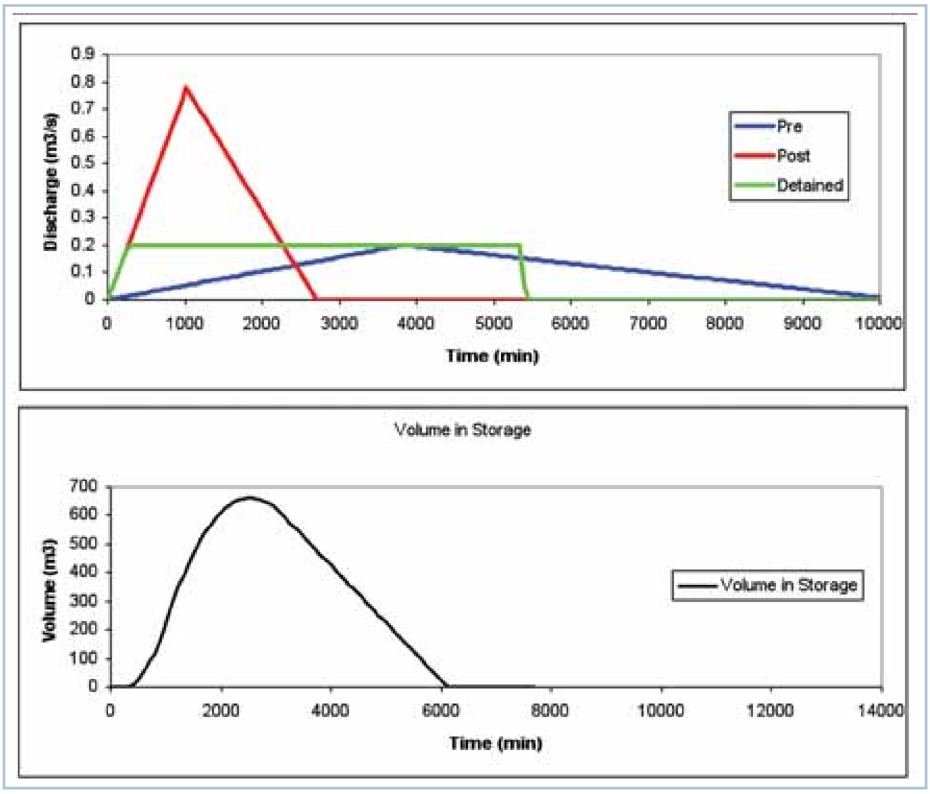


Figure 8 – Results Assuming Triangular Hydrographs



In Figure 8 the same analysis is applied to similarly developed hydrographs, except that the triangular shape of these differs in that the recession time is twice the time-to-peak, for both pre- and post-development cases. Clearly in this case the total runoff volume is much larger than that which would be given by the hydrographs shown in Figure 7.

The result is a required detention volume of 660.3m^3.

In Figure 9 a similar pair of plots are presented, generated this time using the shape of the SCS Unit Hydrograph, well-known to many.

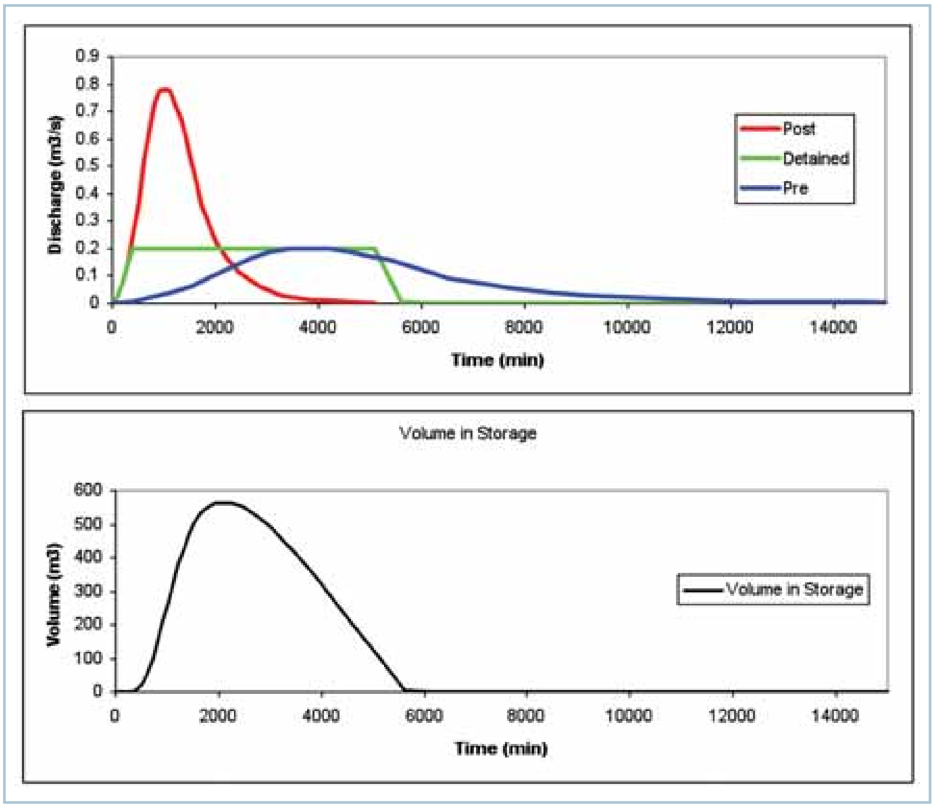
The resulting requirement for detention is 562.8m^3.

Thus it can be seen that hydrograph shape, which is not provided by the Rational Method, is of fundamental importance to the calculation of mitigation works. As alluded to in the introduction to this paper, the Rational Method is frequently put forward in guideline documents as a method by which flow estimates can be made. This is entirely correct. What is often missing, however, is that most assessments in compliance with guideline documents are conducted with the purpose of sizing mitigation works. It is here that the Rational Method has to be used with extreme care, and is often insufficient for the stated purpose.

"In Figure 8 the same analysis is applied to similarly developed hydrographs, except that the triangular shape of these differs in that the recession time is twice the time-to-peak, for both pre- and post-development cases. Clearly in this case the total runoff volume is much larger than that which would be given by the hydrographs shown in Figure 7."

For the specific example used in the analysis above, a range in required detention volume from 440m^3 to 660m^3 can be obtained (a 50% range), depending on the assumption of hydrograph shape. As significant sensitivity to this parameter (hydrograph shape) is shown, an appropriate approach would be to achieve greater accuracy in this for the analyses to be conducted. This greater

Figure 9 – Results Assuming SCS Unit Hydrograph Shape



accuracy in hydrograph shape is something that cannot be provided by the Rational Method, but rather a more detailed alternative approach would be required. This could involve modelling, which would introduce a further parameter in that of temporal rainfall distribution that would require accurate definition.

5. Probabilistic Approach

The Rational Method can be used in a probabilistic approach. The Rational Method Formula may be re-written as

$$q(Y) = F.C(Y).i(t_c,Y).A$$

In the above formula C, q, and i are labelled with average recurrence interval Y years. Using this approach it is not runoff in response to a particular rainfall event that will be the desired outcome. Rather, the intention is to use this approach to estimate discharge for a particular ARI by frequency analysis of observed data.

In application of this method, data requirements include frequency curves of both rainfall of duration equal to t_c and corresponding discharge. If both q and i are known, the equation allows solution for runoff coefficient C.

The relevance to this paper is that the runoff coefficient, C, may not be constant across events of differing ARI. This is recognised in some guideline documents, but not in others. In general C increases with increasing ARI. This method is fully described in Maidment (1992) and is not repeated here.

6. Conclusions

The Rational Method is widely prescribed and recommended for use in peak flow estimation, and has been shown to yield results of acceptable accuracy if used appropriately.

The key parameter in the Rational Method Formula is that of the coefficient C, tabulated values of which appear in many reference texts. These values have been explicitly derived for use when rainfall duration exactly equals catchment time of concentration. Use of published values for C under different conditions is likely to be erroneous.

The Rational Method gives a ratio of inflow to outflow, under the specific conditions of rainfall duration equal to catchment time of concentration.

The coefficient C has been shown to vary both with rainfall duration and with event severity (i.e. ARI).

It is difficult to make use of the Rational Method results to estimate detention storage, without making an approximation on hydrograph shape.

Hydrograph shape for any catchment is dependent on temporal variation in rainfall and also on specific catchment characteristics, and it is difficult to conclude that a single shape should be representative of all catchments.

"As alluded to in the introduction to this paper, the Rational Method is frequently put forward in guideline documents as a method by which flow estimates can be made. This is entirely correct. What is often missing, however, is that most assessments in compliance with guideline documents are conducted with the purpose of sizing mitigation works. It is here that the Rational Method has to be used with extreme care, and is often insufficient for the stated purpose."

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A Reality Check on Flood Risk

Barry Carter, Nick Brown, Neil Blazey – Auckland Council

Abstract

Traditional approaches to flood risk assessments involve modelling catchment systems to determine predicted flood plains and using these to assess flood risks for property and infrastructure. While this is a necessary first step in determining flood risk it is far from adequate.

This paper considers the wide ranging physical dynamics that come into play during actual flood events. A set of factors and processes to determine more realistic flood risks is put forward. The refining of modelling techniques in recent years has misled stormwater practitioners into a false sense of confidence in predicting outcomes of flood events. This paper provides a reality check on what actually happens during extreme flood events and advocates for more consideration of potential blockage, obstructions, changes to waterways during flood events and impacts on water level associated with velocity and momentum.

Consideration of these factors may lead to improved prediction of flood hazards, more effective flood mitigation measures and better preparedness for emergency management and response.

Keywords

Flood risk assessment, hazards, blockage, residual risk, consequences

Presenter Profile

Barry Carter is a Team Leader within the Stormwater Catchment Planning Team of Auckland Council. For the past seven years Barry has been leading the development of catchment plans for the North Shore area. With a background in Civil Engineering Barry has over 20 years experience within Local Authorities and 15 years experience in the private sector.

1. Introduction

In observing what actually happens in extreme flood events it is frequently apparent that the factors related to risk to life and property are not adequately considered in the assessments traditionally carried out by stormwater planners.

"Common practice is to predict flood plains and to do little else to assess flood risk. This paper emphasises the distinction between assessing flood plains and assessing flood risk."

This paper discusses a range of observed flood events and the factors that frequently come into play that have significant effect on the severity of flood risk and consequences.

These observations are then related to common practice for assessment of flood risk and the underlying assumptions normally made in carrying out this work.

Common practice is to predict flood plains and to do little else to assess flood risk. This paper emphasises the distinction between assessing flood plains and assessing flood risk.

A set of factors and processes for determining more realistic flood risks is put forward for consideration.

The objective of this paper is to raise awareness and promote a more realistic assessment of flood risk in order to enable more effective flood mitigation measures and better preparedness for emergency management and response.

2. When Floods Go Bad

Over recent years there have been many images from within New Zealand and around the world of extreme flood events. The following is a sample to provide some context and direction for this paper.

2.1 Tauranga, New Zealand 18 May 2005

- 310mm of rainfall over 36 hours
- 315 houses evacuated
- Landslides undermined houses at top of slopes, debris damaged houses at top of slopes
- $11M infrastructure reinstatement costs plus $65M stormwater improvement works required

Landslide at Otumoetai, Tauranga May 2005

2.2 Matata, New Zealand 18 May 2005

- 308 mm of rainfall over 20 hours, 94mm in peak hour
- 538 people evacuated
- 27 homes destroyed
- 87 homes damaged
- 700,000m^3 of debris (including boulders up to 7m wide)
- $30M insurance claims in the Bay of Plenty area from this event

Debris flows at Matata May 2005

2.3 Queensland, Australia January 2011

- A series of widespread storms over more than 2 weeks from the end of December 2010 until mid-January 2011
- Between 600–1000mm of rain in most Brisbane catchments
- 600mm of rainfall recorded in parts of the Stanley River catchment between 9 January and 13 January 2011
- 33 people killed
- 70 towns and 200,000 people affected
- A$10 billion cost to Australian economy
- A$1.5 billion flood damage insurance claims
- 90,000km of roads damaged

Widespread flooding Brisbane January 2011

2.4 Vernazza, Italy, 25 October 2011

- 500mm of rain in four hours
- 1,500,000m^3 of mud, trees and debris flowed through the valley with debris in the main street up to 4m high
- 300 landslides over an area of 12 square kilometres
- Three people killed
- Town evacuated by sea and all services destroyed
- €108M estimated damage to Vernazza
- Several nearby villages suffer similar damage

Flood debris Vernazza October 2011

3. Consequences of Flood Events

The examples of extreme flood events outlined in 2 above provide a range of common consequences. These can be summarized as follows:

- Loss of life and severe injuries (Between 1990 and 2000 the average yearly loss of life on a worldwide basis as a result of flood events was over 9000.)
- Health impacts from water borne disease and stress

- Damage to buildings and contents ($46M of claims related to flooding in New Zealand during 2011)
- Damage to infrastructure (Including roads, bridges, culverts and services)
- Significant land slips
- Major debris movement

Collectively these consequences have significant social, financial, economic and environmental impacts on the communities and regions affected.

4. Current Practice – Assessment of Flood Risk and Assumptions

4.1 The Modelling Process

Common practice in assessing flood risk is to develop models to predict flood flows and flood extents for a catchment. The process in summary involves:

- Capturing and validating data related to rainfall and runoff and metrics for the stormwater system and terrain
- Building a digital terrain model
- Applying a set of rainfall depth, duration and frequency profiles to a catchment
- Determining runoff characteristics based on topography, geology, permeability, land use and vegetation cover
- Determining and accounting for system features including overland flowpaths, piped network, storage, culverts, bridges, inlets to systems, streams and tidal influences
- Accounting for the areal extent to which the design rainfall will apply
- Developing scenarios related to current and future states for the catchment including predicted land use and imperviousness and the impacts of predicted climate change
- Building a hydraulic model
- Validating, testing and documenting the model
- Running the model to produce predicted flood flows, staging and flood levels for various storm profiles and durations
- Mapping of flood plain extents for selected scenarios

Flood extent maps are the primary tool used to predict flood risk to existing or proposed development. Models can be used to assess the impacts and sensitivities of altering any of the model inputs or assumptions. In this way system performance improvements can be assessed and the scope and nature of land development and improvement works can be optimized.

4.2 Modelling Accuracy

In recent years there have been significant developments in improving the accuracy of data used in modelling work. These improvements include:

- Use of LiDAR surveying to improve the accuracy of digital terrain modelling
- Use of GIS tools to analyse existing and predicted land use, surface types and permeability
- More reliable and longer rainfall and flow gauging records

Development of modelling software and techniques has also enabled refined accuracy of models and outputs. These developments include:

- Quickly evolving development of 2D modelling software
- Rapid Flood Hazard Assessments prior to detailed modelling and data collection
- Move to 64 bit multicore processing to reduce model run times

The improvements in data accuracy are unquestionably valuable. The development of modelling software and techniques also has valuable potential. However, the application of the modelling tools and techniques requires considerable skill and expertise.

Recent experience within Auckland Council has shown that there is a wide variation in quality and reliability of models developed in the Auckland region in the last few years. Common problems encountered include:

- Not validating the physical dimensions and characteristics of networks.
- Assumptions underlying models not being appropriate and/or not being tested for sensitivity
- Application of modelling techniques not being appropriate and leading to gross errors
- Models not being reviewed
- Hand verification of results not being undertaken

The key message is that robust processes and highly skilled, well trained modellers are needed to ensure hydraulic models are fit for purpose and reasonably reflect the likely flood extents within the bounds of the assumptions and scenarios being modelled.

There is significant inherent risk in relying on models that have not been adequately developed and checked. The capability of the software and techniques can easily lead to over confidence in the accuracy of the deliverables.

4.3 Modelling Assumptions and Limitations

If it is assumed that a completed model is reliable within the bounds of its assumptions and limitations the next aspect to explore in terms of flood risk assessment is the adequacy of typical modelling assumptions and limitations.

Commonly models are set up on the assumption that stormwater will be delivered to piped systems or watercourses without restriction or with limited restriction. During major storm events this assumption is invariably invalid at some or many locations within the catchment. The usual faults are:

- The inlets to systems, individually and collectively do not have the capacity to take the modeled flows even if they remain unobstructed
- Inlets and watercourses are blocked partially or totally by storm debris including vegetation, trees, sediment and boulders, vehicles, minor buildings and household furniture
- Assuming all pipes are maintained and operable – no roots or obstructions in any part of the network

Another common assumption is that the watercourses will remain intact through the storm. During major storm events this assumption is often invalid because landslips and erosion occurs and debris is carried through watercourses. This results in the cross sections of the water courses changing as erosion and deposition occurs. Higher than predicted flood levels may occur at some locations which in turn may lead to flood flows being diverted to flowpaths other than those predicted. The erosive power of debris filled flows may also exacerbate erosion, resulting in the development of new flowpaths and a very different flood situation to that predicted.

The assumption that storm flows have the viscosity of water is also frequently invalid and in extreme cases such as the 2005 Matata storm would lead to significant under-prediction of flood levels.

4.4 Hazard Assessment

Putting aside the limitations and concerns expressed above, common practice is to develop flood hazard maps from models to indicate the extent and predicted flood levels resulting from modelled storm events. The risk associated with the limitations of modelling and the underlying assumptions is usually accounted for by applying a blanket freeboard or sensitivity allowance to the flood level, typically 0.5m.

Flood hazard maps are then used to assess risk to existing and proposed development. Options to alter, improve or optimize the performance of systems can then be modelled and assessed.

"Another common assumption is that the watercourses will remain intact through the storm. During major storm events this assumption is often invalid because landslips and erosion occurs and debris is carried through watercourses. This results in the cross sections of the water courses changing as erosion and deposition occurs."

More recently hazards to public safety associated with depth and velocity are being considered and progress is being made towards development of maps to reflect these hazards.

5. Improving Flood Hazard Assessment and Managing Risk

Extreme flood events may or may not exceed an estimated 1% annual exceedance probability event. The challenge is to consider and manage the residual risk for rare events and to mitigate the consequences where this is reasonably practicable.

Having identified the concerns and limitations of current practice related to flood hazard assessment the following discussion puts forward a set of factors and processes for determining more realistic flood risks associated with major storm events and managing risk.

- Ensure the critical assets are identified and represented correctly in models. Often the connectivity and/or dimensions of critical assets are not verified in models and headlosses at these critical structures are poorly understood.
- Have programmes to assess the condition and maintain, improve or renew critical assets. Asset failure during storm events and consequential damage can often be prevented or minimized by having robust proactive asset management programmes.
- Identify and ground truth the nature, capacity and risk of blockage of inlets to systems. In major events the risk of blockage is high and can be very unpredictable. Reliance on inlet capacity is risky. Manage residual risk by building in redundancies such as secondary weir inlets at critical locations. Examples of items blocking inlets include: trees, vegetation, mattresses, hail, garden sheds, cars, containers, signs, blocked trash racks and erosion debris.
- Identify and assess depressions in the catchment. These are areas of particular hazard because depressions can fill, sometimes to several metres depth, if drainage systems block. Run scenarios to account for total blockage, consider fail safe overland flow path exits from depression areas. Do not apply flood risk assessment to these areas simply in terms of freeboard above predicted modelled flood levels. Consider potential flood levels and hazard areas by taking total system blockage and fail safe levels into account.
- Identify and ground truth significant overland flowpaths. Commonly a high percentage of habitable floor flooding particularly in small catchments occurs as a result of obstructions to overland flowpaths. A focus on assessing these overland flowpaths and determining risk and potential improvements can go a long way towards managing flood risk and damage.
- Consider the potential for landslips and erosion in a catchment. This involves study of stability of soils and slopes in the upper

or steep sections of catchments and stability of streams. It is important to understand the geomorphology and history of sensitive catchments. In catchments where these risks are significant consider flood risk scenarios associated with potential erosion and deposition. If nothing else, apply considered engineering judgement in determining additional allowance for flood risk and undertake assessment of mitigation measures. Risk assessment should consider the higher probability of system blockage and the likely consequences of deposition of debris. Measures to keep development clear of likely flow paths and removal of existing development from high risk areas should be considered.

- Take into account flow velocity and energy head.
  - » Flood levels on the outside of fast flowing river bends will be significantly higher than the centre of river flood levels determined by conventional modelling (1D modelling or 1D, 2D coupled modelling is not typically able to calculate super elevation). In such areas where there is current or potential development this assessment of risk and the associated modelling should be undertaken.
  - » Buildings and structures in the path of fast flows will experience flood levels considerably higher than the unobstructed flood levels predicted from conventional modelling. These changes will be associated with the loss of energy as the water meets the obstruction and from turbulence and pressure waves. It is important to identify where such concerns may occur and to take into account the energy grade line and the additional risk that may apply in these locations. Mitigation works involved in such areas may include altering flowpaths, raising floors, providing resilience such as flood shutters to doorways, or removing/relocating buildings.
  - » Develop flood hazard maps identifying potential areas of high velocities during storm events. Much of the loss of life and serious harm associated with storm events arises from people being in or entering fast flowing water.
- Communication of information between stormwater planners, stormwater operational staff, emergency management teams, residents and business owners is an essential process in ensuring that flood risks are understood and managed and that consequences in major storm events are mitigated.
- Understanding and accounting for flood hazard risks by the development community including regulators is an essential component in managing flood risk associated with future development.

Impact of fast flows

"The challenge is to consider and manage the residual risk for rare events and to mitigate the consequences where reasonably practicable."

6. Conclusions

Current processes and methods of flood risk assessment are commonly limited and as a result frequently under-estimate the consequences arising from major storm events. In observing actual storm events landslides, debris flows and impacts of high velocity usually have major significance.

The challenge is to consider and manage the residual risk for rare events and to mitigate the consequences where reasonably practicable.

The development of processes to assess overland flowpaths, the potential for landslips and erosion and accounting for the impacts of high velocity flows as part of the assessment of flood hazards for a catchment will lead to more robust hazard assessment.

Proactive asset management programmes to monitor and mitigate flood risks associated with stormwater systems can contribute significantly to management of flood risk.

Provision of appropriate rules in District Plans can go a long way towards limiting development and risk in flood prone areas.

Effective communication between stormwater planners, stormwater operational staff, the development community, regulators, emergency management teams, residents and business owners is an essential part of managing flood risk and the consequences of major storm events.

Acknowledgements

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Views expressed in this paper are those of the authors and do not necessarily represent policy or position of the Auckland Council.

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Approaches to Water

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

Introduction

Water regulatory reviews are a hot topic at the moment with a number of regional councils undertaking reviews of their approaches to water management. In this article we comment on the issues currently being debated surrounding these approaches. We then move on to briefly discuss the second report of the Land and Water Forum which was released in May 2012 as a follow up to the first (September 2010) report. The last part of this article is devoted to outlining a couple of recent Court decisions with implications for the water sector. The first being a decision of the Supreme Court in relation to the process for bringing prosecutions under the RMA and the second being a decision of the Environment Court in relation to cultural effects of water abstraction and plan change proposals.

Regional Council Reviews of Water Management

At present there are a number of councils throughout the country currently involved in reviews of their approach to water management (e.g. Bay of Plenty Regional Council, Canterbury Regional Council, Environment Southland, Horizons Regional Council, and Otago Regional Council). Some councils are at the beginning of the process (Southland and Canterbury) whereas others (Horizons) are near the end being in the Environment Court.

What is interesting is the degree to which different approaches are being adopted by the councils to water management – from taking a highly regulated and prescriptive approach to all water uses to selective targeting of specific industries.

Indeed, in some instances the approach taken by a Council itself has changed or evolved significantly through the hearings process. An example is the Horizons One Plan which started life as a rather prescriptive and highly regulated approach to water management for dairy farming, cropping, market gardening and intensive sheep and beef farming. This approach was altered to a less regulated approach by an independent hearings panel appointed by the Council with a number of parties (including the Council) now seeking to revert back to a more regulated approach, a position supported by Fish & Game and Department of Conservation.

While some variation is obviously expected in order to respond to local water issues, the degree of difference between the way in which similar activities are treated by different councils is not overly surprising given the current regulatory framework.

While the National Policy Statement on Freshwater Management ("Freshwater NPS") was originally intended to provide some national guidance and direction to standardise (at least somewhat) water management approaches, the resulting NPS has left a lot of discretion to the individual councils. Further, as some of the reviews commenced prior to the Freshwater NPS becoming operative the extent to which the resulting regional plans address the Freshwater NPS differ, depending on the stage of the process that the regional plan is at.

Another factor which has contributed to differences in approach is the complexity of the issues involved in determining appropriate water approaches. A particularly vexed issue is the question of how non-point source discharges should be dealt with. Consideration of this issue has inevitably involved a lot of debate as to who is causing the discharges, the extent of the effects attributable from various land uses to the particular waterbody as well as the appropriateness of, and timeframes for, options to address these issues.

It is currently too early to tell whether, as the Councils move through their plan processes, a more consistent approach to water management will emerge. What is clear though is that there needs to be a change to the way in which water was previously managed.

Adding further fuel to the calls for change is the recently released World Wildlife Fund Beyond Rio Report[1], which notes that despite the New Zealand Government agreeing to maintain ecosystem integrity, to reverse natural resource degradation and intensify efforts to prevent water pollution, water quality has in fact declined over the last 20 years.

In future articles, we plan to provide commentary on the various plan changes as they complete their respective hearings processes.

Land and Water Forum – Second Report

The second report of the Land and Water Forum entitled "Setting Limits for Water Quality and Quantity Freshwater Policy – and Plan Making through Collaboration" ("Second Report") was released on 18 May 2012.

"While some variation is obviously expected in order to respond to local water issues, the degree of difference between the way in which similar activities are treated by different councils is not overly surprising given the current regulatory framework."

The Second Report was produced in response to an invitation from the government to provide more detailed recommendations on the framework for setting and managing objectives and limits for freshwater quantity and quality. It addresses how objectives and limits should be set and the decision-making processes required. A further report will follow in September this year ("Third Report") to address methods and strategies for achieving limits and targets and allocating water (including trading and/or transfer systems.

The Second Report includes a series of 38 recommendations which cover the following matters:

- Setting limits to freshwater resource use in terms of both takes and discharges within a catchment or sub-catchment
- Strengthening the objectives of the Freshwater NPS through –
  - Acknowledging iwi tikanga and values and giving better guidance about their meaning
  - Expanding the objectives of the Freshwater NPS to safeguard human health from pathogenic micro-organisms and toxic contaminants
- Promulgation of a National Environmental Standard which will set out –
  - National minimum state objectives or bottom lines for a limited range of indicators including biometric, physico-chemical, physical, human health and fish productivity
  - Bands above bottom lines (fair, good and excellent) indicating increasing levels of protection for the different waterbody types
- The adoption of collaborative approaches to plan making at national, regional and local levels –
  - The need for greater agility in the planning system to enable minor and technical updates to documents without needing to go through a plan change process
  - Transitional arrangements to stop a water "rush" from occurring while new arrangements are put in place.

The report also addresses the somewhat vexed issue of whether merit appeals of regional council decisions on water policy and planning should be allowed or whether appeals should be limited to points of law. The report concludes that where the collaborative process has been followed appeals should be limited to points off law only, with merit appeals only being allowed where the co-llaborative process can be demonstrated to have failed.

The Government has indicated that it will make no decisions in relation to implementation (or otherwise) of the recommendations in the Second Report until after the Third Report has been received in September.

Recent Court Decisions

Down v R

In our April 2011 article we reported on the Court of Appeal decision in Down v R[2], where the Court was asked to determine whether leave from the District Court was required prior to informations being laid to prosecute unauthorised discharges. The Court of Appeal found that such leave was not required. As expected, the outcome of that case was appealed to the Supreme Court, and on 3 April 2012 the Supreme Court issued its decision. In short, the Supreme Court confirmed the Court of Appeal decision but for slightly different reasons[3].

In examining this issue, the majority of the Supreme Court noted that there are two separate RMA procedures available to a Council to deal with infringement offences (which include unauthorised discharges) – offenders can be issued with an infringement notice (and fee) or they can be prosecuted under s338(1)(a). Under either procedure, the Court found that the leave of the Court was not required before prosecuting an infringement offence. The reasons the Supreme Court gave for this varied slightly between the members of the Court but ultimately the conclusions reached were similar. The following extracts from the case explain the reasoning (and the differences in reaching the outcome of the members) of the Court:

Elias CJ and McGrath J

"[28] It follows that on the ordinary meaning of the text of the two Acts, an infringement notice issued under s 343C of the Resource Management Act does not qualify as an infringement notice under para (k) of the definition of that term in the Summary Proceedings Act. Nor, of course, does it qualify under any of the preceding paragraphs referring to specific statutes. On this analysis, infringement offences under the Resource Management Act are not infringement offences under the Summary Proceedings Act. The Resource Management Act has its own infringement notice procedure, which does not provide for the use of that under s 21 of the Summary Proceedings Act. Therefore, the requirement to obtain leave before laying an information under s 21(1)(a) does not apply.

[30] It follows that s 343B is the pivotal authorising provision in respect of the procedure for dealing with infringement offences under the Resource Management Act. Those responsible for enforcement may commence summary proceedings under s 343B(a), using s 12 of the Summary Proceedings Act, or proceed by infringement notice under s 343B(b). The course they choose is entirely a matter of prosecutorial judgment in every case.

[31] In this judgment we have preferred to focus on the text of the Resource Management Act and incorporated provisions in ascertaining their meaning. While there are differences in the routes by which we have reached

them, we regard our conclusions as to how the statute is to be read as being the same as those of William Young J.

William Young J

[63] All in all, construing the text of the Resource Management Act (including amendments) in light of what might be thought to be the purposes associated with the penalties regime under that Act, I think it is clear that:

(a) Section 343B is not subject to s 21(1) of the Summary Proceedings Act

(b) Section 343C therefore adopts only part of, and not the entire, s 21 procedure

(c) Accordingly, the relevant provisions of the Resource Management Act do not engage para (k) of the Summary Proceedings Act definition of "infringement notice".

[64] Although I have reached this conclusion by a route which is not precisely the same as that followed by McGrath J and there are some differences between us of emphasis and nuance, my reasons are substantially the same as his."

This case is important for all persons undertaking activities regulated by the RMA (including those in the water sector) as it confirms the processes available to the Council for dealing with any breaches of the RMA.

Wakatu Incorporation and others v Tasman District Council

Another recent case, Wakatu Incorporation & ors v Tasman District Council[4], which involved appeals in relation to a community water scheme, is of interest because of the way the Court approached consideration of tangata whenua values.

"The key question the Court asked itself was whether in the absence of any substantive physical effect on the river there could be a spiritual effect on the mauri of the river and/or the relationship of tangata whenua with the river such as to require the prevention of the use."

The Council had sought resource consents and promulgated a plan change to allow it to abstract and use water for the Motueka Coastal Community water scheme. Part of the scheme involved using water taken from within the catchment for areas outside of the catchment. Tangata whenua objected to the proposal to use some of the water outside of the catchment due to the effects that this would have upon the mauri of the river and the relationship tangata whenua had with the river.

Tangata whenua argued that the proposal was in breach of sections 6(e), 7(a) and 8 of the RMA as it did not recognise and protect their relationship with the river; did not enable them to fulfil kaitiakitanga obligations; and did not give effect to the principles of the Treaty of Waitangi. Consequently, tangata whenua sought changes to the resource consents to require that water taken from within the catchment be used within the catchment; and amendments to the plan change to provide for tangata whenua interests.

The Court characterised the concerns raised by tangata whenua as spiritual or metaphysical effects rather than purely physical; and expert evidence was provided by both sides as to the meaning of, and the effect of the proposal on, mauri, mana whenua, mana moana, taonga and kaitiakitanga. The key question the Court asked itself was whether in the absence of any substantive physical effect on the river there could be a spiritual effect on the mauri of the river and/or the relationship of tangata whenua with the river such as to require the prevention of the use. The Court stated:

"[32] ...Each case will turn on its own facts. Linking likelihood of effects on metaphysical values solely to perceived physical effects is not the only test. However, in most cases it has provided the most tangible evidence, or provided the greatest assistance."

...

[61] We note that the perception of an offence against and harm to the mauri of the river lies at the heart of the perception of the offence against other Maori customary values. We also note that it is the use to which the water is put, rather than the extraction itself that is the cause of perceived injury to the mauri of the river.

[62] We have to say that despite its sincerity, elements of this evidence troubles us…

...

[67] Mr Black opined that changing the nature of a waterway can impact on its mauri even where there may be minimal physical impact. But he added:

> [i]t is as much about impact on the beliefs of tangata whenua in the presence and manifestation of the mauri as it is about the health of the resource.

We are not convinced that this represents an effect on the environment.

Further and in relation to tangata whenua values the Court stated:

[71] …A natural corollary of our finding that the effects of the proposed abstraction on the mauri of the river are not such as to warrant refusing consent might be that the consequential effect on other tangata whenua values is also not significant. However we fear that the issue is not quite so simple.

The Court went on to find that while there would be effects on the relationship that tangata whenua had with the river, such effects could be made less than minor by the imposition of appropriate conditions on the resource consent, including the establishment of a tangata whenua consultation group. The Court found that this group could also be a useful mechanism for the discussion of other proposed large scale water takes. The Court asked the parties to confer and agree on changes to the plan which would "give effect to the spirit and intent" of the decision, while reserving the right to decide the wording if agreement could not be reached.

The decision follows other similar cases (such as Ngawha[5]) where while acknowledging the relevance of considering spiritual and metaphysical effects the Court uses the presence of any physical effects to adjudge their significance. There is no word yet as to whether the decision will be appealed. We will report on any developments in the case in future articles.

Footnotes

[1]World Wildlife Fund New Zealand, Beyond Rio: New Zealand's Environmental Record since the Original Earth Summit (Wellington: WWF NZ), May 2012.

[2][2011] NZCA 119.

[3]Down v R [2012] NZSC 21.

[4][2012] NZEnvC 75.

[5]Friends and Community of Ngawha Incorporated v Minister of Corrections [2002] NZRMA 401 at paragraphs [41] and [42].

Left to right – Main aeration basin with 3 x 110 kw aerators in foreground and a total 1300kW of installed aeration, Twin DAF tanks for solids separation, Main aeration basin with 1300kW of installed aeration and sludge return pipes from DAF units in foreground, Close up of an Aqua Turbo aerator, with vertical upflow and radial outflow

Turning Wine into Water – Coping with Rapid Growth in Winery Wastewater at the Blenheim Wastewater Treatment Plant

Stuart Donaldson – Marlborough District Council and Humphrey Archer – CH2M Beca Limited

Over the last eight years, New Zealand's wine industry has experienced an explosion in international popularity, boosting export revenue and enhancing the tourist industry. The Marlborough region, the largest wine producing region in the country, is the centre of this growth with over 22,000 hectares of vineyards. More than 90,000 tonnes of grapes were crushed in Marlborough's Riverlands area during the 2008 and 2009 vintages, increasing to 113,000 tonnes in 2011.

Wineries produce a rapid peak of high strength wastewater for a short period during vintage. With such dramatic growth in the industry, it became evident that the existing Blenheim Wastewater Treatment Plant (BWWTP) no longer had the capacity to treat these peaks effectively. Odour generation had occurred during the 2003 to 2007 vintages as a result of this short term peak loading. Marlborough District Council therefore engaged CH2M Beca to assist in developing a solution, which continued the relationship first started back in 1997.

"With such dramatic growth in the industry, it became evident that the existing Blenheim Wastewater Treatment Plant (BWWTP) no longer had the capacity to treat these peaks effectively."

With a relatively static population of around 28,000, Blenheim's wastewater treatment facilities still satisfied current demand for domestic wastewater treatment. It was therefore decided to separate the treatment of winery and other industrial wastewater from domestic wastewater.

Realising there was a need for more water services for new industries such as the rapidly growing winery sector, Council purchased the water assets of a former freezing works which had closed in 2001. The freezing works had its own wastewater treatment plant conveniently located next door to the BWWTP. If upgraded this provided the ideal opportunity to become a dedicated wastewater treatment plant for industry at Riverlands – meanwhile the existing BWWTP would continue to serve domestic wastewater requirements.

The primary aim of the industrial treatment plant upgrade was to increase its capacity to cope with rapidly increasing loads from the crushing of grapes during harvest in late March and April. The upgrade focussed on increasing the biochemical oxygen demand (BOD) load capacity of the industrial aeration ponds. The normal industrial BOD load to the BWWTP is 1,300kg/day, but this had increased tenfold to over 20,000kg/day during the 2008 and subsequent vintages – a BOD load equivalent to a domestic population of 300,000.

From 2005 to 2008 wineries consistently under-predicted their effluent BOD mass loads. Given the uncertainty of these predictions a staged upgrading strategy was adopted to minimise initial capital expenditure, a decision which proved justified, particularly when the growth rate levelled off, due in part to the effects of the global financial crisis.

Various options were considered for increasing the industrial BOD treatment capacity including a trickling filter, anaerobic lagoon and aeration ponds. A trickling filter was discounted due to the high capital cost. Treating the industrial wastewater in a covered anaerobic lagoon was also discounted due to the low wastewater temperature (requiring a sludge age of around 60 days) and rapid production ramp up (1 – 2 weeks) at the start of the vintage. This rapid start up could not be handled by an anaerobic pond operating at ambient temperature, due to the slow growth of methanogenic biomass.

Aeration ponds were selected as they would have the capability of handling the rapid increase in load. They were also a robust and low capital cost option as the two existing ponds (2.9m depth) could continue to be used.

The ponds were improved with extra aeration and rock lining of the base and sloping banks to prevent erosion caused by the relatively large aerators. Any increased power demand would be short-lived because of the duration of vintage.

For the 2008 vintage the aeration was nearly doubled to 825kW with the aeration ponds operating in parallel as single-pass reactors. For the 2009 vintage the aeration was further increased to a total of 1,800kW.

Additionally, the aeration ponds were converted to operate in series in the activated sludge mode with the biomass separated by

Dissolved Air Floatation (DAF) and returned to the aeration ponds to increase the MLSS. A DAF process was used because biomass in highly loaded winery wastewater treatment processes tends not to settle adequately in clarifiers.

The industrial wastewater received during the vintage is acidic (pH of 4 – 5). Lime is added to the ponds using a tractor spreader to increase the pH to around 7. The incoming wastewater was also high in carbon (from sugars in the grape juice), but relatively low in nutrients, despite co-treatment with meat processing effluent which has high nitrogen. Therefore, nitrogen and phosphorus nutrients were added to the aeration ponds to allow biomass to grow.

The layout of aerators for the 2009 upgrade was based on eight 110kW Aqua Turbo® vertical upflow aerators and space allowed for a further 110kW aerator to be added if the BOD load continued to increase. BWWTP is the largest single site installation of Aqua Turbo® aerators in New Zealand with 24 units and a total installed power of 1,347kW. They have so far proven to be reliable and effective.

“Various options were considered for increasing the industrial BOD treatment capacity including a trickling filter, anaerobic lagoon and aeration ponds.”

The aeration pond upgrades have been and continue to be successful in treating winery effluent and avoiding the generation of unwanted odours. They also provide sufficient operational flexibility to deal with the short term high peak loads without impacting on the operation or performance of the BWWTP. ■

New Zealand Biosolids: Regulation, Risks and Realities

Jim Bradley, Susan Bennett and Garrett Hall – MWH

This paper is an abridged version of a conference paper presented by Jim Bradley at the Australian Water Association Biosolids Conference, 18 – 20 June 2012.

The New Zealand biosolids state-of-play is a mixed bag at present. In the past wastewater management was driven by technical considerations but the sustainability provisions of the Resource Management Act 1991 (RMA) and the Local Government Act 2002 (LGA) are now driving holistic and integrated approaches. Despite this broad legislative framework and the rhetoric about sustainability the actual uptake of beneficial biosolids reuse has, to date, been limited and the majority of municipal sludge and biosolids are landfilled.

There are four main reasons for the lack of good traction for beneficial biosolids reuse:

1. A small and uncertain market for biosolids
2. Quality control issues with some sludge/biosolids treatment plants
3. Resistence to the use of biosolids in primary industry, because of the commercial importance of New Zealand's "clean/green" image and the potential for the negative perception of biosolids to block offshore markets
4. Economic drivers:

» Despite increasing transport and landfill gate charges, landfill disposal is normally the lowest cost and simplest route for sludge and biosolids disposal. However, the Emissions Trading Scheme (ETS) charges will add to landfilling costs.

» There is increasing pressure on local authorities to reduce capital costs of infrastructure provision. This can lead to 'holding pattern' solutions (such as storing sludge) that reduce or avoid capital costs, even at higher operating costs.

» There are costly monitoring requirements in complying with the Guidelines for the Safe Application of Biosolids to Land in New Zealand 2003 (New Zealand Biosolids Guidelines).

Other important drivers for local authorities and industry in managing sludge and biosolids include:

- The need to meet regulatory requirements, particularly the provisions of the RMA and regional and district planning instruments
- The increased quantity of sludge produced in New Zealand from population increases, improved liquid stream processes that remove a higher proportion of the solids, and the need to periodically desludge oxidation ponds and sludge lagoons to maintain performance
- A lack of knowledge around the quality and quantity of sludge and biosolids and the shortage of track record in quality control for producing high quality biosolids
- Social and Maori cultural considerations and restrictions
- 'Resource efficiency' (re-use) drivers, including waste minimisation and greenhouse gas reduction as included in the New Zealand Waste Strategy 2002.

The Regulatory Setting

The application of biosolids to land, regardless of the type of land and land use, is regulated by the RMA through regional plans and resource consents. The Health Act 1950, LGA 2002 and other legislation including those relating to agricultural chemicals, land transport, hazardous substances and waste minimisation also contain provisions to be complied with.

The RMA has a 'sustainable management purpose' and an 'effects-based approach'. The meaning of effects includes positive, potential and actual adverse and cumulative effects on the environment. It also includes 'any potential effect of high probability and any potential effect of low probability which has a high potential impact'. This component of an effects-based assessment brings in risk considerations when appraising sludge disposal and biosolids application to land.

The Guidelines for the Safe Application of Biosolids to Land in New Zealand (The New Zealand Biosolids Guidelines) promote a permitted activity rule for Grade Aa, the highest stabilisation and contamination grade, that would be included in all regional plans that would allow unrestricted use of this grade of biosolids to land. To date only a limited number of the 17 Regional Councils in New Zealand have included such a permitted activity rule. All do, however, include policies and rules on the application/disposal of sludge and biosolids to land, most classifying the activity as discretionary which means each proposal needs to be considered on its own merits through an RMA regulatory process.

Australian and New Zealand Biosolids Guidelines Reviews

In 2009, the Australian and New Zealand Biosolids Partnership (ANZBP) undertook a study led by consultants PSD Pty Ltd to review and compare the Australian and the New Zealand biosolids regulations and guidelines. Jim Bradley and Garrett Hall of MWH in New Zealand provided input on the New Zealand biosolids position.

"In 2009, the Australian and New Zealand Biosolids Partnership (ANZBP) undertook a study led by consultants PSD Pty Ltd to review and compare the Australian and the New Zealand biosolids regulations and guidelines."

While all 14 of the study's recommendations for updating respective guidelines are relevant, the five recommendations considered the most applicable to New Zealand are:

1. "Guidelines should be based on sound science with a proportionate risk basis"
2. "Guidelines should be based around sustainable biosolids use"
3. "Vector attractant reduction standards should be significantly improved with a focus on reducing the odour potential of biosolids"
4. "Guidelines should recognise the need for accountability to the community as well as a statutory reporting requirement"
5. "Contaminant levels for each of the contaminant grades should be updated in line with current international Australian and New Zealand research experience"

The (non-statutory) New Zealand Biosolids Guidelines were developed by the New Zealand Water and Waste Association (now Water New Zealand) and the Ministry of the Environment in 2003. They were developed to assist biosolids producers, dischargers, regulators (regional and district councils) to manage the discharge of biosolids to land. The document stated that five-yearly reviews would be undertaken. The first review was due in 2008 but has not yet occurred, however a review of the guidelines is now being proposed.

At the time of preparing the guidelines it was acknowledged that recommendations 'will only gain force if the regulators (Councils) choose to incorporate them into regional plans and/or in resource consents'. To date this has only occurred to a limited degree.

As well as the same five recommendations made for the Australian/New Zealand Biosolids Partnership Guidelines (as recorded above), the New Zealand Biosolids Guidelines review should also:

- Suggest methods for mitigating, avoiding and remedying risks in accordance with the provisions of the RMA
- Advise on the periodic and relatively infrequent application of biosolids to land as compared to the more continuous and frequent application from processes continuously producing biosolids
- Give specific reasons for the range of metals and organic contaminants included for the guidelines
- Assess the needs and costs of monitoring and associated analysis. For example, testing a single biosolids or soil sample can cost in excess of $2,500 plus the cost to collect and transport the sample
- Address the need for a better understanding of the degree to which nitrogen is released from the biosolids and soil matrix into the soil water matrix, particularly ground water

Biosolids Application to Land – Risks and Realities

The New Zealand Biosolids Guidelines state that "risk management is the key to successfully managing biosolids application to land in New Zealand". The proposed review of the New Zealand Biosolids

> "It's safe to say that economics will continue to be a key driver, if not the single most important decision driver, for local authorities with short term capital and operating costs often driving solutions instead of longer term life cycle costs."

Guidelines should focus on a wide range of issues and particularly soil contamination related matters including appropriate contaminant levels, stabilisation procedures and management and monitoring procedures. The specific methodology and guidance will need to address the risks and realities of the New Zealand environment including:

- The potential impact or damage to product markets, particularly for food production including animal grazing. The importance to New Zealand of overseas primary product markets must be kept in perspective. The Fonterra (Dairy) Co-operative Group's policy, for example, restricts the use of sludge in specified dairying activities.
- Community concerns and perceptions can stand against land application including the 'yuck factor'. Social, community and neighbour issues need to be appropriately addressed through a participatory and consultative approach when considering land application and disposal.
- Maori cultural considerations need to be taken into account including trucking sludge and biosolids past traditional and sacred Maori lands. Maori – tangata whenua cultural and spiritual values need to be worked through in a collaborative and timely manner.
- There are high costs and potential litigation risks associated with obtaining resource consents for long term land application/disposal of sludge and biosolids.

- There are odour and vector control risks of land application for beneficial use and other land disposal practices.
- Assessing the cumulative medium and long term adverse effects on surface and ground water quality from contaminant and nutrient runoff and leaching will be an important factor.
- There should be more attention paid to the end use of the land and greater assessment of biosolids application to that land and in the communication of the possible impacts on the end use of the land.
- Maintaining quality control of biosolids for application to land will be a vital component of any guidance and methodology.
- There are risks with not ensuring resource consents have effective and cost affordable monitoring conditions.
- Reuse as landfill cover and final re-capping/vegetation establishment should be further developed.
- Landfill disposal may become less attractive financially as the ETS charges apply and transport and landfill acceptance costs rise as the value of landfill space increases.

It's safe to say that economics will continue to be a key driver, if not the single most important decision driver, for local authorities with short term capital and operating costs often driving solutions instead of longer term life cycle costs. Potential changes to the economic drivers, such as changing costs of landfill disposal, will need to be taken into account.

While there are limited markets for compost and other reusable biosolids, which will continue to influence decisions around the beneficial reuse of biosolids onto land, there appears to be considerable potential for land restoration to encompass the use of biosolids. For example, quarries, open cast mines and degraded land offer significant opportunities. Such an opportunity is being developed with Solid Energy New Zealand as they reinstate and restore open cast coal mines.

The Way Forward – Road Map Check List

In looking forward, the following ten point road map may act as the 'straw man' for local authorities and the wider industry and market to use as a guiding check list for investigations and decision making.

1. Further develop proactive sustainable management and sustainable development approaches and strategies that acknowledge and promote the resource value of biosolids at the same time as encompassing the four well-beings approach of local authorities – environmental, social, cultural and economic. These approaches and strategies must have future proofing built into them and be able to accommodate future changes.
2. Where appropriate learn from overseas experience but at all times ensure the New Zealand context is well understood and the nature of the New Zealand environment – our soils, land use and markets – is incorporated into any approaches.
3. Ensure an appropriate review of the New Zealand Biosolids Guidelines with output information that is soundly based for New Zealand soils and environments and provides clear direction for the practices promoted with on-the-ground application information.
4. Include appropriate approaches to land application of sludge and biosolids in regional planning documentation including the application of permitted activity rules for high quality biosolids.
5. Apply appropriate risk-based approaches to sludge and biosolids application to land and other disposal and re-use techniques.

6. Ensure investigations and resource consent conditions provide necessary safeguards and have some balance between monitoring practicalities, costs and risks and meeting the Wastewater and Sludge/Biosolids Policy.
7. Appreciate the basis of market-led policies (such as Fonterra's) and, where appropriate, ensure rational use of science, environmental protection and public health factors are taken into account.
8. Further investigate and, where appropriate, use biosolids for quarry, mine and other land regeneration and restoration.
9. Investigate and implement joint local authority shared services for both regional and subregional sludge and biosolids treatment and disposal/re-use approaches particularly where smaller local authorities might share with a larger neighbouring council with a large Wastewater Treatment Plant and associated sludge treatment facilities.
10. Further consideration, as was included in the New Zealand Biosolids Guidelines, of a National Environmental Standard (NES) on biosolids application on land prepared along the same lines as in the recently enacted NES for contaminated land.

A Paradigm Shift Approach – No Sludge Wastewater Treatment

This leading approach through its 'no sludge' solution to wastewater treatment meets the local government benchmarks of environmental, community, cultural and economic needs. The Hastings District Council and MWH working in partnership with local Maori and developed a unique solution which presents a paradigm shift in wastewater treatment and discharge in New Zealand and probably internationally. The solution has been developed in significant part to meet the cultural and spiritual aspirations of tangata whenua in addition to providing treatment of human wastewater. This treatment system includes a low organically-loaded random packed plastic media Biological Trickling Filter (BTF), and Papatuanuku (earth mother) rock passage facility without primary settlement or secondary clarification.

> "The Hastings District Council and MWH working in partnership with local Maori and developed a unique solution which presents a paradigm shift in wastewater treatment and discharge in New Zealand and probably internationally."

The treated human wastewater together with the excess cell biomass flushed off the BTF media is discharged out a long offshore ocean outfall along with a separately treated industrial (trade waste) flow. This concept provides biological transformation and spiritual cleansing of human waste that produces a treated human wastewater acceptable (in accordance with the current resource consent) to return to the marine environment without producing secondary biological sludge requiring further treatment and disposal on land. This approach has also been recently implemented at Gisborne and is planned for Napier City. ■

Rotorua Wastewater Treatment Plant's New Side Stream MBR – Innovation and a New Zealand First

Kevan Brian, Raj Valabh and Ying Yang – AWT Water Limited

Introduction, Background and Procurement Philosophy

In 2008, the Rotorua District Council (RDC) initiated a review of the capacity of their Wastewater Treatment Plant (RWWTP). A capacity study found that to provide improved process redundancy and treatment capacity, the plant would need to be upgraded with the addition of activated sludge clarifiers and greater reactor volume.

The RWWTP is built on an area influenced by geothermal activity and the water level of Lake Rotorua. The ground conditions are therefore challenging for the founding of large water-retaining structures. Preloading and/or piling of the structures is required presenting both construction/design risks and a program risk in terms of the time required for preloading.

A detailed investigation was undertaken to find the most appropriate solution for the plant expansion taking into account geotechnical conditions, space restrictions, existing infrastructure, continuity of operations, whole of life and capital costs. The solution selected was to retrofit one of the three existing but disused reactor clarifier tanks into a membrane bioreactor plant (MBR). This was to be operated as a side stream to the existing activated sludge process.

To ensure RDC plant operators were delivered a plant that met their specific needs, the Principal (Rotorua District Council) engaged AWT Water as consultants to deliver a process and mechanical and electrical design capable of doing just that.

Following the process selection, a workshop with key stakeholders was held to define the boundaries of supply and discuss the most appropriate allocation of performance, quality and risk. It was decided that several groups of equipment would be selected and procured for free issue supply to a contractor/installer. The main free issue package was that of the membranes, screens, permeate pumps, chemical cleaning equipment, and membrane control equipment, which were so grouped to allow for the performance of the membranes to be guaranteed by the single party that was most appropriate to cover this.

In addition to the membrane package, other major equipment items including pumps, mixers, blowers, diffusers, scum removal, PLC and software were selected and procured directly by RDC. Procurement was based on quality, previous performance of similar equipment, knowledge of the suppliers, their field support as well as on whole of life value for money.

Early procurement of these items, which often had long delivery lead times, enabled the project to be delivered within the tight delivery timeframes. An additional benefit of free issue supply was that RDC was able to maintain and manage the equipment and performance guarantees with suppliers directly, rather than through a third party contractor as is often the case.

Design and Innovations

The selected MBR process consists of a suspended growth biological reactor integrated with a GE ultrafiltration membrane system using ZeeWeed® hollow fibre membranes. The ZeeWeed® ultrafiltration membranes are submerged in the bioreactor (in isolated tanks), in direct contact with the mixed liquor. Through the use of a suction pump, a vacuum is applied to a header connecting the membranes. The vacuum draws the treated water through the hollow fibre ultrafiltration membranes and into the pump, which then discharges treated water. Airflow is introduced to the bottom of the membrane modules to produce turbulence to scour the external surface of the hollow fibres. This transfers rejected solids away from the membrane surface, and the airflow also provides a portion of the process biological oxygen requirements.

"Following the process selection, a workshop with key stakeholders was held to define the boundaries of supply and discuss the most appropriate allocation of performance, quality and risk."

The plant was the first MBR in New Zealand to use hollow fibre membranes in the context of municipal wastewater treatment. It is also the largest MBR plant in the country with an average capacity of 7.3ML/d and a peak capacity of 11ML/d. The addition of this MBR extended the RWWTP capacity to allow for the projected growth of the catchment for the next 30 years, as well as providing for immediate redundancy to allow operations staff to conduct maintenance on the existing clarifiers.

The design of the MBR was based upon achieving the highest possible nitrogen removal efficiency with a target total nitrogen in the permeate from the membranes of <4.5mgN/L.

The choice of the process configuration had to satisfy the following constraints:

- The membranes had to be at the "end" of the process train as they are the last stage in the treatment process where activated sludge (mixed liquor) and discharge water (permeate) are separated. The membranes are continuously scoured with air for cleaning, causing this last stage to be highly aerobic. The membranes also require a high recycle rate to prevent an increase in solids concentration in the membrane tanks. This produces a highly aerobic recycle. Any remaining ammonia will be converted to nitrate in this zone and can enter the permeate.
- The levels of nitrogen removal (>85%) required high recycle rates between aerated and non-aerated zones to get enough nitrate and COD together to promote denitrification.

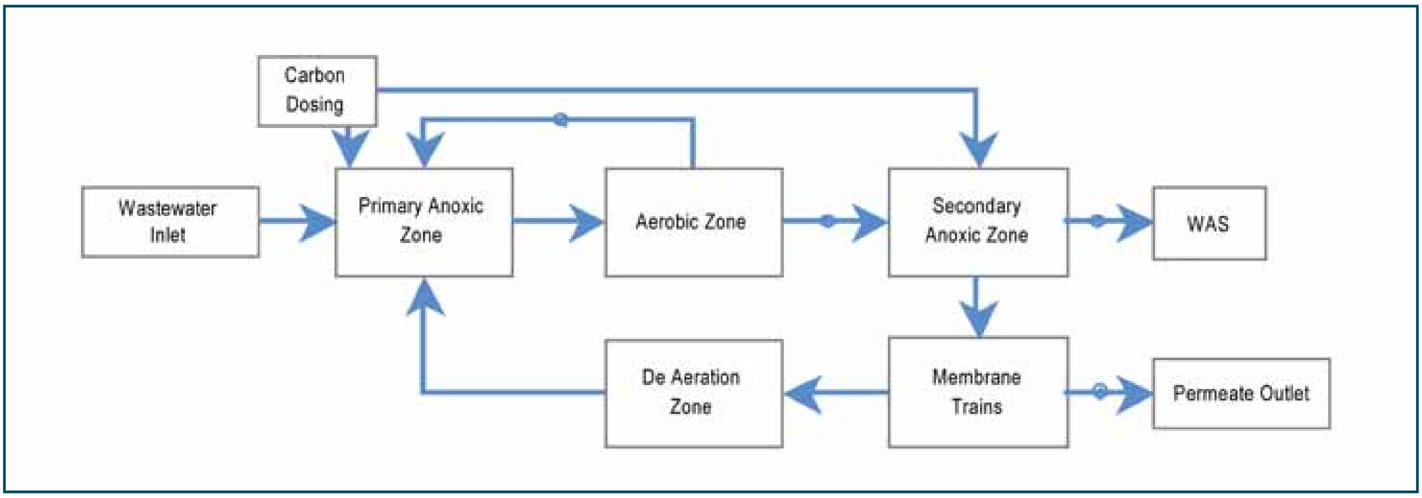


Figure 1 – Side Stream MBR Process Flow Diagram

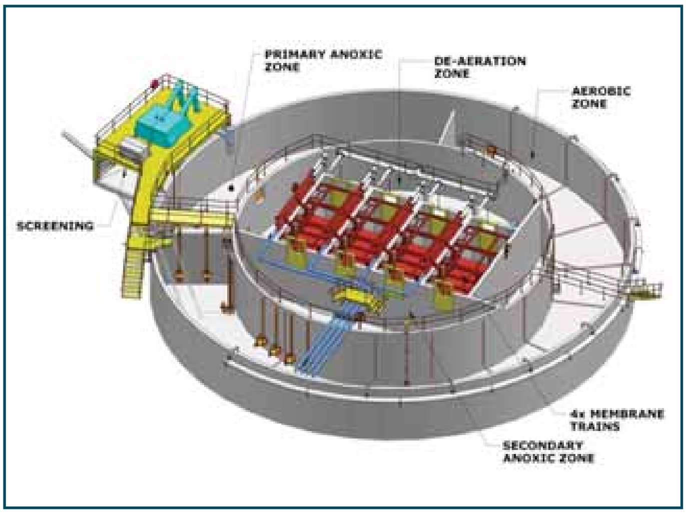
- Primary settled wastewater that is fed to the existing activated sludge process at the WWTP has a low carbon to nitrogen ratio. Additional carbon sources were required to achieve the low oxidised nitrogen concentrations in the MBR permeate.
- The process was to be retrofitted to an old reactor/clarifier (donut) process tank with the disused clarifier located in the centre of the donut and the biological process on the outside.
- The membrane trains have a maximum water depth of 3.05m whereas the diffused aeration system required a water depth of over 3.5m for maximum efficiency.

The basic process configuration selected for the plant was a four stage Bardenpho. As mentioned earlier, the membrane tanks resulted in a highly aerobic recycle, so a deaeration zone was located after the membranes to reduce the dissolved oxygen content before the recycles were directed to the primary anoxic zone. This is shown in the block diagram in Figure 1.

> "The vacuum draws the treated water through the hollow fibre ultrafiltration membranes and into the pump, which then discharges treated water."

The process layout presented an additional challenge as a significant portion of the reactor volume was contained in the old circular clarifier in the middle of the donut. The membranes have to be installed in rectangular tanks within strict tolerances in multiple "trains" such that one of the trains can be taken out of service while maintaining throughput. It was decided to locate the membrane trains within the circular clarifier section of the old reactor and locate the secondary anoxic and deaeration zones on either side of the membrane trains. This is shown in Figure 2.

Figure 2 – MBR layout within existing reactor/clarifier tank



As noted above, the depth of the membrane trains must be 3.05m or less, whereas the fine air diffuser system needs to be located relatively deep to maximise efficiency. In the process layout that was selected, the membrane trains were to be built in 3.05m tanks with a top water level slightly higher than the biological process located on the outside of the donut. This allowed mixed liquor from the out-side of the donut ring to be pumped to the secondary anoxic zone to flow by gravity to the membranes, into the deaeration zone and back to the primary anoxic zone. Using this configuration, we were able to maximise the volume of the reactors and the depth of the aerated zones while minimising pumping and energy requirements. The process configuration essentially has two recycles (see Figure 1) that total 8-11 times the influent flow. This enables the process to achieve very low ammonia and oxidised nitrogen levels.

The carbon to nitrogen ratio (C to N ratio) of a wastewater (measured as COD to TKN) largely determines the extent of nitrogen removal that can be achieved in any nitrifying/denitrifying process regardless of its configuration. An ideal C to N ratio for N removal is between 8-10. At Rotorua, the C to N ratio after primary treatment is approximately 5, meaning that additional carbon is required to remove nitrogen. The ability to feed both raw (screen and grit removed) wastewater and primary settled wastewater to the MBR was provided so carbon from the raw wastewater could aid denitrification and reduce additional carbon requirements. The design allowed the operators to select any range of raw wastewater from 0-50% of the full flow to the MBR.

The civil, mechanical and electrical design of the plant upgrade was centred on the membranes and their ancillary equipment such as the screen, permeate pumps, chemical cleaning and controls. The upgrade design, therefore, needed to be closely intertwined with the relatively fixed system from GE to maintain the performance guarantees to RDC. Further requirements to fit the plant in and around an existing reactor/clarifier, as well as to integrate the final operability of the side stream upgrade within the overall plant, resulted in many design challenges. Design iterations culminated in tender specifications and drawings for the following major works:

- Two feed pump stations – one raw (screened and grit removed) and one post-primary sedimentation – and rising mains.
- Integration of membrane screens (supplied by GE) into feed to plant – placed on a raised platform adjacent to the Membrane tank.
- Membrane reactor designed to maximise the available space within the existing reactor/clarifier. The reactor included a primary anoxic zone with mixing, separation wall, diffused aeration zone, axial flow pumps to recycle to primary anoxic zone and axial flow pumps to feed forward to the raised secondary primary anoxic zone.
- Feed control from the secondary anoxic zone into the four separate membrane trains.
- Outlet from the membrane trains to the deaeration zone and gravity feed back to the primary anoxic zone.
- Membrane module and pipework layout.
- Permeate pipework, pumps setout, permeate tank design and reconnection to existing plant outlet.
- Chemical cleaning setout and chemical pipe design.
- Blower selection and setout for membrane scour and fine aeration.
- Blower building, pipework and pipe bridge.
- Waste Activated Sludge (WAS) pumping and rising main.
- Scum removal system.
- All mechanical and process pipework.
- All control valves, penstocks, and instrumentation.
- All stairwells, bridges, covers, gratings, access hatches, handrails etc.
- Electrical design and integration with existing plant.
- Control Philosophy to integrate with GE and existing plant.

The final design of the reactor tank including the membrane trains utilised almost the entire volume of the tank, enabling RDC to maximise the capacity of the equipment and infrastructure.

The plant was designed using a 3D modelling software called SolidEdge. AWT Water built a full 3D model of the side stream upgrade including the modifications to the existing reactor/clarifier tank, assisting in the process sizing of the complicated tank layout. All equipment, pipework, valves and fittings were included in the model, thus ensuring no clashes during the construction period and minimising discrepancies, and hence variation claims, by the contractor. Figure 3 shows the final designed 3D model of the plant while Figure 4 shows an identical actual view of the plant from an aerial photograph taken prior to wet commissioning. The similarity of the two images emphasises the ability for 3D modelling to enable clear visualisation and comprehension of complex plant designs. This is not only an excellent tool for designers, but also provides significant value to the stakeholders throughout the design process.

Figure 3 – 3D Model of plant

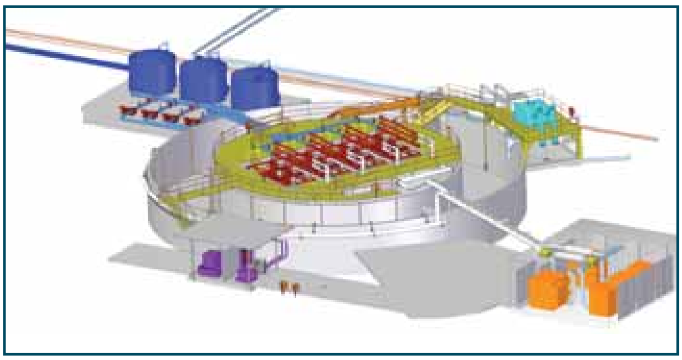


Figure 4 – Aerial photo of new plant

In their boundary definition, RDC determined that given the likely tenderers for this project, the installation contractor would be best suited to carry the risk for the refurbishment of the tank and the design of other structural elements required within the project. Given this, the refurbishment of the existing tanks, installation of internal membrane train walls, coating of the walls, inlet screen stand, pipe bridge, blower building and chemical shelter were all specified in the main installation contract as for design and construct.

Commissioning and Optimisation

Commissioning of the plant upgrade was a challenging process because of the number of different companies and stakeholders involved. The main installation contract was awarded to Downer, who were also engaged to undertake pre-commissioning testing and to provide support personnel during the commissioning process. As part of their supply contract, GE was on site to commission the membrane plant. In addition, the MBR reactor was commissioned by AWT Water, overall programming was undertaken by Horizon, system integration by Citycare, and RDC operators, being the key stakeholders, were also involved. The successful management of this challenging commissioning process was achieved through open and effective communication between all parties.

> "The civil, mechanical and electrical design of the plant upgrade was centred on the membranes and their ancillary equipment such as the screen, permeate pumps, chemical cleaning and controls. The upgrade design, therefore, needed to be closely intertwined with the relatively fixed system from GE to maintain the performance guarantees to RDC."

Process commissioning was completed 28 March 2012 with a performance test of the membranes completed on 10th of April. After this time, optimisation of the process recycles and carbon dosing was started and is on-going at the time of writing. Total nitrogen results in the MBR plant discharge water from 26 April 2012 to date are shown in Figure 5.

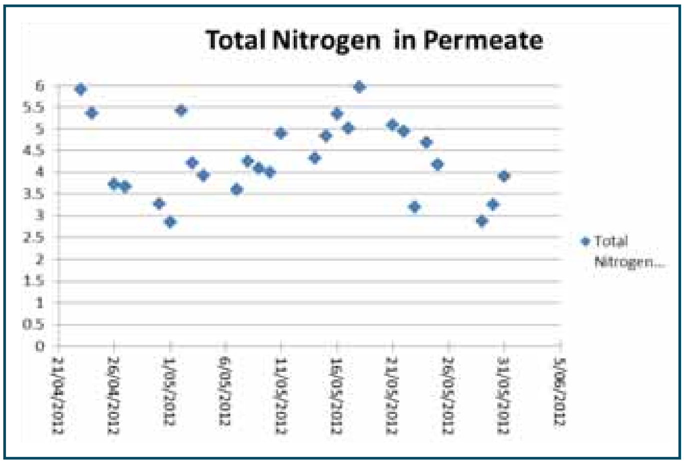


Figure 5 – Graph showing Total Nitrogen Results during commissioning and initial phases of optimisation period

Conclusions

The process to increase capacity and provide redundancy to the Rotorua Wastewater Treatment Plant had many challenges from the initial capacity study through to the final commissioning and optimisation. Sound procurement decisions, innovative use of existing infrastructure, good design processes, effective tools and continuous communication resulted in a plant that is a first for the country, exceeds all performance requirements and is one that all stakeholders are proud of. ■

Setting Up of Subsidy Scheme for On-site Wastewater Systems for Low Income Households in Developing Countries

Ash Deshpande – Harrison Grierson Consultants Limited and Stuart King – Strategy and Economics Limited

Introduction

Low income households in disadvantaged and isolated communities of developing countries generally have poor access to water and sanitation facilities. Provision of a good sanitation system and its upkeep is often neglected due to other household needs taking priority. This predicament carries an inherent risk of negative impacts on health, social well-being and economic prosperity for the community.

"Before the design of any subsidy scheme, it is important to investigate the socio-economic data of the community. An inherent part of this data review should be determination of household income levels and the basic needs poverty line."

In this article, we describe the options for implementing a subsidy scheme based on the assumption that a pot of money is available and identified for a particular community. The source of this capital can either be the government or an international funding agency. From this perspective we have explored various approaches to financing of on-site wastewater systems for low income households in developing countries.

Financing and Subsidy Approach

There are three key components to financing on-site wastewater schemes:

- **Subsidy setting** – The subsidy component relates to the amount of money that will be given in the form of a grant (i.e. money that does not have to be repaid) to a community or household to help pay for the cost of the on-site sanitation infrastructure.
- **Supporting financing** – This component relates to the financing arrangements that the community or household will have to put in place in order to finance that portion of the infrastructure cost which is not covered by the subsidy payment.
- **Maintenance financing** – This element relates to how communities (or households) shall be expected to pay for ongoing maintenance (e.g. de-sludging of septic tanks) of their sanitation infrastructure.

Subsidy Setting

Before the design of any subsidy scheme, it is important to investigate the socio-economic data of the community. An inherent part of this data review should be determination of household income levels and the basic needs poverty line. If possible, a 'willingness to pay' survey for the infrastructure services should also be conducted. Similar surveys carried out in different parts of the developing world have found that households are willing to pay 1 – 2% of their disposable income for sanitation facilities. However, this needs to be confirmed for the community under study.

The subsidy levels, in turn, would be set on the basis of that percentage of average household income that is deemed to be affordable as well as household's perceived willingness to pay. Based on the analysis of the community survey and economic data (mentioned earlier) plus the capital cost of the on-site infrastructure, the contribution of each household as a percentage of annual income should be determined. This value is important in determining the minimum subsidy level applicable for the particular community. For example, if a 50% subsidy translates to more than, say, 5% of the annual income of a household and a 70% subsidy corresponds to less than 5%, of a household's income, then 70% should be targeted as the minimum subsidy level (assuming that the household is willing to pay 5% of their annual income towards the sanitation facility).

Three broad options are available regarding subsidy allocation:

- Separate levels of subsidy financing (i.e. 100%, 70%, 50%, etc.) could be made available with each subsidy level tied to the income of the households comprising a community (or the household directly).
- Alternatively, a simpler scheme could be adopted under which just two subsidy levels are offered to customers – 100% for the very poorest households and some other amount (i.e. 70%, 95%, etc.) for all other households.
- Finally, the simplest solution would be for a single subsidy amount to be made available to households irrespective of their income. This subsidy level could be set on the basis of what an 'average' household can afford.

Table 1 below presents an example of a possible subsidy allocation mechanism for each of the three options.

Household Income (currency units)	Subsidy Permitted (%)
Multiple Level Subsidy Scheme – Average	
< 15,000	100
>= 15,000 but < 25,000	95
>= 25,000	70
Dual Level Subsidy Scheme – Option A	
< 25,000	100%
>= 25,000	70%
Dual Level Subsidy Scheme – Option B	
< 15,000	100%
>= 15,000	70%
Single Level Subsidy Scheme	
N/A	95%
15,000 – poverty line; 25,000 – average income	

Table 1 – Subsidy/Income Scheme – Examples

The perceived advantages and disadvantages associated with each of these options are presented in Table 2.

Option	Advantage	Disadvantage
Multiple Subsidy Levels	Fairest scheme as households pay what they can afford Maximises use of available subsidy funds	Potentially complicated to manage a multiple level scheme Difficulty in validating income levels will mean disputes over which subsidy category households are entitled to
Two Subsidy Levels (100% and 70%)	Poorest households are included Simpler to administer than a multiple-level scheme	Some households that can afford to make more than a 25% contribution will not be required to do so
One Subsidy Level (95%)	Simplest approach to administer – no need to conduct means tests	Poorest will potentially be excluded as they cannot afford even a 5% contribution

Table 2 – Subsidy Options Evaluation

It is also possible that some households may provide in-kind contributions (in the form of labour and materials) that will help defray their cash contribution. Indeed, such in-kind contribution should be encouraged to facilitate take-up. Such contribution can easily be factored into the subsidy scheme. However appropriate measures must be taken to avoid compromising the quality of infrastructure.

Support Financing

It is important for the successful implementation of any scheme that alternative sources of financing are available for communities/households to access in order for them to finance that part of the project implementation cost not covered by a subsidy provision.

There are four general sources of financing that can be available:

- **Commercial loans from banks** – Such loans would almost certainly be of sufficient size to be able to cover the cost of sanitation infrastructure implementation. However, the difficulty is that such loans require collateral and given that many households have limited access to collateral then this may well create an insurmountable problem for many low income households. However, if a community is the loan recipient then perhaps this problem can be ameliorated.
- **Micro-finance/small business lenders** – Given the potential collateral issue facing many households, such micro-finance organisations could potentially play an important role in providing funding for many households as they have limited collateral requirements. The downside of this lending source is that interest rates are typically very high and there is no direct economic benefit to be gained from installing a sanitation facility that can be used to help repay the debt (unlike, for example, using such funding to start a small business).
- **Personal savings** – Some households will have access to existing personal savings while others may choose to start a savings scheme once they have been made aware of the sanitation programme in order to part-finance the investment.

- **Overseas funds** – Remittances from relatives and friends abroad play a significant role for many households in developing countries in either acquiring or maintaining their assets and so might also be expected to figure prominently in assisting with the sanitation investment programme.

Revolving Fund

Under a revolving fund scheme, households can borrow money from a fund established using the original capital or pot of money provided for the scheme. The loans from the fund are made under concessionary terms (e.g. six month repayment grace period, low interest rate, etc.) and communities/households are expected to repay the loan over, say, a two year period. The re-paid loans are then used to make new loans to another or set of households.

However, a Revolving Fund mechanism needs to be properly set up and administered which will likely require external assistance.

Maintenance Financing

There is always a potential risk of neglecting the maintenance of the on-site sanitation facility, especially by low income households due to affordability issues. Therefore, it is imperative that design of any subsidy scheme considers on-going maintenance.

Following are some options for maintenance financing.

- **Septic management fee** – This fee would be applied by the water authority or the local government to all water service customers and would cover the cost of disposing of septage waste. Private septage operators would not directly charge customers for their service but would instead be reimbursed by the local authority. One of the more successful urban sanitation investment programmes is to be found in Burkina Faso where the public utility added a sanitation services levy on to all water bills and used these funds to extend the sewerage network.
- **Voucher scheme** – Placing some of the capital into a fund to finance ongoing maintenance for the septic tanks installed under the scheme. A similar arrangement would be made for all ongoing programmes funded either through donor contributions and/or government. The programme could potentially take the form of a voucher system under which vouchers are issued to households who can exchange them for septic tank maintenance services. The private operators carrying out the maintenance are then reimbursed directly by the fund upon presentation of the vouchers (and other proof that the service has been properly carried out). The fund itself can be administered by a non-government third party such as an NGO, special purpose organisation or even the water authority.
- **Household deposit fund** – Under this option households could be required to provide a deposit. Depending on the scale of the deposit funds, some, or all, of this money could then be used to finance maintenance services. For example, all participating households could be required to place the current average cost of carrying out maintenance into a special account which they would not be allowed to access except for carrying out maintenance activities. Alternatively, a larger amount could be deposited to fund multiple ongoing maintenance services.
- **Community grant applications** – Each community could potentially submit an application to the central government for funding support to finance the maintenance of septic tanks in that particular village.

"Sanitation infrastructure investment is an extremely important enabling mechanism for enhancing the health, social well-being and economic prosperity of any community. Unfortunately, there is no immediately evident economic benefit to be gained from such investment…"

- **Community savings scheme** – Each community could be required to establish a regular savings scheme to which all households would contribute. The funds collected under this scheme would then be used to pay for maintenance services. In Honduras, an NGO called the "Cooperative Housing Foundation" was set up to help communities manage various aspects of village life including septic tank construction and maintenance. The NGO both provided small scale loans to households to build tanks and also assisted with community based savings schemes to pay for septic tank maintenance.
- **Payment instalment plan** – This approach is similar to the community savings scheme except that in this case it would be the organisation carrying out the septic tank maintenance activity that would offer a payment instalment option to its customers.
- **Fines** – Developing a system of fines for non-compliance with routine maintenance which, of course, will require a tank maintenance database to be established, a set of regulations to be drafted and a formal on-going monitoring programme implemented. The enforcement scheme would be targeted both at ensuring tanks are routinely maintained. The revenues collected through the imposition of such fines could be used for a variety of purposes such as to fully (or partially) subsidise the maintenance charges incurred by all households, helping subsidise the cost of replacing faulty tanks, etc.
- **Household responsibility** – Leaving the existing system intact and have households pay their own maintenance costs. This approach would have to be accompanied by an extensive public awareness campaign to try and get households to recognise the importance of regular maintenance as otherwise the environmental and health objectives will be compromised.

Conclusion

Sanitation infrastructure investment is an extremely important enabling mechanism for enhancing the health, social well-being and economic prosperity of any community. Unfortunately, there is no immediately evident economic benefit to be gained from such investment (unlike, for example, investing in a mobile phone, an electricity supply or even a road). Consequently, some creative mechanisms need to be found for financing such investment and all schemes need to be supported by a comprehensive programme of raising community awareness of the importance of good sanitation and associated demand promotion. ■

MBR Technology Reopens DOC Camping Ground

Dr. Steve Kroening – Apex Environmental Limited

Introduction

The installation of membrane bioreactor (MBR) technology has allowed the Department of Conservation (DOC) camping ground at Papatowai, on the Catlins coastal road between Owaka and Tokanui, to reopen following its forced closure due to wastewater disposal issues.

The camping ground had previously been fully serviced but the wastewater treatment system, designed for the site in 1981, was performing poorly due to overloading as the number of visitors increased which meant the facility had to be closed.

Following award of a tender to head contractor Oasis Clearwater Environmental Systems (Oasis), in conjunction with Apex Environmental Limited (Apex), to design, consent, install and commission a new wastewater treatment system, the camping ground was reopened as a recreational area in accordance with New Zealand Standard AS/NZS1547:2000 in time for Christmas 2011.

The upgraded wastewater treatment system features the advanced wastewater treatment technology of an MBR to ensure the surrounding environment is maintained in its pristine condition.

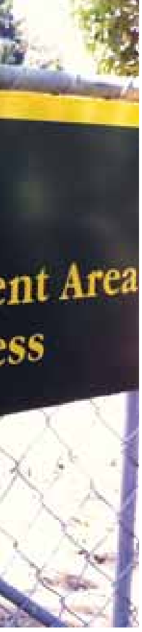
Site Description

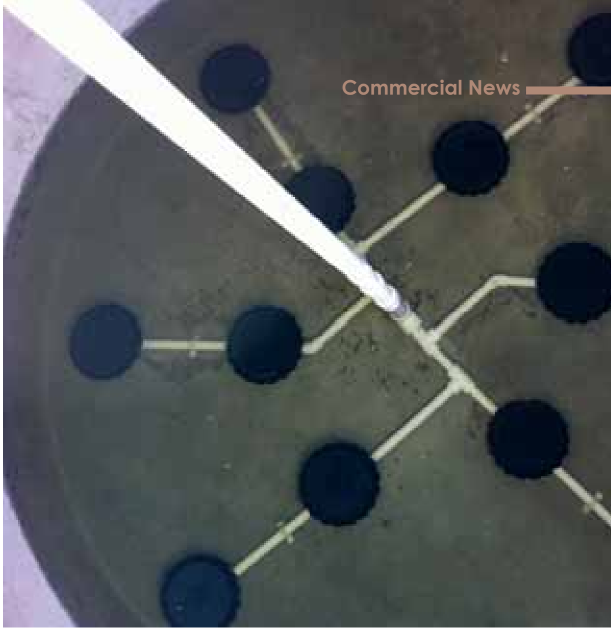
The camping site covers an area of approximately 23,600m^2 including a camping area of 16,600m^2, wardens and maintenance facilities area of 3,500m^2 and an effluent disposal site of 3,500m^2. The camping ground occupies land between the coastal road and the estuary downstream of the confluence of the Tahakopa River and the Maclennan River. The campsite is gently undulating and ground cover is a mix of grass and native bush. A drainage channel extends across this site and connects with a small watercourse that drains to an estuary downstream of the Papatowai Scenic Reserve Wetland that is fed from the Maclennan and Tahakopa Rivers. The wetland is described as a estuarine swamp and saltmarsh above the coastal marine area on the south side of the Tahakopa River adjacent to Papatowai Township.

"The camping ground had previously been fully serviced but the wastewater treatment system… was performing poorly due to overloading as the number of visitors increased which meant the facility had to be closed."

A number of natural, spiritual and cultural values and uses of significance to Kai Tahu apply to the Tahakopa and Maclennan Rivers and the Papatowai Scenic Reserve Wetland. These include the presence of indigenous fish species threatened with extinction, the presence of significant fish spawning areas, the exercising of kaitiakitanga (guardianship) over the rivers, the mauri (life force) of the rivers, and waahi tapu and/or waiwhakaheke (sacred places) associated with the river.

A scoping report by MWH investigated the number of people staying at the camping ground overnight and the number of day visitors including those that travel in cars or buses, picknickers and





Left to right – SINAP membrane module, Commissioning MBR system by filling MBR tank with screened sewage, Department of Conservation Papatowai Camp Ground, Constructing the rock filter, Diffusers in aeration tank

divers. Based on available visitor statistics the report gave a maximum overnight population of 188 and a maximum weekly overnight population of 700. In addition, the report estimated a day visitor count of 20. Using these numbers for design of the new treatment system, the maximum daily flow was estimated to be 12.4m^3/day and the maximum weekly flow to be 46.9m^3 or 6.7m^3/day.

New Wastewater Treatment Plant

The previous wastewater treatment system included separate treatment of toilet waste (black water) and washing water (sullage or grey water). The black water system included a septic tank and soil soakage field with the grey water system including a septic tank, sand filters and discharge into a weeded drain that connects to a nearby estuary. It was not able to be upgraded, and so a new wastewater treatment system design was developed.

From significant past experience, Oasis assumed the untreated wastewater would have a BOD of <340mg/L, suspended solids of <320mg/L, total nitrogen of <85mg/L and oil and grease <35mg/L. Discharge into land is generally the preferred method of disposal of treated wastewater. In this case, however, the site was deemed unsuitable for on-site discharge based on a previous site inspection by Oasis in 2008. In all three test holes that were dug at this time, the least permeable layer was classified as Category 6 at a depth of 300–900mm. From these results the soil was assessed as Category 6 according to AS/NZS1547:2000. For dripline irrigation discharge from a secondary treatment plant the allowable daily rate is 2.1mm/day. The conclusion made was that discharge into land was not practical as the length of dripline required would require a larger area than that available, there would be a strong likelihood of mechanical damage to the dripline, and experience with dripline installed in Category 6 soils raised the risk of pugging and pooling of effluent.

In their report, MWH also suggested the option of installing an oxidation pond plus wetland, providing primary and secondary treatment respectively, followed by ultra-violet (UV) disinfection and disposal to surface water. Connection to a community sewerage scheme was not an option because there is no such scheme and all properties in this township are self contained with their own on-site sewage treatment systems.

Based on these constraints, Oasis and Apex recommended installation of a MBR system that would treat the wastewater to a level where discharge to water would be accepted by affected parties and able to be consented. Apex completed detailed process design and supplied the membrane unit, while Oasis completed installation of the system. The wastewater treatment plant consists of the following components:

- One 3,000L grease trap installed at the amenities block to intercept fats, oils and grease ahead of the treatment plant
- One 20,000L below-ground flow balancing tank providing almost two days of effluent storage under peak operating conditions, including two (duty/standby) submersible vortex pumps
- One 20,000L tank with two Zabel filters to prevent coarse solids from passing, thereby protecting the membranes downstream
- One 20,000L primary aeration tank to reduce BOD and nutrient levels before the MBR tank
- One MBR tank incorporating a SINAP 80-80 membrane module with a standard capacity of 32m^3/day and online suspended solids monitoring

- One 3,000L waste activated sludge (WAS) storage tank
- A simple rock filter so the treated wastewater achieves cleansing contact with Papatuanuku (the Earth Mother) thereby ensuring the discharge is carried out in a manner that is sensitive to Maori cultural and spiritual concerns

The SINAP membrane module consists of 80 flat sheets each with an effective membrane area of 0.8m^2. Sheets are constructed of polyvinylidene fluoride (PVDF) and have a pore diameter of 0.1um. These sheets are located within a stainless steel housing with process connections for the aeration and permeate lines.

A concrete shed houses the electrical control panel plus permeate pump and flow and pressure transmitters. The operation of the MBR is controlled by a Programmable Logic Controller (PLC), which alternates the feed pumps to ensure even wear, controls the flow through the process based on the level in the flow balancing tank, the aeration rates and the regular automated cleaning of the membrane system.

Due to the relative complexity of the system, its remote location and the need for it to run without operator input or local maintenance support, a comprehensive automation and control package including remote access was provided so that the plant could be monitored and operated from anywhere with an internet connection. The system was also designed with buffering capacity up front and a conservatively sized (but still cost effective) membane unit so that the camping ground could remain open while any maintenance requirements are completed.

The expected treated wastewater quality produced by the MBR system is a BOD <15 mg/L, suspended solids <5 mg/L, faecal coliforms <5 CFU/100mL, total inorganic nitrogen <15 mg/L and ammonia <5 mg/L.

Consultation

The contract called for the tenderer to obtain all necessary consents from the Otago Regional Council (ORC) for installation of the proposed treatment solution. On advice from ORC, Apex completed consultation with Kai Tahu ki Otago (KTKO), Public Health South Dunedin and Te Ao Marama Incorporated. KTKO, on behalf of Hokonui Runanga and Waikoau Ngai Tahu Runanga, supported the application providing an Accidental Discovery Protocol (ADP) be used during installation and the system be regularly serviced. Te Ao Marama also required use of an ADP should koiwi (human skeletal remains), waahi taoka (important objects), waahi tapu (place or feature of special significance) or other artefacts be discovered.

Records from the New Zealand Archaeological Association showed the presence of middens in the area. The Regional Archaeologist with the New Zealand Historic Places Trust Pouhere Taonga, advised no assessments had been completed in the area recently and the area had been occupied since the 14th Century. A preliminary site assessment was then completed by Shar Briden of DOC, who dug test pits that did not show evidence of cultural materials. The recommendation made was that the use of an accidental discovery protocol during installation was the appropriate measure.

Assessment of Environmental Effects

An Assessment of Environmental Effects (AEE) was prepared by Apex in relation to the statutory planning documents including the Resource Management Act, the Otago Regional Policy Statement, the Regional Plan: Water and the Regional Plan: Air. Effects on surface water and air quality were judged to be less than minor as the wastewater would be treated to industry-leading standards before discharge, the volume of the proposed discharge would be small, and the discharge would be further diluted when it reaches the watercourse and then the estuary.

In terms of the effects on public health, neighbours and community, the wastewater treatment plant was judged to have a positive effect on the local community in allowing the camping ground to reopen to visitors, with flow-on benefits of increased tourism and spending in the area.

An additional benefit identified was the provision of suitable facilities for freedom campers to use. The issue of the disposal of human waste generated by freedom campers in the absence of proper facilities has been highlighted by the media in recent times and any detrimental effects could increase in the Catlins now the roading has been substantially improved. It was hoped that the reopened camping ground would support and encourage appropriate waste disposal by such tourists.

Results to Date

A consent to discharge for 15 years was awarded in early December 2011 and the the system was subsequently installed and commissioned to allow the site to open and receive Christmas visitors. No items of archaeological significance were found during excavations on site and installation of the system proceeded without delay.

As per agreed consent conditions, the control system automatically emails daily flow data to DOC, Oasis and Apex and this data has shown that an average of 1,200L and a maximum of 4,000L has been treated in a 24 hour period to date. This is well below the consented limit of 12,500L/day but occupancy rates at the camping ground are expected to rise over time with increasing awareness of the site being open.

The remote access system allows full monitoring and control of all equipment which is critical when Apex and Oasis are based four and six hours from site respectively. With relatively low flows through the system to date the membrane unit has not yet required a chemical clean.

> "In terms of the effects on public health, neighbours and community, the wastewater treatment plant was judged to have a positive effect on the local community…"

There have only been two issues with the plant since it was commissioned. One of the vortex pumps in the flow balancing tank had to be replaced after it became blocked with sanitary items and subsequently failed. Notices advising how such materials should be disposed of have now been put in place by DOC. Secondly, the flow balancing tank was forced out of the ground due to road swale runoff from a heavy rainfall event entering the tank excavation. This was redirected away from the tank at the time the tank was replaced, along with the placement of additional concrete, to prevent a reoccurrence.

Conclusion

This case study demonstrates that disposal-to-land is not always an option, or indeed the best option, for treated wastewater. Treatment and communications technologies exist to allow discharge to water in remote locations. We must ensure that industry-leading technology is installed so we can claim to be clean and green with any conviction, particularly in areas of natural beauty that attract overseas tourists to New Zealand. Oasis and Apex are both proud of what the new wastewater treatment system has done for the camping ground in Papatowai and surrounding environment. ■

AECOM Announces Two New Appointments

Water Resources Specialist Boosts AECOM's Service Delivery Stocks

With water efficiency, water quality, conservation, drought prevention and supply and demand issues becoming top priorities for New Zealand, water resources specialist Deborah Lind has joined global professional technical services consultancy AECOM as Associate Director – Water Resources in response to increasing demand for water management services.

With 17 years experience and an industry network that extends beyond New Zealand shores to Australia and the UK, Deborah's reputation for innovation and delivering international best practice significantly boosts AECOM's water management capabilities.

AECOM Water & Infrastructure Services Group Leader in New Zealand, Geoff Milsom, says the addition of Deborah Lind to the team will further enhance AECOM's water management capabilities, both for clients in Auckland and the wider New Zealand community.

"Recent audits of the water sector have indicated there is a real need for better management, regulation and governance to ensure informed decisions and efficient and sustainable water for New Zealand," Mr Milsom said.

"Deborah has a practical knowledge of water supply and demand management and the many challenges and barriers that can hamper the implementation of efficient and sustainable water management initiatives.

"Her experience, both in New Zealand and abroad, places her perfectly to provide our clients with informed consultation and quality solutions to all their water management challenges."

Quake Rebuild and Water Challenges Attract Top Asset

In a boost for its New Zealand arm, global professional technical services consultancy firm AECOM has attracted top water authority John Mackie to oversee its Water and Infrastructure Services operations in Christchurch and Wellington.

Significant investment in the rebuild of Christchurch after destructive quakes in 2010 and 2011, combined with planned investment in irrigation infrastructure in the Canterbury area highlighted a need for AECOM to strengthen its support for clients in the region.

Mr Mackie brings more than 30 years engineering know-how, including many years in leadership capacities for local government. Most recently, Mr Mackie led the Dunedin City Council's Water and Waste Services division and was responsible for over NZ$1.5 billion in water and waste infrastructure, water supply, wastewater, stormwater and solid waste assets.

His impressive track record includes the successful delivery of the $115m upgrade of the Tahuna Wastewater Treatment Plant and development of the Three Waters Vision and 50 year strategy for Dunedin City.

AECOM New Zealand's Water and Infrastructure Services Group Leader, Mr Geoff Milsom, says John brings a wealth of experience in the water utilities area, in both the public and private sector.

"We welcome John to the team. With his proven leadership credentials, first-rate strategic development skills and a celebrated history of involvement across a number of successful major capital works, John is perfectly positioned to provide our clients with assurances that our business understands their perspective and can deliver their projects to specification, within budget and in a timely fashion."

Water Environment Federation Fellowship Appointment

Jay Witherspoon

CH2M Beca has announced the appointment of Jay Witherspoon as a 2012 Water Environment Federation (WEF) Fellow. WEF has over 50,000 members worldwide focused on total water management and services.

This prestigious award is given in recognition of Jay's distinguished accomplishments and contributions to the global water environment. Jay is now based in New Zealand, providing CH2M Beca's clients with even greater access to the international skills and experience of CH2M HILL, a global leader in water and wastewater engineering, construction and operations.

Jay is an International Technology Leader with CH2M HILL and an internationally recognised expert in air emissions assessments, odour control, biosolids management, and total water (water and wastewater) systems resource management and strategic planning. He has 30 years' experience in sustainable plant design and optimization, renewable energy sources, air quality and greenhouse gases evaluations, measurements, and reductions.

"CH2M Beca has announced the appointment of Jay Witherspoon as a 2012 Water Environment Federation (WEF) Fellow. WEF has over 50,000 members worldwide focused on total water management and services."

Jay has also completed projects that capture composting, waste management, water and wastewater operational and regulatory compliance issues, biosolids management, and odour control approaches.

In New Zealand, Jay has worked on several large water, air quality and biosolids projects in Auckland, Hamilton, New Plymouth and Christchurch. He was recently the Programme Manager for Masdar City in the UAE and set up a water sustainability centre of excellence in Sydney, Australia. He will bring extensive knowledge and know how to solve New Zealand's sustainability needs, requirements and environmental concerns. ■

MWH Global Introduces New Edition of Water Treatment Book

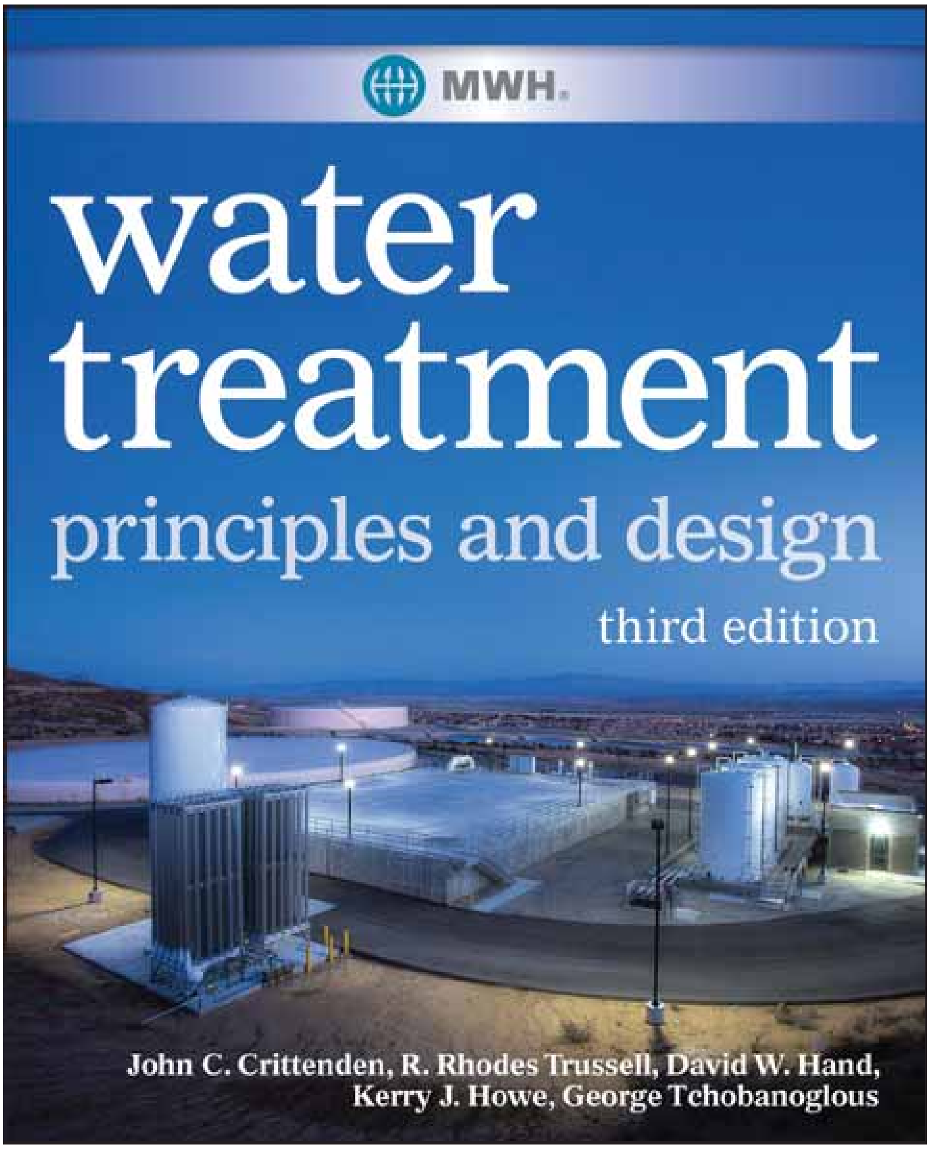
MWH Global has released the third edition of *Water Treatment – Principles and Design*, a 1,920-page textbook for current and future water engineers dedicated to the science and practice of water treatment.

"MWH is extremely fortunate to have assembled an esteemed group of authors for this textbook that we hope will help shape engineering careers and thus positively impact communities around the world for years to come."

Initially released in 1984 with a second edition in 2005, the publication is updated to reflect the rapid development of new technologies, applications and research to tackle emerging industry advancements and current water scarcity challenges.

Among the cover-to-cover revisions in the third edition:

- **Speaking the language** – A table of important terms was added to the beginning of each chapter to assist students and practitioners learning the vocabulary of water treatment.
- **More content** – An entirely new chapter on advanced oxidation was added to address the growing use of this process for treatment of synthetic organic contaminants. Additionally, a new section on pharmaceuticals and personal care products was added to the Removal of Selected Contaminants chapter to address the increasing concern about the presence of these trace organic contaminants in the source waters of water treatment plants.
- **Water treatment in action** – The final chapter includes six new or updated case studies, drawn from MWH expertise in planning and designing nearly 500 water treatment plants. The case studies demonstrate how water treatment processes are assembled to create a water treatment plant, achieving multiple water quality objectives originating from varying water qualities.



"Hundreds of engineers and scholars contributed to the content of this book..."

"Providing communities around the world with a safe and reliable water supply is at the heart of our business and meeting these challenges is closely tied to the training and development of water-focused professionals," said Murli Tolaney, chairman emeritus of MWH.

"MWH is extremely fortunate to have assembled an esteemed group of authors for this textbook that we hope will help shape engineering careers and thus positively impact communities around the world for years to come."

Hundreds of engineers and scholars contributed to the content of this book including primary authors John C. Crittenden, Ph.D., professor at the Georgia Institute of Technology; R. Rhodes Trussell, Ph.D., at Trussell Technologies, Inc. and a former MWH senior vice president and board member; David W. Hand, Ph.D., professor at the Michigan Technological University; Kerry J. Howe, Ph.D., associate professor at the University of New Mexico; George Tchobanoglous, Ph.D., professor emeritus at the University of California at Davis; and James H. Borchardt, vice president of MWH.

Water Treatment – Principles and Design is published by Wiley Publishing and is available at major bookstores and by visiting online retailers.

Water New Zealand Conferences & Events

Trade & Industrial Waste Forum
8 – 10 August 2012
Rydges Hotel, Wellington, New Zealand
For more information visit www.confer.co.nz/tiwf

***Water New Zealand's* Annual Conference & Expo 2012**
'Water – Challenges & Opportunities'
26 – 28 September 2012
Energy Events Centre, Rotorua, New Zealand

For more information on *Water New Zealand* 2012 conferences visit www.waternz.org.nz/events

Other Conferences

85th Annual Water Environment Federation Technical Exhibition and Conference
29 September – 3 October 2012
New Orleans Morial Convention Centre, New Orleans, USA
For more information visit www.weftec.org

Pacific Water Conference & Expo 2012
6 – 9 November 2012
Auckland, New Zealand
For more information visit www.pwwa.ws

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