From the Chair

The state of our water revealed

To know where we are going, we must first know where we are now, and where we have been. Environment Southland's first State of the Environment Report on water essentially acts as a report card on the current state of our precious water resources.

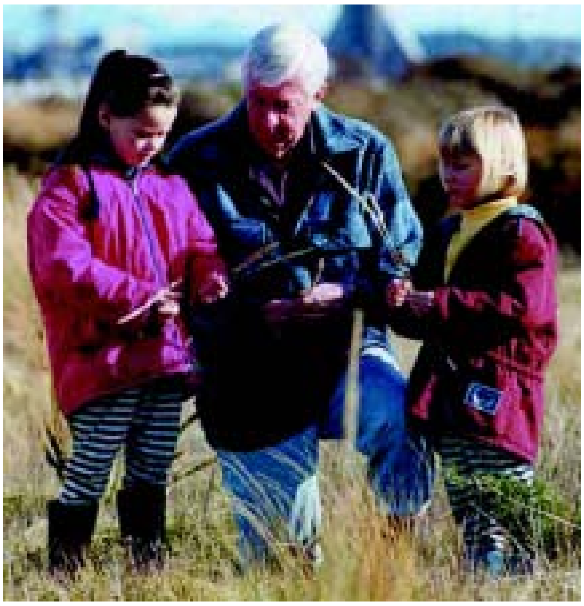
It looks at what is happening, why it is happening and what we are doing about it. It also helps ensure that each Southlander has access to timely and accurate information in one easy-to-read document.

There are emerging issues and challenges we will have to face as a community. However, no one agency can solve all the environmental problems on its own. The environment is everybody's business and we each need to take individual responsibility for our actions. Only together can we make a difference, change attitudes and behaviours about how we care for our precious water resources.

Already Environment Southland has released a Proposed Regional Fresh Water Plan for discussion, so we can all have an input into how we will manage fresh water sustainably in the future.

Southland is a diverse and unique region that we can each make a positive difference to. With your help, future generations will inherit a region that they can be proud of as well as live in, work in and play in safely.

Make good use of the information contained in this report, share it with others. Every single person in this region uses water, so it should touch everybody in some way.



Chairman John Matheson

Yours sincerely

Chairman John Matheson
25 October 2000

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Report Card

The key messages

The state of Southland's fresh water resources has changed markedly since the time of first human settlement and is likely to continue in the future. The overall quality and quantity of our water resources reflect a balance between the natural environment and pressures resulting from human activity.

The availability of water resources in Southland is influenced by variations in climate, demand and land drainage as well as the damming and diversion of rivers and lakes. Similarly, the quality of our water resources can be influenced by the impact of discharges, as well as the cumulative effects of land use.

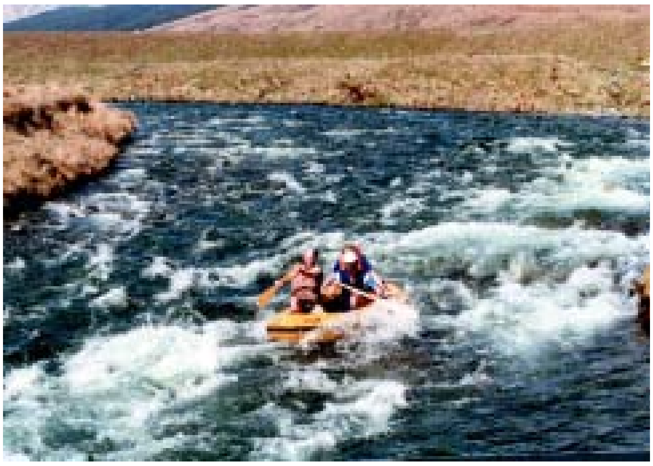
In turn, many of the pressures which impact on water resources are influenced by factors such as community attitudes and economics. For example, in response to changes in the community's expectations over recent years, more stringent controls are now in place to manage the quality and quantity of discharges into our rivers. However, some of the resulting improvements in water quality have been offset by recent changes in land use.

This report card aims to give you a quick overview of the current state of Southland's fresh water resources and ecosystems.

Groundwater

Is there enough to go around?

- Limited data is available to describe how groundwater levels have varied over recent years in response to changes in land use, improved land drainage and relatively dry winters.
- The available information suggests that, although some aquifers are coming under increasing pressure, Southland's groundwater resource is sufficient to meet current demand.



Rafting on the Mararoa River. (Source S. McNeill)

Poor well head protection.

Is it safe to drink?

- The overall quality of Southland's groundwater is generally good. In some areas quality is impaired as a result of naturally occurring variations, while in others intensive land use appears to be impacting on groundwater quality.
- Many individual domestic bores and wells are contaminated due to poor wellhead protection or the localised effects of point-source discharges such as septic tanks, soakage holes and wintering pads.

Surface Water

Is it safe to swim in?

- Not in lowland rivers, but headwaters and Fiordland lakes are excellent.
- Microbial contamination poses a health risk in rivers with developed catchments.
- The health risk is increasing in the Mataura River.

Lake Te Anau.

Is there enough to go around?

- The available information shows that in the major rivers and tributaries there is usually sufficient flow to meet ecosystem and human-use needs. There is less certainty in smaller streams.
- Under drought conditions, there is potential conflict between ecosystem and human-use (especially Oreti and Makarewa Rivers)

Are our fresh water ecosystems healthy?

- Ecosystem health is good to very good in most of the main rivers, but the Mataura and Makarewa Rivers have poor health downstream of major discharges.
- 23 of NZ's 29 species of indigenous fish are found in Southland. Four are threatened.
- Harmful substances, like oxygen depleting substances and ammonia, are limited and have reduced.
- Clarity has improved in many headwater streams, but has not changed downstream.
- Nuisance growths of algae occur in the lower Mataura River and lowland streams.
- In headwaters, algae growth is restricted by frequent floods and insufficient nitrate, elsewhere algae growth is usually restricted by insufficient phosphorus.
- Nutrient levels are increasing in many Southland streams.

Mataura township.

The State of Southland's
Water environment

We are part of the environment in which we live, and are inseparable from it. We use its resources, we relax and play in it, and we find cultural and spiritual identity with it. We also put our wastes into it and modify parts of it to suit our needs.

This report, Environment Southland's first on the state of our environment, is focussed on the region's fresh water resources and ecosystems. It aims to answer the following simple, yet important and often asked questions:

- What are the pressures on our environment?
- What is the current state of our environment and how is it impacting on us?
- Is the state of our environment changing and if so, how?
- What are we doing about the problems?

State of the environment reporting is one of the most powerful tools for informing all of us about our environment. It describes the effects of human activities on the condition of the environment, as well as their implications for human health and economic wellbeing.

Through the initiative and commitment of individuals, communities and government, Southlanders invest in the management of their environment and its resources. State of the environment reporting provides the necessary 'report card' to know whether that investment is producing returns both for the environment and its people.

Aims of the report

As Southland's first comprehensive assessment of its fresh water resources and ecosystems, this report aims to establish a continuing information base for developing sound environmental management strategies and for assessing our progress towards sustainability.

This report is intended to:

- increase community awareness and understanding of natural resources management issues; and
- stimulate community interest in addressing problems affecting fresh water.

It aims to achieve this by describing:

- the issues affecting Southland's fresh water resources;
- the causes of environmental change; and
- the present state or condition of our fresh water resources.

Organising the information

Our environment is exceedingly complex. So complex in fact, that our ability to organise, understand and use environmental information depends on that information being structured in a meaningful way. For this and possibly future reports, we are structuring the information around four key elements: water, coast, land and air.

This report deals with fresh water, and includes all water inland of the coast, both in surface features like rivers, streams, lakes, and wetlands, and in the subsurface as groundwater. The report also brings together the physical and biological components of water. Within this broad structure, our state of the environment reporting system examines:

- key or highly valued or significant resources; and
- specific priority environmental issues, which may vary over time.

We believe that focussing on key resources and issues provides relevance to the reporting, and helps guide our efforts to manage the priority issues.

This report is based around the 'pressure-state-response' (PSR) framework (Figure 1). This framework is founded on the concept of causality: that is, human activities exert *pressures* on the environment and change its *state* or condition. Society *responds* to this in ways that attempt to reduce, prevent or mitigate the adverse changes, or adapt to them.

To provide greater clarity, we have expanded the basic PSR framework in two ways. Firstly, we have expanded the discussion on pressures beyond just those that have the most direct impact on the environment. This is because direct pressures are themselves generally a consequence of powerful

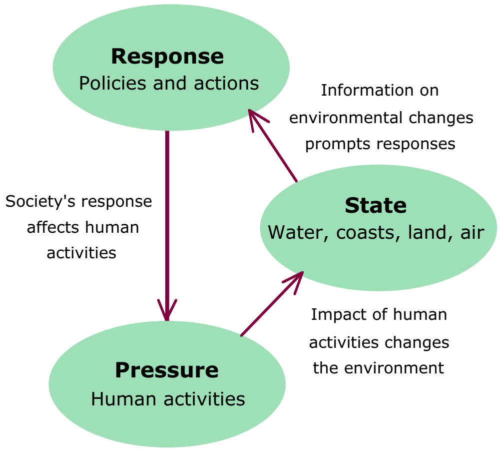


Figure 1 The pressure-state-response (PSR) framework.

underlying environmental, social and economic *drivers*.

Secondly, we have broadened the discussion on state to include not only measures of environmental condition, but also how that condition *impacts* on the values we place on our environment and its resources values.

For many years, a limited number of key economic indicators have been used to judge how the economy is performing. Measures like the Consumer Price Index (CPI) and the Gross Domestic Product (GDP) are broad-brush, aggregated statistics that give an overall picture. While they do not explain why particular trends are occurring they provide reasonable indicators of changes in the economy, assisting decision making and allowing any individual to form an opinion on how the economy is performing overall.

An environmental indicator (see Box: Environmental Indicators) is a physical, chemical, biological or socio-economic measure that is regularly recorded and assessed to provide an indication of some aspect of an environmental issue, and tell us how well we are looking after our environment. However, as with the PSR framework, indicators are simplified representations of a more complex reality.

Where possible, indicator values and trends have been related to available guideline levels or agreed targets or objectives. Over time, this allows us to judge whether our environment is getting better or worse and whether our actions and efforts are making a difference.

All of the indicators need to be used and interpreted with caution. Their interpretation – what they are telling us about whether human activities are becoming more or less environmentally sustainable – is not straight-forward, and is a matter on which there will be debate.

Future directions for state of the environment reporting

As this report is the first of its kind for Southland, Environment Southland is conscious that there is wide scope for improvement. We are still very much at the early stages of reporting comprehensively on the environment. There is much more that could and should be reported in the future. For example, it is often difficult to assess the significance of changes, especially when the benchmarks are lacking or incomplete. In other cases, the ability to evaluate the significance of information lags behind the ability to generate data. It is important, though, that the task of reporting on the environment is begun.

Feedback is essential to improvement, and Environment Southland is keen to receive readers' views on whether the report meets their needs and suggestions for future reports.

Environmental Indicators

Indicators are at the core of state of the environment reporting, and having good indicators is pivotal to the success and usefulness of our state of the environment reporting system. Good indicators should be:

Credible well founded in technical and scientific terms and statistically verifiable and reproducible

Sensitive robust and quantifiable, yet responsive to changes in the environment, and provide early warning of potential problems

Practical able to be monitored regularly and cost-effectively with relative ease, and lend themselves to aggregation and linking with other indicators

Relevant have relevance to policy and management needs, reflect a fundamental or highly valued aspect of the environment, and where possible and appropriate, be consistent and comparable with other local, regional and national indicators

While economists have good indicators, environmental managers are still developing theirs. A lack of data, coupled with an inadequate understanding of environmental processes, means that we lack good indicators in many areas, or the ones that we do have are poor representations of the real world.

Some areas are not amenable to indicator development. Of particular note are indicators of 'response', which are particularly hard to develop. Many responses, such as individual actions or behaviours, are not easily quantified, but their impact manifests itself as changes in the state or pressure indicators.

Southland's Fresh Water Resources
An introduction

Climate

Climate and geology play key roles in determining the nature of Southland's fresh water resources. In turn, Southland's climate is strongly influenced by its geographical position and topography.

Southland, the most southerly and westerly part of New Zealand, lies deep within the zone of mid-latitude temperate westerlies, and is exposed to weather systems moving within this air flow. Within this general westerly flow, there are occasional outbreaks of air of tropical or polar origin. Air of tropical origin can carry large amounts of moisture and be responsible for heavy rainfalls and warmer temperatures, while polar air usually brings cold, showery weather and may result in snowfalls on the main ranges throughout the year, and to lower levels in winter.

The other major factor determining the weather conditions is the topography of the land. The mountains of Fiordland to the west form a partial barrier to airflows coming from the west, north-west and north, and establish two very distinct climate zones. This results in very high rainfalls in the western ranges, and much lower but still generally reliable, rainfall on the lee side.

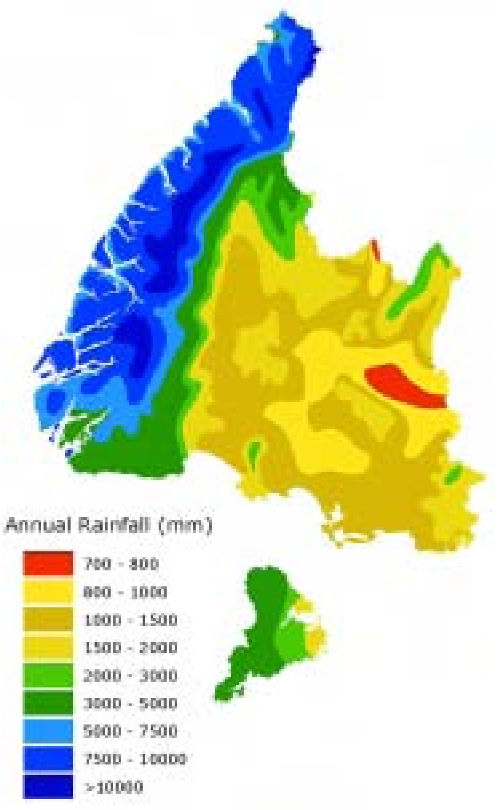


Figure 2 Rainfall distribution in Southland.

In the west, annual rainfall totals reach over 10,000 mm (Figure 2). By contrast, the drier eastern lowlands and hills of inland Southland have annual totals between 700 and 1500 mm. There is a slight increase in rainfall over the whole region in autumn whereas the drier months tend to be in late winter and spring. Dry spells in the east of more than one or two weeks are not common, although significant dry periods can occur.

A third climate zone is found in coastal areas near Foveaux Strait. With no land immediately to the west or south-west to provide any shelter, periods of persistent and strong winds are common. Spring months tend to be the most windy and winter the least.

Rainfall in the coastal belt is generally 1000 to 1200 mm. As a result of the showery weather that many westerly flows bring, the rainfall here is more reliable than inland areas to the north and north-east and long dry periods are quite rare.

Surface water

Southland is drained by four major river systems (Figure 3), the Waiau, Aparima, Oreti and Mataura Rivers. With a combined area of 18,305 square km, these four catchments drain approximately 54 percent of Southland.

The Waiau catchment lies on the eastern edge of Fiordland and is bounded by the Livingstone, Takitimu and Longwood Ranges. With an area of just over 8,000 km^2, the Waiau is the largest catchment in Southland, and the fourth largest in New Zealand. It is also the least developed of Southland's major catchments, with 40 percent of the catchment area under native forest. Tussock pasture covers 30 percent and introduced pasture grasses 16 percent of the catchment.

The Waiau catchment is notable for the relatively large number of lakes it contains (Table 1). Collectively, they make up over seven percent of the total area of the Waiau catchment.

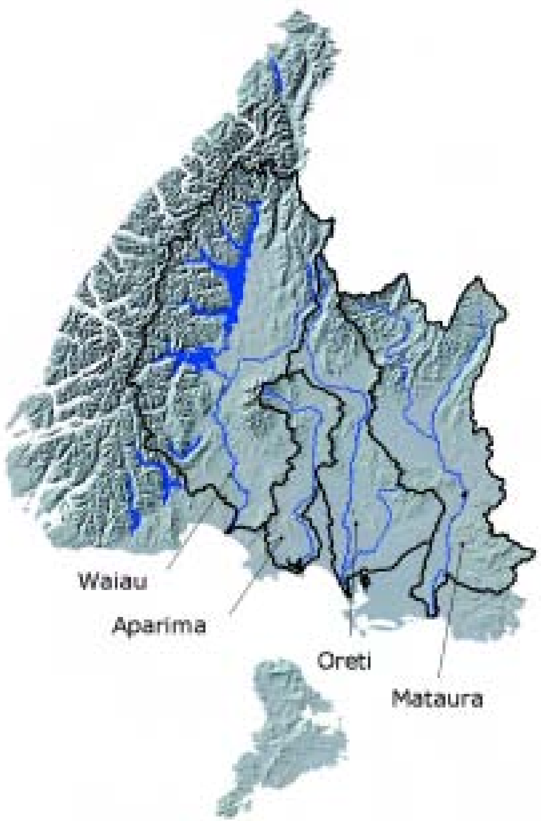


Figure 3 Major catchments of Southland.

After a hydro-electric power station was constructed at the West Arm of Lake Manapouri in the late 1960s, the Waiau River's flow was almost entirely diverted to generate electricity. Prior to the diversion, the Waiau's average annual flow (Table 2) of 520 cubic metres per second (cumecs) was the second largest of any New Zealand river.

Table 1 Characteristics of major lakes in the Waiau catchment. Manapouri catchment area does not include Te Anau catchment area.

Lake	Lake area (sq km)	Catchment area (sq km)	Maximum depth (m)
Te Anau	347	2998	417
Manapouri	143	1428	444
Monowai	32.5	231	161
Nth Mavora	10.8	322	85
Sth Mavora	1.2	20	45
Te Au	2.5	50.3	100
Gunn	1.7	21.8	100

Source: Robertson, B.M., 1993. Waiau Catchment Water Quality Review. Southland Regional Council.

The Aparima River is the smallest of the four main catchments, rising on the steep eastern slopes of the Takitimu Mountains, and draining to Jacobs River Estuary near Riverton. Prior to drainage and agricultural development, much of the lower catchment contained extensive wetlands. Some important areas of wetlands remain in the upper reaches, particularly in the Hamilton Burn catchment.

The Oreti is the third largest river in the region, its catchment covering about 10 percent of the total land area of Southland. The headwaters of the Oreti River drain the high country tussock lands between the Mavora Lakes and the western sides of the Eyre Mountains. Through its middle and lower reaches, the Oreti drains heavily stocked sheep, cattle and deer country. Much of this land was originally wetlands. Extensive drainage, flood control and channel clearance has been undertaken to convert it to productive farmland.

Several tributaries, of which the Makarewa River is the largest, join the middle and lower reaches of the Oreti River. Three of the tributaries, the Winton Stream, Waikiwi Stream and the Makarewa River, receive considerable discharges of industrial and municipal effluent.

Table 2 Characteristics of Southland's four major river catchments. Flow values for the Waiau are given as post and pre-control (bracketed). Mean Annual Low Flow is the average of the minimum flows that occur each year.

Catchment	Catchment area (sq km)	Mean annual flow (cumecs)	Mean annual low flow (cumecs)
Waiau	8,173	162 (501)	21 (274)
Aparima	1,375	8.01	1.48
Oreti	3,510	43.46	7.68
Mataura	5,360	95.71	22.63

The Mataura River is Southland's second largest catchment by both area and flow. The catchment extends from the southern tip of Lake Wakatipu in the north, to Toetoes Bay in Foveaux Strait. The Mataura River has several tributaries, the largest of which is the Waikaia River. The Waikaia accounts for about half of the total catchment area and flow above its confluence with the Mataura.

Like the Oreti catchment to the west, virtually all of the Mataura catchment has been developed for farming. In the middle and lower reaches, farming is intensive. Approximately six percent of the catchment is forested.

The lower Mataura has been an important source of water for use in industrial processing and cooling, and for electricity generation. The lower Mataura has also been a major receiving environment for industrial and municipal effluent. In the mid-1970s, the lower Mataura River was regarded as one of New Zealand's most polluted rivers. The river still continues to receive significant quantities of effluent, from both point and non-point sources.

The Mataura has high recreational values and supports a brown trout fishery of international renown. Its lower reaches also support a significant whitebait fishery.

In addition to the four major catchments, there are many other smaller rivers and stream systems. In general terms, they comprise three broad drainage zones:

- The Tasman drainage zone comprising the western and south-westerly flowing streams of Fiordland. These are mainly short, steep and fast flowing streams, with unmodified catchments.
- The Foveaux drainage zone comprising several small, near-coastal streams draining into Foveaux Strait. Most are highly modified and drain areas of intensive agriculture. This zone also includes those catchments draining the urban areas of Invercargill, including the Waihopai River and Otepuni Stream.
- The Catlins drainage zone, which includes a number of streams and small rivers draining south-east. Most of these waterways also have heavily modified agricultural catchments.

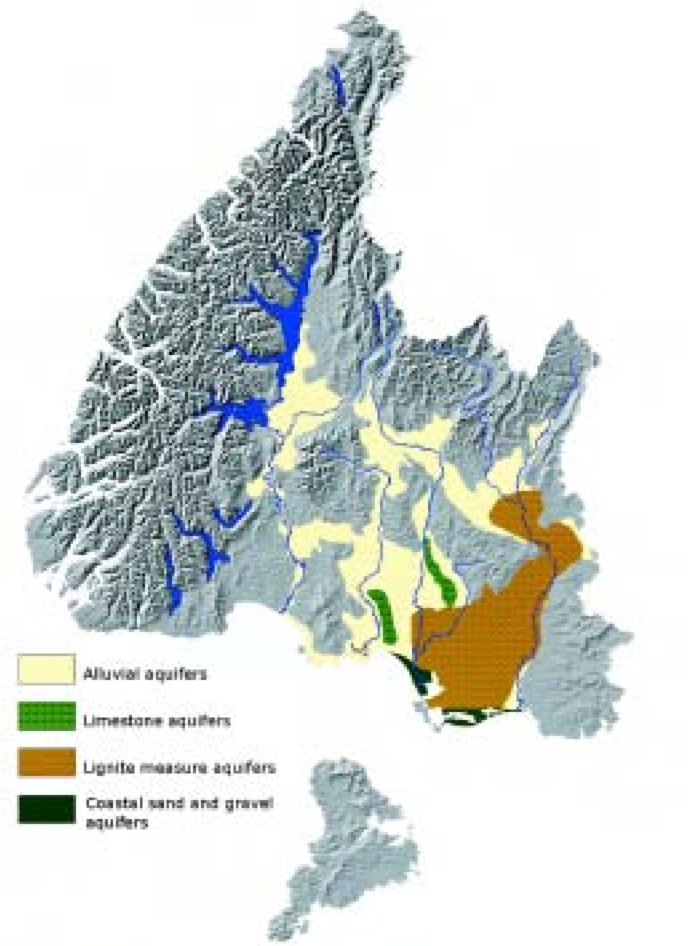


Figure 4 Main aquifer-forming units of Southland.

Groundwater

Groundwater is an integral part of the hydrological cycle in the Southland Region. Many parts of the flat-lying central Southland Plains lack surface drainage and soil moisture recharge forms a major component of the regional water balance. Groundwater also makes a significant contribution to baseflow in the major river systems and spring discharge maintains flow in many lowland streams.

The principal aquifer-forming units (Figure 4) in Southland are the Quaternary alluvial gravel deposits that occur extensively across the plains and downlands of central and eastern Southland as well as the Waimea Plains and Te Anau Basin in northern Southland. These gravel deposits form a series of unconfined aquifers that extend up to 40 m in thickness and overlay Tertiary limestone and lignite measure sediments throughout much of the Region. The deeper sediments also contain a significant groundwater resource in sandstone and fractured limestone sediments that form extensive semi-confined and confined aquifer systems.

The entrenchment of the major river systems into the Quaternary gravel deposits has created wide river valleys along the Mataura and Oreti rivers. Deposits of reworked gravel material form relatively high-yielding unconfined aquifers underlying the recent floodplains of the major rivers.

Elsewhere in the Southland Region the barrier beach sands and gravels of the Tiwai Peninsula and the fractured greywacke basement rocks of the Hokonui Hills and Catlins areas form locally significant aquifers.

The majority of aquifers in Southland are recharged by rainfall infiltration. The combination of relatively high recharge rates (300 to 400 mm per year) with permeable soils and a shallow water table means shallow unconfined aquifers are vulnerable to contamination resulting from land use activities.

Groundwater quality is quite variable across the Region. Unconfined gravel aquifers flanking the major river systems generally contain high quality groundwater but can be impacted by local effects resulting from land use. On the plains and downlands, groundwater quality is commonly influenced by localised geological conditions that may result in elevated hardness (‘hard’ water) or high levels of iron or manganese. The deeper confined and semi-confined aquifers commonly contain high levels of iron that have a significant effect on aesthetic water quality.

The groundwater resource is replenished by rainfall, primarily in the winter months when the amount of water lost from the surface of the ground as a result of evaporation and uptake by plants is at a minimum. Following the pattern of recharge, groundwater levels are generally highest in late spring and lowest in autumn. Longer-term variations in groundwater levels may result from dry winters, improvements in land drainage or increases in the volume of groundwater abstracted.

Wetlands

Wetlands form a significant part of the ecological and landscape character of Southland, and they play an import role in the environment. Wetlands provide important habitats for endemic and migratory water birds and many species of fish, invertebrates and specially adapted plants. They also play an important role in the wider aquatic ecosystem, including flood and erosion control, groundwater recharge, water purification and the maintenance of base flows of streams.

Within the Southland Region, wetlands are located in a wide range of areas, including the coastal margins, downland plains and alpine locations. Southland has comparatively more wetlands than most other regions of New Zealand. Some are of international or national significance, for example, the Waituna Wetland and the Te Anau string bogs. The Waituna Wetland is the largest in Southland and is designated under the Ramsar convention as a Scientific Reserve of International Importance.

Many of the other wetlands are of regional importance. Several are peatlands, for example those on the Awarua Plains and Te Anau Basin. There are also alpine ribbon and cushion bogs within high country areas. The lowland wetlands have been most affected by human activities.

While numerous wetlands remain in Southland, they have been drastically reduced in number and are often considerably reduced in area and 'naturalness' from those that existed prior to human settlement.

Awarua wetlands.

Currans Creek, Waituna wetlands. (source: DOC)

Alpine wetland, Garvie Mountains. (source: DOC)

Oxbow lake and wetland, Makarewa River. (source: DOC)

Southland's Fresh Water Resources

The drivers of change

The factors that result in environmental change are complex. Direct pressures on the environment – the usage of resources or the discharge of pollution – are generally obvious and therefore become the focus of much of our attention. However, these pressures are themselves the consequences of, or responses to, more deeply rooted and less obvious underlying drivers.

This section is designed to provide a context in which to view the information about the state of our region's water resources, presented in subsequent sections. It comprises a broad overview of the natural and human influences – described here as "drivers" – which provoke or create an effect on the environment.

Three main forces of change drive the pressures on Southland's fresh water environment. Environmental factors, principally climate, influence the availability of fresh water resources and the demands placed on them. Changes in the population and its distribution influence both the utilisation of resources and the amount of waste generated. The third main driving force impacting on Southland's fresh water environment is economic development.

Environmental drivers

Our environment is naturally dynamic and, on a range of time scales, many natural processes and phenomena impose pressures on fresh water environments. One of those – climate – continues to show measurable change and has the potential to have significant impacts on our fresh water resources and ecosystems.

The Earth's climate has exhibited marked changes over time scales ranging from millions of years to a decade or less. From geological and other evidence, we know that New Zealand's climate continues to undergo significant change. Up until the mid-19th century, climate change had been driven entirely by natural events and processes. However, there is increasing evidence to suggest that since the industrial revolution human activities may have been influencing the world's climate by raising levels of greenhouse gases (such as carbon dioxide and methane) in the atmosphere.

Two measures of climate that have a profound influence on water resources are temperature and rainfall, and it is for these that the most historical information exists.

Temperature

In the last 100 years, global mean surface air temperatures have risen by approximately 0.3 - 0.6°C (Figure 5). This trend is also apparent in the New Zealand temperature record.

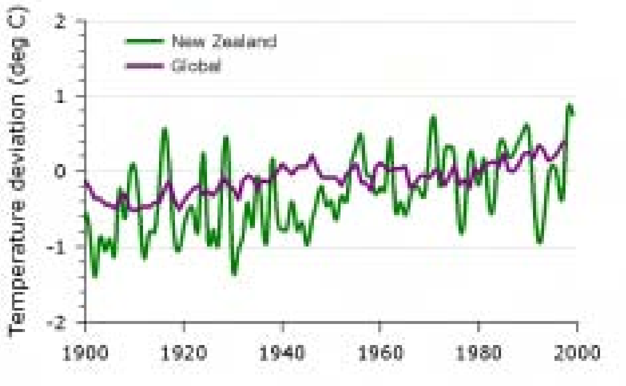


Figure 5 Long-term temperature trends for New Zealand and the world. Trends expressed as deviation from the 30-year average (1961 to 1990).

While average temperatures have increased, the major change has been a reduction in temperature extremes.

Over the last 40 years, the average minimum temperature in Southland has been increasing at over three times the rate of the average maximum temperature. As a consequence, the daily temperature range in Southland is reducing at a greater rate than any other region of New Zealand. This moderation of temperatures is reflected in a reduction in the occurrence of frosts. In the 20 years from 1978 to 1997, there were approximately 12 fewer frosts per year than the average for the previous 20 years.

Precipitation

Another important facet of climate change is how rainfall patterns may alter with time. The evidence of change in Southland's rainfall is less clear than for temperature, in part because rainfall records are fewer and shorter, and in part because it is difficult to pick out longer-term trends from shorter-term variations and cycles.

Current evidence indicates that since the late 1970s, annual rainfalls in the west and south-west have increased by up to 20 to 30 percent. The increase lessens slightly towards the east, reflecting the effects the mountains have on Southland's climate.

Table 3 Trends in annual mean, maximum and minimum air temperature, diurnal temperature range for areas of New Zealand from 1951- 1990. Negative values indicate a decrease.

Area	Temperature trends in °C per decade			
	Mean	**Max**	**Min**	**Daily range**
New Zealand	0.12	0.08	0.15	-0.07
Western N Island	0.13	0.07	0.18	-0.11
Eastern N Island	0.16	0.14	0.18	-0.04
Western S Island	0.18	0.11	0.07	0.03
Eastern S Island	0.10	0.07	0.12	-0.06
Inland Central S Island	0.11	0.04	0.19	-0.15
Southland	**0.14**	**0.06**	**0.22**	**-0.16**

Source: National Institute of Water and Atmospheric Research

Most of the increases appear to be due to an overall rise in winter rainfalls.

Climate, water resources & the future

There are considerable uncertainties in any predictions made about the rate of climate change and its likely effects. While global temperatures are expected to rise, there is less confidence in predictions for regions the size of New Zealand. This is because of the uncertainties in regional climate change prediction, the limited knowledge about sensitivities of some systems (both natural ecosystems and managed agricultural activities) to climate, and the interactions between these systems.

There is an increasing realisation that long-term natural variations may have a significant impact on climate (and therefore water resources), onto which the effects from short-term phenomenon such as El Nino - La Nina cycles or longer-term human-induced variations are superimposed.

Population drivers

Population and patterns of settlement are powerful drivers of environmental change. People consume natural resources and produce wastes. Not surprisingly, there is a strong correlation between population numbers and environmental impacts. Where population grows rapidly, as is currently occurring in Auckland, resources and infrastructure can be strained faster than the impacts can be managed.

Population decline on the other hand, causes different pressures. As the population drops, so too does the net wealth of the community. It is often difficult to justify providing services and to finance environmental protection initiatives. Similarly, short-term economic goals can carry higher priority than long-term sustainability objectives in making decisions about whether to conserve ecosystems or harvest a resource.

Patterns of settlement also exert strong environmental influences. When people live together in clusters, environmental impacts are concentrated in small areas and can have significant downstream effects. On the positive side, the concentration of people provides the opportunities for economies of scale in resource use and waste management.

Population and its distribution

Southland has been experiencing a gradual decline in population since the late 1970s. Between the 1986 and 1996 censuses, Southland's population fell by 7,179. This decline, some 6.9 percent in 10 years, was the largest of all regions in New Zealand. For the same period, the national population growth was 10.9 percent. At the 1996 census, Southland's population stood at 97,101. This represented 10.8 percent of the South Island population and less than 2.7 percent of the total New Zealand population. In June 1999, Statistics New Zealand estimated[1] Southland's population at 94,100.

The estimated 1999 population suggests that the rate of decline has accelerated slightly since 1996. Current projections indicate that Southland's

Table 4 Population distribution and changes in Southland 1986-1999.

Area	1986	1991	1996	% change ('86-'96)
Invercargill	52,818	51,540	49,404	- 6.5
Gore	11,352	10,956	10,620	- 6.4
Minor Urban Areas	8,157	7,878	7,887	- 3.3
Rural Centres	6,546	5,892	5,730	- 12.5
Other Rural Areas	25,341	23,682	23,382	- 7.7
Oceanic/Inlet	63	3	78	23.8
Southland	**104,280**	**99,951**	**97,101**	**- 6.9**

Source: Statistics New Zealand

[1] *Statistics New Zealand, Population 1996-1999 by Region.*

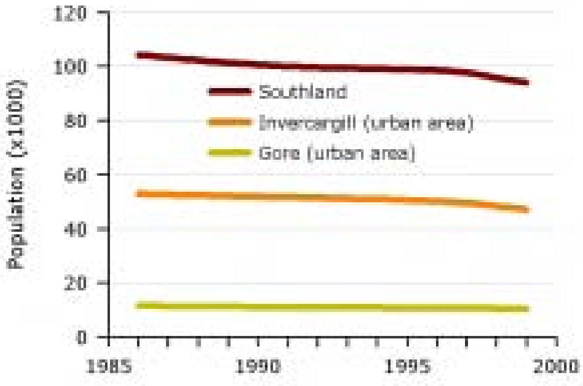


Figure 6 Changes in the population of Southland, and the Invercargill and Gore urban areas, 1986-1999.

population will continue to decline for the foreseeable future. As Figure 6 and Table 4 show, the population decline is evident in both urban and rural areas, reflecting the generally lower population growth in the South Island and the national trend towards northward migration.

Southland's population is more rurally based than most other regions of New Zealand. In 1996, 30.1 percent of Southlanders lived in rural areas, as compared to 14.6 percent nationally. Invercargill is Southland's only major urban area and Gore is the only other sizeable population centre.

In 1996, the average population density in Southland was 2.8 people per square kilometre, considerably less than the national average of 13.1. Only the West Coast region has a lower population density. However, population densities vary widely, so average population density at the regional level reveals little about individual settlements. Furthermore, almost 56 percent of Southland – 19,000 km^2 – is national park or other conservation land.

Economic drivers

More than most other regions of New Zealand, Southland's prosperity was founded upon the suitability of its environment for pastoral farming. For 150 years, agriculture has been the solid foundation upon which Southland's economy grew and at the start of the 21st century the environment continues to support – either directly or indirectly – nearly every aspect of the regional economy.

Agricultural and forestry sector

Agriculture still dominates Southland's economy, its landscape and its environment. In 1999, there were 4,791 farms in Southland covering a total of 12,350 km^2. This represents some 36 percent of the total land area of Southland and, more significantly, 82 percent of the total area of non-conservation land.

Agricultural activities are the largest single contributor of nutrients – nitrogen and phosphorus – to our surface and groundwater resources. They are also the major contributor of microbiological and other contaminants and a major consumer of water resources. The pressures exerted by agricultural activities on the environment are strongly related to land use and productive intensity. Changes in either can have a marked effect on the type, magnitude and extent of the environmental pressures. Major land use types and covers are shown in Figure 7.

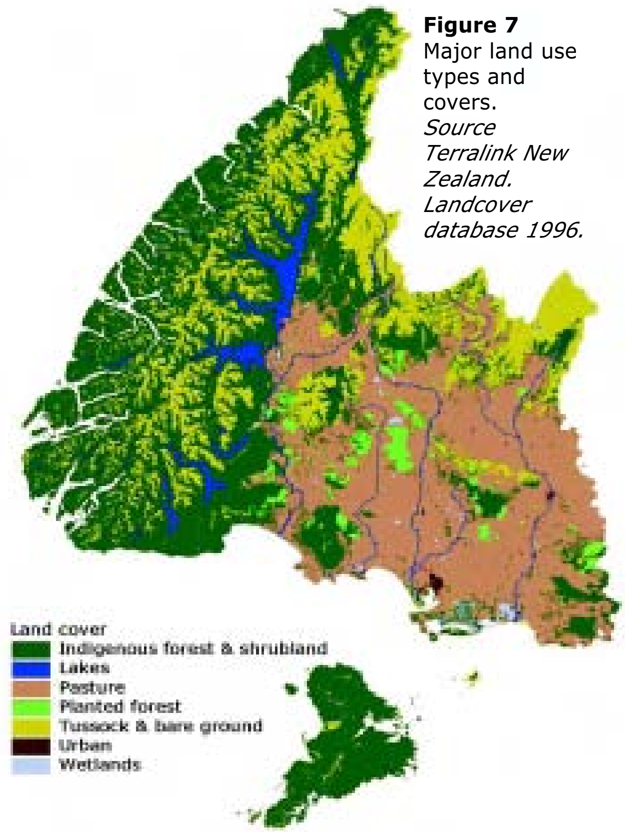


Figure 7 Major land use types and covers. *Source Terralink New Zealand. Landcover database 1996.*

Of the total area of land devoted to agriculture in Southland, some 95 percent of it is used for grazing. This land is primarily used to raise some 6.7 million sheep, 14.7 percent of the national flock. The composition of farming activities is shown in Figure 8.

While farming in Southland has been and still is primarily focused on sheep, the last 10 years have seen substantial change in land use. Sheep numbers have declined 25 percent from 8.9 million in 1990 to 6.7 million in 1999. This decline is the largest of any region in New Zealand for the same period. Goat numbers have reduced significantly during this period, falling by 90 percent from a regional herd of 73,000 in 1990 to 7,100 in 1999.

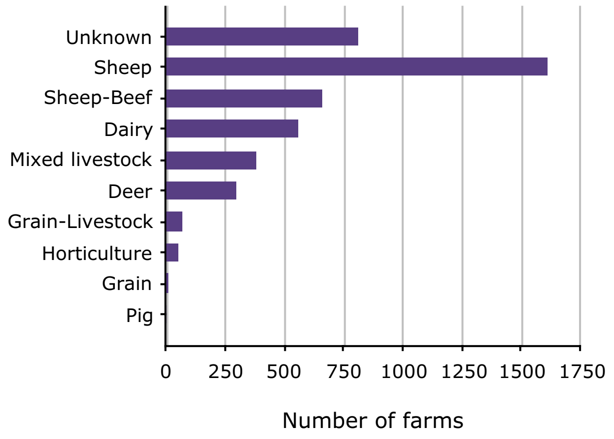


Figure 8 Types of farms in Southland as at June 30 1999. *Source: Statistics New Zealand, Agriculture Production Survey for the year ended 30 June 1999.*

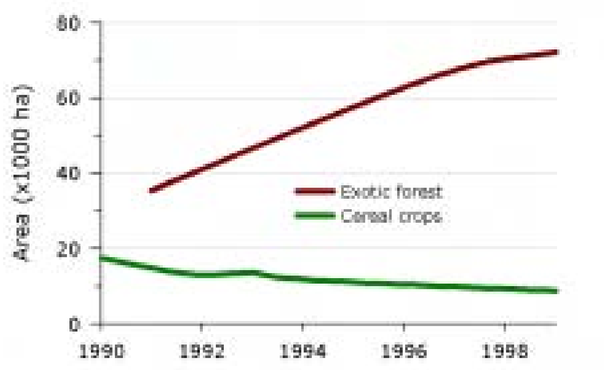


Figure 10 Changes in area under forestry and cereal cropping. *Source: Statistics New Zealand, Ministry for Agriculture and Forestry.*

While sheep and goat numbers have dropped dramatically, there have been significant increases in other stock numbers (Figure 9). Beef cattle numbers rose 23 percent between 1990 and 1999, while in the same period the region's deer herd increased by almost 220 percent.

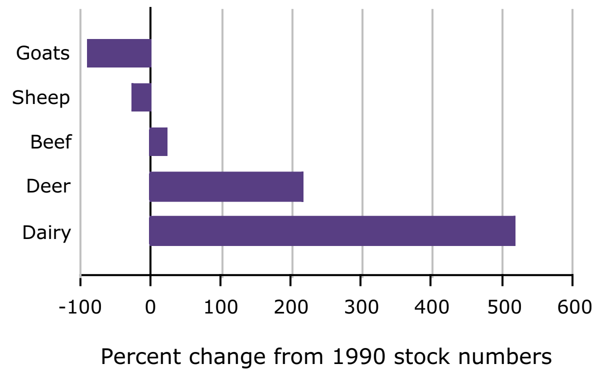


Figure 9 Relative change in stock numbers in Southland between 1990 and 1999. *Source: Statistics New Zealand, Ministry for Agriculture and Forestry.*

Most significant has been the rapid expansion of the dairy industry. Between 1990 and 1999, Southland changed from being a relatively minor dairying region to a significant one. Favourable dairy product prices, coupled with a suitable climate and an abundance of comparatively cheap, good quality land, have seen a large number of Southland properties converted from sheep and cropping to dairying. Over the last 10 years, the number of dairy farms has risen 180 percent from less than 200 in 1990 to over 560 in 1999. Because of increasing herd sizes, the number of dairy cattle has grown even more strongly – from 38,000 in 1990 to 233,000 dairy cows in 1999 – an increase of almost 520 percent.

The five percent of productive land that is not grazed is used for forestry, cropping and horticulture. As Figure 10 shows, there has been a noticeable increase in the area under forestry. At 1 April 1999, the total area under production forest in Southland had grown to 72,118 hectares. This represents a doubling of the area since 1991. While radiata pine dominates the plantings, Southland has relatively more Douglas fir and hardwoods than the New Zealand average.

By contrast, the significance of cereal cropping in Southland has steadily declined since the early 1980s, when approximately 30,000 hectares were in production. In 1999 just 7,800 hectares, or less than one percent of productive land, was sown in cereals in Southland, primarily in barley, oats and wheat.

At about 600 hectares, horticulture in Southland is, by land area, a very small component of the total area under production.

Industrial sector

Agricultural-based processing dominates Southland's industrial base, producing meat, dairy and forestry products. Many of these industries use water and generate significant volumes of waste.

There are several meat-processing plants located throughout the Southland region, with the two largest sited at Mataura and Lorneville. Their total throughput has declined in recent years with falling sheep numbers.

The rapid increase in dairy farming has seen a significant increase in the region's dairy processing capacity. The largest dairy processing plant, at Edendale, has continued to expand since the mid-

1990s. There are also proposals to set up other dairy processing plants in the region in the near future.

The processing of forest products is also a key industry in Southland. Timber is processed at sawmills in western and eastern Southland, timber veneers produced at Kennington, on the outskirts of Invercargill, and fibreboard manufactured at a plant south of Mataura.

As the area of Southland's exotic forest increases, it is anticipated that there will also be an increase in related processing industries.

The largest non-agricultural-based industry in Southland is aluminium smelting at Tiwai Point. Until its recent closure, paper manufacturing at Mataura was also a significant industry.

Tourism sector

Tourism is playing an increasing role in the economic development of Southland so there is a need to conserve the very environment that attracts our visitors.

In 1999, a total of 376,710 guests spent 614,785 nights in commercial accommodation in Southland. Overseas tourists are believed to account for just over half the total number of guests. This was over two times the resident population of Southland.

Future trends in tourist numbers, and their implications are uncertain. If visitor numbers continue to rise at the current rate (seven percent increase between 1998 and 1999), there will undoubtedly be increased pressures on the physical infrastructure (e.g., water, sewage and waste disposal). Furthermore, the increasing number of tourists visiting the better-known attractions is likely to increase pressures on the quality of the environment in these sensitive areas.

Mining Sector

Southland is the third-largest coal-producing region in New Zealand after Waikato and the West Coast. In 1994, Southland produced 150,058 tonnes of bituminous coal and 51,402 tonnes of lignite, accounting for 6.6 percent of total New Zealand coal production.

In the late 1970s the Eastern Southland lignite deposits were investigated for their potential in the manufacture of liquid fuels. While the project did not proceed, it remains a development possibility. In the largest Matura lignite deposit, 35 percent of the deposit lies within the floodplain of the Mataura River. Extensive development of the field would be likely to put pressure on the area's surface and groundwater resources.

Mineral deposits are widespread throughout the region, but most are not economically viable at present. Alluvial gold deposits are found throughout much of Southland, with significant mining occurring in the Waikaia and Waikaka river valleys, with potential for expansion in other areas of the Mataura catchment. Nokomai is one of the largest alluvial gold fields in New Zealand. There are deposits of tin on Stewart Island, and exploration for base metals (e.g., platinum) has been recently carried out in the Longwoods, north of Riverton. Southland has large reserves of high-grade quartz gravels and limestone. The latter is quarried at a number of localities and is used locally as a soil conditioner.

Gravel is extracted from the bed and floodplains of each of the four major rivers. Approximately 420,000 cubic metres of gravel are taken annually for use in the roading and construction industries.

Goldmining in the Nokomai valley

The Concerns

Issues & pressures that cause them

This section looks at the priority issues affecting Southland's water resources. For the purpose of this report these have been divided into four broad categories (Table 5), although in reality there is a large amount of overlap and interaction between the issues. It is important to recognise that these interactions exist and that no issue can be examined or managed in isolation. Equally, because of the constantly changing nature of environmental pressures, the information presents a snapshot in time.

The discussion of each issue includes a description of the pressures which have been identified as driving that particular environmental change. Those indicators of pressure are also outlined in Table 5.

The issues reflect our current knowledge and concerns, but there are undoubtedly issues that exist or are developing of which we are unaware. Equally, good data are lacking for many of our pressure indicators. Such deficiencies are mentioned in this report to flag that there are information gaps that need to be filled to ensure effective environmental management.

Degradation of surface and groundwater quality

The quality of water varies naturally from place to place and from season to season. The most important natural factors influencing water quality are climate, and the physical and chemical composition of the rock and soils through which the water moves.

Human activities also have a major impact on water quality. What people put into water, either directly through discharges or indirectly via run-off from land, affects the quality of surface and groundwater and our ability to safely drink it, swim in it, water our animals with it, and use it in our industries. Degraded water quality also impacts on aquatic life in our rivers, lakes and wetlands.

There are many types of potential contaminants capable of degrading water quality and they come from a variety of sources. These sources are often distinguished on the basis of whether they are a direct (point) discharge or a diffuse (non-point) source discharge.

Point-source discharges arise from well-defined sites, such as industrial premises, sewage systems and septic tanks, stormwater discharges, landfills and other waste disposal areas. Non-point source discharges generally occur over a wide area and are often associated with agricultural or horticultural land use. Contaminants applied to land, including animal wastes, fertilisers and pesticides, can leach down through the soil profile to groundwater, or carried in runoff over or through the ground to waterways. The risk of contamination from these discharges is highest where landuse and contaminant application is intensive.

Point source discharges are largely regulated. Therefore much is known about their location, and the volume and type of wastes being discharged. Non-point sources tend to be more difficult to identify and measure, despite being significant sources of contamination.

Table 5 Priority issues affecting Southland's freshwater water resources and ecosystems, and our measures of pressure

Category	Issue	Measures of Pressure
Degradation of surface and groundwater quality	Health risks from microbial contamination of surface waters The effects of harmful substances on aquatic life The impacts of excessive algal growth on freshwater ecosystems Physical degradation of water and sediments Health risks from contaminated groundwater	Livestock numbers Nutrient loading from livestock Fertiliser usage Pesticide usage Discharges to surface water Discharges to land Landfills and other waste disposal areas Water pollution incidents
Depletion of surface and groundwater resources	Depletion of surface water resources Depletion of groundwater resources	Surface water abstraction Groundwater abstraction
Modification of aquatic habitats	Loss and modification of riparian margins Disturbance and modification of river and stream beds	River modification Drainage channel maintenance Gravel extraction
Biological pressures on aquatic biota and habitats	Spread of undesirable pest species	Distribution and abundance of exotic species

The Issues

Health risks from microbial contamination of surface waters

Many microbiological organisms are found naturally in most surface waters. While some of these organisms are harmless, others are pathogenic (disease causing) and create a health risk for humans and stock. Increases in organism concentration result from human or animal effluent finding its way into water.

The major human health risks are associated with contact recreation (e.g. swimming, boating), untreated domestic supplies, and the use of surface waters in industries that require high standards of hygiene. In Southland, surface waters used for reticulated supply are treated to ensure that consumers are not exposed to contaminated water. Water contaminated with microbiological organisms also pose a health risk to domestic animals. Disease causing organisms that have been found in Southland's waterways include campylobacter, salmonella, cryptosporidium and giardia. The human sources of microbial contaminants are shown in Table 6.

The effects of harmful substances on aquatic life

Many substances can harm animals or aquatic life and should be kept out of rivers. Some substances (like some pesticides, oil, or metals) are obviously harmful, but in Southland aquatic life is more commonly threatened by more 'natural' contaminants. Truly toxic substances are rare in Southland but contaminants that can have and have had widespread impacts are oxygen depleting substances and ammonia.

Substances that deplete the amount of oxygen in water, such as dissolved sugars or milk cause Biological Oxygen Demand (BOD). BOD in large amounts reduces the amount of oxygen in the water enough to kill fish; it also provides food for undesirable slimes like 'sewage fungus'. Ammonia is used as a nutrient by algae but in high concentrations is toxic to aquatic life and can kill fish. Table 6 lists the main sources of BOD and ammonia.

The impacts of excessive algal growth on fresh water ecosystems

The presence of nutrients in excessive quantities in surface waters can, under favourable conditions, promote and accelerate the growth of algae and other aquatic plants to nuisance levels. The proliferation of algae has a number of impacts:

- it deprives aquatic animals and other plants of oxygen, light and space;
- large masses are unsightly and often smelly;
- the decay of large masses of periphyton affects the taste of drinking water.
- recreational activities, such as swimming and fishing, are impacted; and
- some algae also produce toxins (see Box: Blue-green algae).

The major nutrients of concern are nitrogen and phosphorus. Nitrogen is the more soluble of the two and can be washed into rivers, or leach into groundwater. Phosphorus is less soluble and tends to be bound closely to soil particles. Consequently, phosphorus finds its way into streams largely through the erosion of soil. Phosphorus is the most critical nutrient for algal growth in most Southland rivers except for the very clean (oligotrophic) headwaters.

Both nitrogen and phosphorus can be found in all surface waters as a result of natural biological and geological process. Natural concentrations of these

Blue-green algae

Blue-green algae are naturally occurring photosynthetic microscopic organisms commonly found in many of our water ways. They can float at the surface or form slime-like mats of sediments. While looking like and commonly referred to as algae, they are in fact primitive bacteria, more correctly termed cyanobacteria. Blue-green algae were one of the first life forms on earth and have the distinction of being the oldest known fossils - more than 3.5 billion years old.

Like true algae, blue-green algae are natural to all our surface waters. And as with true algae, they proliferate under a combination of certain factors, such as low flow rates, elevated nutrients, high light availability and warm temperatures.

There are a large number of different types of blue-green algae, and it is now known that some of them produce toxins that can affect humans and animals. While no human deaths have been caused by blue-green algae in New Zealand, stock and pet deaths have been reported, and there is also evidence of wildlife being poisoned.

In 1999 and 2000, there were a total of seven dog deaths that have been tentatively linked to blue-green algae in the Mataura River. The blue-green algae thought to be responsible are *Oscillatoria*, which form a brown, black or purple gelatinous scum on the streambed, and are widespread in streams with stable flows, moderate nutrients and plenty of light.

There is currently no evidence to suggest that *Oscillatoria* is a significant public health risk and there are no reports of it causing illness in humans.

nutrients in surface waters are generally low while elevated concentrations are usually the result of human activities.

There are a number of point and non-point sources of nutrients to Southland river systems. The most significant sources are shown in Table 6.

▲ Physical degradation of water and sediments

Aquatic life, like humans, is sensitive to the physical characteristics of water. Both aquatic life and human use is limited by extreme temperatures, extreme pH, poor clarity some colours and too much sediment.

High temperatures are a problem in some small unshaded streams[1], but suspended solids probably have the most extensive impacts on water and sediment quality in Southland rivers.

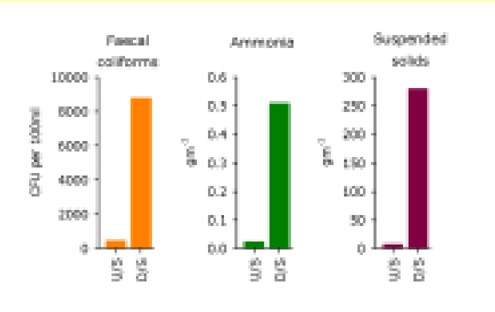
Suspended solids consist of soil, sand, mud and sometimes organic particles like algae. Suspended solids reduces water clarity and light penetration and can make the water look 'dirty'. This limits plant growth, restricts the ability of predatory fish to visually feed, and makes drinking water harder (and more expensive) to treat.

Water with clarity less then 1.6 metres is generally considered to be undesirable for swimming.

Stock and waterways don't mix

When stock get into waterways, the effects on water quality can be significant. This is dramatically illustrated by the graphs below, which show the impacts of deer in a waterway. The graphs show measurements of faecal coliforms, ammonia and suspended sediments upstream (U/S) and downstream (D/S) of the site.

The downstream measurements, were between 19 and 35 times those recorded upstream of the access point. At the downstream site, faecal coliform levels exceeded the recommended guidelines for stock water, ammonia was at levels toxic to fish life, and the suspended sediment concentrations represented a soil loss of over 2.3 tonnes per day.



When suspended solids settle they can degrade aquatic habitats and smother organisms living on the bottom of rivers and lakes. Suspended sediments also transport contaminants (e.g. nutrients, bacteria, or metals) so keeping sediment out of waterways has many advantages. The principle sources of suspended solids are shown in Table 6.

The impact of deer in waterways, an example from the Makarewa catchment.

▲ Health risks from contaminated groundwater

Groundwater quality can be degraded by the input of contaminants from both point and non-point discharges. Water percolating through the soil profile can carry a range of contaminants into groundwater. Bores, wells and soak holes can also act as a direct conduit for contaminants to enter groundwater, or for the exchange of degraded water between aquifers. Aside from naturally occurring levels of iron and manganese in some areas, elevated nitrate levels and the presence of microbiological contaminants are the most widespread groundwater quality issues in Southland. The presence of pesticides residues in groundwater is locally significant in the Edendale area. The common sources of these contaminants are shown in Table 6.

These contaminants, if elevated in groundwater beyond a certain level, can have adverse effects on:

- human use values (i.e. degraded groundwater can be unsuitable for drinking or stock water)
- aquatic ecosystem values (i.e. degraded groundwater can contribute to surface water quality problems)

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[1] *Hamill K.D. (1998). Diurnal fluctuations in the Oteramika Stream: Investigations into temperature, dissolved oxygen and pH. SRC Publication No. 99.*

With over 60 percent of rural Southland reliant on groundwater for some or all of their household supply, contamination of drinking water is an issue with potentially far-reaching consequences. Much of the groundwater currently used for drinking water is either untreated or requires only minimal treatment. If groundwater quality is degraded, additional treatment may be required in order to minimise health risks. This imposes a cost to communities. Alternatively, new supplies might be sought, putting other water resources under stress.

The potential for groundwater contamination is greatest in shallow, unconfined aquifers beneath areas of intensive land use. Aquifers that are tapped by poorly constructed bores and wells are also at risk in localised areas.

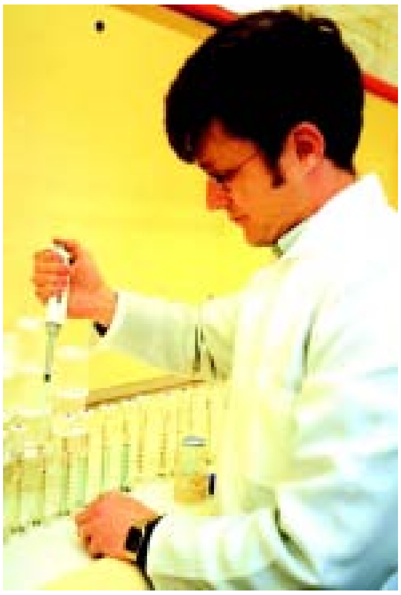

Table 6: Sources of contaminants to Southland waters.
The circles indicate the regional significance of a particular source based on our current understanding. Closed circles represent predominant or significant sources of contaminants; open circles represent possible or minor sources.

	Source of Contaminants	Nutrients	Bacteria	Harmful organic substances (e.g. ammonia, BOD)	Toxins (e.g metals)	Physical degradation (e.g. clarity)	Leaching to groundwater (e.g. nitrate)	Bacteria in groundwater
Point sources discharges	Sewage effluent	●	●	●	○	●		
	Industrial effluent e.g							
	animal processing	●	●	●		●		
	dairy processing	○		○				
	vegetable processing	○				○		
	others	○	○	○	○	○		
	Stormwater			○	○	○	○	
	Cooling water					○		
	Solid wastes (e.g landfills, dumping)	○	○	○	○	○	○	○
Non-point sources (runoff, leaching and direct inputs)	Effluent disposal to land (e.g industrial or farm dairy effluent)	●	●	○		○	●	○
	intensive grazing (e.g. mob-stocking, forage cropping)	●	○	○		○	●	
	Intensive fertiliser use	○		○			●	
	Stock in water courses	○	●	○		○		
	Septic tanks or offal pits	○	○	○		○	○	○
	Silage leachate	○		○			○	
	Inappropriate use of pesticides				○		○	
	Disturbing the riverbed or riverbank	○				●		
	Erosion from land and riverbanks	●				●		
Pathways	Tile drains	●	●	○		○		
	Soakage pits or poor wellhead protection						○	●
	Springs and groundwater seepage	●						

The Pressures

▲ Livestock numbers and nutrient loading from livestock

In Southland, livestock farming is the major component of our agricultural base, with some 7.6 million head of stock at June 1999. Excreta (dung and urine) from livestock is a significant source of nutrients (phosphorus and nitrogen), pathogens and oxygen depleting substances (BOD).

The amount of animal excreta that enters our surface and groundwater via non-point sources is not known and because of a range of highly variable factors such as soil characteristics and climate, cannot easily be estimated. However, knowledge of livestock numbers and types, and their effluent characteristics does provide some indication of the likely pressures and potential levels of contamination. Livestock numbers also give an indication of other potential pressures on water, such as treading and compaction of soils, and damage to stream banks.

Table 7 shows the trends in stock numbers in Southland since 1975.

While absolute stock numbers provide an indication of potential effluent loading into water, other factors need to be considered. Firstly, effluent loading is not the same for all animals. Dairy cows, for example, excrete almost seven times the amount of nitrogen and phosphorus as breeding ewes, while the loading from deer (breeding hinds) is about twice that of a breeding ewe.

Table 7 Stock numbers by year, 1975 - 1999. All numbers are in thousands of stock units. All numbers rounded to the nearest thousand**.**

Year	Stock Numbers ('000)				
	Beef	Dairy	Deer	Goats	Sheep
1975	301	31	-	-	2,541
1980	193	24	19	4	6,959
1985	178	31	44	13	8,837
1990	187	38	124	73	8,932
1991	181	44	150	45	8,454
1992	172	53	160	26	8,041
1993	175	71	162	18	7,807
1994	203	114	185	15	7,851
1995	214	126	186	-	7,688
1996	204	138	191	10	7,457
1999	230	233	393	7	6,738

Source: Statistics New Zealand; Ministry of Agriculture and Forestry

With knowledge of effluent characteristics for each type of animal, it is possible to convert stock numbers to equivalent loadings for nitrogen and phosphorus. These are shown in Figures 11 and 12, respectively.

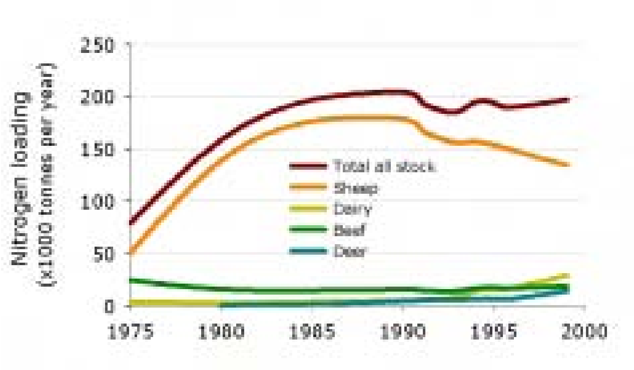

Figure 11 Nitrogen excreted by Southland farm animals, 1975 – 1999.

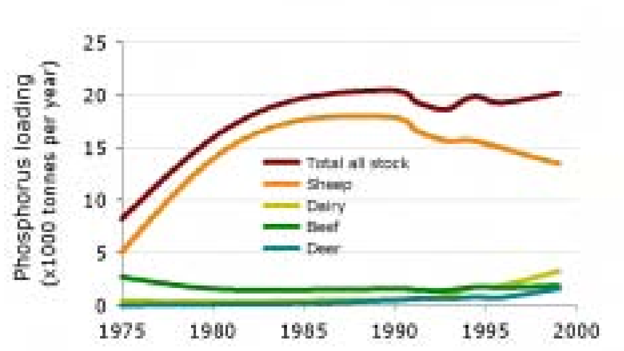

Figure 12 Phosphorus excreted by Southland farm animals, 1975 – 1999.

Figures 11 and 12 show that on 1999 stock numbers, farm stock excrete a total of 200,000 tonnes of nitrogen and 20,000 tonnes of phosphorus each year. While the total quantities of each have remained relatively static over the last 15 years, the relative contributions from each stock type has been changing.

Most obvious has been the decline in contribution from sheep and the increase from dairy and, to a lesser extent, deer. As with stock numbers, this is a relatively crude indicator of pressure. At present, there is insufficient information to reliably estimate the quantities of nitrogen and phosphorus from animal excreta that enter our surface and groundwater resources.

▲ Fertiliser usage

The three main nutrients required for plant growth are nitrogen (N), phosphorus (P) and potassium (K). Fertilisers are applied to farmland in order to provide the nutrients needed by crops and pastures, and maximise production. Although the soil itself contains nutrients, the amounts are often insufficient for optimum plant growth and production. Fertilisers commonly used in Southland include inorganic fertilisers such as superphosphate and urea, and organic fertilisers such as farm dairy effluent and animal manure.

Figure 13 shows the total annual quantity of all fertilisers used in Southland for the six-year period between 1990 and 1996. The data suggests that fertiliser usage increased from 1990 to 1996. A similar trend has been reported[1] at national level, where much of the increased usage is attributed to the use of nitrogen fertilisers by an expanding dairy industry.

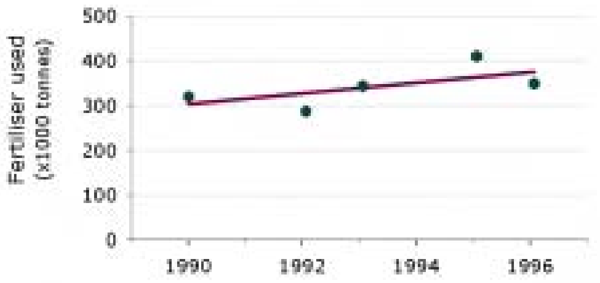

Figure 13 Total fertiliser usage in Southland, 1990 – 1996. *Source: Statistics New Zealand*

Fertiliser use levels can provide an indication of potential pressures on the aquatic environment. However, the complexity of the relationships between soil type, land contour, climatic conditions, crop type and existing soil nutrient means that the relationship between application rates and resulting impacts on water resources is neither simple nor direct.

▲ Pesticide usage

Pesticides are substances used for controlling or destroying pest plant and animal species. However, poor management practice or the use of inappropriate pesticides can have significant impacts on drinking water quality, as well as aquatic plants and animals.

Pesticides vary greatly in their chemical and physical characteristics, and thus in their toxicity, solubility and persistence in water. Many pesticides pose little or minimal threat, while others have a particularly high potential to degrade waters. Little information on pesticide or other agrichemical use is available for Southland. However, a recent review[2] of pesticide usage in New Zealand provides some indication of possible regional trends. The review found that total pesticide use (excluding mineral oil) in New Zealand grew from 1984 to a peak of about 3,700 tonnes of active ingredient per annum in 1994 and then declined to 3,300 tonnes in 1998. The review further found that pesticide use was dominated by herbicides (68 percent) followed by fungicides (24 percent) and insecticides (eight percent).

While pesticide use can provide an indication of potential pressure on water resources and aquatic ecosystems, there is no simple direct relationship between usage volumes and resulting environmental impacts. In other words, using more does not necessarily increase the likelihood of contamination. Rather, contamination is more likely to be a function of either *misuse* (careless handling or disposal of wastes), the physical/chemical characteristics of individual compounds, or usage in environmental settings with high risk factors, such as shallow unconfined groundwater systems and highly permeable soils. More meaningful indicators of the pressures imposed by pesticides and other agrichemicals are not yet available.

▲ Discharges to surface water

At the end of June 2000 there were over 70 consented point source discharges to Southland's river and streams. The types and volumes of those discharges by major catchment are given in Table 8, and the locations shown on Figure 14.

The most significant discharges, in terms of nutrient, BOD and bacterial loadings, comprise:

- animal processing (meat works) discharges into the Makarewa River;
- animal and dairy processing discharges into the Mataura River; and
- sewage discharges into the Mataura River.

Stormwater and other 'wet weather' discharges are significant contributions of suspended solids, including sediment and organic materials. The volume of wet weather discharges to our river systems is not known.

Significant volumes of cooling water are released into the Mataura and Makarewa Rivers, predominantly as a by-product of animal and dairy processing plants. Since the 1970s, the effluent

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1 *The State of New Zealand's Environment, 1997. Ministry for the Environment.*

2 *Review of Trends in Agricultural Pesticide Use in NZ, 1999. MAF Policy Technical Paper 99/11*

Table 8 Consented discharges to water by type and volume in Southland at 30 June 2000. Note that volumes are not generally available for 'wet weather' discharges such as stormwater. 'Other' category is predominantly mine drainage and gravel washing.

Type of discharge	Volume of discharge (m3/day) and numbers of consents (bracketed)						
	Aparima	Mataura	Oreti	Makarewa	Waihopai	Waiau	Other
Animal and dairy processing		28,908 (2)	1,505 (2)	40,058 (4)	287 (1)		
Cooling water		21,200 (2)		18,000 (1)			
Farm dairy effluent	36 (1)	87 (5)	12 (1)		44 (3)	7 (1)	-- (1)
Industrial		9,411 (1)					
Sewage	350 (1)	27,930 (6)	371 (4)	5 (1)	5 (1)	2,330 (2)	32 (1)
Stormwater	-- (1)	-- (3)	-- (2)	18,316 (2)	-- (1)	21 (2)	
Other	-- (3)	460 (5)	1,125 (1)	3,534 (4)		-- (5)	1,500 (2)
Total	**386 (6)**	**87,966 (24)**	**3,013 (10)**	**82,926 (12)**	**336 (6)**	**2,358 (10)**	**1,532 (4)**

loading from point source discharges has improved considerably, particularly in the Mataura River (see Box: Mataura River). This has come about through:

- more stringent conditions on consents (often reflecting increased community expectations);
- application of improved waste water treatment technologies;
- reductions in waste water volumes;
- a significant shift towards land disposal of farm dairy effluent; and
- a reduction in the number of discharges.

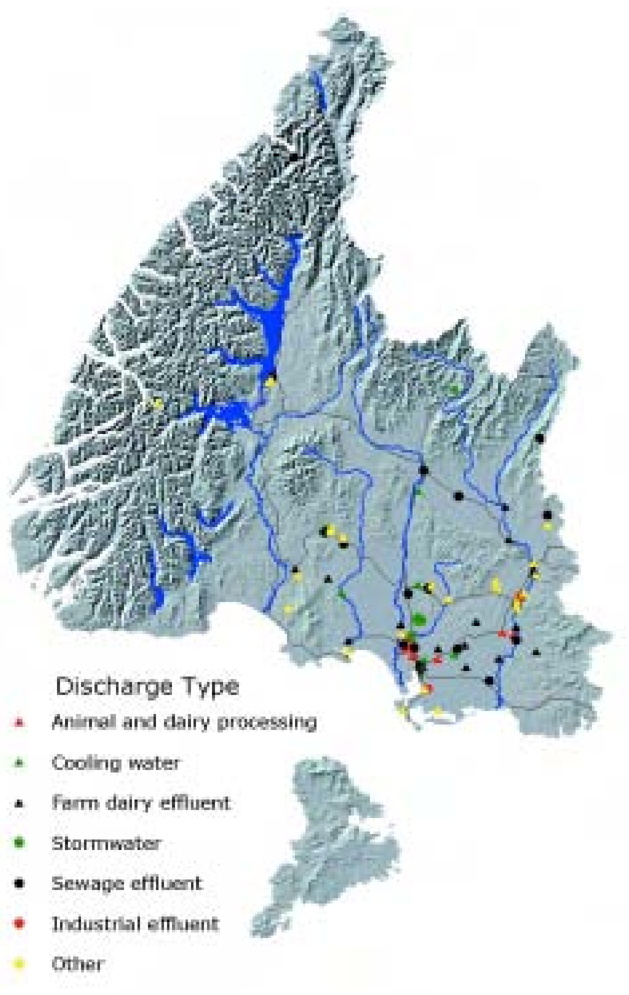

Figure 14 Location of consented point source discharges to Southland's waterways (as at June 2000)

However, in spite of these improvements, point source discharges still have a significant impact on water quality and ecosystems, especially in the lower Mataura and lower Makarewa rivers.

Discharges to land

The total volume of wastewater discharged to land in the Southland region has more than doubled over the last decade and now totals over 23,000 cubic metres per day. Much of that increase is due to expansion of the dairy industry, which has increased by an estimated 9,500 cubic metres per day. While nearly all dairy farms now use land-based effluent disposal systems, it is estimated[1] that this only represents about five to ten percent of the total animal waste produced on a dairy farm. The remaining 90 or more percent is discharged as excreta directly to paddocks, providing a potentially significant non-point contaminant source.

Other significant quantities of wastes discharged to land include meat-processing wastes, and treated sewage. All of these effluents are high in nutrients, faecal bacteria, and oxygen depleting substances (BOD). The locations of consented discharges to land are shown on Figure 15.

[1] Greenwood, P.B. 1999. Irrigation of Farm Dairy Effluent in Southland. Report prepared by SoilWork Ltd for the Southland Regional Council.

The Mataura River

The water quality of the Mataura River has been a concern because of its value as a fishery and pressures from non-point and industrial discharges. Bathing in the lower Mataura River poses a heath risk to humans, and during summer low flows, experiences growths of sewage fungus and extensive proliferations of algae.

Since the Southland Catchment Board undertook the first systematic water quality survey in the mid-1970s, the quality of point source discharges to the lower river has improved. This is due to improved treatment of point source discharges, removing BOD and suspended solids. In 1975, the BOD loading from point source discharges to the river was over 15.5 tonnes per day. In 2000 it was just over 3 tonnes per day. The volume of suspended solids has also reduced dramatically, from 16 tonnes per day in 1975, to just over one tonne per day. A marked improvement in the appearance of the river, with considerable reductions in surface scums and foams (see photos) have also accompanied these changes, most of which have come about through improved effluent treatment at the Alliance's Mataura meat plant.

The situation is less clear with nutrients and faecal bacteria. In part this is because differences in measurement techniques between the early and more recent surveys preclude simple comparisons. However, the quantities of faecal bacteria and nutrients (and particularly phosphorus) in point source discharges remain a significant water quality issue for the lower Mataura River.

Two photos of the Mataura River looking upstream from the Mataura bridge. The photo on the left was taken in 1978 just prior to major improvements in effluent treatment.

The photo on the right was taken in 1979, following improvements in effluent treatment.

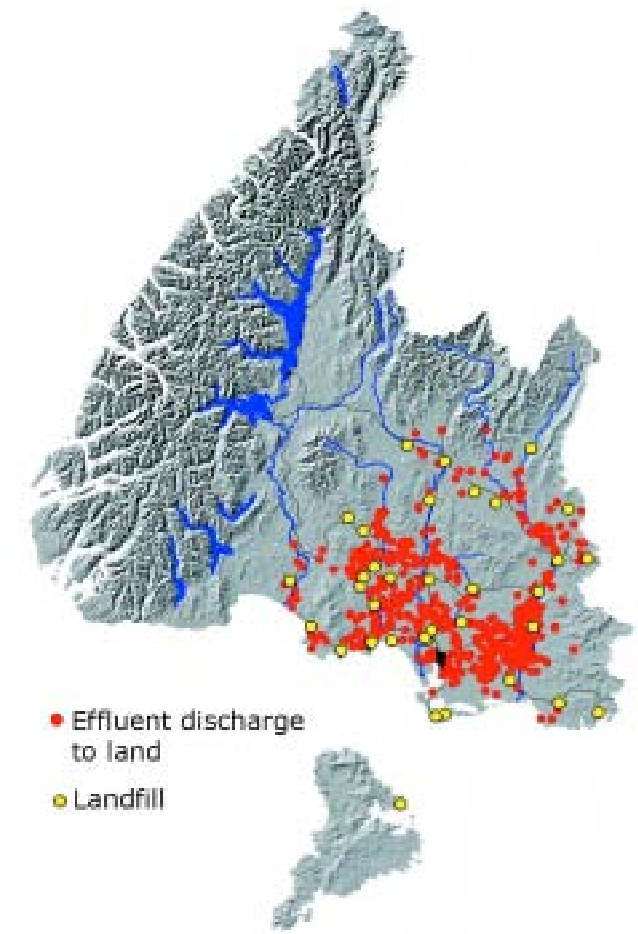

Figure 15 Location of consented discharges to land, as at June 2000.

Septic tanks

Much of Southland's population relies on septic tanks for sewage disposal. Septic tank effluent can be a significant contributor of a range of potential contaminants, most notably nitrate and bacteria, but under most situations their impact is probably negligible. Potential problems exist where the density of septic tanks is relatively high, such as in unsewered townships like Edendale and Wallacetown, and where bores are located close to septic tanks.

Recent studies[1,2] in the Oteramika catchment investigated a range of land uses in the catchment, and assessed their relative contributions of nitrate to the aquifer. The studies estimated that the total nitrate contribution from Edendale, an unsewered township with a population of approximately 500, represented less than two percent of the total nitrate load to the aquifer. This compared with 45 percent from dairy, 20 percent from effluent irrigation, and 22 percent from forage cropping. While the overall contribution from septic tanks was minimal the study showed that on a unit area basis, the amount of nitrate leached to the aquifer from this source was the second highest of all land uses.

[1] *Rekker, J.H, 1998. Oteramika trial catchment groundwater studies: Studies into non-point source groundwater effects in Southland. Report to Southland Regional Council.*
[2] *Thorrald, B., Rodda, H., and Monaghan, R., 1998. Modeling land use effects on water quality in the Oteramika Catchment. Report to the Southland Regional Council.*

▲ Landfills & other waste disposal areas

All landfills and other waste disposal areas, whether operating or closed, have the potential to generate some adverse impacts on surface and groundwater quality. In 1995, there were 37 known municipal refuse disposal facilities in the region, including eight sites that are now closed. In addition, at least 14 refuse disposal sites are operated by private industry. Figure 15 shows the location of all the known refuse disposal facilities.

Offal pits are holes or trenches excavated for the disposal of dead animals. With some exceptions, most dead stock are disposed of on farm. There are approximately 4,700 farms in Southland and it is reasonable to assume that the majority of these farms have some type of offal hole. It is estimated[1] that as many as 400,000 animals are disposed of in offal pits within the Southland Region each year.

▲ Water pollution incidents

Unauthorised pollution incidents – whether accidental or deliberate – place constant pressure on our fresh water resources and ecosystems. Our knowledge of unauthorised pollution incidents relies largely on public complaints. The numbers of incidents recorded are, therefore, more of a reflection of what gets reported rather than the number of incidents that occur.

Figure 16 shows the number of water-related pollution complaints received by Environment Southland for 1998 and 1999.

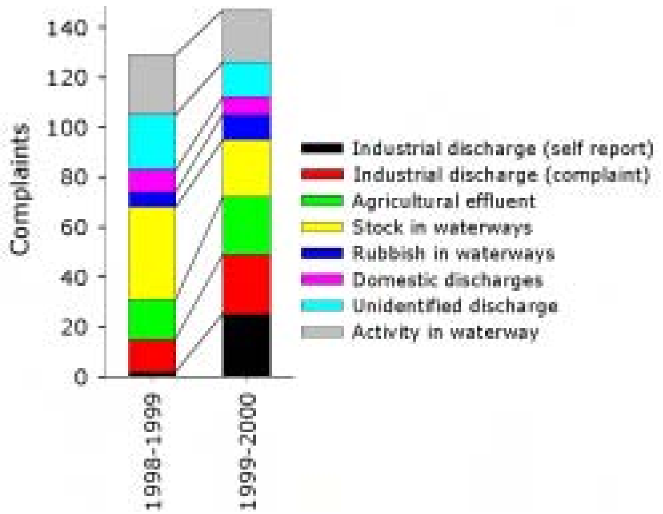

Figure 16 Number of water pollution related complaints in 1998 and 1999.

Depletion of surface and groundwater resources

With its generally reliable and abundant rainfall, and a relatively low demand for surface and groundwater resources, Southland has traditionally had few problems in terms of water availability. In recent years, however, there have been increasing signs that our water resources are under pressure – groundwater in particular.

The 1998-99 drought demonstrated that Southland is not immune from drought and its effects. And while drought has been a relatively rare event in recorded history, an increasing demand for water, coupled with uncertainties of climate change, means that the depletion of Southland's water resources is an issue of increasing importance.

The Issues

▲ Depletion of surface water resources

Rivers, lakes and wetlands support a range of instream values that are largely sustained by a sufficient quantity of water and a particular flow regime. Out-of-stream uses, such as the abstraction, damming and diversion of surface water, can reduce water quantity and alter flow regimes in waterbodies, which can have a number of adverse effects on instream values, including:

- reduction in the quality and quantity of aquatic habitat;
- diminished natural character, amenity, aesthetic and landscape values;
- impact on recreational use;
- impact on cultural and spiritual values;
- reduction in water quality, through decreased dilution capacity and increased temperature;
- reduction of water available to meet the needs of existing and future users; and
- reduction in groundwater recharge rates.

Activities that abstract, dam or divert surface water are important for economic, social, and community health and safety reasons (e.g., surface water use is fundamental for drinking water supply, irrigation, agriculture, industry and power generation). These human use values can also be adversely affected by low flows. At times when water quantity is limited, therefore, there can be a conflict between protecting in-stream values (e.g., ecological and recreational values) and maintaining human use values.

[1] Southland Regional Council, 1996. Regional Solid Waste Management Plan

The total amount of water abstracted from Southland's surface water resources is large by New Zealand standards – some 14 cubic kilometres of water per year. However, more than 99.9 percent of this is abstracted from the Waiau River for power generation.

Excluding the Waiau River, abstractions have historically exerted little pressure on the available surface water or the ecosystems they support, except under very low flow conditions. Nevertheless, intensification of land use is likely to increase the demands on water resources, particularly in drier areas or those where groundwater supplies are limited. Exotic forestry, which is believed to have a significant impact on surface water flows in some parts of the country, is increasing in Southland.

▲ Depletion of groundwater resources

The abstraction of groundwater can have short or long-term adverse effects on aquifer volumes and levels, which in turn can cause:

- a depletion of aquifer storage volumes with an associated reduction in groundwater availability to existing and future users;
- adverse effects on existing bore or well yield due to interference or drawdown effects;
- diminished river and stream flows, and wetland and lake water levels; and
- adverse effects on groundwater quality due to changes in groundwaterflow characteristics.

The significance of these adverse effects depends on the volume and rate of abstraction and on the characteristics of the aquifer from which the water is abstracted.

The shallow, unconfined gravel aquifers are generally of moderate to low permeability and are recharged by localised rainfall. As a result variations in seasonal recharge and abstraction rates can cause significant fluctuations in groundwater levels. On the other hand, the confined and semi-confined aquifers that underlie the gravels generally have a low storage capacity. Abstraction from these aquifers can therefore cause significant drawdown of groundwater levels over a wide area. There is a lack of reliable information to establish groundwater level trends over time in Southland aquifers. However, anecdotal evidence suggests that groundwater levels have declined significantly in some areas in recent years, which may in part be due to the effects of abstraction. In other parts of the Region, groundwater use may not be a significant problem.

The Pressures

▲ Surface and groundwater abstraction

There are approximately 92 consents to abstract surface water and 79 consents to abstract groundwater in Southland. The location of consented surface water and groundwater abstractions, together with their purpose, are given in Figures 17 and 18, respectively.

Total consented water use at 30 June 2000 was approximately 16,083,459 million cubic metres per year (m^3/year). Abstraction from the Waiau River for power generation accounted for more than 99 percent of this total. Of the remainder, 77.2 million m^3/year is taken from surface water and 21.8 million m^3/year from groundwater. The purposes for which this water is abstracted are shown in Table 9.

While the above figures and those contained in Table 9 give an indication of overall water use in Southland, the quantities are not precise because Environment Southland only has information for water abstractions that have a consent.

Table 9 Consented surface water and groundwater abstractions by usage as at June 2000.

Usage	Surface water abstractions m^3 (million)	Groundwater abstractions m^3 (million)	Total abstractions m^3 (million)	% of total abstraction generation)
Irrigation	12.3	4.2	16.5	16.7
Water Supply				
Town	23.3	9.9	33.2	33.5
Rural	0.9	0.7	1.6	1.6
Private	1.2	0.5	1.7	1.7
Industry	37.7	6.5	44.2	44.6
Mining	1.8	0.0	1.8	1.8
Sub-total	**77.2**	**21.8**	**99.0**	
Power Generation	16,083,360	0.0	16,083,360	
Total	**16,083,437**	**21.8**	**16,083,459**	

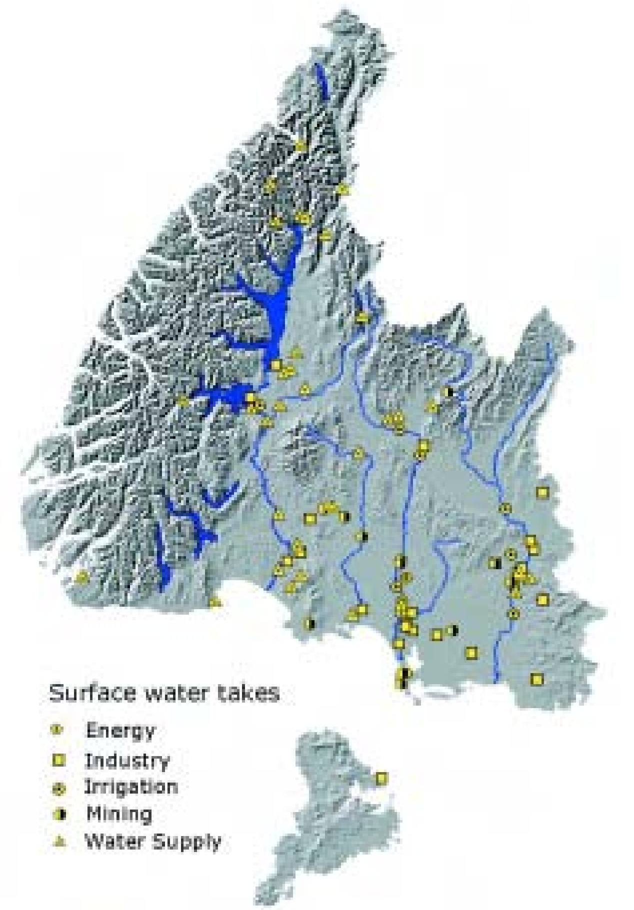

Figure 17 Location of consented surface water takes, as at June 2000.

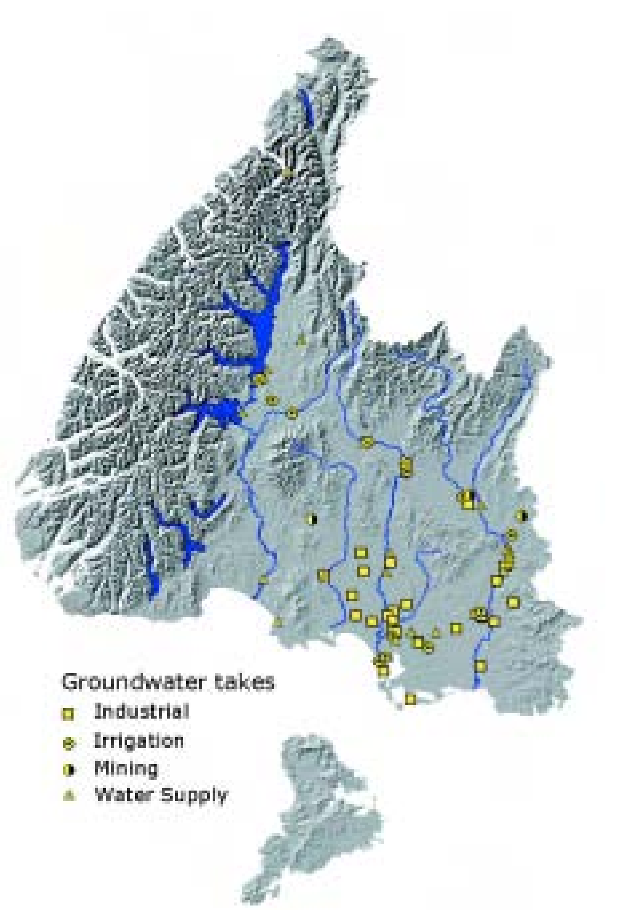

Figure 18 Location of consented groundwater takes, as at June 2000.

Consents are not currently required where water is abstracted for:

- reasonable domestic needs;
- reasonable stock water needs;
- washing down cow sheds and other factory farm ventures;
- milk cooling purposes on dairy farms; and
- a range of other minor activities.

Most of these permitted uses require high quality water, thereby limiting the extent to which surface water is used. Consequently, most of the water abstracted for these permitted uses will be drawn from groundwater. It is estimated that the actual volume of groundwater abstracted in Southland could be up to twice the consented volume.

The quantities of surface and groundwater taken by *consented* abstractions shows little change in recent years. However, there has been some increase in *permitted* abstractions (ie those for which no consent is required), especially in the use of groundwater by the dairy industry.

Restored habitat following gravel extraction, Oreti River.

Modification of aquatic habitats

The beds and margins of a waterbody, whether it is a river, lake or wetland, are integral and important parts of aquatic ecosystems. They provide habitat for aquatic fauna and flora, and the processes that go on within them are essential for healthy functioning ecosystems. This discussion focuses on two issues: a) loss of riparian margins and b) disturbance and modification to the beds of waterbodies.

Habitat and the Giant Kokopu

The giant kokopu is the largest galaxiid fish in the world. It generally grows up to 20 to 30 cm long, although some 60cm specimens have been recorded. They can live for up to 27 years.

For most of their lives giant kokopu live in lowland streams and wetlands and eat koura (fresh water crayfish) and insects. Newly hatched giant kokopu migrate to sea for the winter and are sometimes caught in whitebait nets when they return home in November. Also known as 'native trout,' the adults were a valued food resource for Maori.

Giant kokopu have become rare with a reduction in suitable habitat. They need streams and wetlands with cover to hide beneath; logs, tree roots, overhanging banks and overhanging vegetation are excellent. Provided there is sufficient cover, even small drains will support giant kokopu.

Two views of streams of the Oteramika Catchment near Edendale. The photo on the right shows good giant kokopu habitat, while the photo on the left shows poor habitat.

The Issues

▲ Loss and modification of riparian habitats

There is increasing recognition of the important role that riparian margins play in the maintenance of productive and stable catchments. The most important component of riparian margins is its vegetation. Recent work[1] (see Box: Habitat and the Giant Kokopu) has indicated that well vegetated riparian margins are the major factor affecting the abundance and distribution of aquatic biota in small Southland streams. Riparian vegetation plays several key roles, including:

- *bank stability:* riparian vegetation plays a major role in maintaining the equilibrium of streams and banks, and controlling erosion;
- *ecology and habitat:* vegetated riparian zones are important for maintaining biodiversity. They act as wildlife corridors, and also provide a significant proportion of the food, shelter and breeding sites that aquatic organisms require;
- *buffering and filtering:* vegetated riparian margins form an important buffer and filter strip between landuse and watercourses, intercepting surface water flow and trapping sediment particles and pollutants;
- *temperature control:* in Southland many of our lowland smaller to medium sized streams have lost shading through changes in riparian vegetation. This has led to higher daytime water temperatures in summer. Increased temperatures stress or kill invertebrates and fish and, when combined with increased nutrients, promote algal blooms; and
- *sunlight control:* riparian vegetation reduces the amount of sunlight which in turn limits the growth of algae and other aquatic plants.

Agricultural development has had the most impact on riparian vegetation in Southland. Economic pressures to create additional pasture led to the removal of much of the riparian vegetation along the margins of many rivers and streams in Southland. Agricultural development has also been the driver for much of the encroachment on and loss of wetlands, particularly in lowland Southland.

While the impacts of agricultural expansion on riparian margins have been significant, there have and continue to be other major pressures. Stock access to riverbanks and riparian margins continues to be a problem.

Urban encroachment, a major pressure on riparian margins in more urbanised areas, has been less significant in Southland. Nevertheless, it has had a profound effect on many of the streams in the greater Invercargill area.

The need to protect our communities and livelihoods from the effects of flooding has seen rivers realigned and their banks raised and cleared of vegetation in an effort to remove floodwaters quickly. Where riverbanks were eroding, often as a result from the removal of the original riparian vegetation, introduced species were planted to protect valuable farmland. Some species, such as willow, spread so invasively that they choked and excluded native species. Ironically, these species planted to protect farmland have themselves magnified flood problems.

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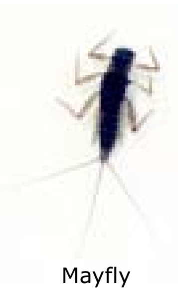
[1] Ryder, G., 1997. Oteramika Catchment surface water biological monitoring surveys. Report prepared for the Southland Regional Council.

Disturbance and modification of river and stream beds

River and streambeds are home to an enormous variety of aquatic animals and invertebrates. Benthic macroinvertebrates are the (mainly) small fauna that inhabit the beds of river and streams, and include the multitude of insects and their larvae, snails, and worms that characterise these fresh water environments.

The numbers of macroinvertebrates that inhabit streambeds can be truly astonishing. Studies have found that some areas of streambed in the Mataura River support populations of up to 5,500 *Deleatidium* mayflies per square metre. These very high numbers are believed to be an important factor contributing to the significance and productivity of the Mataura's brown trout fishery. Those same trout also use the same streambeds for spawning.

Deleatidium, along with other benthic macroinvertebrates, also represent the dominant food source for many native fresh water fish. Unlike trout, many of our native fish are secretive animals, and rely on streambeds for cover.


Mayfly larvae *(Deleatidium)* (Source K. Miller)

As well as their biodiversity values, the beds of rivers and streams also have important human use values. Much of our construction and road gravel is sourced from the beds of rivers and streams. Our rivers and streams are also important as channels for the conveyance of farm and land drainage water. Without them, large parts of Southland would be unsuitable for agriculture. However, the need to maintain that drainage through clearance and excavation can also conflict with biodiversity values.

The Pressures

Measuring the loss or modification of riparian habitats is problematic. Few data are available on the extent and quality of riparian vegetation cover bordering our rivers, lakes and wetlands. With thousands of kilometres of waterways, many of them little more than a few metres wide, data collection remains a challenge. Remote sensing techniques offer some promise, but at this time lack the necessary resolution.

One of the few pressures on riparian habitats for which some information is available, relates to river works activities.

River modification

The need to protect our communities and livelihoods from the effects of flooding has seen rivers realigned and their banks raised with stopbanks and fairways cleared of vegetation in an effort to remove floodwaters quickly. Where riverbanks were eroding, often as a result from the removal of the original riparian vegetation, introduced species were planted to protect valuable farmland.

Table 10 shows the length of stopbanks constructed by the Environment Southland and its predecessors as parts of comprehensive flood control schemes. These continue to be maintained by Environment Southland on behalf of the catchment ratepayers. In addition to those stopbanks shown in Table 10, there are also several hundred kilometres of private stopbanking.

Table 10 Extent of stopbanking in Southland. Only those stopbanks constructed by Environment Southland and its predecessor organisations are shown.

Catchment	Length (km)
Aparima	87
Invercargill City (Waihopai, Kingswell & Otepuni)	30
Makarewa	18
Mataura	113
Oreti	170
Whitestone (Waiau)	22
Upukerora (Waiau)	8
Total	**448**

Fairway clearance - the removal of vegetation to improve flood conveyance - has both positive and negative impacts on riparian habitat. Much of the vegetation now found in the fairways of our major rivers is dominated by introduced species such as gorse, broom and willow. These are highly invasive species and, in the 1960s and 70s, many river fairways became choked with such vegetation. From a riparian habitat perspective, the existence of such vegetation poses a dilemma. On one hand, it is poor quality habitat, increases the likelihood of damaging floods, and can significantly reduce access opportunities. Yet, it many situations, it is the only riparian habitat that exists.

A total of 544 kilometres of cleared river channel is maintained by Environment Southland using chemical spraying. Developments in chemicals and application methods allow greater selectivity of target species and reduced residual effects.

▲ Drainage channel maintenance

Southland's agricultural productivity owes much to its extensive land drainage system. Maintenance of that system, through clearance of aquatic plants and excavation of the bed is necessary to ensure sufficient outfall and effective drainage.

The drainage system comprises both natural, but often modified, streams, and artificial channels. The total length is not known, but is in the order of many thousands of kilometres. Environment Southland is responsible for the maintenance of 1400 kilometres of community drainage systems alone. Of that total, almost 90 percent are maintained by mechanical clearance, with the remained maintained by the use of herbicides.

As well as providing land drainage, the system also provides important habitat for aquatic plants and animals. Drain maintenance activities are, therefore, a potential significant pressure on aquatic habitat.

The evidence regarding the significance of maintenance activities on biota is unclear. Studies have shown measurable impacts on fish populations immediately following maintenance. Over longer time scales, one recent study[1] found no significant change six weeks after maintenance. Over time scales of years, there is less certainty on the effects of repeated maintenance activities, especially on long-lived sedentary species, such as kokopu.

▲ Gravel extraction

Gravel has long been extracted from Southland's riverbeds for use in the local construction industry. Extraction has the potential to impact on aquatic biota living in or adjacent to the extraction site. In addition, the timing of the activities is important, because of the potential impacts on fish migrations and spawning.

Since 1993, an average of 162 consents per year has been issued to extract 1.05 million cubic metres of gravel annually. On the basis of returns, the actual amount of gravel removed is considerably less – an average of 420,000 cubic metres each year.

Over the last seven years, most of the extracted gravel has been obtained from three rivers:

- the Aparima (78,000 cubic metres per year);
- the Oreti River (204,000 cubic metres per year); and
- the Mataura River (79,000 cubic metres per year).

In the last three years, the allocation of gravel from the Mataura River has been reduced to 24,000 cubic metres per year. This is in response to problems arising from historic over-extraction of gravel from that river

Biological pressures on habitat and biodiversity

Southland's rivers, lakes and wetlands have important biodiversity values and nearly 80 percent of all the known species of New Zealand's native fish fauna have been found in the region's various fresh water habitats. The biodiversity values are not restricted to indigenous species, and the quality of Southland's trout fishery is internationally recognised.

While most of the issues discussed previously relate to physical or chemical pressures on our fresh water resources and ecosystems, biological pressures are also of concern. The most significant of these relates to the impacts imposed by introduced plants and animals.

The Issues

▲ Spread of introduced species in aquatic habitats

A long geological isolation from other landmasses, coupled with a relatively recent colonisation by humans, has allowed New Zealand to develop a unique indigenous biodiversity. However, that uniqueness is a two-edged sword, for it means that our indigenous flora and fauna are also highly susceptible to the impacts of introduced species.

The ecological, cultural and economic impacts of introduced pest species are immense and ongoing. A recent report[2] suggests that the economic burden of introduced pest species costs New Zealand over $840 million per year. In terms of terrestrial ecosystems, it has been suggested[3] that introduced pest species have become the greatest single threat to biodiversity, surpassing even habitat loss.

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[1] Goldsmith, R.J. 2000. The response of fish populations in Southland streams to the disturbance of macrophyte removal. University of Otago Wildlife Management Report Number 119.
[2] Hackwell, K, and Bertram, G., 1999. Pests and Weeds: A Blueprint for Action. New Zealand Conservation Authority.
[3] Department of Conservation & Ministry for the Environment, 1998. New Zealand's Biodiversity Strategy. Our Chance to Turn the Tide. A Draft Strategy for Public Consultation.

The exotic species that are found in our fresh water ecosystems have been introduced either deliberately or accidentally. The most obvious deliberate introduction is our exotic fish fauna, which include trout, salmon and perch, introduced over a century ago by sports anglers and acclimatisation societies with little thought to their impact on native species. We now know that trout and salmon, and in particular brown trout, are aggressive feeders, and are known to compete with or predate on native species for both food and territory.

All introduced species have had some adverse impact on our indigenous biodiversity, although not all are universally regarded as pests. Trout, are a highly valued recreational and economic resource that is protected by legislation.

The threat that pest plants pose to our fresh water ecosystems is significant in two ways. Firstly, they are often aggressive colonisers, crowding out native species and significantly altering fresh water habitats. Secondly, there are many means by which they can be spread, including:

- escape or release from aquariums, farm ponds, and aquaculture;
- transfer from infected sites by boats; and
- transfer by animals (e.g., birds).

The Pressures

▲ Distribution & abundance of exotic species

Six species of exotic fish (Table 11) are known to exist in Southland waterways. All were introduced in the 19th century by sports anglers and acclimatisation societies.

Aside from perch and salmonid species (trout and salmon), there are no records of self-sustaining populations of other exotic fish in Southland waterways.

Table 11 Exotic fresh water fish in Southland

Common name	Scientific name	Distribution
Rainbow trout	*Oncorhynchus mykiss*	Restricted to Waiau catchment abundant
Quinnat salmon	*Oncorhynchus tshawytscha*	Widespread but not common
Perch	*Perca fluviatilis*	Widespread and locally abundant
Atlantic salmon	*Salmo salar*	Restricted to Waiau River above Lake Manapouri. Not common
Brown trout	*Salmo trutta*	Widespread and abundant
Brook char	*Salvelinus fontinalis*	Very localised and rare

Southland's waterways contain at least seven species of introduced aquatic plants. However, the total number of species, together with their abundance and distribution is not well known. Some exotic aquatic plants, together with their known distribution, are listed in Table 12.

Table 12 Exotic aquatic plants in Southland

Scientific name	Common name	Distribution
Lagarosiphon major	Oxygen weed	Waihopai River, Otepuni Stream; Drummond
Elodea canadensis	Oxygen weed	Widespread throughout all catchments
Ranunculus tricophyllus	Water buttercup	Widespread throughout Waiau catchment
Juncus bulbosus	Bulbous rush	Lake Hauroko
Myosotis laxa	Water forget-me-not	Lakes Manapouri, Hauroko and Lochie
Ranunculus flammula	Water buttercup	Lake Lochie
Callitriche stagnalis	Starwort	Kingswell Creek

Arguably, the greatest threat posed by an existing exotic aquatic plant is that of the oxygen weed *Lagarosiphon major. Lagarosiphon* is a difficult to eradicate and highly invasive species that takes over from native species by decreasing the amount of light penetrating the water. *Lagarosiphon* growths can also significantly reduce dissolved oxygen levels, as well as impacting on or reducing recreational opportunities, such as boating, fishing and swimming. Ironically, boating is implicated as one of the main means by which the weed has been spread between waterbodies.

Lagarosiphon was first reported in the Southland region in the 1960s from a site on the Waihopai River at Kennington, where it is believed to have been deliberately introduced in a misguided attempt to improve water quality. A survey[1] carried out in 1998 confirmed the existence of *Lagarosiphon* in the lower reaches of the Waihopai River, together with additional sites in the Otepuni Creek and a farm pond at Drummond.

[1]Schwartz, Anne-Marie, 1998. Investigation of management options for Lagarosiphon major in the Invercargill area. NIWA Client Report: CHC98/37.

How do we measure up?

State of fresh water & ecosystems

This section looks at the state or condition of our fresh water resources and ecosystems. Much of the assessment is focussed around physical, chemical and biological indicators that give an indication of the state of those fresh water resources and ecosystems. Where possible, those indicators are assessed in terms of the values we place on our fresh water resources and ecosystems.

Any discussion on state is most usefully framed in terms of our aspirations for a particular resource or ecosystem. Water management objectives from the Proposed Regional Fresh Water Plan have been included, in a simplified form, to provide that context.

The state of water quality

The quality of water is described in terms of:

- its current state (based on the most recent one to three years of data) across the region or within a catchment or aquifer; and
- whether the state is changing through time.

Water quality can only be assessed meaningfully when it is related to a particular use or environmental value. Water quality need not be the same for all uses and water that is good for some uses may be unacceptable for others. For instance, water that is unacceptable for swimming because of microbial contamination might still be suitable for industrial cooling water.

Appendix 1 lists the water quality standards and guidelines used to assess water quality.

Environment Southland's goals

The Proposed Regional Fresh Water Plan contains a range of goals and objectives relating to the quality of Southland's surface fresh water resources. Broadly speaking, these seek to prevent any further deterioration in quality and, where possible, bring about improvements.

The Proposed Plan aims:

- *To protect surface water quality throughout the region and maintain existing high water quality in the Fiordland National Park and on Stewart Island.*
- *To maintain or enhance surface water quality in designated catchments to be suitable for native fish, brown trout, contact recreation and water supply purposes by the year 2010:*
- *To maintain and enhance the water quality of lowland rivers and lakes (outside Fiordland National Park and Stewart Island) so that they are, at a minimum, suitable for stock drinking, native fish and brown trout by 2005 and for contact recreation, in terms of human health risk, by the year 2020.*

The Proposed Regional Fresh Water Plan's objective for groundwater quality is that aquifers meet drinking water standards by the year 2010.

How do we measure up?

▲ Is surface water quality suitable for swimming? - faecal bacteria

Excessive faecal contamination currently presents an unacceptable health risk in many Southland rivers (see Figures 19 and 24 and Box: Bad Bugs).

Most of the Mataura River poses a health risk to swimmers. Only in the headwaters above Parawa, and in the upper reaches of the Waikaia River does water present a low health risk.

Faecal contamination has worsened in the Mataura River (at Otamita) since 1975 and sampling near Gore since 1994 has confirmed this deterioration.

The headwaters of the Oreti and Aparima rivers have excellent water quality, but faecal contamination causes a health risk to bathing the in the lower reaches. Faecal contamination has not changed in either river since 1994, but there has been an improvement in the Oreti River since 1977[1] and early records suggest a deterioration in the Aparima river.

The Fiordland lakes and most of the Waiau River have excellent water quality. At Tuatapere faecal contamination has increased since 1979 and the health risk is now border-line. No change has occurred since 1994.

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[1] *Data from Invercargill City Council at Branxholm.*

Catchments with high intensity landuse have more faecal contamination than catchments with low intensity landuse. Dairy farms are sometimes blamed, but excessive faecal contamination has also been found in areas dominated by exclusively sheep and beef farms. Land management is just as important as landuse to prevent faecal material entering streams with runoff or from stock in the water.

▲ Is surface water quality suitable for aquatic life? - harmful substances

Most rivers contain very little BOD and ammonia. Discharges to the Mataura and Makarewa rivers occasionally have enough BOD to allow sewage fungus to grow. But fish kills are infrequent and are usually associated with unexpected effluent spills.

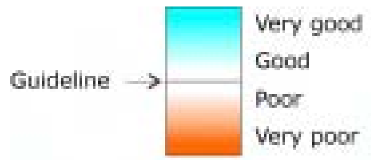
It has not always been this way. In the 1970s, prior to improvements in effluent treatment, dissolved oxygen was depleted to low levels in the Mataura River and high ammonia levels excluded fish from parts of the Makarewa River.

Records from the last 10 years show a continued trend towards less BOD in the major catchments (where monitored) (see Figure 20).

Ammonia levels have decreased over the last 20 years in the Mataura, Oreti and Waiau rivers. This improving trend has continued since 1989 in the Oreti and Waiau rivers (see Figure 21). However, a deterioration has occurred in the Waituna Creek, and there has been no recent (5 year) improvement in the Makarewa River (at Taramoa) which still rates poorly.

Long term improvements in the levels of ammonia and BOD probably reflect better treatment of effluent discharges entering the rivers, but some of the recent (5-10 year) improvements could reflect climatic factors.

Key to reading the maps



The position of the arrow shows the existing water quality in relation to the guideline. Blue is better than the guideline, red is worse.

The direction of the arrow shows where water quality is trending. An arrow pointing horizontally indicates no change.

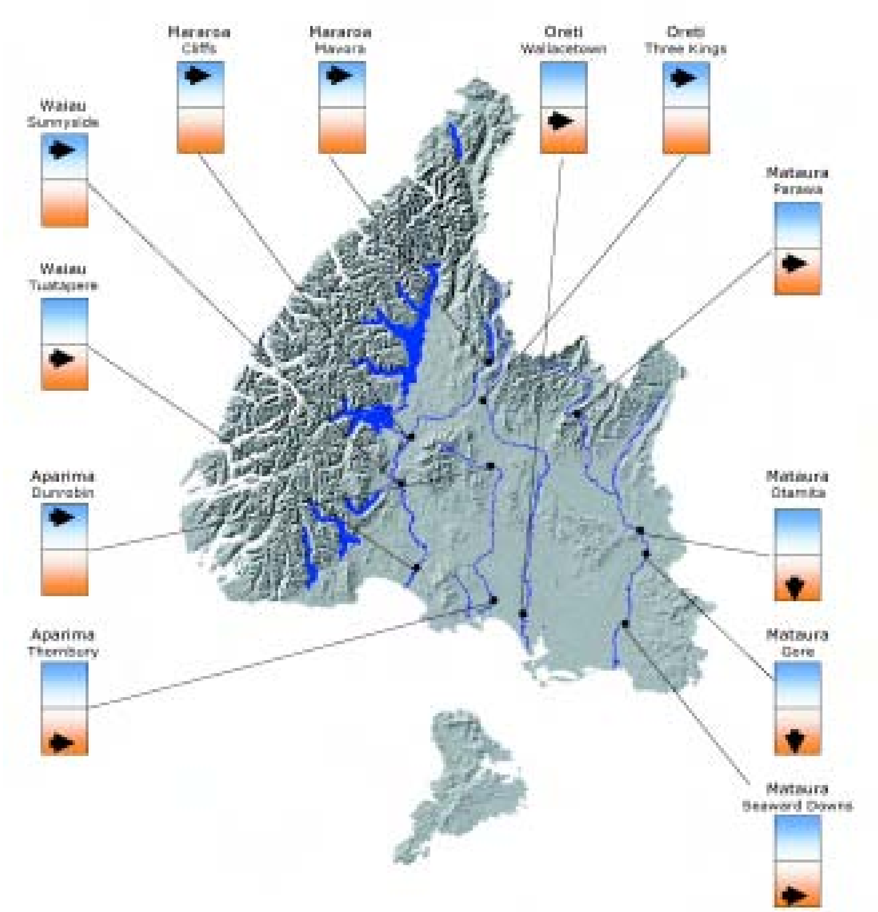


Figure 19 Faecal bacteria levels and trends

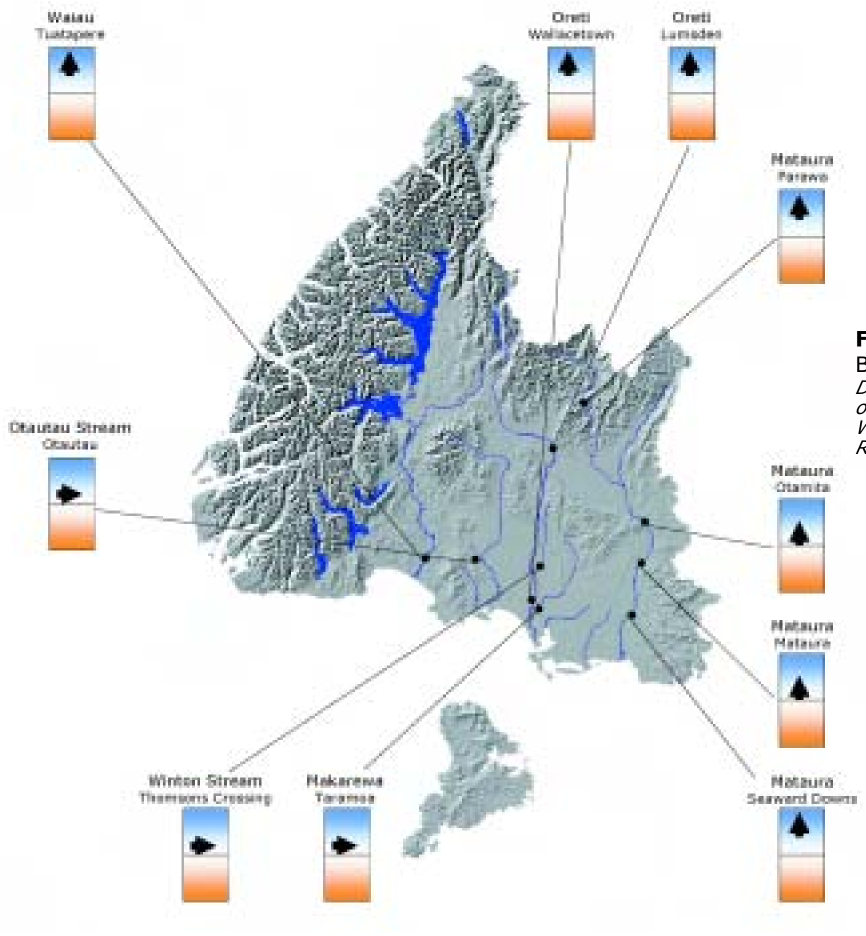


Figure 20
BOD levels and trends.
Data at some sites courtesy of National Institute of Water and Atmospheric Research

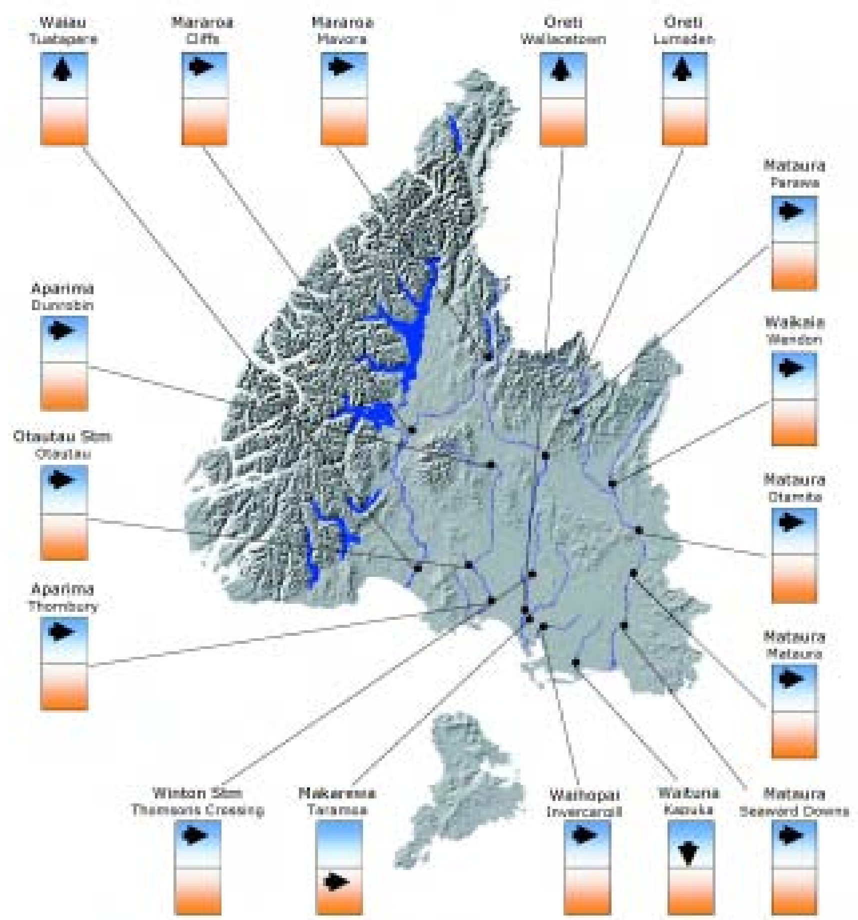


Figure 21
Ammonia levels and trends

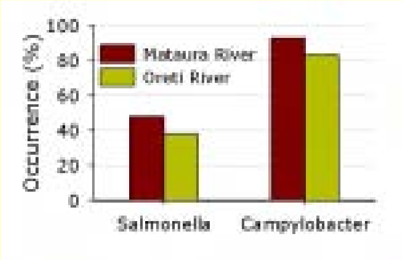
Bad Bugs

"Is the water safe?" The answer to this question depends in part on the presence or absence of pathogens—viruses, bacteria, and protozoans that can cause disease. Increasingly, monitoring and regulatory emphasis is focused on the presence of pathogens that may lead to waterborne diseases in humans and domestic animals. Pathogens can enter a waterbody from a range of sources, including inadequately treated sewage, faulty or leaky septic systems, farm and urban runoff, and wildlife.

Direct testing for pathogens is very expensive and generally impractical. Instead, monitoring for pathogens uses "indicator" bacteria—so called because their presence indicates that faecal contamination may have occurred. The bacteria most commonly used as indicators of faecal contamination are total coliforms, faecal coliforms, *Escherichia coli (E. coli),* and enterococci. Although indicator bacteria do not necessarily cause illness, they are normally abundant in human waste where pathogenic organisms are also likely to exist.

In New Zealand freshwaters, the relationship between indicator bacteria and pathogens is poorly understood. To provide the much-needed information, the Ministry for the Environment is co-ordinating a four year microbiological research programme (the "Bad Bugs" programme) to investigate disease-causing organisms in fresh water. Two Southland sites, one on the Oreti River at Wallacetown and the other on the Mataura River at Gore, were each sampled 29 times between December 1998 and February 2000.

The "Bad Bugs" programme identified potential pathogens at both sites. Two of those, salmonella and campylobacter, were commonplace. The adjoining figure shows the percentage of samples taken during the programme that was contaminated with each pathogen.



Campylobacter is the major cause of human gastro-enteritis in New Zealand, while salmonella and campylobacter are the two most common causes of abortion in sheep. While the health significance of the findings is not yet well understood, the study does confirm the presence of pathogens in Southland's waterways.

▲ Is surface water quality suitable for aquatic life? - nutrients

Nitrogen and phosphorus are important nutrients for plant growth both on farms and in rivers. However, unlike pasture, the rapid growth of plants and algae in rivers can degrade the habitat of aquatic fauna, as well as reducing aesthetic and recreation values.

The upper catchments of the region's major rivers contain little nitrogen, but excessive concentrations are common in lowland areas. (Figures 22 and 24). Nitrogen concentrations have increased in all of the major catchments in the last two decades, with degradation being particularly rapid in the last decade. Only the Otautau Steam, a tributary of the Aparima River, has shown any improvement in nitrogen levels. The bulk of the nitrogen in Southland rivers is derived from non-point sources, in particular those associated with cropping, intensive grazing, and fertiliser usage. The increase in nitrogen probably reflects an increase in these activities.

Low phosphorus concentrations limits the growth of algae in many Southland rivers (Figures 23 and 24). However, increasing phosphorus concentrations have been recorded in all the major catchments. No sites are showing an improvement. While nitrogen levels fail the guidelines in nearly all the developed catchments, the lower levels of phosphorus are currently limiting ecosystem degradation. This may be short-lived, however, if phosphorus levels continue to rise.

The sources of phosphorus vary between rivers. Point sources are significant, especially in the Mataura where the bulk of the phosphorus loading to the river comes from sewage and meat works discharges. This is evidenced by the significant increases in algal growth downstream of the meat works discharge at Mataura, which has degraded the habitat to the extent that mayfly populations in the river are severely reduced immediately downstream of the discharge (see Box: Phosphorus, algae and the Mataura mayfly). Point sources are believed to make significant contributions of phosphorus to Winton Stream and the Makarewa and Waihopai rivers.

As with nitrogen, non-point sources arising from intensive agricultural land use also contribute phosphorus. Because phosphorus has a strong affinity for soil, phosphorus contamination is likely to be linked to land use and management that results in soil erosion.

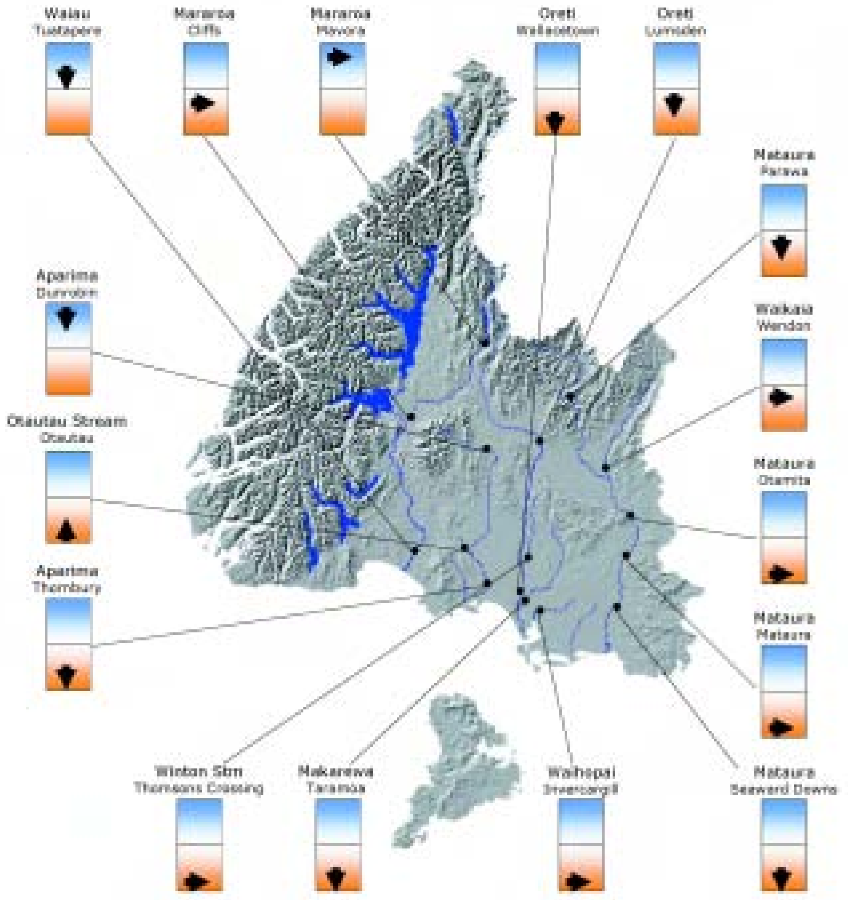


Figure 22
Nitrogen levels and trends
Data at some sites courtesy of National Institute of Water and Atmospheric Research

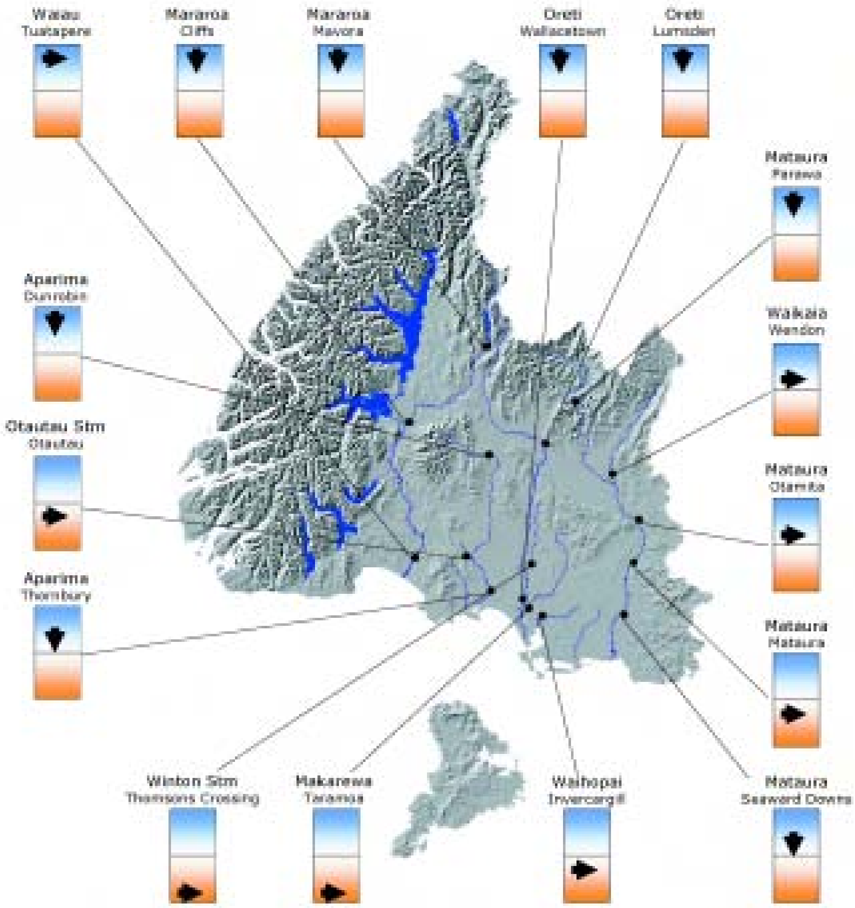
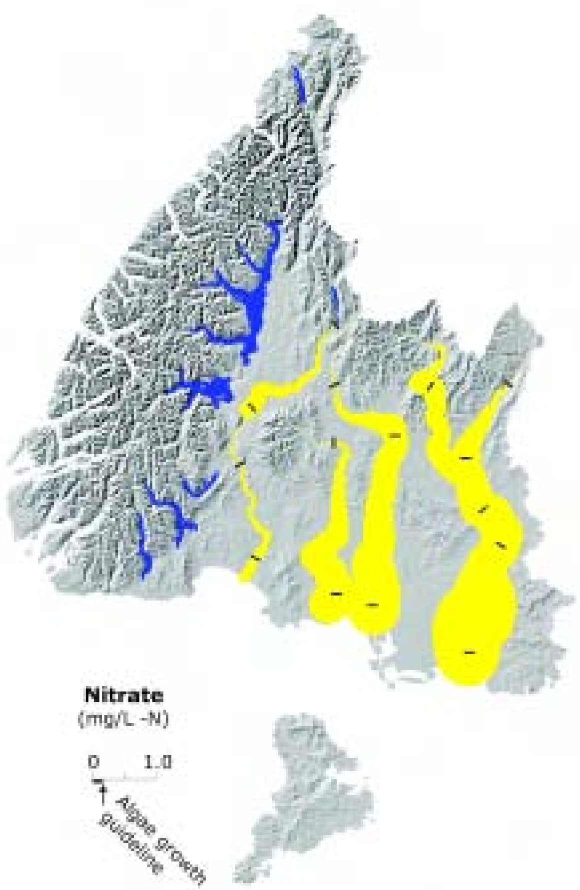
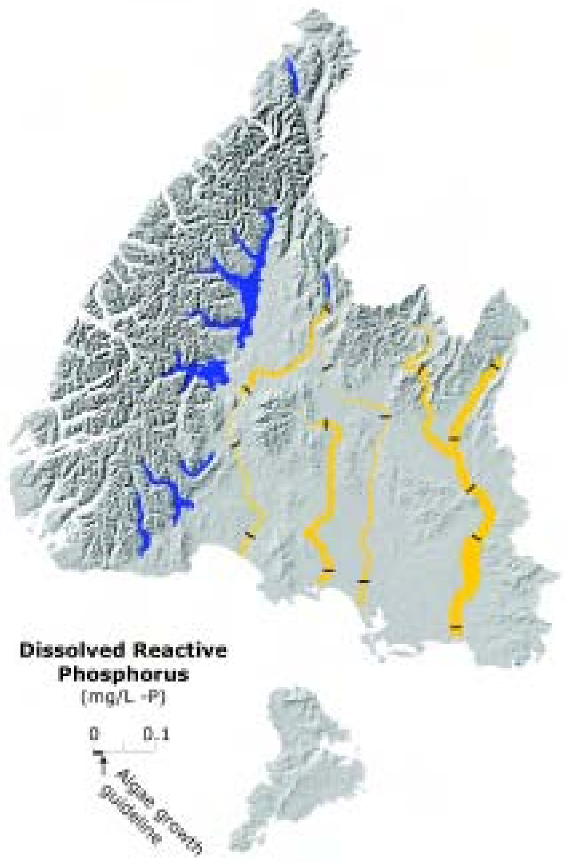


Figure 23
Phosphorus levels and trends
Data at some sites courtesy of National Institute of Water and Atmospheric Research





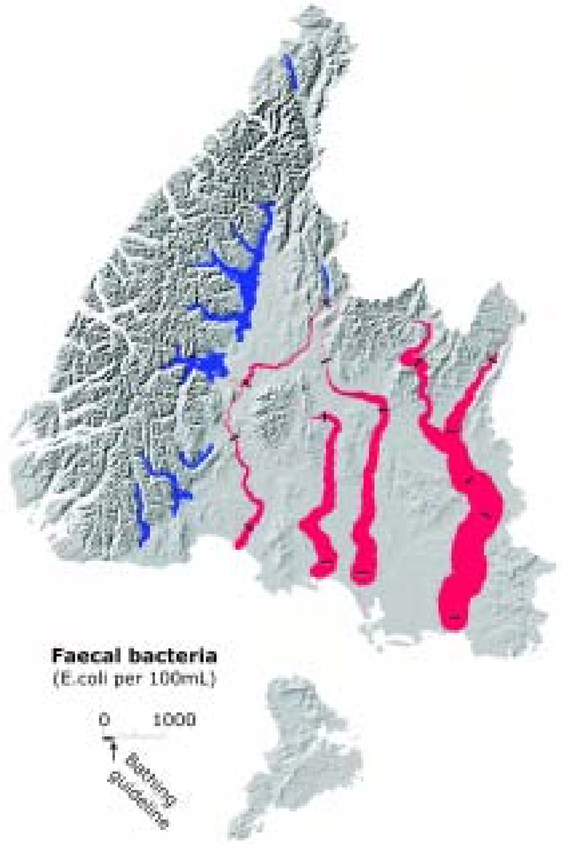


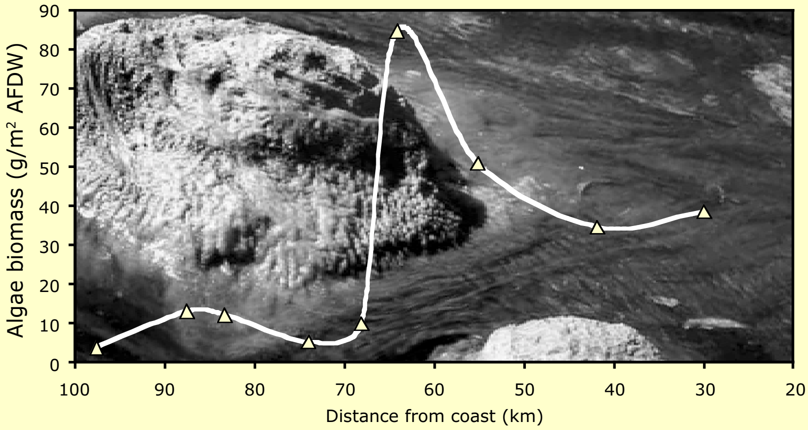
Figure 24 Levels of nitrate, dissolved reactive phosphorus, and faecal coliforms in the Waiau, Aparima, Oreti and Mataura rivers.

Water quality progressively declines as rivers flow through more intensively used land. These graphs depict increasing degradation by making the river width proportional to the level of contamination. The black bar at each sample site compares the median concentration in the river with guideline levels.

For scaling reasons the concentration of faecal bacteria immediately downstream of Mataura have been reduced to one-third of their true concentrations (i.e. actual median value 1700 FU/100ml).

Data at some sites courtesy of National Institute of Water and Atmospheric Research

Phosphorus, algae and the Mataura mayfly



The Mataura River is a superb brown trout fishery, with mayfly abundant throughout the river. Water quality declines markedly in the lower reaches where the river receives effluent from several point source discharges. The most significant phosphorus inputs to the river are associated with the discharge of freezing works effluent at Mataura.

With warm summer conditions and stable river flows, the high phosphorus inputs in the lower Mataura can result in widespread algal blooms. This is graphically illustrated in the figure at right. During the summer of 1998, algae progressively smothered the riverbed downstream of Mataura, excluding mayflies and other sensitive macroinvertebrates. With conditions at an optimum for growth, the amount of algae biomass increased dramatically, and the number of mayfly declined to less than half its original population. In contrast, sites further upstream had relatively stable populations of algae and mayflies.

▲ Does the water look clean? - water clarity

Water clarity measures the distance one can see through water. Poor clarity makes the water look dirty and restricts the ability of some fish to feed. Clarity also indicates the amount of suspended solids in the water, which can smother the stream bed. Water clarity greater then 1.6 metres (during base flows) is rated as good for swimming.

In the last two decades water clarity (Figure 25) has improved in the lower Waiau River and in the upper reaches of the Oreti and Mataura Rivers, reflecting the huge soil conservation efforts of the 1970s. Clarity has also improved in the Otautau and Winton streams.

However, clarity is deteriorating in the lower Mararoa River, and has not improved in the lower reaches of the Aparima, Oreti and Mataura rivers, suggesting that the sources of reduced clarity are now concentrated in lower catchments. Runoff and high stocking rates may be significant factors.

▲ Is groundwater quality suitable for drinking? - nitrate

Figure 26 shows the spatial distribution of nitrate levels in Southland aquifers. Nitrate levels are generally low along the periphery of the Southland Plains and increase in central areas where land use intensity is highest. Isolated areas such as the Oreti Plains and portions of the Mataura River floodplain exhibit elevated nitrate levels, close to the drinking water standard. The high nitrate levels detected in these areas are thought to reflect a combination of intensive land use and local geology which allows nitrate to leach relatively readily through thin permeable soils into the underlying unconfined aquifer.

Results of a recent regional ‘snapshot’ survey[1] showed that approximately three percent of bores and ten percent of wells contained nitrate concentrations in excess of drinking water standard. In the majority of cases these elevated levels were attributed to localised “hotspots” caused by poor wellhead protection allowing entry of surface runoff or the location of the bore or well in close proximity to a point-source discharge such as a septic tank.

On a regional scale, the major source of nitrate input into groundwater is likely to be from the leaching of dung and urine deposited by grazing animals. Other significant sources may include land disposal of effluent and fertliser application, as well as the cumulative impacts of point-source discharges such as septic tanks.

Due to a lack of historical monitoring data, it is not yet possible to assess whether recent changes in land use have had a significant impact on nitrate levels.

[1] *Hamill, K. D., 1998. Groundwater quality in Southland: a regional overview. Southland Regional Council Publication Number 96.*

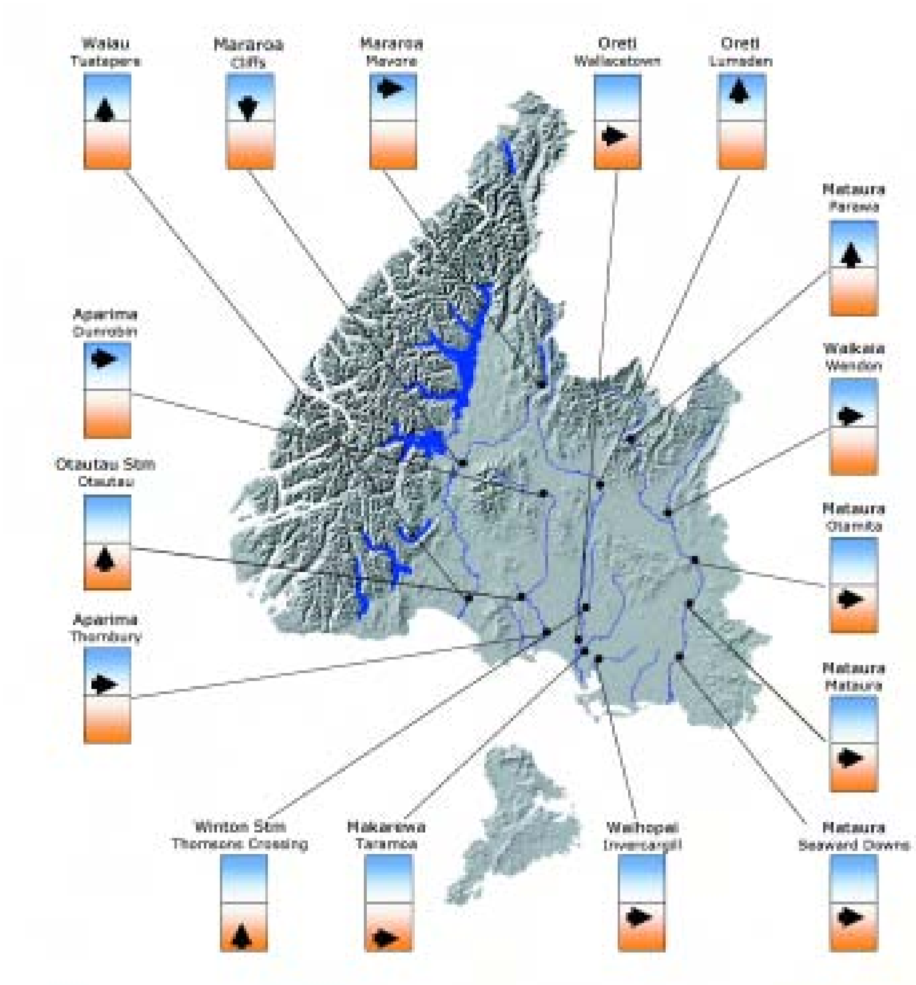


Figure 25 Water clarity levels and trends.
Data at some sites courtesy of National Institute of Water and Atmospheric Research

Is groundwater quality suitable for drinking? - faecal bacteria

Microbial contamination of groundwater is a widespread problem in Southland. Figure 27 shows the distribution of bores and wells in the 1997/98 'snapshot' survey that contained faecal bacteria indicating potential contamination. Overall, indicator bacteria were detected in 40 percent of the 350 wells and bores tested. No spatial patterns were observed in distribution of sites containing faecal coliform bacteria, suggesting this contamination is generally localised.

The type of well or bore used is likely to significantly influence the likelihood of microbial contamination. The snapshot survey showed that faecal coliform bacteria were present in 76 percent of the large diameter dug wells sampled, while 25 percent of bores showed similar contamination. The major factor contributing to this contamination appears to be poor wellhead protection allowing surface runoff to enter the bore or well, or contamination from a nearby point source discharge such as a septic tank, soakage hole or wintering pad. The higher proportion of wells affected by

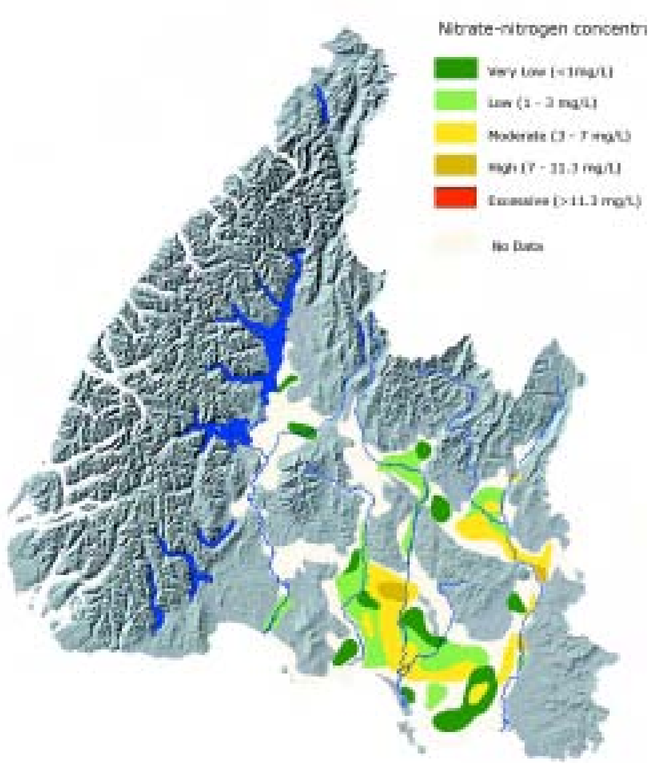


Figure 26 Nitrate concentrations in Southland's groundwater.

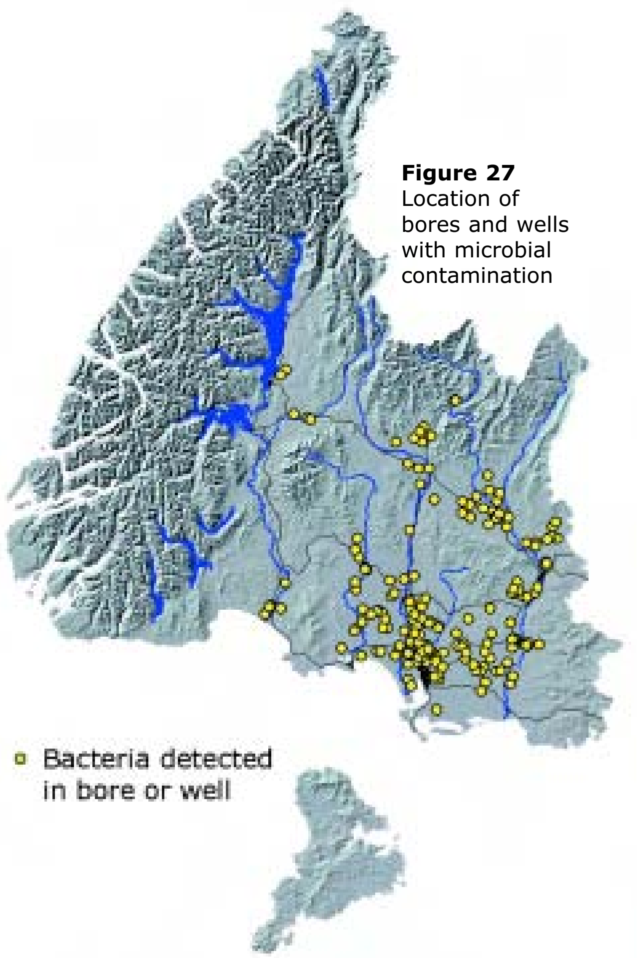


Figure 27
Location of bores and wells with microbial contamination

microbial contamination may reflect the age and poor condition of many sites and the ability of infiltrating soil moisture to enter through gaps in the well casing.

In a majority of cases, microbial contamination can be significantly reduced by simple steps to improve wellhead protection and by ensuring bores and wells are regularly maintained.

▲ Is groundwater quality suitable for drinking? - pesticides

Recently completed investigations have found trace concentrations of a total of seven pesticide active ingredients in groundwater in the Edendale area. The concentrations of the pesticide residues detected are well below the maximum limits prescribed by drinking water standards. Nevertheless, their presence in groundwater highlights the vulnerability of unconfined aquifers in some areas to contamination from land use activities.

The state of water quantity

Knowing how much water we have, and where, are fundamental requirements for resource management purposes. River flows and groundwater levels may change due to climatic shifts (wetter or drier periods), or alterations of land use (e.g., afforestation, land drainage) and decrease due to increasing consumption.

River flows and groundwater levels show a large amount of natural variation, and establishing a 'normal' range requires long records. Detecting trends and being able to separate natural from human-induced changes is both information hungry and analytically complex.

Environment Southland's goals

The Proposed Regional Fresh Water Plan's objective for surface water quantity is that there should be sufficient water to support the reasonable needs of the community and protect ecosystem health.

The Proposed Regional Fresh Water Plan objective for groundwater quantity is that the total volume and rate of groundwater abstraction will be sustainable.

How do we measure up?

▲ Is there enough surface water to go around? - river flow regimes

River flows across the region vary throughout the year (Figure 28) in response to rainfall, with drier weather resulting in lower flows. In our lowland streams, summer and autumn are the seasons of lower flows. In many of our high country catchments, winter is also a time of low flows because precipitation is bound up as snow.

Southland's longest flow record is a little over 30 years in length, and most others are considerably less. At present there is insufficient record to determine whether flow regimes are changing. This situation may alter, as more flow information becomes available.

▲ Is there enough surface water to go around? - river flow vs demand

This ratio of available flow to demand is a powerful indicator of the state of our surface water resource. Two sources of information are needed: first, estimates of the amount of water available; and second, estimates of the present abstractions plus ecosystem needs.

While reliable information exists for water availability and consented abstractions, our understanding of ecosystem needs is not well developed. Environment Southland has recently begun work aimed at identifying those needs. Until those needs have been assessed, Environment Southland has proposed the allocation of a proportion[1] of the mean annual low flow to meet ecosystem needs.

Excluding the Waiau, the consumptive demands on our surface water resources are very small. Table 13 shows amount of water abstracted as a percentage of mean annual low flow (MALF) for the Aparima, Oreti, Makarewa and Mataura rivers. This 'stress ratio' gives an indication of the potential pressure exerted by abstraction on the river system. Numbers less than one indicate that the available resource exceeds the demands placed on it (including ecosystem needs). As the number approaches or exceeds one, the river is potentially under stress, as the demands placed on the water resource begin to exceed supply.

Table 13 Available flow and demand for major Southland catchments**.** All flows in cubic metres per second. A value greater than one indicates that the water resource is in danger of being over-allocated.

River	Available flow (MALF)	Demand		Stress Ratio
		Abstraction	Ecosystem	
Mataura (Seaward Downs)	22.63	0.62	11.32	0.53
Oreti (Wallacetown)	7.68	1.05	3.84	0.64
Aparima (Thornbury)	4.14	0.03	2.07	0.51
Makarewa (Counsell Rd)	1.83	0.36	0.92	0.70

▲ Is there enough groundwater to go around? - groundwater levels

Where groundwater is abstracted faster than the rate of natural recharge, water levels will fall. Continued abstraction beyond the rate of recharge is not sustainable. Declining water levels can have a range of adverse effects, including reduced surface water flows, intrusion of poor water quality and a general reduction in the availability of the resource. This is an unsustainable practice in the

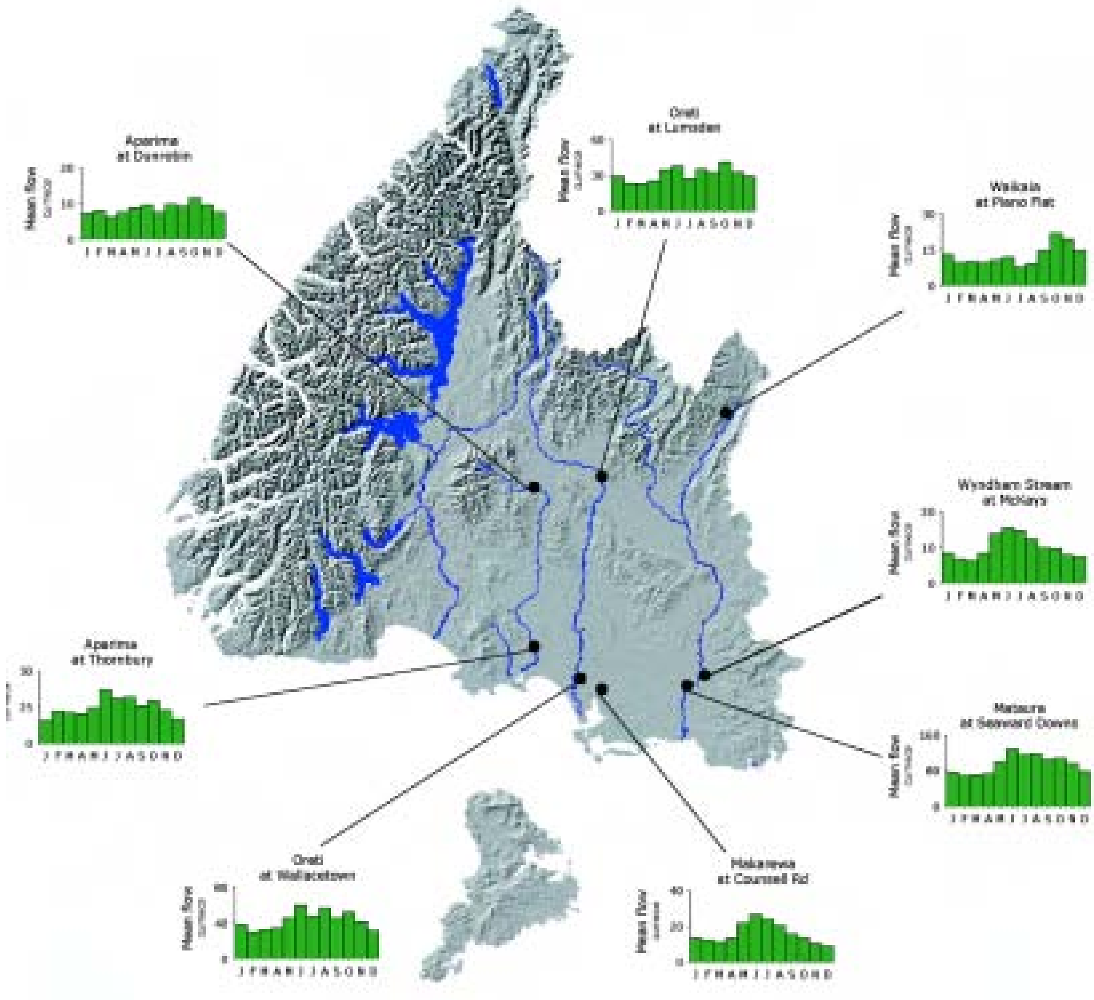


Figure 28 Flow regimes of selected Southland rivers

[1] That proportion is 50 percent of Mean Annual Low Flow (MALF) where MALF is greater than 1 cubic metre per second, or 66 percent of MALF where MALF is equal to or less than 1 cubic metre per second

long term, and can stress natural and modified ecosystems that depend on groundwater for their survival.

Anecdotal reports suggest that groundwater levels have declined in many parts of Southland in recent years. While this is of concern, data is required to separate the effects of the apparent increase in abstraction in some areas from natural variations in response to fluctuations in rainfall and river flows.

The state of our fresh water ecosystem

Environment Southland's goals

The Proposed Regional Fresh Water Plan intends that the diversity and integrity of aquatic and riverine habitats will be maintained or enhanced.

How do we measure up?

▲ How healthy are our fresh water ecosystems? - macroinvertebrates

Aquatic macroinvertebrates include insects, snails and worms that live on the beds of rivers and streams. They show varying degrees of sensitivity to water quality degradation and the condition of their habitat. The diversity and type of species present alters with changes in the habitat and water quality. Their sensitivity to their environment makes them useful indicators of environmental quality.

Each habitat is characterised by its own unique macroinvertebrate community. High quality, gravel-bottomed streams with good riparian vegetation are typically dominated by the larvae of mayflies, caddisflies, some stoneflies and sometimes beetles. As streams are degraded the more sensitive macroinvertebrates such as stoneflies, mayflies and many caddisflies decline and disappear. Very degraded streams have macroinvertebrate communities dominated by *Diptera* larvae (two winged flies), worms and sometimes snails.

One way of measuring macroinvertebrate diversity and, by inference, ecosystem health, is through the Macroinvertebrate Community Index (MCI). The MCI scores a stream's habitat on the basis of the macroinvertebrates present. A stream with better habitat health supports more sensitive species, which gives it a higher score.

Rivers with MCI scores below 100 are generally considered to have poor habitat health while MCI scores above 110 indicate good habitat health.

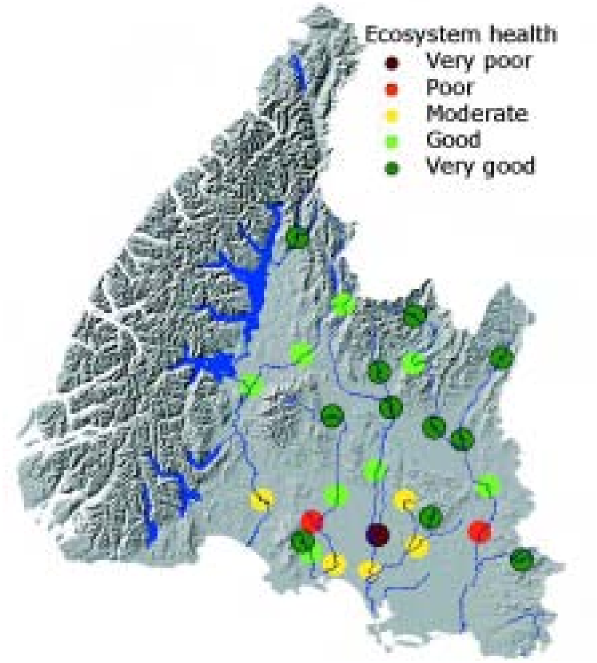


Figure 29 Macroinvertebrate diversity and habitat health in Southland rivers.

Figure 29 shows the habitat health of rivers in Southland. Habitat health is generally excellent in the headwaters and declines downstream. Good habitat health in the Mataura River degrades after effluent discharge at Mataura. Lowland streams generally have poor habitat health.

The excellent situation in headwater streams reflects cooler water from forest covered areas, less fine sediment, less organic pollution (for example BOD) and less periphyton growth in unmodified catchments.

▲ How healthy are our fresh water ecosystems? - native fish

Southland has a rich and diverse native fish fauna, with some 23 species of fish and two species of fresh water crayfish (koura) known to inhabit the region's fresh water streams, lakes and wetlands for at least part of their life cycle (Table 14). This compares with 29 known native species for the whole of New Zealand.

Much of the knowledge about the distribution and abundance of our indigenous freshwater fish has been built up from sightings, rather than systematic and regular surveys. Consequently, our knowledge of the distribution and abundance of indigenous fish is far from complete.

One species of native fish, the grayling *(Prototroctes oxyrhynchus)*, is known to have become extinct in recent history. Abundant when Europeans first arrived, the grayling succumbed to agricultural pressures to finally disappear in the 1930s.

Four of Southland's indigenous fresh water fish are listed[1] as threatened with one, the shortjawed kokopu, listed as Category A (i.e., facing extinction and with the highest conservation priority).

A peculiarity of New Zealand's indigenous fresh water fish is the high number of diadromous species, such as lamprey, eels, torrent fish, giant kokopu, and koaro. These are species that complete some part of their life stage in the marine environment. They are migratory fish and, as such, are affected by barriers to migration such as weirs, dams and low flows.

Other threats to native fish include degraded water quality, loss of habitat, especially riparian margins, and predation by introduced species such as trout and salmon. Some native species including eels, whitebait (galaxiads), lamprey and koura are also highly sought after for human consumption. In Southland, five different galaxias comprise the whitebait catch; giant kokopu, koaro, inanga, shortjawed kokopu (rare) and banded kokopu.

Good riparian habitat, Northern Southland.

Table 14 Southland's native freshwater fish fauna

Common name	Scientific name
Yelloweyed mullet	*Aldrichetta forsteri*
Shortfinned eel	*Anguilla australis*
Longfinned eel	*Anguilla dieffenbachii*
Torrentfish	*Cheimarrichthys forsteri*
Roundhead galaxias	*Galaxias anomalus*
Giant kokopu (1)	*Galaxias argentreus*
Koaro (1)	*Galaxias brevipinnis*
Flathead galaxias	*Galaxias depressiceps*
Banded kokopu (1)	*Galaxias fasciatus*
No common name	*Galaxias gollumoides*
Inanga	*Galaxias maculatus*
Alpine galaxias	*Galaxias paucispondylus*
Shortjawed kokopu (1)	*Galaxias postvectis*
Lamprey (kana kana)	*Geotria australis*
Upland bully	*Gobiomorphus breviceps*
Common bully	*Gobiomorphus cotidianus*
Giant bully	*Gobiomorphus gobioides*
Bluegilled bully	*Gobiomorphus hubbsi*
Redfinned bully	*Gobiomorphus huttoni*
Common smelt	*Retropinna retropinna*
Yellowbelly flounder	*Rhombosolea leporina*
Black flounder	*Rhombosolea retiaria*
Stokell's smelt (2)	*Stokellia anisodon*
Indigenous crayfish	
Freshwater crayfish (koura)	*Paranephrops zealandicus*
Freshwater crayfish (koura)	*Paranephrops planifrons*

Notes
(1) Denotes threatened species.
(2) Not verified

How healthy are our fresh water ecosystems? - aquatic and riparian habitats

At present, there is little or no information on the extent and condition of aquatic habitat in Southland. While a complete assessment for Southland has not been done, we do know that signficant amounts of near-pristine aquatic habitat exist in areas of conservation estate such as Fiordland and Stewart Island (Rakiura).

Outside of the conservation estate, macroinvertebrate and fish populations currently provide the best information for assessing the quality and extent of aquatic habitats in Southland. It is hoped that future state of the environment reporting will contain an assessment of aquatic habitat.

1 Department of Conservation. 1994. Setting Priorities for the Conservation of New Zealand's Threatened Plants and Animals. (2nd Edition, collated by C. Tisdall). Department of Conservation, Wellington.

Our response to
The problems

Society reacts to environmental changes and issues in a variety of ways. For example, efforts to improve surface water quality are being initiated by individuals, landowners, care groups, industry, iwi, and government. Those efforts also take a range of forms, including regulation, promotion and adoption of best practice, monitoring and reporting, cleaner production and streamside planting.

It is difficult to measure and report on society's response to issues. Firstly, many responses cannot easily be quantified directly. Secondly, when two or more responses are directed at a particular issue, it can be difficult to identify their relative impacts. Thirdly, our awareness of what responses are taking place is incomplete and disjointed.

This report deliberately avoids documenting an exhaustive list of responses, because any such list would inevitably fail to do justice to the myriad of actions and initiatives being undertaken by others. The discussion here is limited to the existing and upcoming responses put in place by Environment Southland, to address the region's water management issues. However, it is acknowledged from the outset that many organisations, *ad hoc* groups and individuals are involved in this area – both jointly and independently.

The success or failure of efforts to protect our fresh water resources and ecosystems ultimately depends on the actions and initiatives of individuals, communities, landowners, resource users, and government. In time, it will hopefully be possible to provide a more complete picture.

Policy responses

Environment Southland has produced two policy documents to guide the use and management of the Region's fresh water resources - the Regional Policy Statement and the recently released Proposed Regional Fresh Water Plan.

The Regional Policy Statement is a mandatory, statutory document that sets out the environmental issues of significance, together with the policies and methods to achieve integrated environmental management.

The Proposed Regional Fresh Water Plan was prepared in recognition of the importance of Southland's fresh water resources and ecosystems. It proposes a set of objectives for the region's surface and groundwater resources, and sets out the policy and methods to achieve those objectives. Measures include:

- identifying specific management purposes and objectives for surface and groundwater resources, and setting relevant standards;
- setting minimum (or maintenance) flows for the regions rivers and streams; and
- recognising that certain activities are a legitimate and permitted (i.e., no consent required) use of water, provided the effects do not compromise the management purpose and objectives.

Rules are proposed in the Proposed Regional Fresh Water Plan to protect surface and groundwater resources. They include the requirement to obtain consents for certain point source discharges, large water takes and certain activities on the beds or margins of lakes and rivers.

In Southland, pest plants are managed through the Regional Pest Plants Management Strategy. This strategy, published in 1996, designates *Lagarosiphon* as a total control pest plant. Environment Southland is currently reviewing its pest management strategies. Initial consultation and discussion has identified several aquatic animals and plants, which have the potential to cause adverse effects in Southland's waterways. These include 'coarse fish', such as rudd, tench and koi carp, and plant species including crack willow (*Salix fragilis*), reed sweet grass (*Glyceria maxima*) and *Lagarosiphon*.

Two other regional policy documents have a bearing on water management; the Regional Solid Waste Management Plan and the Regional Land Effluent Application Plan.

Education and extension responses

Non-regulatory methods such as environmental education, extension and advocacy are used when:

- it is believed that these methods are the best way to achieve the environmental result that people want; or
- the link between the adverse effect and the activity is not direct or obvious to the person who does the activity (e.g. people washing chemicals and detergents into the stormwater system)

Environmental education

Environment Southland is committed to the use of environmental education throughout the community. Children, as tomorrow's decision-makers, are especially targeted through programmes such as:

- 'Brucies Buddies', a club for 4 to 14-year-olds aimed at raising general environmental awareness; and
- the production of environmental teaching resources as part of the school curricula.

Extension, advocacy and best management practices

Agricultural land use is a significant pressure on the quality of our water resources and ecosystems. Environment Southland, through its land sustainability programmes, provides advice and extension on general land management. Much of this work is aimed at reducing non-point source contamination from agricultural activities.

Adoption of best practice methods for all land uses and activities has the potential to bring about substantial improvements in the quality of our fresh water resources. Environment Southland strongly supports the development and use of voluntary guidelines and codes of practice. The guidelines and codes that are promoted include:

- New Zealand Forest Code of Practice
- Riparian Management Guidelines
- Code of Practice for Fertiliser Use
- Sustainable Application of Agrichemicals
- Growsafe.

Environment Southland has also developed codes of practice for drainage maintenance, gravel extraction and the disposal of farm dairy effluent, to help minimise the effects of these activities on our fresh water resources.

Care groups and other community responses

Landcare groups are autonomous community groups with an interest in promoting sustainable land management while working to enhance the environment in their local area. Environment Southland provides administrative and technical support to landcare groups in the Southland Region.

Many community-based farm discussion and monitoring groups operate in Southland and Environment Southland provides technical support to these groups.

Schools are specifically targeted through Environment Southland's Adopt-a-Stream programme. This programme, which was begun in 1999, encourages schools to 'adopt' a section of stream. Through the use of specially developed classroom materials and field activities, the programme aims to increase awareness and understanding of river issues. Over ten schools are currently involved in the programme. A Community Partnership Strategy has been recently completed. This strategy sets the scene for Environment Southland's policies and community priorities in sustainable land management.

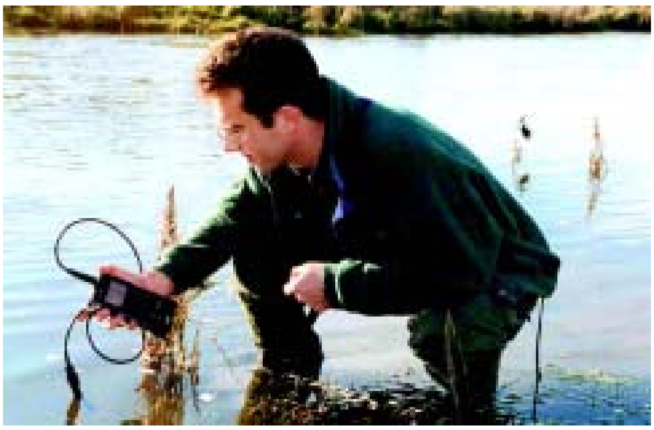
Monitoring responses

Monitoring is a key component of Environment Southland's response to the region's fresh water management issues, and is fundamental to making sound decisions and assessing our progress and performance. Long-term monitoring provides the only way of telling whether changes are occurring to the environmental state, and of estimating the rate of change and its significance.

Currently, surface water quality monitoring is directed at:

- bathing water quality (faecal bacteria);
- ecological monitoring (macroinvertebrates and algae), and
- general water quality (e.g., nutrients, BOD, clarity, ammonia).

Approximately 40 sites are monitored on a routine basis across the region. These programmes have been operating since 1994.



In response to increasing concerns about the quality of the region's groundwater resources and the potential impacts of intensive land use, Environment Southland began routine monitoring of groundwater quality in 1998. The programme regularly monitors nutrients, faecal contaminants, and several other water quality parameters at over 30 sites throughout the Southland Region.

Information both from the surface and groundwater quality monitoring programmes is provided to the region's territorial and health authorities, as part of a partnership to safeguard the community from the adverse effects of contaminated bathing and drinking waters.

In addition to the quality of water resources, Environment Southland also carries out monitoring of resource quantity. River flows, river levels and rainfall are monitored at over 50 sites throughout Southland. The longest running flow monitoring sites have been operated for more than thirty years. Most flow records are, however, much less than this.

Many of these sites are linked by radio telemetry to provide immediate access to the information. Technical staff use the data to assess water resources and their availability, but the information is also used extensively by anglers and resource users.

A groundwater-monitoring programme has been established to provide information on groundwater levels, how they vary in time and to provide early warning of unsustainable groundwater usage.

Environment Southland, in partnership with the Department of Conservation, undertakes surveillance monitoring of the aquatic pest plant, *Lagarosiphon*.

Investigation and research responses

These long-term monitoring programmes are supplemented by investigations and research aimed at better understanding specific issues, or developing better management techniques.

Several recent investigations have been targeted at water management issues. They include:

- a region-wide, risk-based assessment of soils and land uses;
- the investigation of pesticide residues groundwater in the Edendale aquifer;
- an assessment of water quality and sources of contaminants in the lower Mataura River; and
- a region-wide 'snapshot-survey' of approximately 350 bores and wells across Southland, for levels of nitrate and microbial contaminants.

Environment Southland also supports or provides input into 'fundamental' research that will benefit or improve fresh water management. Current investigation and research programmes include:

- development of habitat based classification systems for rivers, to provide a more sound base for developing minimum flows and river management policies and objectives;
- improved groundwater monitoring indicators;
- improved techniques for monitoring and assessing the health of wetlands;
- development of guidelines for bore installation and maintenance; and
- development of guidelines to minimise the impact of drain maintenance activities.

Regulatory responses

Environment Southland's policy responses establish, among other things, a regulatory framework with 'rules'. Rules specify the 'status' of activities (i.e. permitted, controlled, restricted, discretionary or prohibited) and set out the conditions or standards and terms that must be met in order for the activity to go ahead, with or without resource consent.

Rules are necessary to ensure that the adverse effects of activities such as discharges, water abstraction, and gravel extraction, are avoided, remedied or mitigated. As well, rules provide certainty for resource users as to what can and can't be done.

To ensure that the environmental standards and conditions set out in plans, consents and relevant legislation are met, Environment Southland carries out various compliance monitoring programmes. While the priority is education and extension, when necessary and appropriate, enforcement proceedings are instigated.

Other responses

Environment Southland undertakes a number of other responses to protect Southland's valued fresh water resources and ecosystems. These include:

- maintaining a 24 hour pollution response and clean-up capability;
- providing financial and other incentives to land owners to maintain and protect riparian habitat;
- pest eradication; and
- carrying out habitat restoration and improvement as part of the management of our flood protection infrastructure.

Appendix

Regional fresh water quality standards and guidelines

This table shows guidelines for surface and groundwater parameters used in this report. Surface water parameters have been divided into four categories (very good, good, poor, and very poor) in order to describe the state of water quality in the report.

Issue	Indicator	Unit	Water quality categories			
			Very good	**Good**	**Poor**	**Very poor**
Surface Water						
Health risk from bathing	E. coli	CFU/100mL	≤70	≤126 [1]	>126	>410
Excessive algae growth	Nitrate	gm^{-3}-N	≤0.04	≤0.15 [2]	>0.15	>0.5
Excessive algae growth	Dissolved reactive phosphorus (DRP)	gm^{-3}-P	≤0.007	≤0.015 [2]	>0.015	>0.03
Depletion of oxygen	Biochemical oxygen demand (BOD_5)	gm^{-3}	≤1	≤2 [2]	>2	>4
Toxicity to fish	Ammonia	gm^{-3}-N	≤0.066	≤0.26 [3]	>0.26	>1.22
Bathing aesthetics and aquatic life	Clarity (at baseflow)	metres	>3.2	≥1.6 [4]	<1.6	<0.8
Groundwater						
Suitable for drinking	Faecal coliforms	CFU/100mL		≤1 [5]	>1	
Suitable for drinking	Nitrate	gm^{-3}-N		≤11.3 [5]	>11.3	

Notes

1 Ministry for the Environment and Ministry of Health (1998). *Bacteriological water quality guidelines for marine and fresh water.* Wellington. Trends in faecal contamination were assessed using faecal coliform data.

2 Ministry for the Environment (2000) New Zealand periphyton guideline: Detecting, monitoring and managing enrichment of streams. By B Biggs, NIWA . Guidline value based on 24 day growth period.

3 (USEPA, 1986). *Quality criteria for water.* Total ammonia is more toxic at warmer temperatures and higher pH. Total ammonia of less than 0.066 g/m^3 will protect aquatic life against chronic toxicity at pH 9 and 30°C. Total ammonia (NH_4^+-N + NH_3-N) of less than 0.26 g/m^3 will protect aquatic life against chronic toxicity at pH 8.5 and 20°C. (USEPA, 1986).

4 Ministry for the Environment (1994). *Water quality guidelines No.2. Guidelines for the management of water colour and clarity.*

5 Ministry of Health (1995). *Drinking water standards for New Zealand.*

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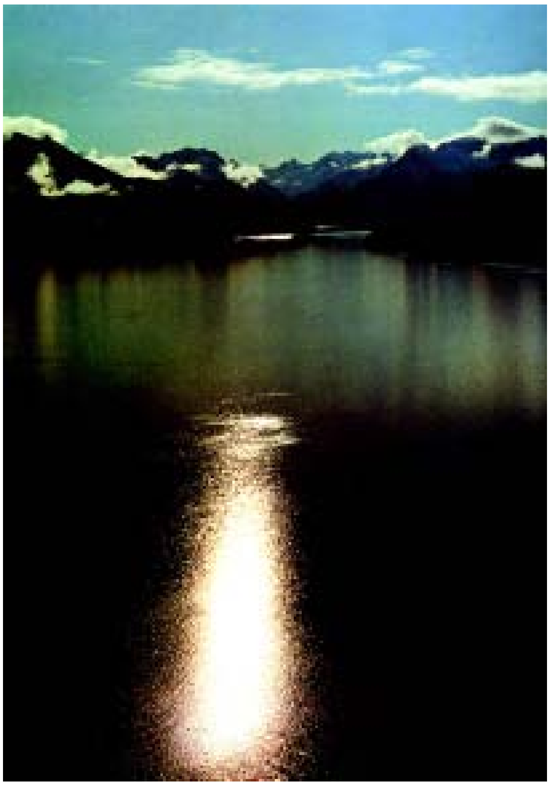

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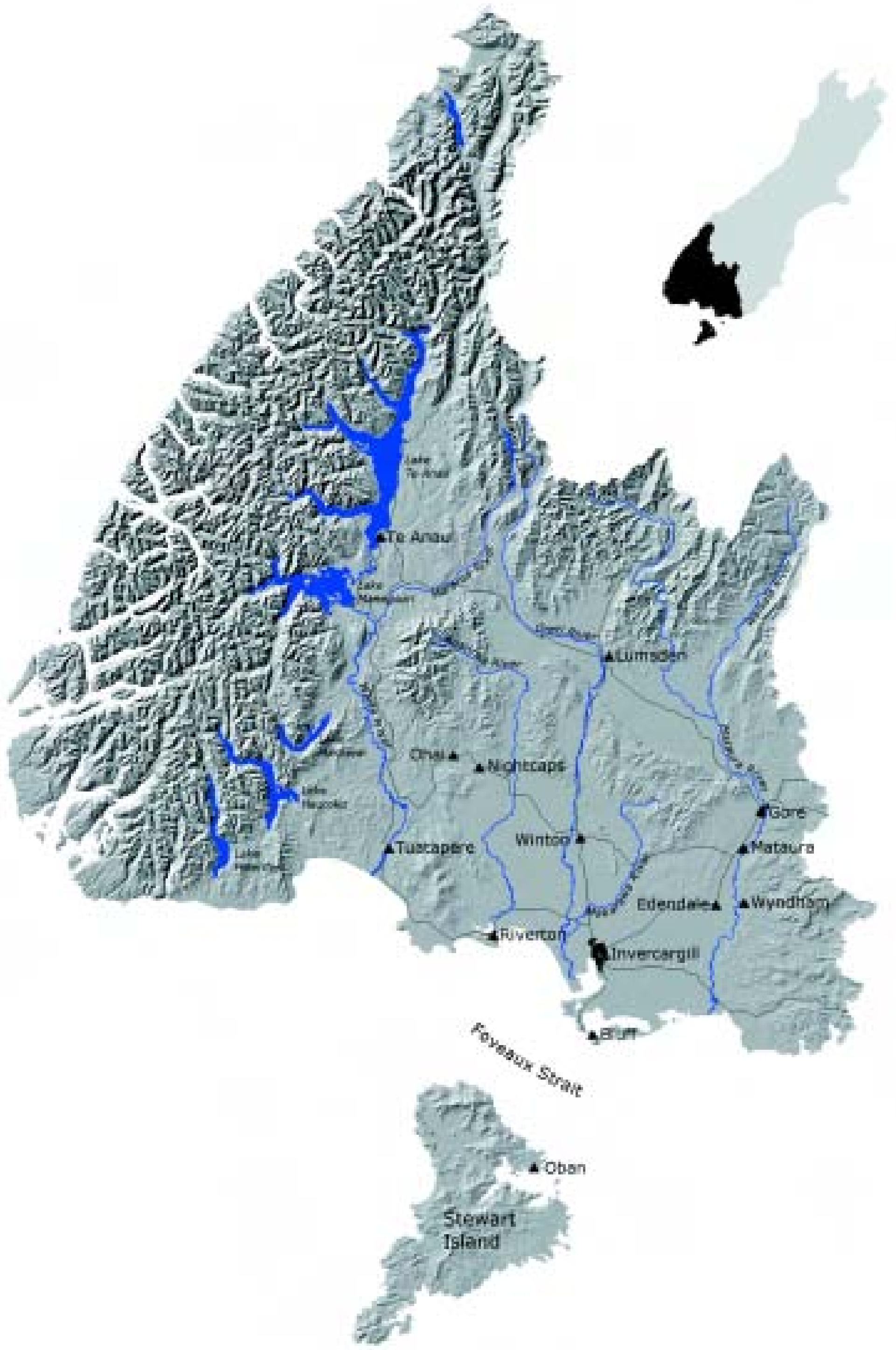

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