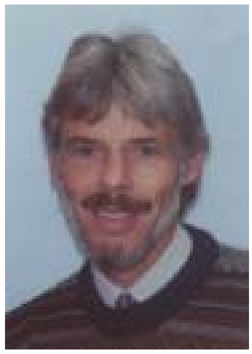
Foreword



This is Nelson City's fourth State of the Environment Report. The focus is on the quality of our rivers and streams.

The first 'rules' in New Zealand for water use were developed by Maori communities to prevent spiritual and physical pollution of sites of significance along with food-gathering areas. In the first century of European settlement there was more concern with controlling the quantities of water, particularly flood water, than with worrying about its quality. By the 1950s, however, the effects of sewage, industrial discharges and agricultural runoff were obvious in many rivers and streams. In the following decades of growing environmental awareness, concern about water quality became more widespread.

Now, under the Resource Management Act 1991, the value of waterways and the aquatic life must be considered for their own sake along with management of the water for a wide range of human uses and values including drinking water, household use, recreation and industry.

Extensive monitoring has been carried out to assess the health of Nelson City's waterways, and the results of this monitoring work will form the basis for the Council's fresh water management provisions, due to be publicly notified during the first half of 2003.

The chapter titled 'fresh water quality in the Nelson region' shows that many of the main streams running through Nelson City are degraded and not an ideal environment to sustain biological life. Nelson's most impacted waterways are generally small streams in Stoke, Bishopdale, Atawhai and The Glen.

Community representatives, Councillors and staff are involved in a working party considering the issues and options for managing the Council's rivers and streams. Once the working party has an agreed position public comments on the best ways to manage our streams and rivers will be sought. Once the proposed management methods have undergone scrutiny through the public submission process they will become part of the Nelson Resource Management Plan.

The Council makes this State of the Environment Report freely available to provide background information for people interested in fresh water management who may want to make a submission on the proposed freshwater management plans as well as for anyone who wants to know more about the state of Nelson's waterways and the pressures on them.

Councillor Derek Shaw

Chair Environment and Planning Committee
Nelson City Council

Acknowledgements

Nelson City Council would like to acknowledge the following organisations and people for their contributions to environmental monitoring and reporting in Nelson

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Nelson City Council staff

Cover Photo: Maitai River, Nelson: Aaron Quarterman, September 2001

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Introduction

Nelson's fresh water quality

In Nelson we live close to streams and the sea. We expect the waters of our streams and the sea to be clean, not only for ourselves, but for visitors to our region. Significant impacts on water quality can have ripple effects, affecting food gathering, recreational opportunities and commercial fisheries as well as health and safety.

Because urban areas are largely paved, rainwater cannot be absorbed by soil and vegetation. Nelson, like most other towns and cities, has stormwater systems which channel rainwater into gutters and drainage pipes, eventually discharging it through outfall pipes into streams, lakes and coastal waters. If this collected stormwater carries chemicals and other material it can be a significant source of pollution.

The other important impact on stream and river health comes from clearing surrounding land of its existing vegetation.

With all the pressures that people impose on New Zealand's surface waters and groundwaters, it is no surprise to find that water flows and quality have been widely affected. The natural character of many waterways has also been lost, something which is listed as a matter of national importance in the Resource Management Act (RMA).

The 1997 NZ State of the Environment Report noted that water monitoring tended to focus almost exclusively on the quantity and quality of water, and little on its ecological properties.

This was also true of Nelson which has long standing data for river levels and water quality for recreational health, but limited knowledge of the health of communities living in the streams. This has been remedied with a comprehensive study of the stream health of Nelson's waterways and an even more thorough ecological study of the Maitai River. New guidelines for interpreting contamination levels of stream sediments has also contributed to our knowledge of overall stream health.

About this report

Part 1 – Fresh Water Quality

Regular monitoring of stream health allows us to assess the impacts that our activities are having on our waterways. It helps us to identify "problem areas" where water and stream habitat quality are deteriorating, so that changes can be made in the river or catchment management to halt or reverse the problem.

During 2000 and 2001 stream health was monitored at 38 sites throughout the Nelson region. These were spread over 23 waterways, including the Maitai River, Wakapuaka River and Whangamoa River (and some of their tributaries), and a range of smaller streams in Stoke, Nelson City, Atawhai and the Glen.

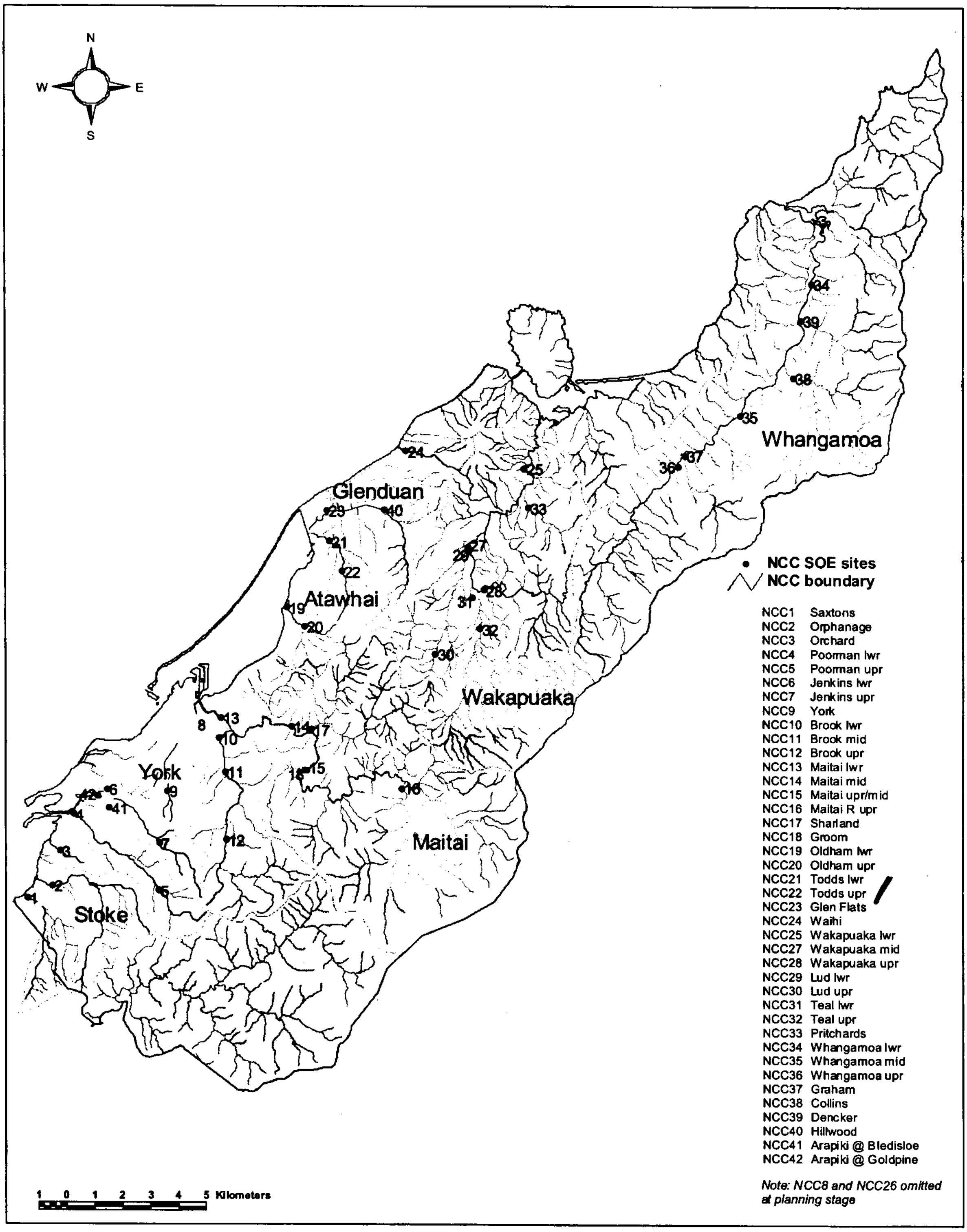

Figure 1 Map of catchments being monitored and site locations in the Nelson City region.

A wide range of physical, chemical, and biological characteristics of waterways can be measured or assessed to tell us about various aspects of stream health. Sampling was carried out in Nelson on five occasions (every three months). A range of water chemistry variables was measured on each sampling trip and water flow in each stream was also gauged regularly. Assessments of the stream bed, stream banks and algal slime were made on at least two of the sampling trips, and samples of aquatic animals were also collected on two occasions. Water temperatures were recorded every 1 to 1½ hours for 12 months in the Maitai, Brook, Wakapuaka and Whangamoa Rivers, and also at Saxtons Creek. The results of this work are summarised in Part 1 of this report.

Part 2 - Recreational water quality
With such a good climate, many Nelson residents and visitors are attracted to our beaches and rivers for swimming and other recreation during summer.

There is a link between water quality and swimming-associated illness. For this reason Nelson City Council carries out regular sampling of water quality to ensure it is safe for swimming.

That data has been interpreted according to the national Recreational Water Guidelines 1999, which use bacteria levels to indicate when water can be regarded as safe, potentially unsafe, and highly likely to be unsafe. (The guidelines were superseded in June 2002 but indicator levels remain largely unchanged.)

In most cases Nelson water has been shown to be safe. However, higher bacteria levels have been shown to occur during and after heavy rain.

Part 3 – Maitai River Habitat and Flow Study
Maintaining minimum flows by avoiding taking too much water out of the river for other uses is a key way to avoid impacting on the aquatic ecosystems in the Maitai River.

Council takes water from the river for Nelson City's water supply (as well as from the Roding River). The Council obtained a new consent to take the water from the Roding River in 1999 and has recently renewed its consent to take water from the Maitai River. To increase our understanding of the Maitai River for the fresh water resource management provisions, a comprehensive ecological study has been conducted.

This study examined what animals are inhabiting the bottom of the river (such as caddisflies and slugs) as well as what fish communities are living in the Maitai River. It looked at their distributions, and assessed river flows required to maintain the health of these communities.

The outcome of this study will provide an "optimum" flow for maintaining the ecological habitats of the river. This ideal figure will be used as a starting point for discussion about water levels in the river, and may be adjusted depending on the other human values that need to be provided for.

Part 4 - Contamination of Sediments

Sediments are the fine particles which settle on the beds of streams and rivers. When contaminants attach to sediments they become trapped in the bed of the stream or river and influence water quality. Contaminated sediments can impact on plants and animals living on the river bed, and any fish that feed on those plants and animals.

On behalf of the Council, Cawthron Institute has reviewed and summarised all previously collected sediment quality data, bringing it together in one report. This provides a consistent set of results across the Nelson area against which to compare the results of future sediment monitoring. As part of this project, several other sediment samples have been collected to provide additional information for some waterways.

The results of the study provide baseline environmental information against which to identify areas where more sediment sampling is necessary as well as areas where further sampling will not be required in the near future; and to provide information for upcoming stormwater consent applications and for the fresh water resource management provisions.

Part 5 - Fish passage

Many fish have to journey all the way to and from the sea at some stage in their life cycle. However, even the strongest of these migratory species can be prevented from swimming upstream by barriers such as incorrectly placed road culverts. If barriers are placed in the way of migrating fish, their choice of habitat becomes limited and this in turn causes a decline in their numbers.

A brochure outlining ways we can ensure that structures in waterways such as weirs, culverts, fords and bridge aprons do not prevent fish from reaching their preferred habitats has been produced, and detail of this work is included in this report.

Part 6 – Flow monitoring

As the river ecology project (reported in part one of this State of the Environment report) progressed it became clear that Council needed a better understanding of flow in minor streams, particularly the period and frequency of low flow.

Assessment of the urban streams suggests that flows in these streams fell to a one in 10 year low flow during the monitoring period (2000/2001). This analysis provides a useful benchmark for considering how much water the Council could allow to be taken out of these streams for irrigation or other uses.

Part 7 – Groundwater levels and flows

Groundwater resources in the Nelson region are limited, with little information on the available resources which do exist. However, there are a number of springs and private wells / bores on rural properties which draw water from underground reserves.

Groundwater resources can be at risk from a range of activities such as intensification of land use, increased fertiliser use, high stocking rates, irrigation, septic tank effluent, offal pits, landfills and use of pesticides.

Once an aquifer becomes contaminated, many of the existing uses of groundwater could be placed at risk, and alternative sources of water may need to be sought or water may need to be treated. By the time contamination has been detected it is usually too late to carry out preventative measures.

Therefore the priority for groundwater contamination should be avoidance, rather than mitigation.

The Council's commitments

Freshwater monitoring and management carried out by the Council is guided by the Nelson Regional Policy Statement, which sets out how Council will manage Nelson City's important natural resources. A summary of these follows. The full text of the objectives and policies are listed in *Appendix 3.

- Maintain and enhance the water quality of Nelson's streams and rivers in order to protect their ability to support aquatic life

- Assessing the current values and uses of streams and rivers and to manage those waterways in order to:
  - protect urban water supplies to a drinking standard
  - protect fish and other wildlife
  - protect areas of cultural value
  - protect water quality for recreational purposes including swimming

- Keep to a minimum the volume of contaminants such as sediment, chemicals, refuse and debris entering waterways

- Control discharges from specific sites through resource consents and conditions so that water quality standards continue to be met over time

- Manage the edges of streams and rivers in a way that enhances or maintains water quality

- Recognise the impact contaminated stormwater can have on water quality and where possible reduce that impact.

- Recognise the cultural and spiritual values that water has for tangata whenua. If an area of a water way is of high value to tangata whenua, management provisions should include active measures to protect and enhance these values.

Other reports

So far the Council has produced four state of the environment reports. The three previous reports covered the following topics:

- The environment as a whole (1999)
- Land (2000)
- Air and noise (2001)

Please contact the Council if you would like a copy of any of these reports. The 2003 State of the Environment Report will be about coastal issues.

Feedback

Please forward any comments about this report, including the monitoring work programme in Appendix 2, to:

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Iwi perspective on fresh water quality issues

Within the origins of Maori culture, Ranginui and Papatuanuku are spiritual beings, while Tane Mahuta (Guardian of the Forest), Tawhirimatea (Guardian of Winds and Airways), and Tangaroa (Guardian of the Seas) are their uri (children).

Ranginui (Sky Father) and Papatuanuku (Earth Mother) were parted by their children which resulted in the tears of Ranginui creating the waterways. Thus all parts of the environment are inter-related.

State of the Environment monitoring and reporting transcends the domains of Tangaroa and Tawhirimatea as well as Tane Mahuta.

Based on their whakapapa[1], Tangata whenua are kaitiaki[2] for these spiritual beings and as such will protect the mauri (life force) of these areas.

Tangata Whenua take a holistic approach to the management of the environment. Tangata Whenua consider that air, earth, water and flora and fauna are all interconnected elements of the environment. This is the approach advocated by the Resource Management Act under sections 5, 6 and 7.

Involving Tangata Whenua within the Nelson rohe[3] in State of the Environment monitoring recognises the rangatiratanga[4] that Tangata Whenua hold throughout the Nelson rohe which has been recognised in Te Tiriti o Waitangi (Treaty of Waitangi). Te Tiriti o Waitangi is referred to in section 8 of the Resource Management Act.

Water quality

As a taonga tuku iho[5], water like all other natural and physical resources, is to be valued, protected and utilised with respect.

Water, as one element of the whole, is the source of life and sustenance. Waterways, as entire systems, contain the following elements:

- mauri, which joins the physical and spiritual elements and which links water to every other part of the natural world;
- mana, which can give water a high status and represents its significance in sustaining all life;
- tapu, is sometimes addressed by the use of water and other resources.

The health of water ways reflects the health of the people and all things relying on it for sustenance.

Water is viewed as a taonga (treasure) because it carries the lifeblood of the land and the well-being of all living things depends on it for their existence. The collection of food (mahinga kai) from rivers, lakes, wetlands and estuaries which is utilised by the

[1] Genealogy
[2] Guardian
[3] Whakatu area
[4] Maori sovereignty
[5] A treasure passed down.

iwi to maanaki (care for and look after) the manuhiri (guests) . It reaffirms links with the kaitiaki. Life-supporting capacity and the holistic approach of integrated water management is also an underlying philosophy of the RMA.

Because of kaitiaki responsibilities, Tangata Whenua have accumulated a considerable body of mautauranga (customary knowledge) relating to the use of the natural resources. This traditional knowledge – including mahinga kai (food sources) and waahi tapu – is regarded as taonga. Tikanga[6] and mautauranga are an important part of on going tribal traditions. Different tikanga are associated with each Iwi. Mahinga kai, the tikanga of gathering food and other resources from estuaries, lakes, rivers and wetlands, carries a deep historical and cultural significance to Tangata Whenua. Mahinga kai, is a principal source of food for many families, and is often harvested using traditional science and harvesting techniques, such as phases of the moon and flowering of native trees.

It is essential to Tangata Whenua that they are involved in the decision making and improvement of the water quality of Nelson.

Iwi Environmental Performance Indicators Project

Plans prepared by Nelson City Council and monitoring work undertaken and reported have improved in terms of embracing traditional Iwi knowledge or values. However in the past, an Iwi perspective has not always been taken into account.

Nelson City Council is committed to building relationships with Iwi and ensuring Iwi involvement in environmental monitoring programmes. A pilot project is being undertaken to address these issues and has three objectives.

- To prepare an statement recording of Iwi world view/s for the NCC area.
- To establish and trial a process by which NCC and Iwi can work towards agreed indicators for air quality, water quality, coastal and land based management issues within the NCC area.
- To identify potential funding and applyfor this funding to develop Iwi indicators.

Nelson City Council believe the project will lead to an improved understanding of resources.

The development of an Iwi world view or several world views will provide the reference point from which more specific monitoring programmes that reflect these view(s) can be developed. It will reflect the holistic framework that reflects Iwi environmental management practices. This project is the start of what may become a far bigger project to record and enable the Council to give effect to Iwi mautauranga[7] and taonga.

The project began in September 2002 and will involve hui and interviews with Iwi and the recording of this knowledge in a resource management style framework suitable for inclusion within both Iwi and Council planning documents. It is expected that the draft project report will be finalised by the end of May 2003.

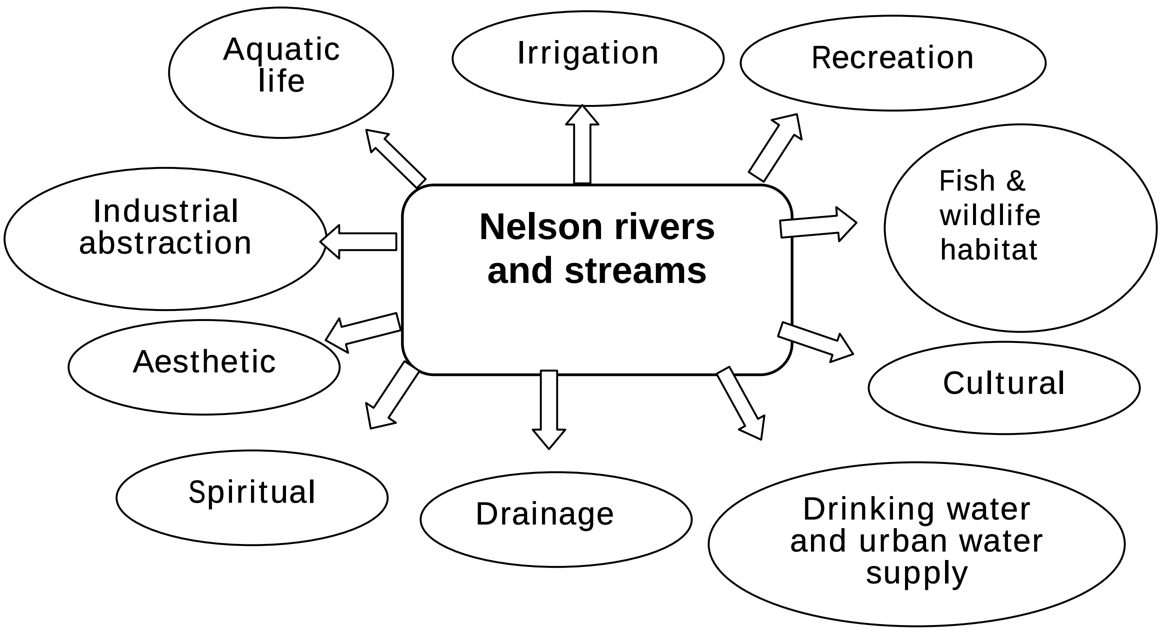
[6] Customary protocol
[7] traditional Maori knowledge

Part One - Fresh water Quality in the Nelson Region 2000/2001

Why is the quality of our rivers and streams important?

Rivers and streams are vital components of Nelson's environment. Healthy waterways enhance the beauty of Nelson's landscape and are valued for recreation, culturally, spiritually and as a home for wildlife. The entire region benefits by having unpolluted swimming holes, good quality habitat for fish and other aquatic life and clean water for water supplies, irrigation and industrial use. Streams also serve an important purpose as drainage systems, particularly in urban areas, where they receive runoff from our roads and buildings via the stormwater system.

Figure 2: uses and values



The Nelson region has four major river systems: the Maitai, Wakapuaka, Whangamoa and Roding, as well as a host of smaller streams that drain into the Waimea Estuary and Tasman Bay.

Although some of our waterways have their headwaters in native bush, many are surrounded by plantation forests or agricultural land, and urban waterways flow through and beneath residential properties, streets and industrial areas. Our activities on land can have direct impacts on the quality of our waterways and the values that we place on them. As rivers and streams descend from headwaters to the sea, runoff from the surrounding land can introduce contaminants. Natural and human-induced changes in channel shape, streamside vegetation and water volume occur along a river's course and can also affect water quality and instream habitat.

What impacts affect our water quality?

Water quality in rivers and streams is strongly linked to activities in their surrounding catchments. Contaminants such as nutrients, heavy metals, fine sediments and faecal bacteria enter waterways via direct discharges (e.g., from the urban stormwater system or industrial discharges) and indirect discharges (e.g., runoff from agricultural or cleared land). These contaminants can have a variety of negative impacts on water quality. For example, inputs of nutrients such as nitrates and phosphates can lead to increased growth of algal slimes. As well as being visually unappealing, these growths can cause taste and odour problems in drinking water, clog industrial and irrigation intakes, make waters unsuitable for swimming or wading and clog whitebait nets and fishing lures. Fish activity and spawning, and survival of "pollution-sensitive" aquatic animals (such as mayfly larvae) can be affected by changes in water chemistry and habitat. Heavy metals can be toxic to aquatic animals, killing them or affecting their breeding. Water contaminated with faecal bacteria can make people (or stock) sick and can pass on infectious diseases, making water unsuitable for swimming or drinking. Unless we work to minimise the entry of contaminants into our waterways, they will compromise many of the things we value about our fresh waters.

Table 1: sources and impacts of common contaminants

Common contaminants	Where they come from	Impact on waterways
Nutrients (such as nitrates and phosphates)	• Runoff from agricultural & cleared land • Runoff from urban land	• Increased growth of algae (slime) and / or aquatic plants • Decreased amounts of oxygen in the water, or big daily fluctuations in oxygen (due to algae growth)
Heavy metals	• Urban stormwater runoff (from residential & industrial properties & roads) • Many are bound to fine sediments	• Can be toxic to aquatic animals, killing them or affecting breeding • Can bio-accumulate (increase in quantity in animals) • End up in estuaries or the sea where they can be toxic to marine life
Pesticides	• Agricultural & garden runoff	• Can be toxic to aquatic animals

Common contaminants	Where they come from	Impact on waterways
Fine sediments	• Runoff from cleared/ harvested land and earthworks • Urban stormwater runoff (e.g. roads, gardens, construction sites) • Unvegetated / crumbling stream banks (commonly caused by stock trampling)	• Decrease water clarity • Decrease habitat for aquatic animals, by filling in the gaps between stones in the streambed • Interfere with fish spawning • Increase loads of nutrients and other pollutants, which are bound to sediments
Faecal bacteria	• Runoff from agricultural land • Stock crossings or stock grazing riverbanks / drinking from streams • Seepage from septic tanks • Doggie doos	• Make water unsuitable for swimming and other contact recreation • Pass on infectious diseases

Some of the practices that take place in and around our waterways speed up the delivery of contaminants to fresh waters, or make water quality problems worse. One example is removal of plants from stream banks. Streamside vegetation is important because it stabilises stream banks and provides shade which keeps water cooler and provides cover for animals living in the river. In addition, fallen logs and tree roots in the banks and streambed provide habitat for fish and aquatic animals. When plants are removed the stream banks may be easily eroded by high flows, runoff or stock trampling, and fine sediments can enter the stream more readily. Without shading from trees or overhanging plants, rapidly spreading slimy algal growths often develop, particularly if nutrient concentrations are also high. High summer water temperatures often occur in small unshaded urban streams, and can easily reach levels that kill or affect the health of fish and other aquatic animals. Taking water out of the river for water supplies or irrigation can also put pressure on waterways by reducing the area of streambed habitat for fish and aquatic animals, reducing flushing which can result in silt building up in streambeds and stagnant waters, and by increasing water temperatures.

Why monitor our waterways?

Regular monitoring of stream health allows us to assess the impacts that our activities are having on our waterways. It helps us to identify "problem areas" where water and stream habitat quality are deteriorating, so that changes can be made in the management of the river or surrounding land to halt or reverse the problem.

How is water quality measured?

A wide range of physical, chemical and biological characteristics of waterways can be measured or assessed to tell us about various aspects of stream health. Some of the factors that we measured are described below.

Table 2: methods of monitoring stream health

What was measured?	How was this measured?	This tells us about:
Stream bank vegetation	Field assessments of: • vegetative cover • dominant vegetation • % shading of channel.	• Stream bank stability • Potential for algal slime growth due to lack of shade • Potential for high water temperatures due to lack of shade • Pleasantness of the area
Stock access	Field assessments of: • fencing of waterway for stock exclusion • banks and channel for evidence of stock.	• Stream bank stability • Possible faecal contamination • Possible nutrient enrichment
Substrate size of stream bed	% composition of six size-classes ranging from boulders to silt.	• Habitat for aquatic life • Inputs of fine sediments • Pleasantness of the area
Stability of banks and stream bed	Visual field assessment using a "Stream channel stability assessment" form.	• Stability of banks and stream bed • Habitat for aquatic life
Water temperature	• Field measurements using temperature probe. • Continuous temperature loggers (hourly measurements over a 12 month period at some sites).	• Suitability for fish and aquatic animals

What was measured?	How was this measured?	This tells us about:
pH, conductivity, dissolved oxygen	Field measurements using field meter.	• Suitability for aquatic life
Nutrients (nitrate, phosphate)	Water samples analysed in the Cawthron laboratory.	• Nutrient enrichment • Potential for algal slime growth
Water clarity (turbidity, visual clarity, total suspended solids)	Measured using field meter (turbidity), black disc & periscope (visual clarity) and in the Cawthron laboratory from a water sample (total suspended solids).	• Pleasantness of the area • Recreational value • Suitability for aquatic life • Inputs of fine sediments upstream
Indicator bacteria (*E. coli)*	Water samples analysed in the Cawthron laboratory.	• Suitability for contact recreation • Suitability for drinking water
Aquatic animals (macroinvertebrates such as mayflies, worms and snails)	Sample collected from stream bed. Analysed in the Cawthron laboratory for: • kinds of animals that are present • which animals are abundant and which are rare.	• Aquatic life • Overall water quality • Indexes are calculated to describe the kind of community that is present, which tells us how healthy the stream is
Slime growth (periphyton)	Field assessments of: • the kinds of slime present on the streambed • the proportions of different kinds of slime Slime was collected and examined in the Cawthron laboratory to determine which species were present.	• Pleasantness of the area • Level of nutrient enrichment • Suitability for aquatic life • Suitability for recreation

What monitoring has been carried out in Nelson?

During 2000 and 2001 stream health was monitored at 38 sites throughout the Nelson region. These were spread over 23 waterways, including the Maitai River, Wakapuaka River and Whangamoa River (and some of their tributaries), and a range of smaller streams in Stoke, Nelson City, Atawhai and the Glen. The Roding River was not monitored by Nelson City Council in 2000 / 2001 since only the headwaters are in the Nelson region, but it is monitored further downstream as part of the Tasman District Council's monitoring programme. The headwaters of the Roding will be monitored as a condition of Nelson City Council's consent for the Roding water supply intake.

Sites were selected to represent the range of land uses in Nelson. Some waterways were monitored at more than one site, so that changes in water quality along the length of the river could be assessed. Five of the sites were located in "pristine" areas where water quality was unlikely to be impacted by contaminants or modifications to the channel or river banks. These sites give us a benchmark against which quality at the more impacted sites can be compared. They will also give us information about the impacts of any regional or global environmental change on waterways. For example, if a region-wide drought caused increased slime growth at the pristine sites, increased slime growth at the more impacted sites could also be attributed to the drought, rather than to an increase in contaminant inputs.

Sampling was carried out on five occasions (every three months). A range of water chemistry variables was measured on each sampling trip (as described in the table above) and water flow in each stream was also gauged regularly. Assessments of the stream bed, stream banks and algal slime were made on at least two of the sampling trips, and samples of aquatic animals were also collected on two occasions. Water temperatures were recorded every 1 to 1½ hours for 12 months in the Maitai, Brook, Wakapuaka and Whangamoa Rivers, and also at Saxtons Creek.

What were the results?

The quality of the sites that we monitored is summarised in the following pages, which are divided into five groups of sites in different catchments or locations. The overall quality of each water chemistry, habitat and biological factor has been assessed in relation to the quality of the "pristine" reference sites, and also in relation to guideline values that specify acceptable and unacceptable levels of contaminants for the various values / uses that we have for our waterways. Biological indicators, which were calculated from the communities of aquatic animals and algal slimes that were found at each site, also tell us about the overall water quality at a site.

Table 3: Catchment / Site Grouping - ***Stoke Fan & York Stream***

Main Landuse:*Urban / residential. Some agriculture, industrial & reserve land.*

Good quality Moderate quality Poor quality	Saxtons	Orphanage	Orchard	Poorman upper	Poorman lower	Jenkins upper	Jenkins lower	York	Arapiki
Stream size	SMALL	MEDIUM	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Stream banks	Moderate	Moderate	Moderate	Good	Good	Moderate	Moderate	Moderate	Poor
Stream bed	Poor	Moderate	Good	Good	Moderate	Good	Moderate	Poor	Poor
pH & conductivity	Poor	Good	Good	Good	Good	Good	Poor	Poor	Good
Oxygen	Poor	Poor	Poor	Good	Good	Moderate	Good	Moderate	Good
Bacteria	Poor	Poor	Poor	Good	Poor	Poor	Poor	Poor	Poor
Nutrients	Poor	Moderate	Poor	Good	Moderate	Moderate	Moderate	Moderate	Poor
Water clarity	Poor	Moderate	Poor	Good	Good	Poor	Poor	Poor	Poor
Sediment contaminants	Good	Good	Poor	-	Poor	-	Moderate	Poor	Poor
Water temperature	Poor	-	-	-	-	-	-	-	-
Aquatic animals	Poor	Moderate	Poor	Good	Poor	Good	Poor	Poor	Poor
Slime growth	Poor	Poor	Moderate	Good	Good	Good	Poor	Good	-
OVERALL QUALITY	Stream health of concern	Stream health of concern	Stream health of concern	Good stream health	Moderate stream health	Moderate stream health	Stream health of concern	Stream health of concern	Stream health of concern

Table 4: Catchment / Site Grouping - ***Maitai Catchment***

Main Landuse: *Mixed urban, exotic forestry, agriculture & native bush.*

Good quality / Moderate quality / Poor quality	Brook upper	Brook mid	Brook lower	Maitai upper	Maitai upper/mid	Maitai mid	Maitai lower	Sharland	Groom
Stream size	MEDIUM	MEDIUM	MEDIUM	LARGE	LARGE	LARGE	LARGE	MEDIUM	SMALL
Stream banks	Good	Good	Good	Good	Moderate	Good	Good	Moderate	Poor
Stream bed	Moderate	Moderate	Good	Good	Good	Good	Good	Moderate	Good
pH & conductivity	Good	Good	Good	Good	Good	Good	Good	Moderate	Good
Oxygen	Good	Good	Good	Good	Good	Good	Good	Good	Good
Bacteria	Good	Poor	Moderate	Good	Good	Good	Poor	Poor	Moderate
Nutrients	Good	Good	Moderate	Good	Good	Moderate	Moderate	Poor	Poor
Water clarity	Good	Good	Moderate	Good	Good	Good	Moderate	Moderate	Moderate
Sediment contaminants	-	-	Moderate	-	-	Good	-	-	-
Water temperature	Good	-	-	Good	-	-	Moderate	-	-
Aquatic animals	Good	Poor	Poor	Good	Poor	Moderate	Poor	Good	Good
Slime growth	Good	Good	Good	Good	Good	Good	Moderate	Good	-
OVERALL QUALITY	Good	Moderate	Moderate	Good	Moderate	Good	Moderate	Moderate	Moderate

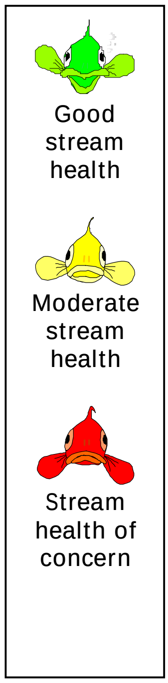


Table 5: Catchment / Site Grouping -*Atawhai & Glen Streams*
Main Landuse: *Urban / residential & agriculture.*

Good quality / Moderate quality / Poor quality	Oldham upper	Oldham lower	Todds upper	Todds lower	Waihi	Hillwood
Stream size	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Stream banks	Good quality	Good quality	Poor quality	Moderate quality	Moderate quality	Poor quality
Stream bed	Poor quality	Poor quality	Good quality	Poor quality	Good quality	Poor quality
pH & conductivity	Good quality	Moderate quality	Good quality	Good quality	Good quality	Good quality
Oxygen	Poor quality	Good quality	Moderate quality	Moderate quality	Moderate quality	Poor quality
Bacteria	Moderate quality	Poor quality	Poor quality	Poor quality	Poor quality	Poor quality
Nutrients	Poor quality	Poor quality	Moderate quality	Poor quality	Poor quality	Poor quality
Water clarity	Moderate quality	Good quality	Good quality	Moderate quality	Moderate quality	Poor quality
Sediment contaminants	-	Poor quality	-	-	-	-
Aquatic animals	Poor quality	Poor quality	Poor quality	Poor quality	Poor quality	Poor quality
Slime growth	Moderate quality	Good quality	Good quality	Moderate quality	Good quality	Poor quality
OVERALL QUALITY	Stream health of concern (red fish)	Stream health of concern (red fish)	Moderate stream health (yellow fish)	Stream health of concern (red fish)	Stream health of concern (red fish)	Stream health of concern (red fish)

Table 6: Catchment / Site Grouping - *Wakapuaka Catchment*
Main Landuse: *Exotic forestry & agriculture. Some tracts of native bush & residential development.*

Good quality / Moderate quality / Poor quality	Wakapuaka upper	Wakapuaka mid	Wakapuaka lower	Teal upper	Teal lower	Lud upper	Lud lower	Pritchards
Stream size	LARGE	LARGE	LARGE	MEDIUM	MEDIUM	SMALL	SMALL	SMALL
Stream banks	Good	Good	Moderate	Good	Good	Poor	Good	Moderate
Stream bed	Good	Good	Good	Moderate	Good	Good	Moderate	Good
pH & conductivity	Good	Good	Good	Good	Good	Good	Good	Good
Oxygen	Good	Good	Poor	Good	Good	Good	Moderate	Good
Bacteria	Good	Moderate	Moderate	Good	Moderate	Poor	Poor	Moderate
Nutrients	Good	Good	Moderate	Good	Good	Poor	Poor	Moderate
Water clarity	Good	Good	Moderate	Good	Moderate	Moderate	Moderate	Good
Water temperature	Good	-	Good	-	-	-	-	-
Aquatic animals	Good	Good	Moderate	Good	Good	Good	Good	Good
Slime growth	Good	Good	Moderate	Moderate	Moderate	Good	Moderate	Good
OVERALL QUALITY	Good	Good	Moderate	Good	Good	Moderate	Moderate	Good

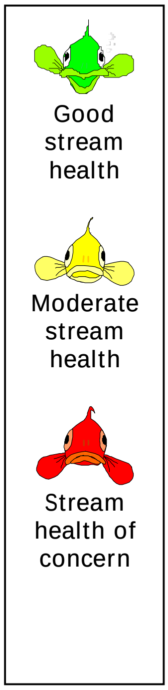
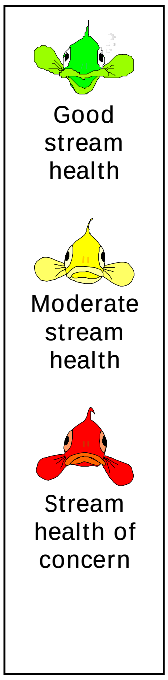
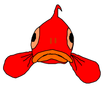


Table 7: Catchment / Site Grouping - *Whangamoa Catchment*
Main Landuse: *Exotic forestry & native bush. Some agriculture.*

Good quality / Moderate quality / Poor quality	Whangamoa upper	Whangamoa mid	Whangamoa lower	Graham	Collins	Dencker
Stream size	LARGE	LARGE	LARGE	MEDIUM	MEDIUM	MEDIUM
Stream banks	Good	Good	Good	Good	Good	Moderate
Stream bed	Moderate	Good	Good	Good	Moderate	Good
pH & conductivity	Good	Good	Good	Good	Good	Good
Oxygen	Good	Good	Good	Good	Good	Good
Bacteria	Good	Moderate	Poor	Moderate	Poor	Poor
Nutrients	Moderate	Good	Good	Good	Good	Good
Water clarity	Good	Good	Good	Good	Moderate	Good
Water temperature	Good	-	-	-	-	-
Aquatic animals	Good	Good	Good	Good	Good	Good
Slime growth	Good	Good	Moderate	Good	Good	Moderate
OVERALL QUALITY	Good	Good	Moderate	Good	Moderate	Moderate



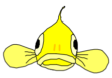
How did the sites compare?



The most impacted waterways in the Nelson City region are small streams in urban and rural Stoke, Bishopdale, Atawhai and the Glen.

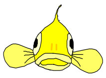
- All of these streams are physically, chemically & biologically degraded, although some were less degraded in the upper reaches.
- Presence of fine-grained bed sediments (silts & sands) commonly contributes to physical degradation of these streams. This can occur via direct run off into the channel (especially in streams flowing through agricultural land or in streams with unstable banks) or via the stormwater system that drains residential properties and roads. Stream banks are destabilised at some sites by channel work or stock trampling, no doubt contributing to bed sediment loads.
- Overall water quality is poor, with these streams commonly having low levels of oxygen in the water, poor water clarity, high summer temperatures, high bacterial contamination, elevated nutrient concentration and, in some cases, higher conductivity (water containing more dissolved salts will conduct more electricity). In addition, elevated levels of sediment contaminants occur in many of these streams.
- Communities of aquatic animals are impoverished, with only the most tolerant kinds of animals (such as worms and snails) able to inhabit these streams. Rapid spread of slime and aquatic plants are also common in the nutrient-rich and often unshaded channels.

Water quality deteriorates with distance downstream in all three major rivers in the Nelson City region, but to varying extents.



The Maitai River exhibits the greatest decline in water quality between the upstream and downstream sites.

- Water quality generally is good at the three upstream Maitai River sites, with high levels of oxygen in the water, low nutrient and bacterial concentrations and good water clarity.
- Compared with the three upstream sites, the downstream site has increased levels of bacterial contamination (in some cases well above trigger levels for contact recreation), decreased water clarity and high summer water temperatures.
- Communities of aquatic animals are of good quality at the uppermost site, but are slightly to severely impacted at the three downstream Maitai River sites.
- Deterioration in quality downstream along the Maitai River is largely due to poor water quality in its tributaries. The Brook has particularly poor communities of aquatic animals at its downstream sites, and Sharland Creek and Groom Creek have poorer water quality than the main part of the Maitai River. Communities of aquatic animals at Sharland Creek and Groom Creek are of good quality.



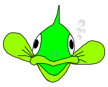
Water quality also declines between upstream and downstream sites in the Wakapuaka River, but not to the same extent as in the Maitai River.

- The upstream Wakapuaka River sites are generally in good condition with good quality river banks, beds, water and aquatic life.
- The downstream Wakapuaka River site is of poorer quality, with low dissolved oxygen and poor water clarity at times, and higher concentrations of bacteria and nutrients than at the two upstream sites. The community of aquatic animals is moderately to severely impacted and slime growth is more common.
- As in the Maitai catchment, water quality at the downstream Wakapuaka site is no doubt influenced by the moderately poor water quality in some of the tributaries (such as the Lud River), although land use impacts on the main part of the river (mainly agricultural) probably also contributed to the decline in quality.

All three sites on the Whangamoa River had good water and habitat quality, and healthy groups of aquatic animals occurred throughout the river system.

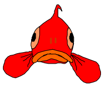
- Although some water quality factors in the Whangamoa River declined with distance downstream, the downstream site is relatively unimpacted compared with similar sites in the Wakapuaka and Maitai Rivers.
- Water and habitat quality is more degraded in two of the smaller waterways (Dencker Creek & Collins River) than in the main part of the river. The decrease in quality is due to increased fine sediments in the beds, which probably contributed to poor water clarity (particularly after even minor rainfall) and increased bacterial concentrations.

- Inputs from more degraded tributaries (contributor streams), impacted by forestry and agricultural landuses, flowing into the Whangamoa River, probably causes the slight deterioration in water quality at the downstream Whangamoa site.



The Roding River has good water quality, similar to that in the Whangamoa River.

- Data collected some distance downstream of the Nelson City region's boundary on the Roding River (as part of the TDC's state of the environment monitoring) indicates that water quality is good, with high levels of oxygen in the water, high water clarity, low nutrient concentrations and low bacteria concentrations. Communities of aquatic animals are indicative of good quality or slightly affected environments.
- Water quality in the upstream part of the Roding River will be assessed when consent monitoring downstream of the Roding Reservoir begins.



Poorer quality aquatic animals were found at sites receiving urban and agricultural runoff than at sites with native bush and pine forestry catchments.

- Our data indicates that the aquatic critter communities are poorer at sites receiving runoff from urban and agricultural lands, with the presence of poor quality animals like snails and amphipods (crustaceans) strongly associated with these sites. Not surprisingly, communities at these sites are also associated with a decline in water quality.
- Communities at sites receiving runoff from areas of mainly native bush and pine forestry catchments are associated with good quality animals like mayflies, stoneflies and caddisflies.
- Our analysis does not show a discernible difference between aquatic critter communities in native bush and pine catchments.

More detail about the waterways

Streams in Stoke and Nelson City

- Generally, the small streams in Stoke and Nelson City (Saxton Creek, Orphanage Creek, Orchard Creek, Lower Jenkins Creek, York Stream and Arapiki Stream) are of very poor quality.
-
- Many of the streams that we sampled are physically degraded by a high amount of fine sediments in the stream bed and a lack of shade from streamside plantings.
- All of the sites (except for the Poorman upper site in the Marsden Valley Reserve) have degraded water quality; such as very low concentrations of oxygen in the water, poor water clarity, high water temperatures, high concentrations of indicator bacteria and high concentrations of nutrients.
- Communities of aquatic animals are in most cases indicative of very poor water quality. Pollution-tolerant worms, snails and midge larvae are common, rather than pollution-sensitive mayflies, stoneflies and caddisflies.
- Slimy algal growths are common due to high nutrient levels, high water temperatures and lack of shade.
- Poorman Valley Stream (which flows from Marsden Valley through Stoke beside Broadgreen Intermediate and Nayland College) is the best quality stream that we sampled in Stoke and Nelson City. The upper site in the Marsden Valley Reserve is of good quality with low levels of contaminants and healthy communities of aquatic animals. However, the lower site is of poorer quality, with more fine sediments in the stream bed, high concentrations of bacteria, higher nutrient concentrations and some contamination of the sediments with heavy metals. The community of aquatic animals is indicative of very poor quality.
- Jenkins Creek is of poorer quality at the downstream site than upstream, but several water quality indicators are of concern even at the upstream site, including occasional low oxygen concentrations, high bacteria concentrations, elevated nutrient concentrations and poor water clarity. Stock have access to

the stream channel at the upstream site, and probably contribute to the poor water quality.

The Maitai River and tributaries

- The quality of the water, stream bed and banks at the three upstream Maitai sites is good, with well-vegetated river banks, little sand and silt in the river bed, well oxygenated water, low nutrient and bacteria concentrations and good water clarity. However, the quality of aquatic animals at the upper/mid site (near the motor camp) and the Maitai mid site is moderate to poor.
- Water quality is poor at the Maitai lower site (near Riverside Pool). Bacterial concentrations are high – in some cases well above trigger levels for contact recreation, summer water temperatures and nutrient concentrations are high, and water clarity is poor at times. Aquatic animals are indicative of poor water quality and there is an increase in slime growth.
- The three tributaries that were monitored (The Brook, Sharland Creek and Groom Creek) generally have poorer water quality than the Maitai River.
- The Brook is in good condition at the upper site where it is surrounded by native bush. However, it decreases in quality downstream with poorer water clarity and increased nutrients at the lower site (below the Manuka Street ford), and high bacteria concentrations at the mid and lower sites. The quality of aquatic animals also decreases at the downstream sites.
- The small Groom Creek tributary was dry for much of the summer and autumn, when monitoring took place, but when it is flowing it has relatively poor water clarity, high nutrient levels and high bacteria concentrations. However, aquatic animals in Groom Creek are indicative of good water quality.
- Sharland Creek has very high nutrient levels, and fine sediments in the stream bed mean that water clarity is poor at times. Bacteria concentrations are commonly high. However, aquatic animals are indicative of good water quality and little slime growth was found.

Streams in Atawhai and the Glen

- These small streams all have very poor water quality. Bacterial contamination is high at all four streams, which is not surprising considering that stock have access to the channel in three of them. Nutrient concentrations are very high in all of the streams, and water clarity is variable but generally poor.
- The streams are physically degraded to varying extents. All but Waihi Creek have fine-grained and highly mobile beds. This was particularly noticeable during the summer and autumn of 2001, when low flows and a lack of flushing allowed fine sediments to accumulate in the stream beds.
- In response to the poor water and habitat quality, communities of aquatic animals are of very poor quality at all of the sites.
- Oldham Creek has occasional high bacteria levels at the upper site and regular high bacteria levels at the lower site. Both sites have high nutrient concentrations, fine-grained stream beds and poor animal communities. The upper site has lower oxygen concentrations in the water, poorer water clarity and more slime growth than the lower site. Contaminants (heavy metals) are present and are found to be increasing in bed sediments at the lower site.

- Todds Valley Stream is in poor condition, particularly at the lower site (just upstream of SH6). It is not well shaded at either site, the stream bed at the lower site is fine-grained and highly mobile, levels of oxygen in the water are occasionally low and concentrations of bacteria and nutrients are high at both sites. Water clarity is relatively good (compared with other small streams in Atawhai, the Glen and Stoke), but it declines in quality at the downstream site. Communities of aquatic animals are of poor quality at both sites. Slime growth is low at the upper site but is higher downstream.
- Hillwood Valley Stream is the poorest quality stream in this group, with low shading, trampling of the stream banks by cattle, a very fine-grained and highly mobile stream bed, low levels of oxygen in the water, high bacteria and nutrient levels, poor water clarity and rapid spread of slime growth. Aquatic animals are of poor quality, but they showed some improvement over the monitoring period, which may have been related to a reduction in the amount of fine sediment in the bed.
- The Waihi Creek site is less physically degraded, with coarse-grained material on the stream bed and vegetation along the stream edge that shades the channel and keeps slime growth to a minimum. However, water quality is poor, with high nutrient concentrations, poor clarity and occasionally high bacteria levels, and the aquatic animals are of very poor quality.

The Wakapuaka River and tributaries

- The sites on the Wakapuaka River decrease in quality with distance downstream.
- The upper site (a short distance up the Whangamoa Saddle) and mid site (at Hira) are in good condition, with well-planted stream banks and high shading, high oxygen levels in the water, low nutrient levels and cool water temperatures. Both of the sites have large-grained beds, although some fine-grained gravels and sands are also present in reasonably high proportions. Water clarity is high and bacteria concentrations are low at the upper site, but both show some deterioration at the mid site. Both sites have healthy communities of aquatic animals and slime growth is low.
- The lower Wakapuaka site (just upstream of the bridge on Maori Pa Road) is of poorer quality, with low oxygen levels and poor water clarity at times, and higher concentrations of nutrients and bacteria than at the two upstream sites. The community of aquatic animals is moderately impacted, and there is more slime growth than there is upstream. Although water temperatures are higher than at the upstream site, they are always below the lethal range for fish and aquatic animals.
- Pritchards Stream is relatively unimpacted, although it has elevated nutrient concentrations and, on one occasion, high bacteria levels, possibly caused by occasional stock access and/or runoff from other land uses (such as exotic forest and scrub) in the area. The stream bed is coarse-grained (mainly boulders and cobbles) and the banks are well-planted, shading the channel. Levels of oxygen in the water and water clarity are high, and a healthy community of aquatic animals is present. Slime growth is generally low, although thick slimy mats do develop after periods of similar flow rates, probably due to the high nutrient concentrations.

- Both Teal River sites are well-shaded by streamside plants and have coarse-grained beds of boulders and cobbles, although the amount of fine sediments was relatively high at the upper site on one occasion of monitoring. Levels of oxygen in the water are high and nutrient concentrations are low, but moderate slime growth indicates that nutrient levels are not low enough to be limiting slime development. Water clarity is generally good but decreases following rainfall, particularly at the lower site. Bacteria concentrations are low at the upper site, but are commonly elevated at the lower site. Healthy communities of aquatic animals are found at both sites.
- Although the Lud River sites also have relatively healthy communities of aquatic animals, water quality tends to be poorer than that in the Teal River. In particular, oxygen levels are relatively low at the Lud lower site (just upstream of SH6), and both sites commonly have poor water clarity, high nutrient concentrations and high bacteria concentrations. The upper site has grazed, unfenced stream banks, but slime growth is surprisingly low despite the low amount of shading. In contrast, the lower site has moderate slime growth, despite the high amount of shading provided by the steep stream banks and stream bank vegetation.
- Monitoring carried out by the Wakapuaka River Care group in 2000 detected similar patterns in quality of aquatic animals, slime growth and water chemistry throughout the Wakapuaka catchment, with deterioration in quality in the downstream Wakapuaka River.

The Whangamoa River and tributaries

- Sites on the Whangamoa River generally have good water and habitat quality.
- All three Whangamoa River sites have well-vegetated river banks and coarse-grained beds, although small amounts of fine gravel/sand are also present, particularly at the two upstream sites. Oxygen levels and water clarity are high at all three sites, and water temperatures at the lower (and probably warmest) site are cool enough in the summer months not to adversely affect fish and aquatic animals. Nutrient levels are occasionally high at all of the Whangamoa sites, but generally decrease downstream with the highest levels occurring at the upper site. Good quality aquatic animals (such as mayfly and caddisfly larvae) are dominant at all three sites.
- Slime growth and bacteria concentrations are higher at the Whangamoa lower site than they are upstream, indicating that there is some decline in quality along the river.
- The three sites on tributaries of the Whangamoa River (Graham, Collins & Dencker) have well-vegetated banks, but stock access to the channel was observed upstream of the Dencker site. These rivers predominantly have coarse boulder/cobble beds, although Collins and Dencker have more fine sediment than Graham. This probably contributes to occasional poor water clarity at Collins and Dencker, which was observed after even relatively minor rainfalls. Bacteria concentrations are elevated at all of the tributary sites during heavy rainfall (including the relatively pristine Graham Stream), but Collins and Dencker sometimes have high concentrations during stable flows as well. All three sites have low nutrient concentrations, well oxygenated water, and macroinvertebrate communities are indicative of good water quality. Dencker has prolific slime growth on some occasions, whereas there is very little slime growth at Graham or Collins.

Where to from here?

The information that we have collected so far gives us a good idea of the quality of Nelson's streams and rivers at the moment. This information will be used as a "yardstick" against which data collected in the future can be compared, and it will allow us to judge if water quality and stream health are changing (for better or worse) at any of the sites.

In order to keep costs of ongoing monitoring down, fewer sites will be monitored long-term than were monitored in the first year of the programme and less information will be collected overall. Nelson's major waterways will still be a focus of the monitoring programme, which will include seven sites in the Maitai catchment, seven sites in the Wakapuaka catchment and five sites in the Whangamoa catchment. Eight sites in the small streams of Stoke, Bishopdale, Atawhai and the Glen will also be retained. Five sites will continue to be used as "reference sites". These sites are located in "pristine" areas and they give us a benchmark against which quality at more impacted sites can be compared. They also give us information about the impacts of any regional or global environmental change on waterways. Water quality tests (for oxygen, nutrients, clarity, pH, dissolved salts & bacteria) and visual assessments of any changes to river banks or stock access will be done every three months. The river bed, aquatic animals and slime growths will be assessed annually and temperature will be monitored continuously at five sites. Also, now that we have some baseline data, monitoring can be resumed at any of the sites (at any time in the future) to help determine if a specific issue is having an impact on stream health (e.g. development of urban subdivisions, logging operations or stream restoration activities).

As well as ongoing monitoring of water and habitat quality, several other projects are underway to improve our knowledge of Nelson's rivers and streams, and to help us manage our freshwater resources better. A regional plan for management of fresh waters is being developed, which deals with how we classify our fresh waters, water allocation, management of stream banks, wetland management, activities within riverbeds and discharges (e.g. from and stormwater and septic tanks). An "IFIM" (Instream Flow Incremental Methodology) study is being carried out on the Maitai River, which will tell us how river habitat changes at different flows. This will help us to determine how to best manage flows in the Maitai so that important values of the river (such as good habitat for trout and native fish) are maintained into the future. Each year Nelson City Council carries out a recreational waters monitoring programme which includes the bacterial quality of popular swimming holes. Details of this work are included in Part 2 of this report. Continuous monitoring of flow levels for major rivers occurs and periodic spot gaugings of minor streams are carried out. Details of this work are included in Part 6 of this report.

Want to find out more?

This information has been taken from a technical report (prepared for NCC by the Cawthron Institute) entitled "Surface Water Quality in the Nelson Region 2000/2001". Copies are available from NCC for the cost of copying, or you can view the report at NCC reception or the Elma Turner Library.

Part Two - Recreational water monitoring

Introduction - why monitor?

There is an established link between water quality and swimming-associated illness risks.

Nelson has many excellent beaches and rivers. Combined with good climate and high visitor numbers over the summer months those beaches and rivers are used intensively for recreational uses.

Nelson City Council has obligations under the Resource Management Act 1991 and the Health Act 1956 to monitor environmental factors affecting the environment and public health. This includes reducing or managing conditions that are likely to affect the environment or affect the health of people in that environment.

In the case of recreational waters where people have close contact with that water, the quality of water may affect people's health.

Water contaminated by sewage and excreta may contain a diverse range of pathogens (disease causing micro-organisms such as viruses, bacteria and protozoa). These organisms may pose a health hazard when the water is used for recreational activities such as swimming and other "high contact" water sports. During these activities there is a reasonable risk that water could be swallowed, inhaled, or enter ears, mouth or nose, or cuts in the skin; allowing pathogens to enter the body.

Research is continuing into the health risks associated with contamination of water by sewage and excreta. Until recently scientists believed that gastro-enteritis was the main health effect from contact with polluted water, but it is now becoming clear that respiratory health effects, such as coughs and colds, also occur and may be more common than gastro-enteritis.

In most cases, the ill-health effects from exposure to contaminated water are minor and short-lived. However, the potential for more serious diseases such as Hepatitis A, protozoan infections and salmonellosis exists.

The guidelines use "acceptable" swimming-associated illness risks of 8 and 19 users per 1,000 bathers for fresh water and for marine water, respectively, as was used in the 1992 guidelines. These risk values have been adopted by the US Environmental Protection Agency (USEPA). The adoption of these risk levels means that these guidelines are consistent with international practice.

The guidelines use bacteria contamination as the only indicator of water quality. They do not cover impacts of other contaminants either on the environment or the health of people exposed to that environment.

The New Zealand Marine Bathing Study (1994) found that:

- The relationships in New Zealand between indicator bacteria and health effects are consistent with those found overseas. As a result of this we can be confident applying the results of overseas research to management within New Zealand.

- There is no significant difference between the health risks associated with animal and human sources of contamination. Therefore, the guideline values should apply irrespective of location and time even where the source of contamination is likely to be runoff from pastoral land or streets. For example, there is no justification, from a health perspective, for not sampling after heavy rainfall, if people are swimming or likely to be swimming. That is, sampling programmes should be based on the number of people (likely) to be swimming, whether or not there has been a heavy rainfall event.

- Of the bacteria that are easily measured (and therefore can be used as indicators of water quality), enterococci has the clearest relationship with health effects in marine waters. (Note: E. Coli die off in salt water and therefore are not suitable indicators of water quality in the marine environment.)

- *Escherichia coli (E.Coli)* is the preferred indicator for fresh water. The pathogens occurring in contaminated fresh water are the same as those occurring in marine waters, except that protozoan cysts (e.g. *Giardia* and *Cryptosportidium)* survive better in fresh water. Enterococci should not be used in fresh waters, because some enterococci in fresh waters arise from natural sources, such as the decay of leaf material. For this reason, enterococci levels can be very high in pristine waters, but these high levels do not necessarily indicate high levels of pathogens.

- Bacteriological levels in shallow water are closely related to health effects.

The Standards

Monitoring has been carried out in accordance with the *Recreational Water Guidelines 1999* (and earlier guidelines). The 1999 guidelines set out three levels of control and management.

They are:

- **Clean:** "Safe" for bathing (classified by the guidelines as GREEN), requiring councils to continue surveillance (e.g. routine monitoring).

- **Potentially unclean:** "Potentially unsafe" (classified by the guidelines as AMBER 1 and AMBER 2), requiring councils to undertake further investigation, such as more detailed monitoring to assess the health risk. The amber

STANDARDS	MARINE	FRESH
GREEN (SAFE)	RM<35	RM<126
AMBER 1(ALERT)	RM>35,SS<136	RM=126-273
AMBER 2 (ALERT)	SS=136-277 *	SS>273 *
RED (UNSAFE)	SS>277 *	SS>410*

- * 2 Consecutive Samples
- SS = Single Sample
- RM = Running Median

condition is reached through two mechanisms: an increase in the running median or alternatively a high single sample result.

- **Highly likely to be unclean:** "Highly likely to be unsafe" (classified by the guidelines as RED) requiring urgent action from councils such as closing a beach.

The guidelines set out different management options depending on the alert level. Repeated Amber results require an investigation to establish pollution sources and increased monitoring. Where two results in a row are Red then steps need to be taken to warn bathers or even close beaches.

The Recreational Water Guidelines have recently been upgraded and developed. They have been issued in draft form for use during the 2001/2002 summer. While unchanged for freshwater, there have been significant changes for marine recreational waters. The guidelines provide a framework for combining monitoring data with assessments of the effects of surrounding land use to set a grading for each area. Nelson City will have enough monitoring data by March 2003 to establish provisional gradings for the key sites.

Background to the Guidelines

In the early 1990s the Department of Health developed the '*Provisional Microbiological Water Guidelines for Recreational and Shellfish -Gathering Waters in New Zealand'*. This was the first guideline provided for regional councils to monitor recreational water quality.

As a result a joint monitoring programme was carried out over the summer of 1992/93 to establish the quality of recreational waters in the Nelson/Tasman area. The participants were Nelson/Marlborough Area Health Board, Tasman District Council (TDC), and Nelson City Council (NCC). The results were reported as: '*Bathing Waters Survey: Nelson and Tasman Regions – Summer 1992/93*.

The survey was repeated the following year (1993/94) and a similar report prepared. That survey was the last time a combined TDC and NCC survey took place.

Over the 1994/95 summer an epidemiological (incidence and distribution of diseases) study was carried out around the country to test the suitability of the water guidelines. Rabbit Island Beach was part of that study with the survey work being carried out by Tasman District Council.

As a result of that national study a report titled '*Health Effects of Bathing at Selected New Zealand Marine Beaches'* was published in 1995. After further work at a national level the '*Microbiological Water Quality For Marine and Fresh Water Guidelines 1998'* were published by the Ministry for the Environment. (Replacing the Department of Health's '*Provisional Microbiological Water Guidelines for Recreational and Shellfish -Gathering Waters in New Zealand').*

Nelson City Council did not carry out any further sampling of recreational waters after the 1992/93 work until sampling re-commenced during the 1998/1999 summer. Over the past four summer seasons regular sampling of both marine water and fresh water sites has been carried out. The remainder of this report summarises that sampling and associated work including investigation of sources of pollution.

The Sites

Figure 3

Figure 4

Site 1 - Cable Bay (northern end of beach)
Site 2 – Atawhai (windsurfing area opposite Dodson's Valley)
Site 3 - Rocks Rd (steps opposite Richardson St)
Site 4 – Tahuna 3 (Rocks Rd end of Tahuna Beach – Abel Tasman statue)
Site 5 – Tahuna 2 (middle of Tahuna Beach opposite skating rink)
Site 6 – Tahuna 1 (western end of Tahuna Beach – Blind Channel)
Site 7 – Parkers Cove (end of Parkers Rd)
Site 8 – Monaco (next to wharf at end of Monaco Peninsula)
Site 9 – Girlies Hole (Maitai River 300m upstream from Nile St bridge)
Site 10 – Sunday Hole (Maitai River)
Site 11 – Smiths Ford (Maitai River)

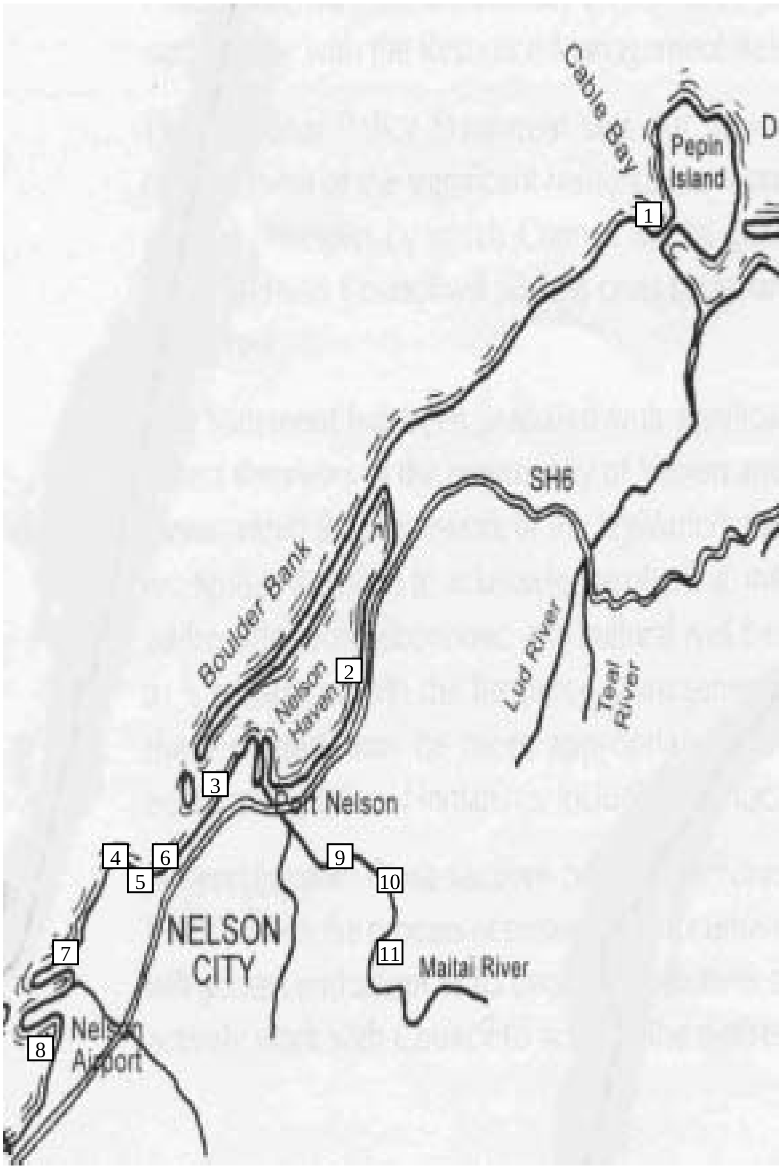
Throughout the monitoring programme the two key sites have been halfway along Tahuna Beach (Tahuna 2) and Sunday Hole because they both attract a high level of recreational use. For this reason these two sites have been sampled more frequently than the other sites. The extra samples increase the statistical accuracy of the results for these sites.

The Results

The table on the following page gives a break down of the number of samples taken at each site over each of the past four years and the number of samples falling in the Green, Amber 1, Amber 2, and Red categories.

From those results a general understanding of the water quality at each site can be established.

Figure 5: recreational water sampling results



STANDARDS	MARINE	FRESH
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RED (UNSAFE)	SS>277 *	SS>410*
• * 2 Consecutive Samples • SS = Single Sample • RM = Running Median		

	98/99	99/00	00/01	01/02	**TOTAL**
1 CABLE BAY					
Total Samples	9	7	5	6	**27**
Green (Safe)	8	5	5	5	**23**
Amber 1					
Amber 2	1	1			**2**
Red (Unsafe)		1		1	**2**
2 ATAWHAI					
Total Samples	9	7	5	5	**26**
Green (Safe)	8	6	4	4	**22**
Amber 1					
Amber 2					
Red (Unsafe)	1	1	1	1	**4**
3 ROCKS RD					
Total Samples	9	5	2	5	**21**
Green (Safe)	9	5	2	5	**21**
Amber 1					
Amber 2					
Red (Unsafe)					
4 TAHUNA 3					
Total Samples	0	22	0	0	**22**
Green (Safe)		21			**21**
Amber 1					
Amber 2		1			**1**
Red (Unsafe)					
5 TAHUNA 2					
Total Samples	9	31	17	21	**78**
Green (Safe)	7	26	17	21	**71**
Amber 1		2			**2**
Amber 2	1	1			**2**
Red (Unsafe)	1	2			**3**
6 TAHUNA 1					
Total Samples	0	23	17	11	**51**
Green (Safe)		19	16	10	**45**
Amber 1					
Amber 2		4	1	1	**6**
Red (Unsafe)					
7 PARKERS COVE					
Total Samples	9	0	0	0	**9**
Green (Safe)	1				**1**
Amber 1	5				**5**
Amber 2					
Red (Unsafe)	3				**3**
8 MONACO					
Total Samples	9	6	17	10	**42**
Green (Safe)	8	4	16	9	**37**
Amber 1		2		1	**3**
Amber 2			1		**1**
Red (Unsafe)	1				**1**
9 GIRLIES HOLE					
Total Samples	9	6	6	11	**32**
Green (Safe)	7	6	5	10	**28**
Amber 1	1				**1**
Amber 2	1		1	1	**3**
Red (Unsafe)					
10 SUNDAY HOLE					
Total Samples	9	33	17	21	**80**
Green (Safe)	2	28	14	16	**60**
Amber 1	3	1	1	3	**8**
Amber 2	3	2			**5**
Red (Unsafe)	1		1	1	**3**
11 SMITHS FORD					
Total Samples	9	6	5	3	**23**
Green (Safe)	8	6	5	3	**22**
Amber 1					
Amber 2	1				**1**
Red (Unsafe)					

In general all sites are considered safe for most of the time. However all sites from time to time have results that fall within the Amber or Red range. When samples are taken other details such as tide, wind, rain, temperature, current usage, number of swimmers, and animals present are recorded. Analysis of this data has shown that most Amber or Red samples are related to rain events. Additional sampling has been carried out during rain events to better understand the relationship.

As a result the following conclusions have been made:

- Water quality at both the marine and fresh water sites are affected by rain.

- Fresh water quality is affected almost immediately with the first flush of rain quickly raising the bacteria levels. However once the effect of the first flush has passed the levels quickly return to an acceptable standard. This happens even if the rain continues.

- The effects on marine waters are delayed by a day. It is assumed that it takes an extra day for the freshwater to enter Tasman Bay, mix and be carried to beach sites. However once the rain stops the levels quickly return to acceptable levels.

By way of illustration during November 1999 there was a heavy rain event extending from 5 November through to 6 November 1999. Daily samples were taken at both Sunday Hole and Tahuna 2 during the rain and for three days following to assess the effect. Results were as follows:

Table 8: effects of rain on water quality

	Sunday Hole	**Tahuna 2**
	E.coli / 100ml	Enterococci/100ml
05-Nov-99	165	75
06-Nov-99	890	240
07-Nov-99	200	2000
08-Nov-99	62	560
09-Nov-99	62	10

As can be seen both sea and fresh water sites were affected by rain.

At Sunday Hole the water quality is affected almost immediately with the first flush of rain raising the E.coli and Enterococci levels quickly. However even though this rain event lasted over two days, once the effect of the first flush had passed the levels quickly returned to an acceptable standard.

Perhaps not unexpectedly the main effects at Tahuna 2 were delayed by a day. It is assumed that it took an extra day for the freshwater to enter Tasman Bay, mix and be carried to Tahuna Beach. However once the rain had ceased the levels quickly returned to acceptable levels.

On later samples where rain events had caused high readings, re-samples 24 hours later were all found to have returned to an acceptable level.

The public of Nelson should be aware that there is an increased health risk when swimming during or shortly after rain events. The heavier the rain event the higher the health risks.

In addition to the rain affected results, there have been a number of unexplained high results. In particular the Atawhai and Cable Bay sites exhibit ‘rogue’ one-off high results, even though the general quality at those sites is excellent and the sampling was not carried out during rain events. Investigation of both sites has not found an obvious cause.

The Maitai River swimming holes are the most marginal in terms of water quality. Low river flows and diffuse pollution sources, coupled with high recreational use over summer, makes it important that monitoring continues and that public awareness is raised to ensure that there is a general understanding of the risk, especially during/after rain events.

Additional Monitoring Work

In addition to routine monitoring work, sanitary surveys have been carried out over the past four years to identify pollution sources. This work, outlined below, has been a combination of field inspections and additional sampling.

- **Full Sanitary Survey of the Maitai River June – Oct 1999**

  The Environmental Survey identified potential pollution sources to the Maitai River.

  No proven link was found between defective septic tanks/effluent disposal systems and pollution levels of the Maitai River, even though some systems were obviously defective.

  Further monitoring was recommended to confirm whether Sharlands Creek is a continuing and significant source of pollution (see next section).

  It was considered that the main source of pollution was from stock and animal waste run-off from the surrounding land, either directly, or indirectly via smaller streams flowing into the Maitai River.

  Policies and practices for the management of activities alongside streams and on the surrounding land are required to limit the effects of pollution from these sources. As part of that work interrelated issues such as the effects of herbicide and pesticide use, fertiliser use, forestry practice, and farming practices need to be considered

  The level of E.coli pollution in the Maitai River is consistent with other rivers flowing through similar areas in Nelson and Tasman.

The levels of pollution found during recreational water monitoring were considered marginal for recreational use. It should be noted however that the guidelines for recreational use in fresh water are **interim and must be used with caution**.

- **Further investigation of Sharlands Creek and other tributaries to the Maitai River**

  The survey of the Maitai River identified Sharlands Creek as a possible significant source of pollution. A number of samples taken over the 2000/2001 summer found that there were consistently high levels of pollution in Sharlands Creek. Although those levels were reduced by the dilution factor on contact with the Maitai, there is no doubt that Sharlands Creek is a significant contributor to the overall levels found at Sunday Hole and Girlies Hole.

  Inspection of the Sharlands Creek catchment showed no obvious point sources of pollution but did show stock feeding and resting beneath the trees along the creek bed. It confirms the findings of the main survey that the main source of pollution is from stock and animal waste run-off.

- **Effects of Corder Pond on Atawhai Results**

  It was suspected that the occasional 'rogue' high readings at Atawhai could coincide with the monthly draining of Corder Pond as one event coincided with release of impounded water from the pond near the sampling location. It had been planned to take readings before and after the pond was drained. However this has not been possible as Corder Pond is now left to drain naturally.

- **Field Survey and additional sampling of tributaries to Waimea Estuary between Parkers Cove and Richmond carried out during 2000/2001**

  A field survey was carried out to identify all sources/tributaries that discharge to the Waimea Estuary between Parkers Cove and Saxtons Road. Samples were taken from Saxton Creek, Maire Stream, Parkers Stream, Poorman Valley Stream, Jenkins Creek, Orphanage Creek, and Orchard Creek. All exhibited medium to high loadings of pollution. This was not surprising considering the nature of their catchments and the low water flows.

  However although they had consistent high loadings of pollution, those loadings did not seem to influence the results at Monaco or Tahunanui.

- **Investigation of Pollution Sources at Cable Bay**

  A check has been made of possible sources of pollution in the area. No obvious source has been found to explain the occasional 'rogue' result at this site.

Future Monitoring/Management Options

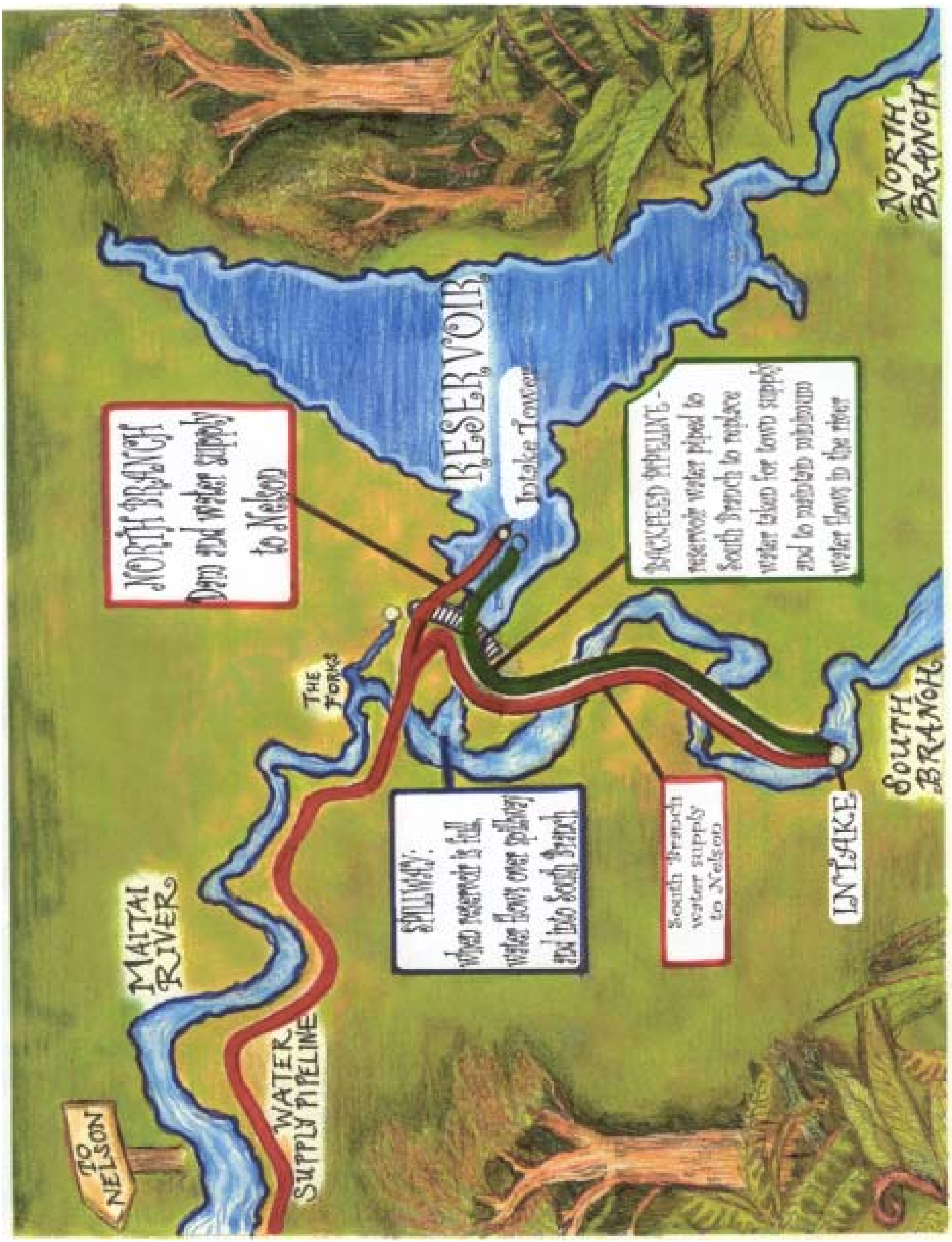
The key management strategies should be:

- Continued sampling in accordance with the guidelines. The current level of sampling at each site is considered adequate.
- Increasing database of results and completing catchment assessments so that marine sites can be graded in accordance with the 2001 guidelines.
- Develop education strategies to inform recreational users of the times when there is a higher risk (during and shortly after rain events).
- Development of appropriate policies and practices applying to riparian and catchment management in order to limit the effects of pollution from these sources. As part of that development interrelated issues such as the effects of herbicide and pesticide use, fertiliser use, forestry practice, and farming practices such as stock access, will need to be considered.
- Investigate the potential for land management changes in Sharlands and Groom creeks to minimise stock waste entering these streams.
- Continue additional work as required to identify pollution sources.
- Continue liaison with the Nelson Medical Officer of Health and Tasman and Marlborough Councils to ensure sharing of skills and knowledge and to maintain a consistent approach.

References

- Microbiological Water Quality For Marine and Fresh Water Guidelines
- Provisional Microbiological Water Guidelines for Recreational and Shellfish -Gathering Waters in New Zealand. (1995,1998,1999 and 2001)
- Bathing Waters Survey: Nelson and Tasman regions – Summer 1992/93 (Fenemor, Cameron, Box)
- Bathing Waters Survey: Nelson and Tasman regions – Summer 1993/94 (Fenemor, Cameron, Box).
- Report on Recreational Water Monitoring Programme – NCC 1998/1999 (Lawrence).
- Report on Recreational Water Monitoring Programme – NCC 1999/2000 (Lawrence).
- Environmental Survey Maitai River, Nelson, June – Oct 1999 (Lawrence).

Figure 6: How the Maitai water supply system works



Part 3 - Maitai River Habitat and Flow Study

Introduction – maintaining minimum flows

There are many reasons to maintain the river in a healthy state. The Maitai River is a source of Nelson's drinking water but it is also highly valued by the community for its recreational and natural values. Keeping enough water in the river to maintain its healthy state is the reason for setting limits on how much water can be taken from the Maitai River for Nelson City's water supply.

There is a requirement that the flow level in the Maitai River doesn't go below a certain level. Low flows occur naturally from time to time, but it is the Council's job to make sure that the effects of taking water from the river are either avoided or reduced.

This year an indepth study has been done to find out what animals are inhabiting the bed of the river and what fish communities are living in the Maitai River, how widespread they are throughout the river, and to assess how much water flowing down the river is required to maintain the health of these communities.

There are a number of methods for establishing what these minimum flow levels should be, including:

- historical flow records to identify the river's "natural" flow over time;
- looking at the hydraulic geometry of the river (e.g. width, depth and velocity);
- using local and traditional knowledge to establish flows; and
- matching flow levels to the flow level which is required to maintain aquatic species (the method described in this report).

Although a minimum flow regime has already been established for the Maitai River through the consents process, there hasn't been a detailed study of how that flow affects the animal and plant communities in the river. The Council is in the process of preparing a fresh water management plan and requires good information on which to base its provisions. For this reason, the Council commissioned an "IFIM" study (Instream Flow Incremental Methodology) on the Maitai River, to assess the relationship between changes in flow and ecological indicators.

How much water do we take from the river?

Nelson City's daily water use ranges from 20,000m^3 in winter up to a maximum of 35,000m^3 in summer. Up to one third of that water comes from the Roding River, but the total water take from that river is restricted to leave a minimum flow level in the river. The required minimum flow is currently 75 litres per second but will increase to 100 litres per second by July 2008. The rest comes from the Maitai River. The total amount taken from the South Branch for the urban supply is replaced back into the river with water from the dam.

Water usage has reduced since water metering was introduced in July 1999. Prior to that time, summer water usage reached peaks of up to 43,000m^3.

The Maitai Dam is located on the North Branch of the Maitai River, at the end of the Maitai Valley Road, approximately 8 km out of town. The dam is 200 metres upstream of The Forks, where the North and South Branches meet to form the main part of the Maitai River. The Maitai reservoir covers 32 ha and extends about 1 km upstream from the dam.

Generally Maitai water is drawn from the South Branch intake but where there isn't enough South Branch water or it is of poor quality, water can be drawn from the North Branch Reservoir. Figure 6 shows how this system works.

Water flowing from the North Branch of the Maitai River is dammed and stored in a reservoir. When the reservoir is full, any additional water flows over the dam spillway and flows down the Maitai River.

The place where the north and south branches of the Maitai River join up is called the Forks. Water flow is continuously monitored immediately below the Forks. As part of the Council's existing resource consent for taking water from the river for urban water supply there is a requirement for the flow of the river at this point to be at least:

(i) 300 litres per second from 1 May to 31 October
(ii) 175 litres per second from 1 November to 30 April

The Council has recently renewed four of the resource consents related to the Maitai River water supply scheme. The four consents are:

- to continue to dam the North Branch
- to take surface water (subject to maintaining full flows at the junction of the North and South Branches)
- to discharge scour water (water that has been through the water supply pipes)
- to discharge overflow water from the reservoir into the South Branch

As part of this resource consent process the Council has consulted with iwi, Department of Conservation and the Fish and Game Council. These discussion have led to agreements to enhance the river system. These will include work on an eel management programme to reestablish eels in the North Branch tributary and for a significant amount of planting to be done further down the river (at this stage scheduled for winter 2003).

Figure 7: Maitai dam and reservoir

Figure 8: flow recording station, Maitai River, approximately 250m below The Forks

IFIM Study

The IFIM Study examines the suitability of water flow conditions in the Maitai River for indicator animals and fish. (IFIM stands for Instream Flow Incremental Methodology.) All plants and animals are adapted to a limited range of flow conditions. In the aquatic environment, instream habitat usually refers to the physical habitat – water speed, water depth, the characteristics of the river bed, and often includes vegetation growing beside the river (shading and cooling the water, and dropping leaves).

Fish and critters (such as insect larvae, snails and worms) will generally be most abundant where the habitat quality suits them best. In the IFIM study, flow requirements for the habitat of fish and critters were assessed by examining the relationships between actual water flow of the Maitai River and suitable habitat (flow conditions for the species measured).

The IFIM Study measures the shape of the channel and height of the water at representative parts of the river. Different fish have different habitat (flow) preferences. The study looks at how habitat changes with the amount of flow in relation to habitat preferences of specific species. Therefore we can work out the effect of changed flows in the river on the different fish species.

This study involved the following process:

- identifying specific sampling areas in the river, which are representative of the river as a whole;
- undertaking field work at the sample areas to establish physical properties (eg area covered by water, type of river bed), existing ecology, and hydraulic characteristics (eg width, depth, water speed);
- matching up the field data with the known preferred flow conditions (habitats) for chosen indicator species (trout and native fish); and
- identifying a "optimum" flow for the Maitai, which provides the best habitat conditions for the indicator species.

While the IFIM study will produce an "optimum" flow, it should be noted that this flow is not an absolute figure and may not be appropriate for establishing the flow regime for the whole river. The IFIM study considers ecological habitat only, and does not take into account other human values. The optimum flow (for aquatic ecological habitat) is only one component of a range of values which need to be provided for. The Maitai River clearly has significant values as a water supply source, and for its recreational attraction. The IFIM optimum flow figure will provide a researched and viable starting point for discussion, but will not necessarily be adopted as the minimum required flow for the river.
A similar IFIM study was conducted for the Roding River in 1995 and it was used as a tool to assist in the setting of the minimum flow for that river.

Results

The results from this project were not available at the time the State of the Environment Report was printed. The results will be made publicly available as soon as they become available.

Where to from here

This information will assist with the Council's management of Nelson's freshwater resources. Matters which the Council is required to manage include:

- activities and planting in riverbeds and on the margins;
- activities on the surface of water;
- discharges (to land and water);
- water take, use, and abstraction;
- amenity, natural character, heritage and Tangata Whenua values;
- damming and diversion;
- river and stream flows and levels; and
- water allocation.

The Nelson Regional Policy Statement has established regional objectives, policies and methods for managing water bodies in Nelson. The Council is now in the process of developing specific fresh water provisions to be included in the Nelson Resource Management Plan and these will assist in fulfilling the objectives and policies of the Regional Policy Statement. These provisions will include minimum flows, water quality standards and allocation limits.

The sustainable management of the region's water resources raises many challenging issues, and there will be a range of opinions about their significance and how they should be resolved.

A fresh water working party has been established to scope the issues and ways to address them. Public consultation will be carried out once the issues have been identified and preferred management options chosen.

References

Benthic macroinvertebrate and fish communities in the Roding River and their minimum flow requirements, Cawthron Report No. 288 for Nelson City Council, by John Hayes and John Stark, July 1995.

Part 4 - Contamination of Sediments

Introduction - why monitor sediments?

Sediments are the fine particles which settle on the beds of streams and rivers.

When contaminants attach to sediments they become trapped in the bed of the stream or river and influence water quality. Contaminants can also affect plants and animals living on the sediments on the river bed, and any fish that feed on those plants or animals.

Many chemical contaminants attach to sediments on the river bed rather than remaining in the water. Therefore, sediments act as a record of the historical existence of contaminants as well as indicating the recent flow of contaminants into waterways.

Reasons to monitor sediment contamination are:
- elevated levels of contaminants may be poisonous to people;
- sediment dwelling (benthic) species are directly impacted by contaminated sediment. Impacts include interference with growth and reproduction as well as mortality;
- biomagnification of contaminants through the food chain (concentration of contamination levels for species higher up the food chain such as fish and humans who eat the fish);
- water quality for other uses such as recreation; and
- contaminants bound to sediments may remain in the stream or river for long periods of time and continue to accumulate to higher concentrations.

Stormwater is one of the main ways contaminants enter streams and rivers. Stormwater is essentially rainwater which runs off hard surfaces such as roofs and roads, carrying contaminants from the surrounding land. Common stormwater contaminants include trace metals (eg copper, lead and zinc), hydrocarbons (eg oil), and biocides (herbicides and insecticides).

The guidelines

Nationally, we are only just developing the science to work out what good, bad and indifferent look like in terms of contaminant levels. It has only been in the last 18 months that the ‘Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000’ have been available. These guidelines identify concentration levels at which there could be an effect on the stream water quality and plants and animals living in that stream. A concentration level is specified for a lower threshold which indicates a possible biological effect and for an upper threshold level which indicates a probable biological effect.

The advantage of monitoring sediments rather than surface water is that sediments are a record of past events and therefore sampling does not need to rely on targeting the exact time of discharge as the sediment retains the record. The difficulty has been to isolate the sources of the contamination. However, if a problem is detected, the

Council will know where to target resources to find the sources in the surrounding land uses.

Previous Investigations

Water flows through the greater Nelson City area via eight main river and stream systems. From south to north, these are: Saxton Creek, Orphanage Creek, Poorman Valley Stream, Jenkins Creek/Arapiki Stream, York Stream, Brook Stream, Maitai River, and Oldham Creek. These are shown in Figure 9 on the next page.

Most previous monitoring of sediments in Nelson waterways has been carried out in the Maitai River, Jenkins Creek/Arapiki Stream, and York Stream because they flow through the main industrial areas of the city and are therefore more likely to have contaminants draining into them.

Fuel storage, commercial port activities, vessel maintenance and repair occur in the Port area so the main potential for contamination is trace metals from ship anti-fouling materials and hydrocarbons such as oil. The contaminants tend to be discharged and accumulate directly in the waters of the Haven and the lower Maitai River.

Water from the Tahunanui industrial area drains into the Jenkins and Arapiki Streams. A range of activities have been undertaken in the area including historic timber treatment and vehicle assembly.

Water from Vanguard and St Vincent Streets drains into York Stream and the Vanguard Street drain which discharge into Saltwater Creek. Activities in this area include vehicle maintenance and repair, joinery and seafood processing.

Earlier monitoring work identified a number of areas where contamination levels exceeded guideline levels. In response the Council commissioned further sampling to help isolate the sources of contaminant and undertook door-to-door visits of industrial and commercial premises to identify and rectify sources of contamination.

The current project has a number of purposes:

- to consolidate sediment quality data into one report, providing a consistent set of results across the Nelson area against which to compare future sediment monitoring;
- to evaluate the effectiveness of previous work to reduce contamination levels; and
- to extend the area surveyed in order to identify any additional areas of contamination

Figure 9: Nelson waterways and the surrounding catchments

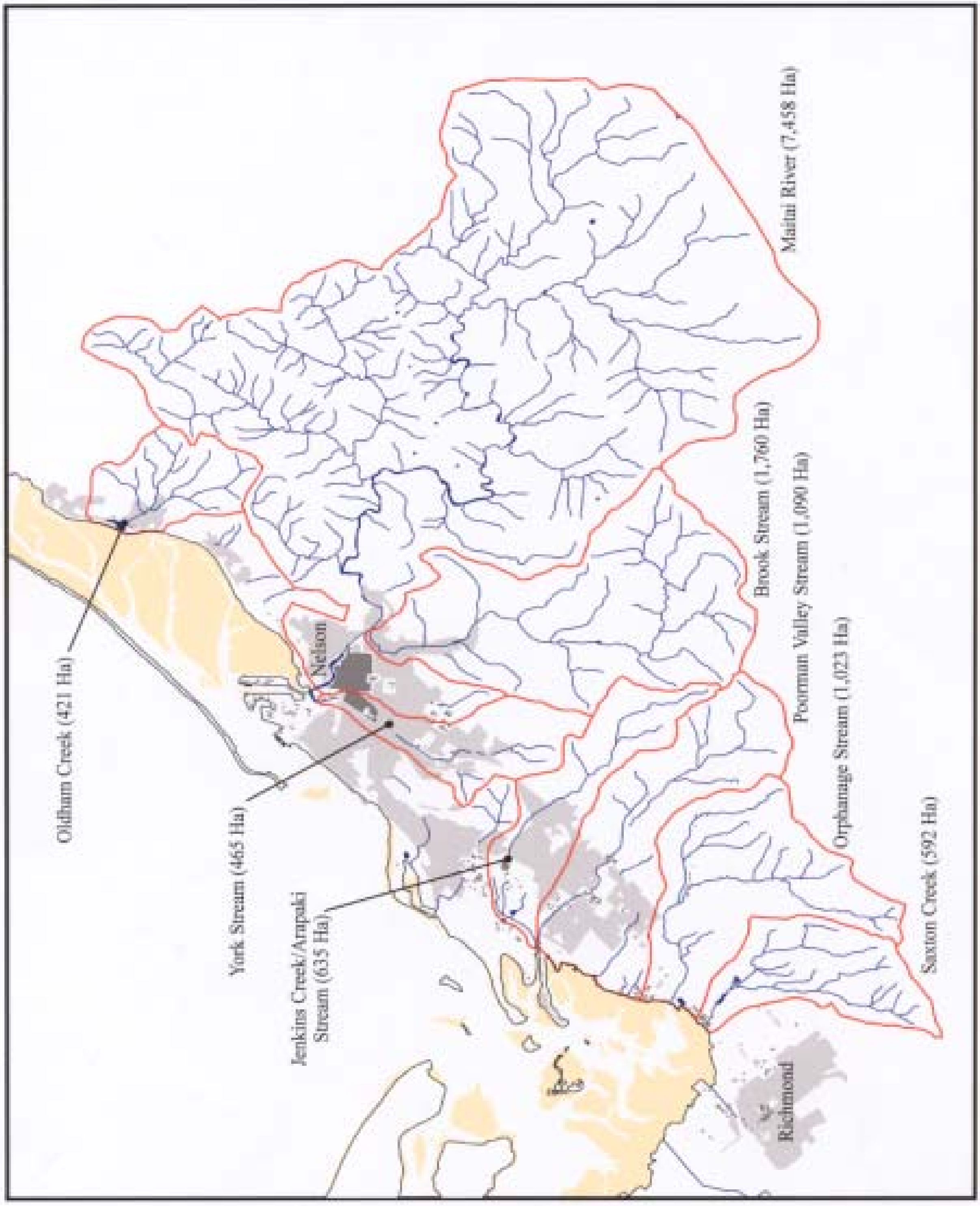


Table 9 - summary of sediment sampling results (A3 table)

Methodology

A variety of different studies into sediment quality have been conducted in the past few years. Some of these studies have been done to provide the Council with information about water quality in specific areas . Others have been carried out by industries as part of resource consent applications in the Port Nelson, Tahunanui and Vanguard/St Vincent Street areas.

On behalf of the Council, Cawthron Institute has now reviewed and summarised the range of data previously collected. It has also collected several other sediment samples to fill information gaps and to provide additional information for some waterways.

The results of the study provide baseline environmental information against which:

- to identify areas where elevated contaminant levels indicate more sediment sampling is necessary;
- to identify areas where current contaminant levels are of little or no concern and further sampling will not be required in the near future; and
- to provide information for upcoming stormwater consent applications.

Results - What we know about the catchments

Saxton Creek catchment
Very low levels of contaminant have been found in the upper Saxton Creek catchment, which is primarily rural and forestry, however the lower catchment does receive runoff from the freezing works which has the potential to discharge trace elements.

Orphanage Creek
Similar to Saxton Creek, this catchment drains rural and forestry areas as well as runoff from the freezing works. Sediment contamination is unlikely to be a major problem given the land use.

Poorman Valley Stream
This catchment drains residential and urban areas, where runoff from roads would be expected to have the biggest effect. Zinc is often present in stormwater as a result of vehicle component wear and from galvanised metal, eg roofing iron. The PAHs (polycyclic aromatic hydrocarbons such as lubricants) are reasonably common in residential stormwater and are the result of incomplete combustion of fuel and vehicle lubricants.

Jenkins Creek/Arapiki Stream
This catchment drains industrial and residential areas. Problem areas and contaminants are well identified. No expansion of current monitoring is required.

York Stream
This catchment consists of industrial and residential to semi urban areas. Contaminants and levels are fairly well defined. No expansion of current monitoring is required.

Brook Stream
This catchment consists of urban/residential and agriculture/forest areas where little contaminant build up would be expected. However, sampling has showed heavy metals as well as PAHs and SVOCs (semi volatile organic compounds such as petrol) exceeding guideline criteria.

Maitai River
In the Port Nelson area there are high levels of heavy metals (cadmium, copper, chromium, zinc, nickel and lead) as well as elevated levels of PAHs and SVOCs. These results reflect the industrial nature of the Port area and do not reflect the Maitai River catchment as a whole. This catchment area consists of a combined urban, industrial, forest and agricultural land use.

Oldham Creek
This catchment consists of residential to semi-urban areas so low levels of contaminants would be expected. However, levels were higher than expected.

Table 10: the source and effects of some common contaminants.

Contaminant	Source	Effects
Copper	Vehicle component wear Copper plumbing (use of which is increasing)	
Zinc	Vehicle component wear Galvanised metal (eg roofing iron)	Zinc is held to the surface of suspended material. Zinc is an essential trace element requirement for many aquatic organisms, but too much can limit growth. Zinc has been found to increase in quantity in freshwater animal tissues but this is not generally considered a problem.
Lead	Historic exhaust emissions and historic lead plumbing	Lead is strongly held to the surface of clay, soil substances and other suspended material. Lead can increase in quantity in aquatic organisms but is generally not available at sufficient concentrations to cause significant problems. Lead can impact on reproduction and cause spinal deformities.
Cadmium	Industrial processes	
Chromium	Industrial processes	
Nickel	Industrial processes	
PAHs (polycyclic aromatic hydrocarbons)	Incomplete combustion of organic materials such as fuels and refuse Lubricants and bitumen Release of crude oil and petroleum products Commonly found in road run off	PAHs are strongly held to the surface of sediment, suspended matter and organic matter. UV light increases the toxicity of PAHs. Can cause tumours in fish Uptake in tissues can result from sediment contamination. PAHs affect growth and hatching and can cause death. They also affect growth and can kill algae.
Biocides (including herbicides and insecticides)	Herbicides used to control plant growth along roads and footpaths and around buildings (although the most commonly used herbicides (eg Roundup) rapidly degrade in the aquatic environment	

Where to from here

This compilation of historical sediment contamination levels on a geographic basis can be used as a baseline to help identify areas that may require additional work.

If high levels of contamination are found in future, more intensive monitoring would be carried out, and there would be a requirement to identify and eliminate the source of contamination, and/or a tightening of mitigation actions. This would be picked up during resource consent applications to discharge stormwater.

If high levels of contamination are found, as a temporary measure additional treatment could be required, such as further filtration and treatment prior to discharge, until the contamination source is controlled.

Sediment sampling was recently required for an upgrade of the stormwater system in Collingwood Street. A temporary consent for stormwater discharges has included funding for sediment sampling.

The best option to improve stormwater quality and therefore reduce sediment contamination is to treat the source of the contamination. The second best option is to treat the water prior to discharge.

Treatment options include filters in the kerbside sumps (which are not vey expensive and are easy to retrofit); outlet filters (which do reduce the discharge capacity of the stormwater system); swale (grass) drains instead of kerb and channel (which are being considered for limited use in new areas, but are not practical to retrofit); surfaces for car parks which allow natural soil filtering (easier to apply to new developments as existing hard surfaces are expensive to retrofit); wetlands and detention ponds which settle and filter stormwater (again a practical option for new subdivisons, but difficult and expensive to retrofit).

The best time to think about methods to reduce stormwater contamination is at the time of new development.

In addition, the community may need to consider whether copper plumbing and zinc roofing are appropriate construction materials given the level of contamination in the stream and river sediments. Current Building Codes do not allow for regional variations so this would need to be addressed at the national level. Raising public awareness locally would be one way to reduce this effect.

A further round of monitoring will be undertaken in the near future to further refine our understanding of contamination levels. Poorman Valley Creek and Brook Stream are the highest priority for targeted work, because these catchments have not been studied very much and various contaminants have been identified in elevated concentrations.

Medium priority for targeted work are: Saxton Creek, Orphanage Stream and Oldham Creek. Limited data is available so some additional investigation may be needed. Low priority for targeted work are Jenkins Creek, York Stream and Maitai River which have all been thoroughly sampled and contaminants and sources are well identified.

References

A review of sediment contaminant levels in Nelson area catchments, Cawthron Report No. 627, prepared for Nelson City Council by Paul Barter and Sinnet Frisk, March 2001.

Contaminant Levels in Stream Sediments: York Stream Industrial Area, Nelson, Cawthron Report No. 436, Prepared for Nelson City Council by Leigh Stevens, February 1998.

Australian and New Zealand Guidelines for Fresh and Marine Water Quality, draft, July 1999. Prepared under the auspices of Australia and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

ANZECC guidelines, page 8.3-190 Version – October 2000.

Part 5 - Fish Passage

The Ministry for the Environment and several councils including Nelson City Council sponsored production of a Cawthron Institute brochure on fish passage. The brochure looks at where migratory freshwater fish are typically found and at ways to ensure that structures in waterways such as weirs, culverts, fords and bridge aprons do not prevent fish from reaching their preferred habitats. The brochure is especially aimed at rural landowners but is of benefit to anyone considering constructing or upgrading structures in streams.

Freshwater fish are found in a surprising variety of habitats – from small stream courses hardly big enough to wet your shoes to steep mountain streams seemingly miles from anywhere. Few people realise that many of these fish have had to journey all the way from the sea at some stage in their life cycle.

Freshwater fish have varying abilities for making their way inland from the sea. Some only inhabit streams and wetlands within our coastal lowlands. Others are able to penetrate great distances inland, some climbing steep waterfalls in their quest for the ideal place to live. Yet even the strongest of these migratory species can be prevented from moving upstream by an incorrectly placed road culvert.

Figure 10: elvers (young eels) climbing the damp surface of a vertical rock wall in their attempt to migrate over the Roding Dam

For fish, small streams are as important as large rivers. Streams that some fish choose to live in are so small they can be easily overlooked as habitat for fish. These smaller streams are the usual domain of most New Zealand native freshwater fish, but are often used by juvenile trout as well. When viewed collectively, the myriad of small streams throughout New Zealand are home to millions of fish. The fish produced and reared in these small streams are the source of valuable fisheries in the rivers downstream.

If barriers are placed in the way of migrating fish, their choice of habitat becomes limited and this in turn causes a decline in their number. Anytime a simple structure such as a culvert is placed in a stream, there is potential for it to impede fish passage.

The best time to consider fish passage is before a structure, such as a culvert, is built or placed in a stream. The culvert should be as wide or wider (if a pipe) to allow the stream course to assume its natural character within the structure. In other words nothing should be created that alters the natural stream course and that might risk impeding fish passage through the structure. At this stage, the most important consideration is ensuring the structure has a minimal effect on the natural characteristics of the stream.

This is done best by choosing a design that does not add any additional physical feature into the stream course. For example, the structure should not create a waterfall where there was previously a gentle meander. If this rule of thumb is followed, there is a much better chance that fish will cope with passage past the structure.

Guidelines for installation of new culverts

- Choose sites with a minimum of stream bed slope.
- Culvert width should be as wide or greater than the stream bed.
- Culvert slope should conform to the natural streambed slope.
- Culvert alignment should conform with the natural stream channel.
- Embed culvert below the normal stream bed.
- Allow natural stream bed material to settle throughout the culvert length.
- Armour the inlet and outlet with rock or other suitable material.
- Maintain and monitor the site.

The rock ramp fish pass

A solution for providing fish passage at an existing structure is building a rock ramp. This simple design can be adapted to a wide range of existing structures. This is not only a proven design but is one that can be easily built without elaborate engineering detail. Because the design is an adaptation of natural stream features it blends well in all surrounds.

The cross-section of the concrete ramp should be dished into a shallow v shape. This will ensure that during low flows, the confined channel will provide a suitable depth of water for fish to swim. During high flows the dished shape of the ramp will provide low velocity shallows and a splash zone along its outer edges that fish will be able to utilise to swim upstream.

Figure 11: rock ramp illustration

Large rocks, with diameters up to a quarter of the width of the ramp, should be placed to form a zig zag staircase that slows down the flow and forms small pockets of still water and eddies in which fish can rest. When installed correctly the design should replicate a natural rapid in both appearance and function. The ramp and rocks should lead all the way to the culvert so that as much still water as possible is created at the culvert outlet. While the aim is to reduce the energy of water discharging from the culvert, the ramp and rock placement should not cause water to back up such that the culvert becomes completely inundated during high flows.

Figure 12: any fish passage design should represent a natural rapid in both appearance and function.

Aim for a slope of 1: 20. For ramps at structures less than 0.75 metres in height a ramp slope up to 1: 15 can be considered. The benefit of this design is that it can easily be adapted for culverts, weirs, bridge aprons and virtually any structure in a river up to about 1.5 m in height.

Part 6 - Flow Monitoring

Introduction

River flows are significant in a number of ways. The most obvious is when the river is in high flood and it threatens to break its banks and harm people or property. More subtle are extreme low flows where there is so little water left in the river that the animals living in the river cannot survive, habitat is lost, water temperature rises, and oxygen levels fall.

Between these extremes are a range of issues related to people wishing to take (abstract) water from rivers for domestic, stockwater, or other productive purposes, and people wishing to dispose of unwanted water into a river (discharge) including stormwater, process water and effluent.

In order to understand and provide for the competing demands on our rivers we need a network of flow recording sites operated over a sufficiently long period of time so that records include a variety of different conditions.

Flow records throughout New Zealand are comparatively short in duration. This makes calculation of extreme events difficult. Extreme flood flows or drought flows occur infrequently and the short duration of our records may mean that for some sites this type of event has yet to be recorded. This usually leads to under representation of these events within our records. Another complication can occur where by chance a number of very infrequent events occur close together and are included in our record. This can result in an over estimation of the frequency of these events.

Background

Nelson City Council maintains a flow (hydrology) monitoring network. This includes continuous flow recorders located on the upper Maitai River at the forks, the upper Roding River at the caretakers house, the mid Wakapuaka River at Hira, and the lower Collins River near its confluence with the Whangamoa River. It also has access to continuous flow recordings from the Teal River and is currently negotiating a continuous recorder site on Orphanage Creek.

As well as continuous flow recorders, the Council also maintains a number of rain gauges and commissions periodic gauging of rivers and streams including those not having continuous recorders. Gauged streams include the smaller urban streams of the Stoke Fan and Atawhai area along with the peri urban streams of the Glen area.

As the river ecology project (reported in part one of this SoE report) progressed it became clear that the Council needed a better understanding of flow in all rivers and streams and in particular minor streams during low flow periods.

A separate monitoring project was commissioned involving regular gauging of smaller streams every three months at the same time that river ecology monitoring was undertaken. The gauging project coincided with a prolonged period of spring and summer drought during which some streams experienced their lowest measured flows.

Drought of 2000-2001

The drought of 2000-2001 was very similar to that of 1973 which has been considered the benchmark event in recent times, in that it was spread right across the top of the South Island. The main difference between the two is the 1973 drought began in early December and finished in mid-April (although there was some rainfall in mid-March), while in the case of the 2000/2001 year there was some rain through December, and the really dry period went from January on into early May.

Assessment of the severity of droughts depends on how you measure them, which in turn depends on why you are undertaking the assessment. A dryland farmer may be interested in the period of soil moisture deficit when growth does not occur, a farmer with irrigation may be interested in the period of low flow in a river when irrigation water is not available or the total water available during the irrigation season, and a meteorologist may be interested in the volume of rainfall versus evaporation over time. All these indicators are connected but when you are looking at low flows other factors such as length of record, topography, geology, soils, and aspect can make a significant difference to your assessment.

These considerations need to be kept in mind when considering the 2000/2001 drought. Examination of Nelson Airport rainfall data suggests this drought had a 26-27 year return period (3.7 – 3.8% probability of occurring in any one year).

Examination of seven day low flow records gives varying results river by river. The Wairoa River had a 21 year return period drought (4.8% probability in any one year), The Wakapuaka (Hira) had a 40 year return period drought (2.5% probability in any one year), and The Whangamoa (Collins tributary) had a 50 year return period drought (2% probability in any one year).

A more relevant analysis for water supply is the yield over a longer period. Therefore low flow statistics were calculated for 3, 4 and 5 month means of river flow in the Wairoa River. The Wairoa River is generally within Tasman District Council area but lies adjacent to Nelson and has a tributary, the Roding, with headwaters in the NCC area):

Table 11: low flow statistics

	3 month mean	4 month mean	5 month mean
2001	1660 l/s (31 yr return period)	1937 l/s (40 yr return period)	3033 l/s (39 yr return period)
1973	2015 l/s (23 yr return period)	2455 l/s (27 yr return period)	3004 l/s (40 yr return period)
1992	2557 l/s (15 yr return period)	2948 l/s (19 yr return period)	3679 l/s (23 yr return period)
1983	3291 l/s (9 yr return period)	3324 l/s (15 yr return period)	3213 l/s (34 yr return period)

Assessment of the urban streams based on gauging and correlation with continuous recorders suggests that flows in these streams fell to a one in 10 year low flow in 2000/2001. This analysis provides a useful benchmark for considering how much water Council could allow to be taken out of these streams for irrigation or other uses. It will provide valuable background for preparation of the Nelson Freshwater Plan

Flow correlations

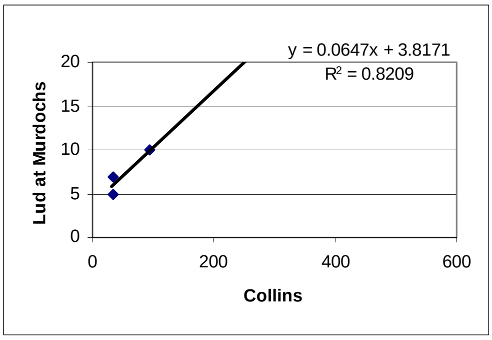
While the number of continuous flow recorders operating on Nelson rivers is limited by cost and site considerations, the similar characteristics of many of the catchments makes it possible to produce synthetic flow records for those catchments without continuous recorders. The river and stream gauging programme outlined in the previous section gave the Council the opportunity to examine the relationship between rivers to see how well the flows of a continuously monitored river would explain variability of flow in adjoining rivers and streams.

In order to assess this relationship a number of flow gaugings are required for each stream representing different levels of flow. Generally the larger the number of gaugings which can be compared, the greater the confidence we have in the results. Generally a minimum of 3 gaugings is needed for any confidence and 5 or more are desirable.

Statistical analysis is used to explain just how well variations in one dataset explains variations in another. The regression squared (R^2) value is often used to indicate the degree of fit. The closer the R^2 is to 1 (either +1 or – 1) the better the fit of the data and hence the correlation. The closer the R^2 to 0 the worse the correlation.

The main factors influencing the degree of correlation are similarities and differences between the catchments being considered. Differences in vegetation cover, aspect, soils, rock type, rainfall and a host of other factors alter the rate and volume of water entering the stream. Our assessment highlights this and shows just how important it is to closely match the catchment of the stream you wish to predict to one with a continuous record.

Figure 13: Lud Road End Site Correlations



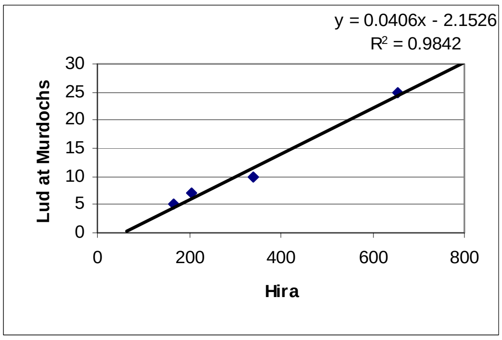
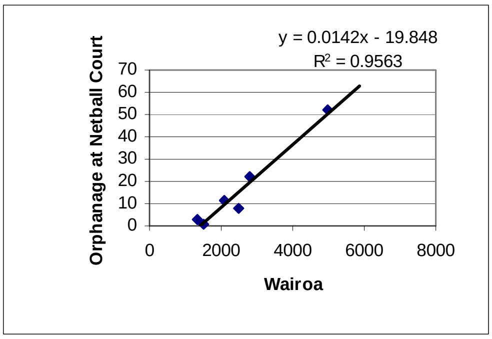
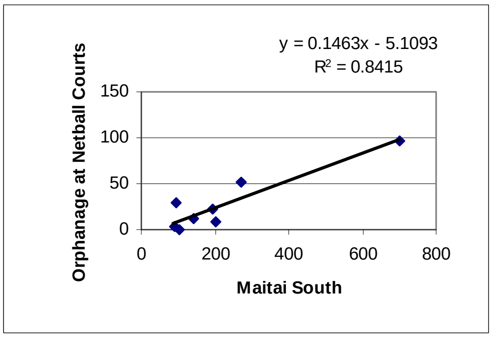


Figure 13 shows two correlations for the road end site in the upper Lud. One correlation is with the Collins River recorder site and the other with the Wakapuaka River recorder site at Hira. Both sites show good correlations with the Lud flows and either could be used to predict most flows of the Lud but it is no surprise that the Wakapuka recorder site at Hira gave the best correlation a near perfect R^2 of 0.9842. This is because the Lud is a headwater tributary of the Wakapuaka and enters the main river just above the recorder site.

Figure 14: Orphanage Creek Correlations





The records generated were then statistically analysed to establish their flow distribution. Seven day flows were used to even out short term flow variations. Measures generated include:-

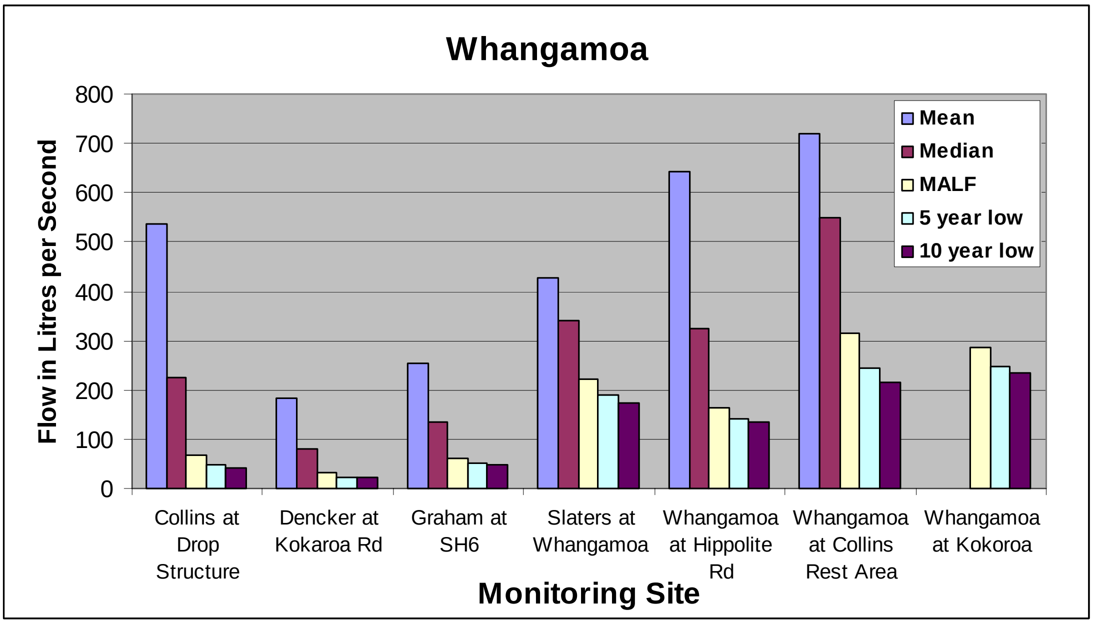
- the mean or average flow (sum of all records divided by number of records)
- the median flow (the middle number in the sequence)
- the mean annual low flow or MALF (the average of all low flows)
- the 5 year low flow, (the low flow that would be expected to occur every 5th year),
- and the 10 year low flow (the low flow expected to occur once every decade).

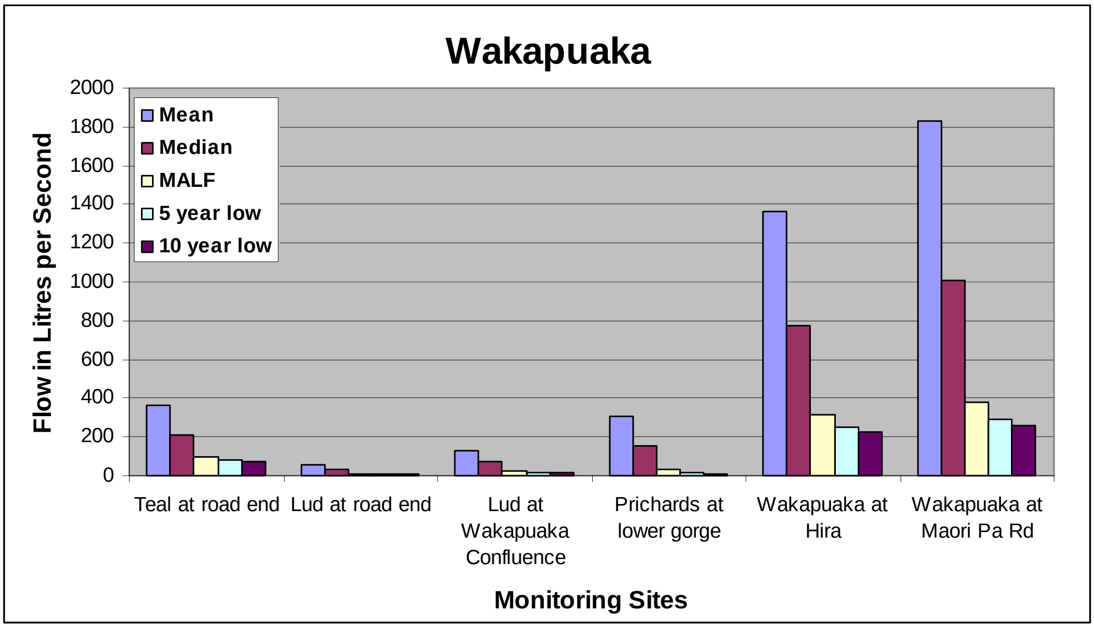
The results of this analysis are presented in the following figures (15 to 20). The results are based on the best information we currently hold and therefore are as accurate as we can currently achieve. None the less they should be treated with a degree of caution.

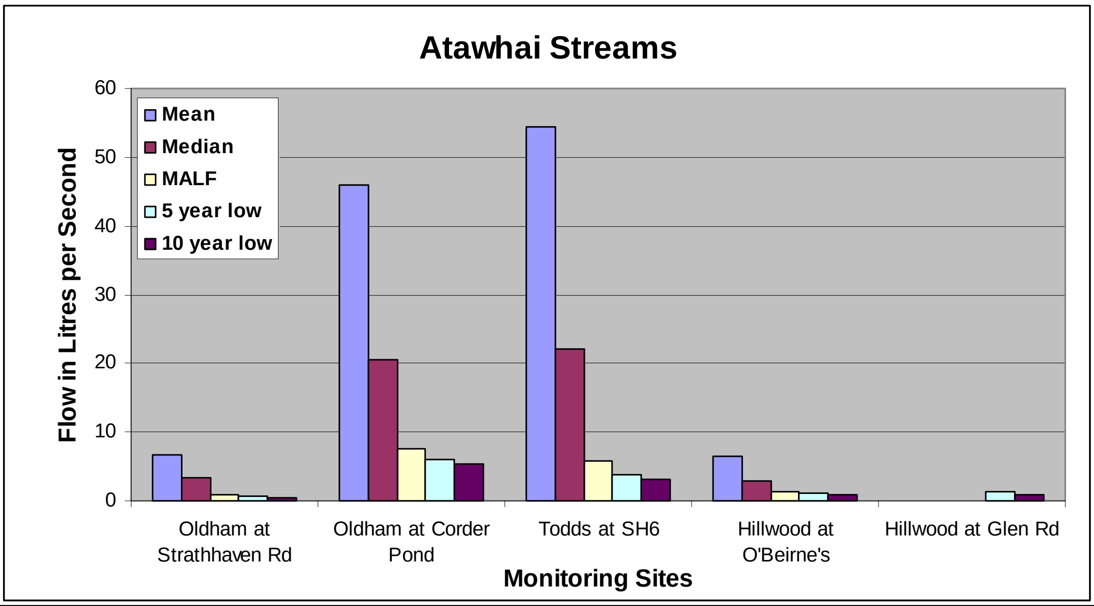
The records also include an unknown amount of abstraction. Resource consents cover most of these abstractions although some such as domestic and stockwater takes are permitted without Council consent being required. Even where a resource consent exists it will usually only specify a maximum rate or volume of abstraction which is rarely if ever taken. In the absence of full records of volume over time being kept by people abstracting water from our rivers, the actual amount taken at any one time can only be a best estimate. Fortunately there are currently only limited demands on most of Nelson’s rivers so the volume abstracted will be comparatively small and should make little difference to the analysis. The exception to this is water taken for urban supply from the Roding and Maitai Rivers. Here abstraction forms a greater proportion of the natural flow of these rivers and as a consequence a larger number of monitoring sites have been established both upstream and downstream of the urban water supply intakes. Additional monitoring sites along with better estimates of actual take makes it easier to assess the natural or unmodified flows of these rivers.

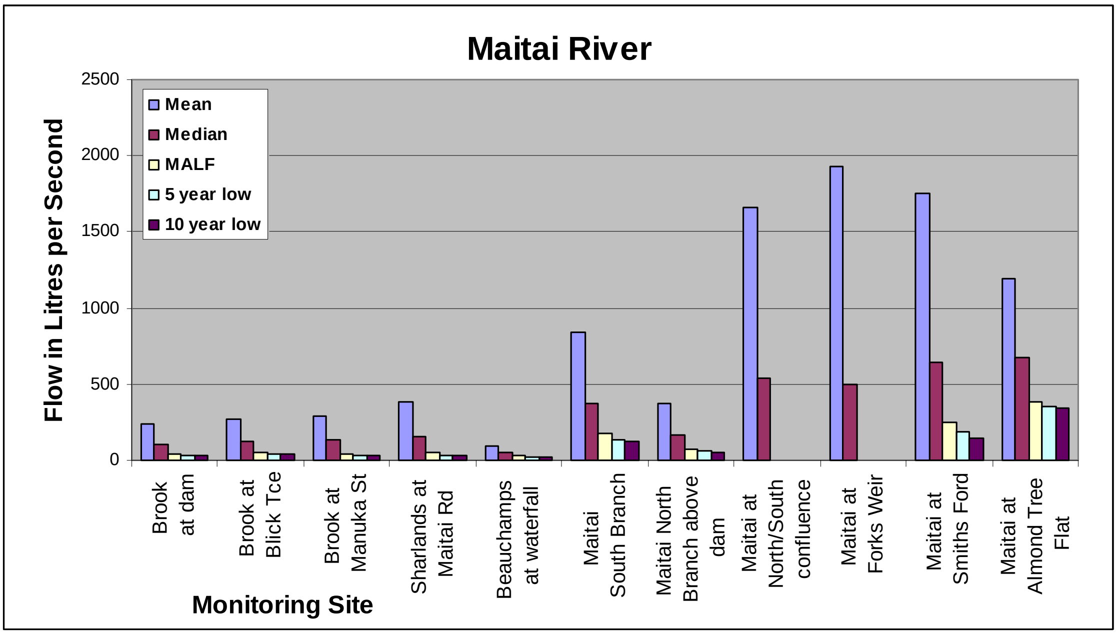
Over time with longer continuous records and further spot gauging our records will improve and the statistics presented in the following figures will be refined.

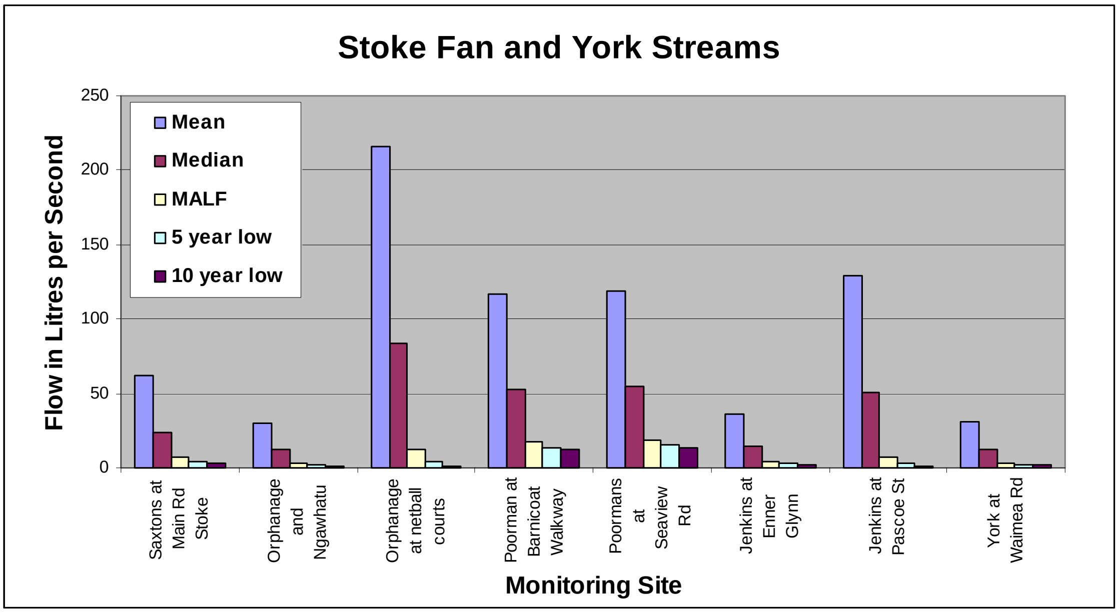
Figures 15 to 20 (following pages): flow rates

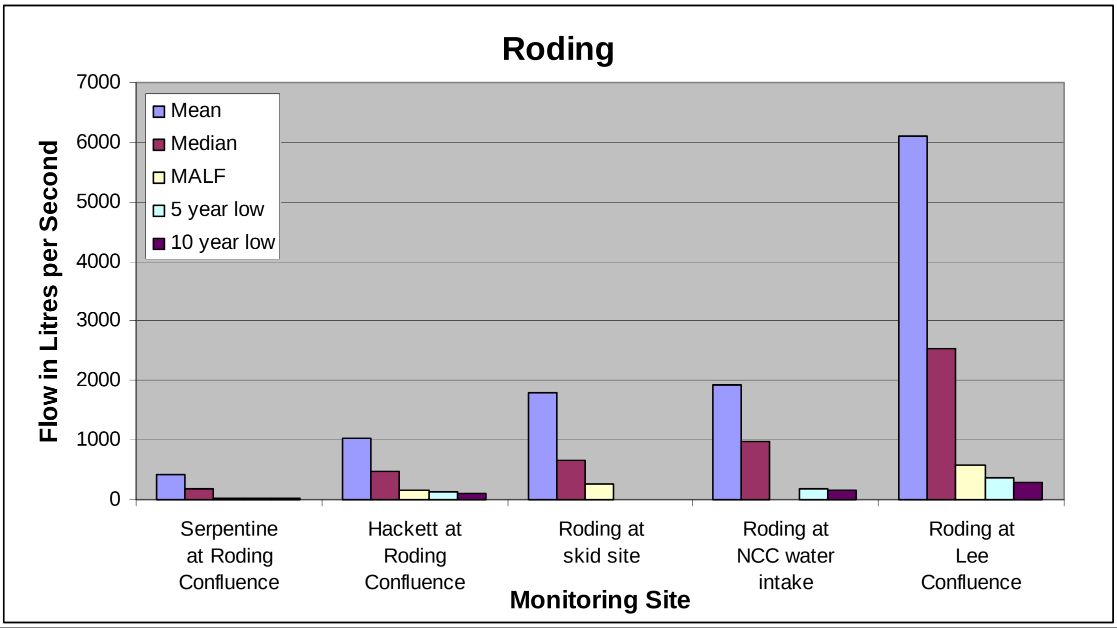

Whangamoa
Flow in Litres per Second
800
700
600
500
400
300
200
100
0
Mean
Median
MALF
5 year low
10 year low
Collins at Drop Structure
Dencker at Kokaroa Rd
Graham at SH6
Slaters at Whangamoa
Whangamoa at Hippolite Rd
Whangamoa at Collins Rest Area
Whangamoa at Kokoroa
Monitoring Site


Wakapuaka
Flow in Litres per Second
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Mean
Median
MALF
5 year low
10 year low
Teal at road end
Lud at road end
Lud at Wakapuaka Confluence
Prichards at lower gorge
Wakapuaka at Hira
Wakapuaka at Maori Pa Rd
Monitoring Sites


Atawhai Streams
Flow in Litres per Second
60
50
40
30
20
10
0
Mean
Median
MALF
5 year low
10 year low
Oldham at Strathhaven Rd
Oldham at Corder Pond
Todds at SH6
Hillwood at O'Beirne's
Hillwood at Glen Rd
Monitoring Sites


Maitai River
Flow in Litres per Second
2500
2000
1500
1000
500
0
Mean
Median
MALF
5 year low
10 year low
Brook at dam
Brook at Blick Tce
Brook at Manuka St
Sharlands at Maitai Rd
Beauchamps at waterfall
Maitai South Branch
Maitai North Branch above dam
Maitai at North/South confluence
Maitai at Forks Weir
Maitai at Smiths Ford
Maitai at Almond Tree Flat
Monitoring Site


Stoke Fan and York Streams
Flow in Litres per Second
250
200
150
100
50
0
Mean
Median
MALF
5 year low
10 year low
Saxtons at Main Rd Stoke
Orphanage and Ngawhatu
Orphanage at netball courts
Poorman at Barnicoat Walkway
Poormans at Seaview Rd
Jenkins at Enner Glynn
Jenkins at Pascoe St
York at Waimea Rd
Monitoring Site


Roding
Flow in Litres per Second
7000
6000
5000
4000
3000
2000
1000
0
Mean
Median
MALF
5 year low
10 year low
Serpentine at Roding Confluence
Hackett at Roding Confluence
Roding at skid site
Roding at NCC water intake
Roding at Lee Confluence
Monitoring Site

References

Drought Statistics for the 2000/2001 Summer. Tasman District Council 2001 (Martin Doyle)

Flow Correlations for Nelson Rivers. Envirolink 2002 (Tony Hewitt)

Flow Summaries Nelson Rivers. Envirolink 2002 (Tony Hewitt)

Part 7 - Groundwater levels & flows

Introduction

Groundwater resources in the Nelson region are limited, although there is little information on the available resources which do exist. However, there are a number of springs and private wells / bores on rural properties. There are also wells throughout the urban area still used for irrigation purposes. Many of these are located in the Wood area within the gravel fan of the Maitai River.

There is potential for over-use which can disadvantage users and reduce the reliability and quality of supply because the size, yield and extent of groundwater resources, including springs, is not known. It may also result in an unsustainable use of the water resource.

Groundwater Resources

Aquifers

Local geology provides useful clues about potential groundwater resources. Much of Nelson City, including Stoke, is located on alluvial plains[8] formed largely of gravel deposited by the Maitai River, The Brook, and the Stoke streams draining the Barnicoat range.

Appleby Gravel formation is the dominant groundwater unit within the central city and Nelson North (Wakapuaka River valley and lower Whangamoa River valley). In the city a significant quantity of water has historically been extracted for home and commercial gardens, mostly in The Wood area. The gravel is around 6-7m thick, and is recharged directly from the Maitai River and, to a larger extent, by rainfall. However, dredging of Nelson Haven, and the consequent lowering of the bed of the river, has led to a drop in the water table reducing both recharge and aquifer storage. Historical testing shows that underground water in the Appleby Gravel was susceptible to contamination from leaking sewage, stormwater and, adjacent to the coast, seawater. Elsewhere, the Appleby Gravel is less permeable (i.e. contains more silt) with a corresponding reduction in groundwater volumes and availability. The groundwater resource in the Appleby Gravel is susceptible to depletion from over-abstraction.

The Stoke Fan Gravel underlies much of Stoke from Annesbrook to Richmond, but not under Tahunanui. The gravel within about 15 metres of the surface contains small unconfined[9] and confined[10] aquifers. These aquifers are not likely to be connected, and are recharged directly from streams, surface flows, and rain falling on the fans. They are therefore prone to depletion from over-abstraction, particularly during summer due to the lower rainfall and lower flow rates of streams and rivers. The aquifers, in particular the unconfined ones, are susceptible to contamination.

The Tahunanui area is dominated by marine-deposited Tahunanui Sand with local gravel. Rain water, supplemented by small streams which intermittently drain the Port Hills, infiltrates directly

[8] alluvial plains comprised of materials such as gravel and sand depostited by rivers and streams.
[9] an "unconfined aquifer" describes a deposit layer containing underground water which has a permeable upper layer.
[10] a "confined aquifer" describes a deposit layer containing underground water which is confined by an upper and lower impermeable layer.

into the sand and accumulates as a layer of fresh water on top of salt water. The groundwater slowly moves towards the coast where it discharges as a series of seeps below the high water mark. The amount of water is not large, and can become saline with over-pumping. It commonly contains iron compounds, and is highly vulnerable to contamination from sewage leakage and stormwater.

The lower hills in the rest of Nelson City, including the Port Hills, are composed of clay-bound Moutere Gravel and Port Hills Gravel formations or siltstone dominated rocks. These formations have very low permeability and therefore have very limited groundwater potential. However, the Moutere Gravel west of the Nelson region contains ill-defined confined aquifers capable of yielding significant volumes of water. Such aquifers, if they exist in Nelson, will be at a depth of several hundred metres below the surface although drilling to over 100m at the Stoke Freezing Works failed to encounter any significant quantities of water in the Moutere Gravel.

Springs

Isolated springs occur throughout the Nelson region. A one-off survey[11] and local information on Nelson North water supplies (Wakapuaka catchment and Cable Bay), indicates that many rural households obtain their domestic water supply from springs. These springs are characteristically small and form the surface outlet of groundwater flowing along planes of weakness, such as joints, bedding, and shears in the underlying basement rocks that form the high hills in the east of the region. Because of the abundance of planes of weakness, the volume of groundwater stored in the rock is large, even though the springs are small.

Zones of weakness such as along the Flaxmore Fault, have resulted in a line of small springs on the west side of the Grampians and the hills east of Nelson Haven. A line of springs, marking the Waimea Fault, are present at the toe of the western flank of the Barnicoat Range. Some of the basement rocks, such as the Brook Street Volcanic Group, are weakly mineralised resulting in locally elevated levels of iron and changes in pH in the groundwater.

Where more permeable layers within the Port Hills Gravel intersect the ground surface small springs occur locally. Despite the occurrence and use of spring water, there is little, if any information on the hydrological characteristics, such as yield and flow rate, of these springs.

The combined geological information, limited groundwater data and local knowledge, indicate that underground water in the Nelson region can be separated into the types shown in Table 12 on the following page.

Analysis of the known information on groundwater resources suggests that the biggest resource is contained within unconfined aquifers, particularly in The Wood. However, as unconfined aquifers are hydraulically linked with surface flows, over-abstraction of one will affect the other.

[11] Environmental Inspections Limited – 1997 water survey of Nelson North residents.

Table 12: Groundwater Resources of Nelson Region

Type	Characteristics	Recharge source	Reliability	Flow rates	Yield
Unconfined aquifers	River fans and flood plains on valley floors, reasonably extensive but shallow & susceptible to contamination and flow variability; hydraulically linked to surface flows.	Predominantly surface water, rivers, streams, stormwater runoff and rainfall.	Variable, depending on surface flow and rainfall. There is also a short lag time between rainfall and recharge.	Variable, depending on surface flow and rainfall.	Variable, depending on surface flow and rainfall. May yield relatively high volumes in The Wood area or adjacent to the Maitai River further upstream. Urbanisation increases the impervious surface. Reductions in stormwater seepage can reduce the overall yield.
Confined Aquifers	Small and isolated.	Underground flows and lateral seepage from surface flows.	Usually moderate to high.	Variable – low to locally moderate flows.	Unknown but most likely low. Susceptible to depletion by over abstraction.
Springs	Sporadically located, usually high quality water but in some rocks it can be weakly mineralised.	Rainfall and streams.	Moderate to high, depending on lag time for recharge.	Low.	Unknown but most likely low to moderate. May be susceptible to depletion by over abstraction and lowering of the water table in dry conditions.

Adverse effects of land use activities on underground water levels and flows

Groundwater resources are at risk from a range of activities such as: intensification of land use, increased fertiliser use, high stocking rates, irrigation, septic tank effluent, offal pits, landfills and use of pesticides. These can all lead to deterioration in groundwater quality. Changes in vegetation cover, such as from pasture to trees, can also reduce recharge which in turn may affect groundwater flows in springs and shallow wells.

The volume of water moving through an aquifer will affect the concentration of contaminants in it. Generally, a high rate of groundwater flow will dilute and disperse contaminants entering an aquifer. However, this may result in low concentrations of contaminants spread out over a large area.

Downward contamination of aquifers

Near the coast, confined groundwater systems have a strong upward pressure gradient, (i.e. each aquifer is at a higher pressure than the aquifer above it) so that there is an upward leakage of water from the deeper aquifers. This upward pressure can form a natural barrier against any downward movement of water and contamination from activities on the surface.

If hydraulic pressures in the confined aquifers are reversed by abstractions, then aquifer water quality may be adversely affected. This is because the pressure reversal allows downward movement of poorer quality groundwater from shallower aquifers, or the downward leakage of chemicals or contaminants from the ground surface, estuaries or lagoons. The downwards pathway can be via the inside or the outside of the well casing, or gaps in the confining layer.

Lateral saltwater intrusion in aquifers

Saltwater intrusion is potentially a serious problem in coastal areas. The freshwater–saltwater boundary represents the zone where downwards pressure exerted by the weight of the seawater matches the pressure in the aquifer caused by the groundwater.

Excessive groundwater pumping could reduce the pressure within an aquifer allowing the boundary between fresh and salt water to migrate inland and invade coastal water wells. Once an aquifer is contaminated with saltwater it is very difficult and costly to remedy, even if the boundary is restored seaward.

Reduced availability of groundwater

Groundwater levels fluctuate in response to water usage and, particularly in spring and autumn, recharge by rainfall. In Nelson, it is thought that there is a relatively short "lag time" between the flow of water from surface to ground. The lag time may be days or weeks, as compared to years or even tens of years in other regions. However, for springs in basement rocks it is possibly years.

During the summer, groundwater levels decline because of the lack of rainfall recharge and groundwater abstraction, and during droughts shallow wells or low-flow springs may dry up. This situation will worsen if a drought continues into the following winter and there is little or no natural recharge of the aquifers. It may take a considerable time before winter recharge restores the groundwater to its pre-drought levels.

Table 13: Point-source discharges which contribute contaminants to surface water or groundwater

Activity or land use	Effects on groundwater mainly where the aquifers are unconfined:
1. Offal pits	Faecal and chemical contamination of drinking water pumped from shallow groundwater.
2. Septic tank effluent	Faecal and chemical contamination of drinking water pumped from shallow groundwater.
3. Stormwater and land drainage water which has been collected and directed by pipes, channels or drains	Increasing chemical contamination and faecal contaminant concentrations in groundwater.
4. Water tracers	Potential for radioactive, microbiological, and chemical contamination of groundwater.
5. Cooling water	Destabilisation of the physical and chemical aquifer equilibrium.
6. Swimming pool water and backwash water	Chemical contaminants killing off groundwater micro organisms and other biota which perform the function of degrading other groundwater contaminants.
7. Silage pits and animal effluent slurry stores	Seepage of leachates into groundwater affecting chemical and microbiological quality.
8. Disposal of septic tank sludge	Faecal contamination of drinking-water pumped from shallow groundwater.
9. Landfills, excavation and backfilling of pits	Leachates of contaminants from any animal, vegetable and chemical matter disposed of in the pit or during backfilling.
10. Industrial activities/land uses using, transporting, or storing chemicals	Risk to humans and stock if they get into drinking-water supplies and impacts on surface water ecosystems when ground water re-emerges as springs.
11. Sinking and pumping from bores (wells)	• Creating pathways for contaminants to migrate from the land surface into aquifers and confined aquifers • contaminants drawn down into deeper aquifers • reduce the upward pressure gradient in confined aquifers • induce saltwater intrusion • depleted groundwater resource with reduced capacity to assimilate contaminants.

Table 14: Non-point source discharges which contribute contaminants to surface water or groundwater

Activity or land use	Effects on groundwater mainly where the aquifers are unconfined:
1. Fertiliser application	Increasing nitrate concentrations in soils which leach into the groundwater.
2. Runoff from intensive farming, especially where the land is irrigated	• Increasing nitrates in groundwater • faecal contamination of drinking water pumped from shallow groundwater • pesticide contamination of groundwater.
4. Animal manure spread on land (liquid or solid).	• Increasing nitrates in groundwater; and • faecal contamination of drinking-water pumped from shallow groundwater.
5. Pesticides	Accumulation in groundwater which places drinking water supplies at risk.

Where to from here

Monitoring & investigations

The Council has very limited data on Nelson aquifers. While exploratory wells produce data logs from time to time, this limited data is dispersed and is only now being collated. It is difficult to justify spending extensive sums of public money on further groundwater investigations at present, given the absence of abstractive pressure and the availability of alternative surface supplies of water.

A combination of geological logs from new wells, historical data, and information supplied with resource consents will continue to be the main source of information for the Council for the foreseeable future.

Groundwater management considerations

Problems are most likely to arise in areas where there is a high demand for groundwater, many wells and/or high abstraction rates. Having regard to the lack of information, the management issues are whether or not some type of restriction should be put in place to safeguard the aquifer or the linked surface water resource and to ensure there is no long-term decline in groundwater levels.

One particular consideration is the relationship between surface water flows and groundwater. Local knowledge, analysis of the underlying geology, and limited bore testing indicates that Nelson's groundwater resources are commonly closely hydraulically linked to surface water sources. This means that any abstraction from groundwater will have a direct effect on the surface water. However, the effect of groundwater abstraction on surface flow is not the same for every river, which raises the following management issues:

- a proportion of the groundwater being abstracted may originate from sources other than a surface stream, e.g. direct rainfall recharge;
- wells which are hydraulically connected to larger rivers may have lesser effects than wells connected to small streams;

- the effect of a well on river flows can vary depending on factors such as location of the well relative to the river channel, the depth of the well, pumping rates, and local aquifer conditions;
- the effect of individual wells on surface flows is often imperceptible while the cumulative effect of many small groundwater takes may cause flows to decline or disappear altogether.

There is currently a large information gap in terms of the relationship between groundwater and surface water in Nelson.

In the absence of information, the precautionary principle should therefore be applied in considering the management options.

Once an aquifer becomes contaminated, many of the existing uses of groundwater could be placed at risk, and alternative sources of water may need to be sought or water may need to be treated. By the time contamination has been detected it is usually too late to carry out preventative measures. Cleaning up groundwater contamination can be expensive, and in some cases it may not be technically feasible. Some contaminants can persist for a long time (decades) in aquifers because of their slow rate of breakdown, and/or because groundwater flow is insufficient to flush out the aquifer.

The priority for groundwater contamination should therefore be avoidance, rather than mitigation.

References

Johnston, M.R. *Geology of the Nelson Urban Area; Institute of Geologic and Nuclear Science* (1979). P.D. Hasselberg, Wellington, and information supplied by Dr. Mike Johnston.

Appendix 1 Regional Policy Statement Indicators

Quality of Natural Waters

WA1.8.1 Monitoring of water quality showing that water classifications are achieved and conditions placed on water, coastal, and discharge permits are being met.

WA1.8.2 Monitoring of the marine environment in the port area showing no new introduced exotic organisms or chemical/heavy metal contamination.

WA1.8.3 Monitoring of indicator shellfish species and instream fauna.

Water Allocation

WA2.8.1 Monitoring of water abstractions, river flows, and the health of in-river plant and animal indicator species (undertaken by both Council and water abstracters), showing that river flows are not being artificially reduced to levels where significant adverse effects are occurring.

WA2.8.2 Monitoring of water allocation plans showing that the provisions and environmental outcomes of the plan are being met.

WA2.8.3 Monitoring of abstractive water usage showing that water is being used beneficially and efficiently.

WA2.8.4 Frequency of water shortages.

WA2.8.5 Reduction in domestic water usage per capita and reduction in usage per unit of production.

Proposed Nelson Resource Management Plan Indicators are not yet available – as the fresh water plan is currently being prepared.

Appendix 2 Monitoring the State of the Environment – Proposed Work Programme 2002

Environment	Project	Proposed Work	Existing Commitment
Freshwater	Hydrology	Operation of existing NCC recorder sites (Contract with TDC)	RPS: WA2.8.1
	Hydrology	Gauging of smaller streams every 3 months until correlations are well developed with continuous recorders.	
	Hydrology	Establish new recorder site on Orphanage Stream to represent the small urban streams	
	Ecology	River Ecology Monitoring up to 40 sites 4 times per year plus analysis including a Macroinvertebrate Community Index (MCI) once per year	
Air Quality	Particulates	Particulate air quality monitors 2 machines one at NCC reference site daily other roving monitor 2 daily	RPS: DA1.8.1 DA1.8.2
	Particulates	Operate a meteorological monitoring station at the NCC reference site.	
	Gas	Assist with operation of NO_2 ,CO, and Benzene monitors as part of the Southern Link investigations	
	Modelling	Preparation of a CALMET (meteorological) data set for CAPUFF modelling of Nelson air pollution (a computer model to predict the effect of specific discharges on air quality).	
	Source apportionment	Analysis of air quality monitoring filters to establish the nature of the particles collected and their likely sources	
Marine Contact Recreation	Water Temperature	Install and maintain a continuous record of coastal water temperature	RPS: CO1.8.2, NA5.8.2 NRMP: CMe.11
	Flora	Collate sea bed vegetation data for NCC area, identify and fill gaps	
	Fauna	Research fisheries and catch data to establish the distribution and abundance of various marine animals within the NCC area	
	Uses and Values	Collate usage and value data as part of a reassessment of the potential for aquaculture within the NCC area	
	Bathing Sites	Monitoring and reporting of bathing water quality at popular swimming and contact recreation locations over the summer period	

Environment	Project	Proposed Work	Existing Commitment
Amenity Values	Noise	Noise Monitoring at planning zone centres and zone boundaries to confirm plan provisions and assess plan effectiveness	RPS: DA2.8 NRMP: DO10e.3, ICe.5, SCe.1, INe.3, OSe.3, RUe.3
Natural Hazards	Landslide	Re survey of benchmarks on the Tahunanui landslide to establish existence and rate of movement Monitoring of Hazard events including survey of Tahunanui Landslide, Tahunanui Beach, Flooding and landslide events	NRMP: DO2e.2
	Seismic	Investigation of Waimea Flaxmore fault system to better understand fault location nature and magnitude of movement	
	Coastal	Resurvey of benchmarks on Tahunanui beach to assess rate and magnitude of beach change.	
	Flooding	Definition of the extent of rural flooding as and when it occurs	
Iwi	Indicators	Work with the Iwi Resource Management Advisory Komiti to develop a process to record an Iwi world view/s and to start the development of Iwi based indicators for each environment	RPS: TW1.10.3 NRMP: DO1e.1
Biodiversity	Conservation areas	Extending survey of significant conservation areas	RPS: NA3.8.3
	Revegetation	Joint project with DOC to prepare a guide for native revegetation within the Nelson area	
Biosecurity	Marine	Undaria Survey of Nelson Haven infestation.	RPS: NA4.8.1 WA1.8.2 NRMP: CMe.4
	Marine	Support Voluntary clearance of Undaria by dive clubs from Nelson Marina	
	Terrestrial	Work with TDC bio security staff on monitoring of Nelson pest infestations	
Research		Contribution to SMF projects (Waimea, Waiora, ICM)	
Data Management	Develop Database	Development of a monitoring database to store all NCC monitoring data and to assist data query and retrievals including future linking to the NCC web site.	RPS: RM1.7.1
Reporting	SOE	State of the Environment Report preparation and printing	RPS: RM1.7.1

Appendix 3 Regional Policy Statement Objectives and Policies referred to in this Document

RPS objectives

Quality of Natural Waters

WA1.2.1 The maintenance and enhancement of the quality of inland water to protect the life supporting capacity of aquatic ecosystems and in specific areas, for urban water supply.

WA1.3.1 Following consultation with appropriate agencies including tangata whenua and the wider community, to classify all inland and coastal waters within the Nelson City area, based on one or more of the following:

(i) protection of urban water supplies to a drinking water standard;
(ii) protection of instream fisheries and wildlife values;
(iii) protection of areas of cultural value;
(iv) protection of recreation values for contact recreation purposes; and/or
(v) protection of coastal waters to preserve aquatic ecosystems, fisheries, fish spawning, gathering of shellfish and other food, and to safeguard the potential development of aquaculture.

WA1.3.2 To minimise the volume of contaminant entering water from non-point sources, including sediment, chemicals, refuse and debris.

WA1.3.3 To control point discharges through the use of resource consents and appropriate conditions in order to ensure that water quality classifications are met and sustained.

WA1.3.5 To manage riparian and coastal margins in such a way as to enhance or maintain water quality.

WA1.3.6 To recognise and, where possible, reduce, adverse effects on water quality resulting from contaminated stormwater.

WA1.3.7 To recognise and provide for the cultural and spiritual values of water to tangata whenua.