

**Summary of Catchments with Data Suitable for Use in the
Evaluation of Landcover Effects on Water Availability**

SMF2167: Report No 4

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1. Introduction

Project 2167: Land Cover Effects on Water Availability is funded by a grant from the Ministry for the Environment's Sustainable Management Fund. The purpose of the project is to provide information and tools to assist water and land managers make the best allocations of water resources for all end-users.

Within the project, a series of bibliographies have been prepared providing information on hydrological data for radiata pine (*Pinus radiata*) plantations, Douglas fir (*Pseudotsuga menziesii*) forests and plantations, and New Zealand land-use studies (Rowe et al. 2001a, 2001b, 2001c).

This report provides information on catchments that have gauged streamflows and contain a substantial proportion of exotic plantations, either *P. radiata* or Douglas fir. In order to have a basis for assessing changes to the streamflow regime, control catchments with stable land use have been sought. These catchments may have a single land use or be a mix of, say, native forest and pasture. Also included in this listing are a number of raingauges.

2. Background

There are worldwide concerns that increased establishment of plantations of exotic forest species for wood fibre production, either as a result of conversion of native forests and scrublands or afforestation of pasture and native grasslands, may have a detrimental effect on the environment. New Zealand is no different to most other countries in this regard. Attention has focussed on the following concerns:

- harvesting trees will cause accelerated erosion and sedimentation problems
- plantations are a monoculture, which decreases biodiversity
- acidification and compaction will degrade soil quality
- streams will dry up after forests are planted, especially in the low-flow season.

However, there is evidence to show that for forest management in general:

- erosion and sedimentation issues are short term only, and when taken over the full rotation, plantation forests are often less damaging than other land uses (e.g., McLaren 1996, Phillips et al. 1990)
- plantations do sustain a wide-ranging biological diversity (e.g., Allen et al. 1995; Ledgard 1995)
- changes to soil quality may be positive (e.g., Davis & Lang 1991) and may lead to improvements in the hydrological properties of the soil (R.J. Jackson, unpublished data).

The main concern raised when proposals are made to establish plantation forests in the headwaters of catchments is that there could be diminished water yields. In water-short areas, conflicts can then arise between foresters who need to 'use' rain water to meet the biological needs of trees for growth, and downstream-users who require water for municipal, stock-water and irrigation supplies, or to sustain minimum levels in rivers for recreation, or to maintain in-stream habitats, especially at times of seasonally low flows. Water managers then have the unenviable task of allocating scarce resources to all users. Conflicts in the allocation process can lead to litigation in the Environmental Court.

The draft National Agenda for Sustainable Management Action Plan (Ministry for the Environment (MfE) 1999) states 'There has been a substantial research effort in New Zealand and overseas on studying the impacts of changing land use on water yield, such as afforestation. This research is at a point where a guideline needs to be produced'. This report, and others in the series, while aimed at providing a foundation to reduce conflicts between land and water managers, could be used in the preparation of such a guideline.

2.1 SMF Project 2167: Land Cover Effects on Water Availability

Workshops in Nelson (March 1999 sponsored by Tasman District Council, Landcare Research, New Zealand Hydrological Society; Rowe 1999) and Rotorua (May 1999, New Zealand Forest Research Institute, Site Management for Sustainable Forestry) identified that water resource issues were still in the forefront of the list of concerns held by land managers (foresters, agriculturalists, etc.), water resource managers (regional and district councils) and other water users (recreationalists, environmentalists, etc.). Discussion with people outside these workshops indicated that these concerns were highly relevant. The principal questions confronting water resource managers were:

- What is the effect of a particular land use on useable water resources?
- How do I allocate scarce water resources when land-use change affects availability?
- What information, resources, and tools are available to help me with these questions?

In 1999, Tasman District Council and Landcare Research applied to the Ministry for the Environment's Sustainable Management Fund for funding to undertake a review of available literature, gather hydrological

and land-use data from New Zealand catchments, and develop a decision support resource to enable water and land managers to make more informed decisions on water resource allocations. The successful application resulted in this project, SMF2167: Land Cover Effects on Water Availability.

2.2 New Zealand plantation forests

At 1 April 1999, the New Zealand exotic forest estate covered 1.73 m ha, 6% of New Zealand's land area. *Pinus radiata* D. Don is the number one plantation species grown comprising more than 1.56 m ha, over 90% of the total plantation area (NZFI undated). *Pinus radiata* is commercially grown mainly in rainfall regimes between 600 mm and 2500 mm/year, and below about 1000 m altitude. Douglas fir (*Pseudotsuga menziesii*) is the next most significant species planted, 86 000 ha, and is found mainly in the lower South Island or at higher altitudes, often above 1000 m. About 82 000 ha of other species are grown, including eucalypts (NZFI undated).

Between 1992 and 1999, new plantations were being established at over 60 000 ha per year, peaking in 1994 when about 96 000 ha were planted. Rates have dropped, however, and the provisional estimate for 1999 was about 25 000 ha (NZFI undated). Most of the new plantings are on pasture land both improved (about 44%) and unimproved (about 44%), with the balance in scrubland (12%) (MAF 2000).

2.3 Sources of hydrological data

Catchment studies at Glendhu (Otago), Maimai (West Coast), Donald Creek and Moutere (Nelson), Ashley (Canterbury) and Purukohukohu (Central North Island) provide the bulk of the information on the hydrology of New Zealand forests, but for *Pinus radiata* plantations or native forests, not Douglas fir plantations. Apart from Moutere and Ashley, these are higher rainfall areas where concerns about water yields are not high. This is in contrast to, say, Nelson and the east coasts of both islands where water is often scarce in summer and the most relevant data comes from studies at Donald Creek, Moutere and Ashley. Hydrological studies at Makara (Wellington), Puketurua (Northland), Ashley, Moutere and Purukohukohu are the main sources of pasture catchment data while Glendhu provides information about native tussock grasslands. Reviews by Fahey & Rowe (1992), McLaren (1996) and Rowe et al. (1997) summarise some of these studies while two books published by the New Zealand Hydrological Society (Mosley 1992; Mosley & Pearson 1997) provide good summaries of the wider aspects of New Zealand hydrology.

There are many sites throughout New Zealand where flow records have been collected. Many of these are now closed, however, as networks have been reviewed or were set up for specific, short-term purposes. This report lists those sites that seem to the author to be of most importance for reviewing land use change.

3. Water Resources and Land-use Data

The data in this section is summarised by region and include catchments operated by territorial authorities, the National Institute of Water and Atmospheric Research (NIWA), Landcare Research (LCR) and Watercare Services. In each of these groupings, there are summaries of a particular area focussing on one or more catchments with exotic plantation. Site details have generally been sourced from Walter (2000).

The dominant land use in each of the catchments is shown in the tables. This has been derived mainly from 1:250 000 maps but some 1:50 000 maps have been used. In some cases the various territorial authorities have provided more accurate distributions of the various landuse categories.

Graphs that show the extent of streamflow records for each site indicate approximate land use in the catchment upstream of the streamgauging point:

- pasture or tussock grassland
- ▲ trees – native forest, or exotic plantation, or both
- mixed land use
- △ scrub
- precipitation.

Abbreviations used for the recording authorities are:

ARC	Auckland Regional Council
EBOP	Environment Bay of Plenty
ECAN	Environment Canterbury
ESTH	Environment Southland
EW	Environment Waikato
GDC	Gisborne District Council
HBRC	Hawke's Bay Regional Council
HMW	horizons.mw
LCR	Landcare Research
MDC	Marlborough District Council
NIWA	National Institute for Water and Atmospheric Research
NRC	Northland Regional Council
ORC	Otago Regional Council
TDC	Tasman District Council
TRC	Taranaki Regional Council
WCRC	West Coast Regional Council
WRC	Wellington Regional Council
WS	Watercare Services

3.1 Northland Region

Mangakahia Suite

One set of gauged catchments with high percentages of exotic plantations as advised by Northland Regional Council in the Northland Region centred on the Mangakahia River to the east of Whangarei. Table 1 lists the suite of associated catchments and nearby rainfall stations with potential for use in this study. Fig. 1 shows the periods of record for these stations with the gaps indicating where whole calendar years are missing.

Table 1 Northland Region: Mangakahia suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Opouteke @ Suspension Bridge	NRC	1046651	P6:891114	Dec 1984		105		Native + exotic
Mangakahia @ Gorge	NIWA	46618	P6:878189	Dec 1960		246		Exotic + native + pasture
Mangakahia @ Titoki	NRC	46626	P7:059071	Feb 1983		798		Exotic + native + pasture
Kaihu @ Gorge	NRC	46611	P7:727042	Mar 1970		116		Pasture + native + exotic
Kaihu @ Maropiu	NIWA	46612	P7:770000	Oct 1958	Feb 1971	162		Pasture + native + exotic
Hikurangi @ Moengawahine	NRC	46625	P6:050167	Apr 1960		189		Native + exotic + pasture
Puketurua @ Puketitoti	NIWA	46660	P6:075151	Jan 1964	Aug 1986	2.48		Pasture
Opahi @ Pond	NRC	47527	P5:764436	Feb 1966	Jan 1994	106		Pasture + native
Rainfall								
Brookvale in Opouteke	NRC	536812	P6:891113	Nov 1987			120	
Pukewaenga in Puketurua	NIWA	546030	P6:084138	Oct 1963	Sep 1985		71	
Okarika in Wairua	NRC	546216	Q6:163203	Feb 1988			106	

Of these catchments, the Opouteke River catchment has the most extensive area of forest, over 80%, with perhaps 25% in exotic plantations at 1989 and limited scope for expansion thereafter (NZMS262-2). The Kaihu River catchment, adjacent to the Opouteke River, has the potential to be useful as a control catchment against which to compare flows from other catchments, although there has been plantation development. The flow record from Kaihu River @ Gorge does begin earlier and could be compared with the Opahi Stream to

the north. There are comparable periods between the Kaihu River @ Gorge and the Mangakahia River which has data available for two sites. The Mangakahia River Gorge site record begins in 1960 while the record at the Titoki gauging station starts in 1983. There is also an area of exotic forest establishment in the Mangakahia River in addition to that already noted for the Opouteke River. While spanning a long period from the early 1960s, the Hikurangi River record has a gap of nearly 16 years.

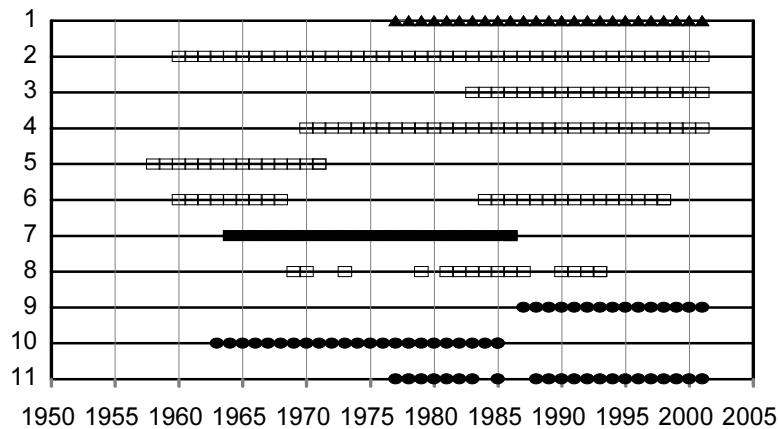


Fig. 1 Periods of record for stations in the Opouteke suite. Streamflow sites are: 1 Opouteke @ Suspension Bridge; 2 Mangakahia @ Gorge; 3 Mangakahia @ Titoki; 4 Kaihu @ Gorge; 5 Kaihu @ Maropiu; 6 Hikurangi @ Moengawahine; 7 Puketurua @ Puketitoti; 8 Opahi @ Pond. Rainfall sites are: 9 Brookvale in Opouteke; 10 Pukewaenga in Puketurua; 11 Okarika in Wairua.

Mangahahuru Suite

The second suite of catchments is based around the Mangahahuru Stream north-east of Whangarei (Table 2, Fig. 2). The Glenbervie catchments were in exotic forest, but their short records may be limited to an indicator of water yield from mature forests in this region and for a short period after harvesting. The longest running data is from the Mangahahuru Stream, which is dominantly native forest but with a significant exotic forest component. The time span of the Ngunguru River record to the south is potentially the best control catchment but the Puketurua catchments may also prove useful.

Table 2 Northland Region: Mangahahuru suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Mangahahuru @ County Weir	NRC	46674	Q6:295170	Dec 1968		20.5		Native + exotic
Ngunguru @ Dugmores rock	NRC	4901	Q6:378164	Aug 1969		12.5		Native
Glenbervie @ Quarry	NIWA	5513	Q6:327163	Dec 1976	Jan 1985	0.63		Exotic
Glenbervie @ Pines	NIWA	5515	Q6:334167	Apr 1979	Jul 1990	0.16		Exotic
Glenbervie @ Log Bridge	NIWA	5516	Q6:329164	Apr 1979	Jul 1990	0.13		Exotic
Puketurua @ Puketitoi	NIWA	46660	P6:075151	Jan 1964	Aug 1986	2.48		Pasture
Rainfall								
Okarika in Wairua	NRC	546216	Q6:163203	Feb 1988			106	
Noble Todd in Ngunguru	NIWA	546413	Q6:401228	Jul 1968	May 1988		155	
Polerain in Ngunguru	NRC	546416	Q6:404213	Oct 1987			150	
Glenbervie in Hatea	NIWA	546301	Q6:325152	Aug 1947			100	
Waitangi Rd in Glenbervie	NIWA	547312	Q6:327163	Sep 1977	Jun 1990		180	
Pukewaenga in Puketurua	NIWA	546030	P6:084138	Oct 1963	Sep 1985		71	

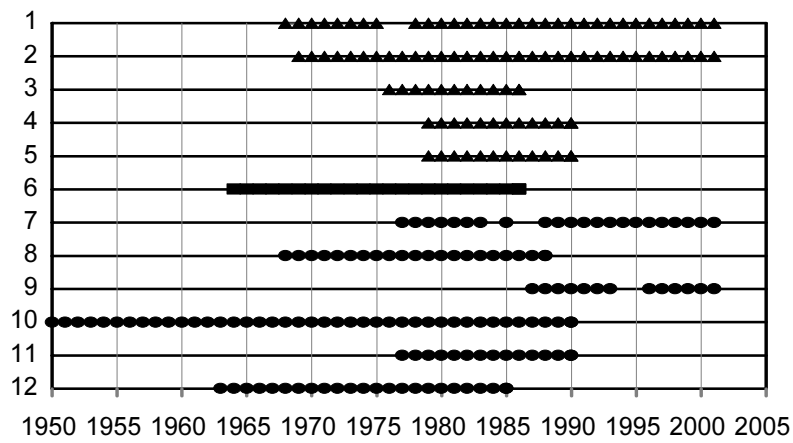


Fig. 2 Periods of record for stations in the Mangahahuru suite. Streamflow sites are: 1 Mangahahura @ County Weir; 2 Ngunguru @ Dugmores Rock; 3 Glenbervie @ Quarry; 4 Glenbervie @ Pines; 5 Glenbervie @ Log Bridge; 6 Puketurua @Puketitoti. Rainfall sites are: 7 Okarika in Wairua; 8 Noble Todd in Ngunguru; 9 Polerain in Ngunguru; 10 Glenbervie in Hatea; 11 Waitangi Road in Glenbervie; 12 Pukewaenga in Puketurua.

3.2 Auckland Region

Wellsford Suite

Auckland Regional Council advised that the Waiwhiu Stream north of Wellsford may be suitable for this project. Another catchment in the area with exotic forest is in the Topuni River. These two catchments make up the basis for the Wellsford suite listed in Table 3 and Fig.3.

Table 3 Auckland Region: Wellsford suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Waiwhiu @ Dome Shadow	NIWA	45702	R9:569376	Nov 1967		8.03		Exotic + native
Topuni @ Old North Road	NIWA	45903	Q8:417542	Dec 1976	May 1986	0.88		Exotic
Kokopu @ McBeths	NIWA	46465	Q7:184077	Jun 1977	Aug 1986	3.08		Pasture
Hoteo @ Gubbs	ARC	45730	Q9:460340	Aug 1977		268		Exotic+ pasture + native
Tamahunga @ Quintals Falls	ARC	6501	R9:662400	Feb 1978		7.97		Pasture + native + exotic
Mahurangi @ College	ARC	6806	R9:586319	Jun 1982		46.8		Exotic+ pasture + native
Rainfall								
Goat Flat in Waiwhiu	NIWA	643610	R9:589386	Oct 1967			177	
Kaipara Forest in Topuni	ARC	642512	Q8:419540	Sep 1977	May 1986		15	
Kokopu Block Road in Kokopu	NIWA	547212	Q7:184077	Sep 1977	Aug 1986		115	
Oldfields in Hoteo	ARC	643510	Q9:459393	May 1978			55	
Quintals Falls in Tamahunga	ARC	643713	R9:657409	Nov 1992			15	
Tuckers in Tamahunga	ARC	643712	R9:657405	May 1977	Sep 1992		17	

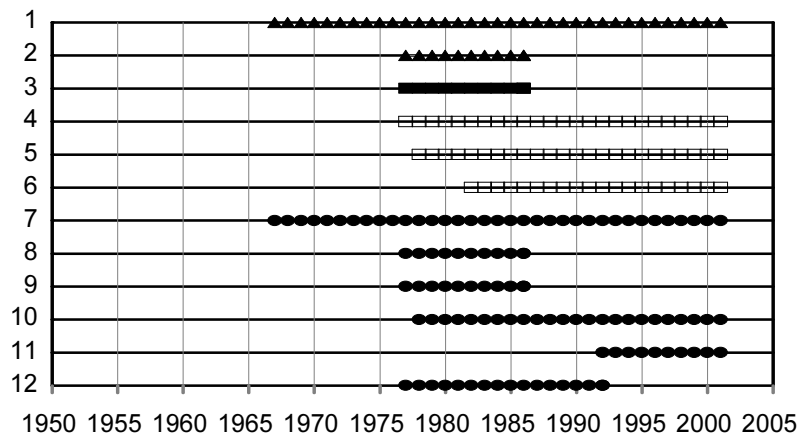


Fig. 3 Periods of record for stations in the Wellsford suite. Streamflow sites are: 1 Waiwhiu @ Dome Shadow; 2 Topuni @ Old North Road; 3 Kokopu @ McBeths; 4 Hoteo @ Gubbs; 5 Tamahunga @ Quintals Falls; 6 Mahurangi @ College. Rainfall sites are: 7 Goat Flat in Waiwhiu; 8 Kaipara Forest in Topuni; 9 Kokopu Block Road in Kokopu; 10 Oldfields in Hoteo; 11 Quintals Falls in Tamahunga; 12 Tuckers in Tamahunga.

There are 10 years of data from Topuni Stream, a small totally pine forested catchment. Comparisons may be made with Kokopu Stream, a pasture catchment and used by Riddell & Martin (1982) in an analysis of water yield from catchments with native forest, exotic plantations and pasture.

The Waiwhiu Stream, with about half the catchment in pine plantations in the mid-1970s, has the longest record and has now been through one rotation with harvesting taking place from 1995. There is, unfortunately, no other long-term record nearby with which to compare changes to the hydrologic regime for the early part of the study although Waugh (1980) made comparisons with the Ngunguru River included in the Mangahuru suite. The Hoteo River, Tamahunga Stream and Mahurangi River catchments do offer possible comparisons in the later part of the study.

Kumeu Suite

Another potential suite has been identified from NZMS262-3 (Auckland) in the Kumeu area. Table 4 lists the catchments and rainfall stations, with Fig. 4 showing the periods of record.

Of the catchments in the Kumeu suite, Rangitopuni Stream measured at Walkers with an exotic forest cover of about 50% has potential. For a comparison catchment, the most suitable appears to be Huapai Stream, Records at the other sites begin several years after the Rangitopuni Stream record begins.

Table 4 Auckland Region: Kumeu suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Rangitopuni @ Walkers	ARC	7805	R10:550948	May 1975		81.5		Exotic + native + pasture
Huapai @ N Z Particle Board	ARC	45301	Q10:487905	Mar 1977		6.61		Pasture + horticulture
Kumeu @ Maddren Weir	ARC	45315	Q10:498908	Dec 1983		47.6		Pasture + horticulture
Ararimu @ Old North Road	ARC	45326	Q10:453943	Dec 1983		66.8		Exotic + native + pasture
Waikoukou @ Longlands	ARC	45346	Q10:459954	Jul 1985	May 1994	4.23		Native + pasture
Rainfall								
Zanders in Ararimu	ARC	647510	Q10:494985	Nov 1978			35	
Maddren Weir in Kumeu	ARC	647513	Q10:489908	Dec 1993			35	
Airbase in Whenuapai	ARC	647601	R11:559893	Sep 1945			24	
Walkers in Rangitopuni	ARC	647614	R10:550946	Sep 1978			100	

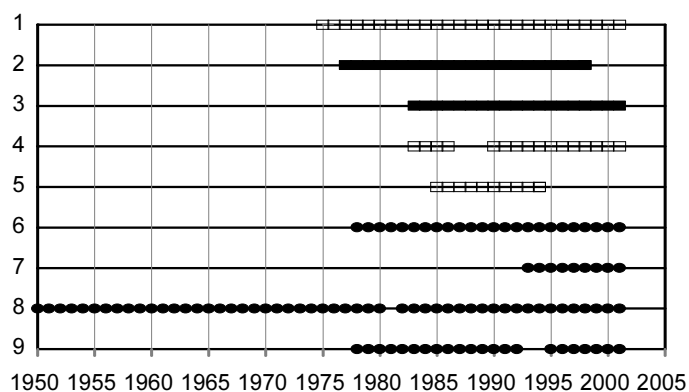


Fig. 4 Periods of record for stations in the Kumeu suite. Streamflow sites are: 1 Rangitopuni @ Walkers; 2 Huapai @ N Z Particle Board; 3 Kumeu @ Maddren Weir; 4 Ararimu @ Old North Road; 5 Waikoukou @ Longlands. Rainfall sites are: 6 Zanders in Ararimu; 7 Maddren Weir in Kumeu; 8 Airbase in Whenuapai; 9 Walkers in Rangitopuni.

3.3 Waikato Region

Moumoukai Suite

Watercare Services have managed three catchments since the late 1960s in the Hunua Ranges, south-east of Papakura (Table 5, Fig. 5). Two were cleared of scrub and planted in radiata pine and Japanese cedar and have been monitored to date.

Table 5 Waikato Region: Watercare Services (WS) Moumoukai suite at Mangatawhiri

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Land Cover
Streamflow							
Moumoukai North	WS	153479	S12:021547	Dec 1967		0.08	Scrub
Moumoukai Central	WS	153480	S12:020546	Dec 1967		0.114	Japanese cedar
Moumoukai South	WS	153481	S12:020543	Dec 1967		0.149	Radiata pine
Rainfall							
Moumoukai North	WS			Jan 1968			
Moumoukai Central	WS			Jan 1968			
Moumoukai South	WS			Jan 1968			

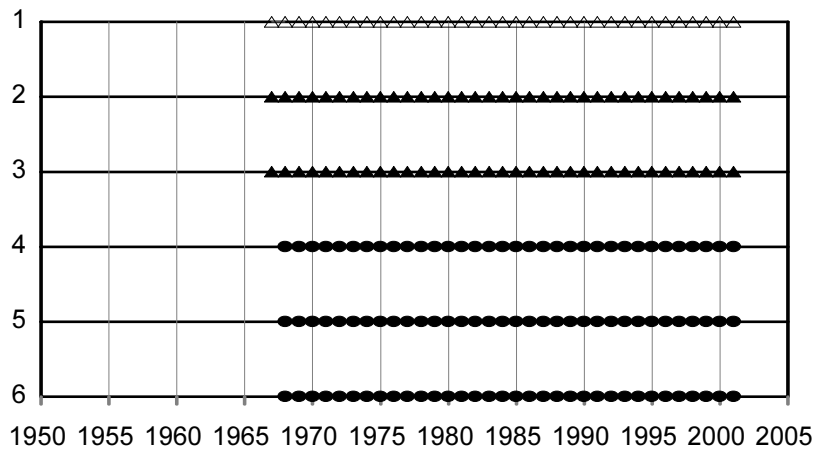


Fig. 5 Periods of record for stations in the Moumoukai suite. Streamflow sites are: 1 Moumoukai North; 2 Moumoukai Central; 3 Moumoukai South. Rainfall sites are: 4 Moumoukai North; 5 Moumoukai Central; 6 Moumoukai South.

Coromandel Suite

Environment Waikato identified sites in the Coromandel that have about 10-year records (Table 6, Fig. 6). The Wharekawa River, which has a large block of Tairua Forest and Opitonui River, with about 50% in plantation, have harvesting taking place so there is the potential to show the related hydrological consequences of that action and indicating any differences with native forest. The Mahakirau River could be the control catchment for Opitonui River. The Tairua River may be a suitable control for the Wharekawa River with the Waiwawa River between both plantation forests being another possible control catchment.

Table 6 Waikato Region: Coromandel suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Opitonui @ D/S Awarua	EW	11310	T11:428883	Jun 1991		29		Exotic + native
Wharekawa @ Adams Farm Bridge	EW	12509	T12:623468	Jun 1991		46.5		Exotic + native
Mahakirau @ E309 Road	EW	11605	T11:411793	Sep 1987	Mar 2000	20.5		Native
Waiwawa @ Rangihau Road	EW	11807	T11:488705	Jul 1991		120		Native + pasture + scrub
Tairua @ Broken Hills	EW	12301	T12:537518	Jul 1975		118		Native + pasture + scrub
Rainfall								
Pinnacles in Kauaeranga	EW	750710	T12:512585	Jan 1976			625	
Catleys in Kauaeranga	NIWA	751410	T12:466551	May 1975	Jan 1994		126	
Wharekawa in Tairua	EW	752810	T12:554377	May 1991			300	
Castle Rock in Matawai	EW	658610	T11:384873	Sep 1990			340	

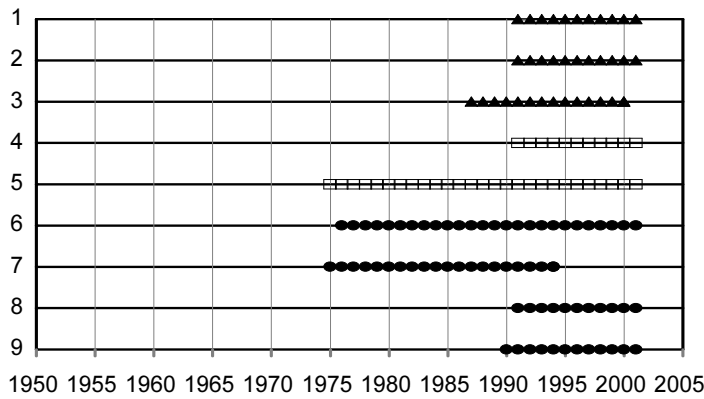


Fig. 6 Periods of record for stations in the Coromandel suite. Streamflow sites are: 1 Opitonui @ D/S Awarua; 2 Wharekawa @ Adams Farm Bridge; 3 Mahakirau @ E309 Road; 4 Waiwawa @ Rangihau Road; 5 Tairua @ Broken Hills. Rainfall sites are: 6 Pinnacles in Kauaeranga; 7 Catleys in Kauaeranga; 8 Wharekawa in Tairua; 9 Castle Rock in Matawai.

Purukohukohu Suite

Table 7 and Figure 7 list stations established within the Purukohukohu Experimental basin in the 1960–70s. Puruki was harvested in the late 1990s and is one of a few gauged stations in New Zealand that has been monitored throughout a full rotation of pines. There are differences in flow from these catchments that were attributed to the variable nature of the volcanic geology as the catchment geographic boundary may not reflect the hydrologic boundary (Dons 1987). Nonetheless, this suite is one of the better monitored in New Zealand.

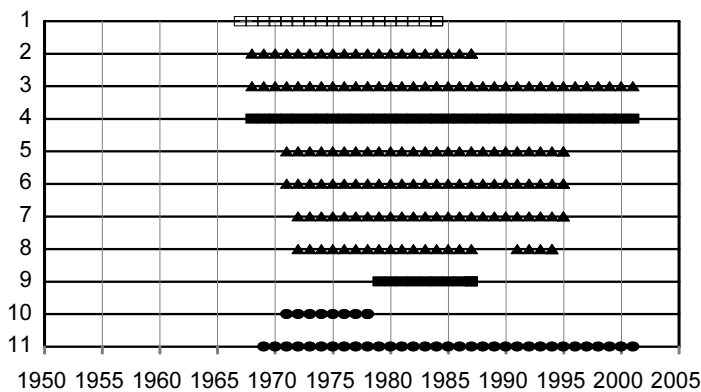


Fig. 7 Periods of record for stations in the Purukohukohu suite. Streamflow sites are: 1 Purukohukohu @ Weir; 2 Purukohukohu @ Puruorakau; 3 Purukohukohu @ Puruki; 4 Purukohukohu @ Purutaka; 5 Purukohukohu @ Puruki-Rua; 6 Purukohukohu @ Puruki-Toru; 7 Purukohukohu @ Puruki-Tahi; 8 Puruwai @ Gorge; 9: Te Waru in Puruhou. Rainfall sites are: 10 Purukohukohu; 11 No. 4 in Purukohukohu.

Table 7 Waikato Region: Purukohukohu suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Purukohukohu @ Weir	NIWA	1143407	U17:923025	Jan 1967	May 1984	1.69		Exotic + pasture + native
Purukohukohu @ Puruorakau	NIWA	1143408	U17:912036	Dec 1968	Jan 1987	0.37		Native
Purukohukohu @ Puruki	NIWA	1143409	U17:912031	Dec 1968		0.34		Exotic
Purukohukohu @ Purutaka	NIWA	1143442	U17:911035	Dec 1968		0.23		Pasture
Purukohukohu @ Puruki-Rua	NIWA	1443423	U17:908031	Feb 1971	Jan 1995	0.1		Exotic
Purukohukohu @ Puruki-Toru	NIWA	1443424	U17:908030	Feb 1971	Jan 1995	0.14		Exotic
Purukohukohu @ Puruki-Tahi	NIWA	1443463	U17:912031	Dec 1972	Jan 1995	0.1		Exotic
Puruwai @ Gorge	NIWA	1443433	U17:921039	May 1972	Oct 1994	0.28		Native
Te Waru @ Puruhou	NIWA	1543487	U17:911024	Dec 1979	Jan 1987	35		Pasture
Rainfall								
Purukohukohu	NIWA	864231	U17:906038	Feb 1971	Feb 1978		631	
No. 4 in Purukohukohu	NIWA	864201	U17:907037	May 1969			626	

Tokoroa Suite

A suite of catchments near Tokoroa (Table 8 and Fig. 8) has mixed land use with pine plantations in a number of catchments. Much of the pine establishment began in 1969 and predates flow recording (Dell 1982). There are considerable variations in runoff associated with the porous nature of much of the geology in the region and

Dell (1982) noted that individual catchments here may not be watertight.

Table 8 Waikato Region: Tokoroa suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Waimakariri @ Waimakariri Road	EW	1009208	T15:607508	Dec 1977	Apr 1987	77		Exotic + native
Oraka @ Pinedale	EW	1009213	T15:562447	Jul 1979		136		Exotic + native + pasture
Waipapa @ Ngaroma Road	NIWA	43435	T16:425166	Apr 1964		137		Native + pasture
Rainfall								
Ngaroma in Punui	EW	853510	T16:325162	Jun 1982			720	
Muir's Road in Oraka	EW	861012	U16:701363	Jun 1979	Sep 1989		300	
Overdale Road in Oraka	EW			Jun 1989				
Kaimai in Rapurapu	EW	759916	T15:684648	Nov 1992			625	
New North Road in Pokaiwhenua	NIWA	862010	U16:743262	May 1963	Jan 1994		517	

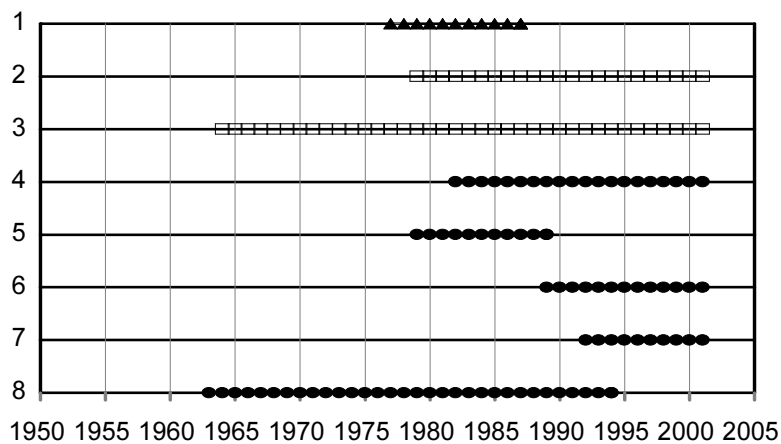


Fig. 8 Periods of record for stations in the Tokoroa suite. Streamflow sites are: 1 Waimakariri @ Waimakariri Road; 2 Oraka @ Pinedale; 3 Waipapa @ Ngaroma Road. Rainfall sites are: 4 Ngaroma in Punui; 5 Muir's Road in Oraka; 6 Overdale Road in Oraka; 7 Kaimai in Rapurapu; 8 New North Road in Pokaiwhenua.

3.4 Bay of Plenty Region

Pokairoa Suite

Streams were monitored in the Pokairoa Stream catchment in the Northern Boundary of Kaingaroa Forest between 1993 and 2001. Harvesting in the Pokairoa Stream commenced at about the time monitoring began (Rowe et al. 2001d). There are, therefore, no good long-term control catchments as harvesting occurred in all catchments within 3 years of recording commencing. Hence, this set is probably of limited value.

Tarawera/Kaituna Suite

Two other catchments which are possibilities are the Kaituna and Tarawera Rivers which drain into the Bay of Plenty. However, the best Kaituna River record, at Te Matai (Site 14614), being tidal rules out this station. The long-term record from the Tarawera River has been subject to analysis a number of times (e.g., Dons 1986; Pang 1993) with the Whakatane River being used for comparison (Table 9).

Table 9 Bay of Plenty Region: Tarawera suite

Site	Data Source	Site Number	Grid Reference	Start	Area (km ²)	Land Cover
Streamflow						
Tarawera @ Awakaponga	EBOP	15302	V15:412557	May 1948	906	Exotic + scrub + pasture
Whakatane	NIWA	15514	W15:609475	Feb 1952	1557	Native + pasture

3.5 Gisborne District

Mangatu Suite

Extensive planting of eroding hill country began in the Mangatu/Waipaoa area of the Gisborne District about 1960. Therefore, this region has the potential for evaluating changes in flows resulting from forest establishment. The sites of interest are listed in Table 10 and the period of record shown in Fig. 9. However, the most relevant streamflow recording sites were not established until much of the planting had been done and the forests were maturing. Planting in the Waingaromia River occurred later and may be best for detecting early trends. Rapidly shifting streambeds and stream channels in some catchments may render them unsuitable for low-flow analyses.

Table 10 Gisborne District: Mangatu suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Waipaoa @ Waipaoa Station	GDC	19702	Y16:339126	Jan 1979	Mar 1987	183		Exotic + native
Waipaoa @ Kanakanaia Bridge	GDC	19701	Y17:354932	Jan 1960		1580		Exotic + native + pasture
Mangatu @ Omapere	GDC	19712	X17:288026	Aug 1983		183		Exotic + native
Waihora @ No. 3 Bridge	GDC	19706	Y17:396973	Dec 1986		110.6		Pasture
Waikohu @ Mahaki	GDC	19708	X17:223977	Oct 1979		144		Native + pasture
Waihuka @ No. 3 Bridge	GDC	19714	X17:230936	Dec 1986		79.2		Pasture
Waingaromia @ Terrace	GDC	19711	Y17:411043	May 1979		175.3		Exotic + pasture
Rainfall								
Waipaoa Station in Waipaoa	GDC	873811	Y16:339126	Jan 1967			165	
Omapere in Mangatu	GDC	873712	X17:288026	Aug 1983			110	
Mahaki in Waikohu	GDC	874710	X17:223997	May 1970			70	
Terrace in Waingaromia	GDC	874913	Y17:412041	Nov 1976			115	
Kanakanaia Bridge in Waipaoa	GDC	874812	Y17:354932	Jul 1981			38	

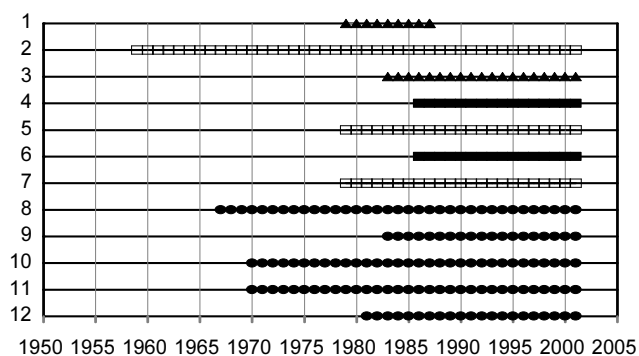


Fig. 9. Periods of record for stations in the Mangatu suite. Streamflow sites are: 1 Waipaoa @ Waipaoa Station; 2 Waipaoa @ Kanakanaia Bridge; 3 Mangatu @ Omapere; 4 Waihora @ No. 3 Bridge; 5 Waikohu @ Mahaki; 6 Waihuka @ No. 3 Bridge; 7 Waingaromia @ Terrace. Rainfall sites are: 8 Waipaoa Station in Waipaoa; 9 Omapere in Mangatu; 10 Mahaki in Waikohu; 11 Terrace in Waingaromia; 12 Kanakanaia Bridge in Waipaoa.

Te Arai Suite

Table 11 and Fig. 10 show sites in the south of the district around the Te Arai catchment in which afforestation has begun in more recent years, mainly since about 1990. There is, therefore, potential to assess changes with afforestation, but records are short.

Table 11 Gisborne District: Te Arai suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Te Arai @ Pykes Weir	GDC	19766	X18:286604	Jan 1984		82.7		Pasture + native + exotic
Gentle Annie @ Weir	NIWA	19778	Y18:313716	Oct 1983	Jan 1993	3.2		Pasture
McPhails Stream @ Waingake Road	NIWA	19779	X18:298643	Nov 1983		3.98		Pasture
Rainfall								
Pykes Weir in Te Arai	GDC	878816	X18:285604	Feb 1988			50	
Waingake in McPhails	NIWA	877811	Y18:306641	Jan 1984	Jan 1994		48	
Wairenga-O-Kuri	GDC	878817	X18:270692	Aug 1987			315	

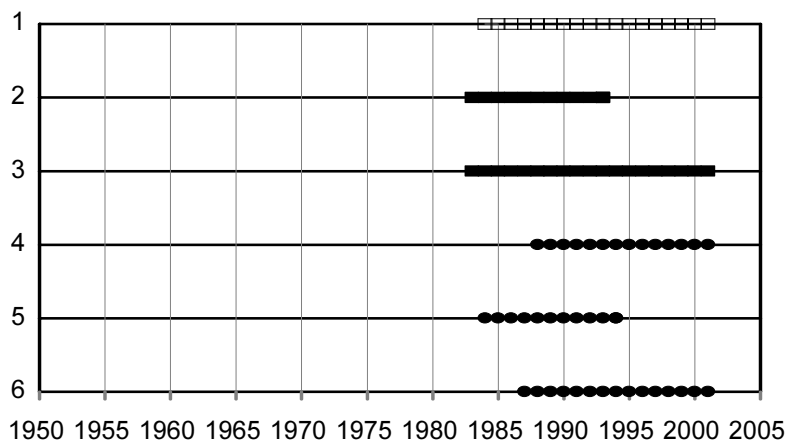


Fig. 10 Periods of record for stations in the Te Arai suite. Streamflow sites are: 1 Te Arai @ Pykes Weir; 2 Gentle Annie @ Weir; 3 McPhails Stream @ Waingake Road. Rainfall sites are: 4 Pykes Weir in Te Arai; 5 Waingake in McPhails; 6 Wairenga-O-Kuri.

3.6 Hawke's Bay Region

Wairoa Suite

One of the most extensive network of gauged rivers with plantations present is in Hawke's Bay. Table 12 lists sites identified as potentially useful in the northern region about Wairoa River and the periods of record are shown in Fig. 11. Many of the exotic forests established in these catchments existed before streamflow measurements began hence the records generally will reflect mixed land use with mature forests. Plantations generally are less than 50% of a catchment and, as catchment sizes tend to be large, changes may not be easy to detect. In addition to the sites listed in Table 12, the Te Arai suite listed in Table 11 will provide additional comparative data for assessing any observed changes at the Kopuawhara River catchment. A further complication with this set is assessing any effect of Lake Waikaremoana water storage on outputs of the Waiiau River system which may make the use of Waiiau River not feasible.

Table 12 Hawke's Bay Region: Wairoa suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Waiiau @ Ardkeen	HBRC	21493	W19:818417	Mar 1988		1315		Exotic + pasture + native
Aniwaniwa @ Aniwaniwa	HBRC	1021404	W18:725654	Dec 1988		50.78		Native
Hopuruahine @ The Cascades	HBRC	1021407	W18:634702	Dec 1989				Native
Ruakituri @ Sports Ground	HBRC	21499	X18:992556	Oct 1985		512		Native+ pasture
Waiatai @ Taits Bridge	HBRC	21302	X19:976335	May 1979	Jan 1985	13.2		Exotic + pasture
Kopuawhara @ Railway Bridge	HBRC	20101	Y19:306319	Apr 1981		54.5		Exotics + native + pasture
Hangaroa @ Doneraille Park	HBRC	21437	X18:088642	May 1974		596		Native + pasture
Mokau @ SH38	HBRC	21420	W18:663667	Jan 1990		36.7		Native
Mohaka @ Glenfalls	NIWA	21803	V20:240188	Mar 1961		997		Exotic + native + pasture
Mohaka @ Ruapunga	NIWA	21801	W19:672285	Feb 1957		2370		Exotic + native + pasture
Rainfall								
Bushy Knoll in Hangaroa	HBRC	876410	X18:992719	Nov 1986			564	
Aniwaniwa in Waikaretaheke	HBRC	877112	W18:719648	Mar 1977			671	
Doneraille Park in Hangaroa	HBRC	877512	X18:088642	Jul 1985			160	
Sports Ground in Ruakituri	HBRC	878410	X18:992556	Jan 1989			70	
Kellihers in Waiiau	HBRC	879210	W19:818417	Mar 1988			30	
Upper Waiiau in Waiiau	HBRC	869910	W19:512474	Apr 1985			260	
Nga Tuhoe In Ruakituri	HBRC	877214	W18:819649	Jun 1985			520	
Mt Manuoha at L Waikaremoana	HBRC	876110	W18:686748	Oct 1989			1372	
Ruapani in Waikaretaheke	HBRC	877113	W18:690666	Apr 1976			945	

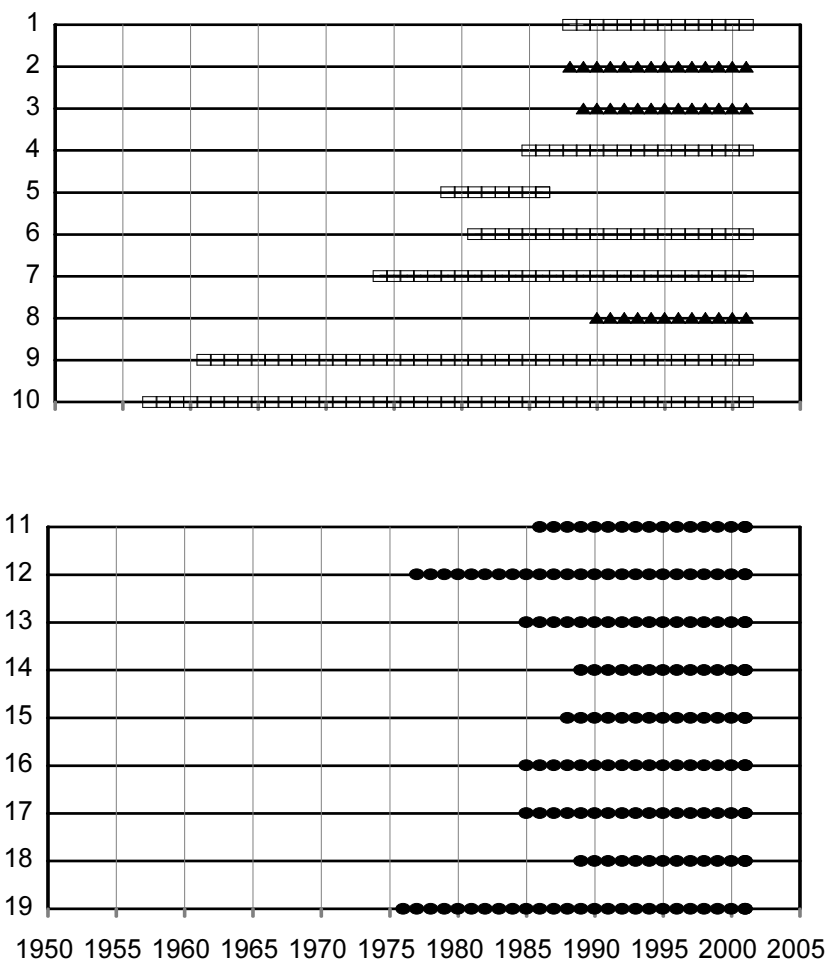


Fig. 11 Periods of record for stations in the Wairoa suite. Streamflow sites are: 1 Waiiau @ Ardkeen; 2 Aniwaniwa @ Aniwaniwa; 3 Hopuruahine @ The Cascades; 4 Ruakituri @ Sports Ground; 5 Waiatai @ Taits Bridge; 6 Kopuawhara @ Railway Bridge; 7 Hangaroa @ Doneraille Park; 8 Mokau @ SH38; 9 Mohaka @ Glenfalls; 10 Mohaka @ Ruapunga. Rainfall sites are: 11 Bushy Knoll in Hangaroa; 12 Aniwaniwa in Waikaretaheke; 13 Doneraille Park in Hangaroa; 14 Sports Ground in Ruakituri; 15 Kellihers in Waiiau; 16 Upper Waiiau in Waiiau; 17 Nga Tuhoe in Ruakituri; 18 Mt Manuoha in L. Waikaremoana; 19 Ruapuni in Waikaretaheke.

Esk Suite

A second set of catchments in the Hawke's Bay region is centred on Eskdale north of Napier (Table 13; Fig. 12). As for the Wairoa suite, many of the exotic forests established in these catchments existed before streamflow measurements began, plantations generally are less than 50% of a catchment, catchment sizes tend to be large, and, therefore, changes may not be easy to detect. The Pakuratahi Stream and Tamingimingi Stream have been used recently as a catchment pair to assess the effects of harvesting a mature forest (Pakarutahi) on streamflow. **Table 13** Hawkes Bay Region: Esk suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Esk @ Berry Road	HBRC	22809	V20:377128	Jun 1992		58.68		26% exotics + 74% pasture
Esk @ Waipunga Bridge	HBRC	22802	V20:391591	Nov 1963		254		27% exotics + 62% pasture + 11% scrub
Tutaekuri @ Ngaroto Road	HBRC	23047	V21:219888	Apr 1991		377.5		
Tutaekuri @ Puketapu	HBRC	23001	V21:357812	Dec 1968	Jun 1980	792.5		11% exotics + 57% pasture
Tutaekuri @ Puketapu F/W	HBRC	23032	V21:357812	Apr 1978		792.5		11% exotics + 57% pasture
Mangaone @ Rissington	HBRC	23019	V21:300893	Jun 1990		218		23% exotics + 63% pasture
Tamingimingi @ Top Ford	HBRC	22714	V20:420977	Apr 1993		7.99		21% exotics + 76 % pasture
Pakuratahi @ Forest Glade	HBRC	22715	V20:438997	Sep 1993		3.44		87% exotics + 13% pasture
Ngahere @ Ngahere Weir	NIWA	23005	U20:043070	Feb 1968		0.521		52% native + 42% scrub
Ngaruroro @ Kuripapango	NIWA	23104	U20:969974	Sep 1963		370		39% native+ 29% scrub
Rainfall								
Tangoio in Esk	HBRC	963812	V20:443048	Dec 1987			720	
Fishers in Pakuratahi	HBRC	963814	V20:438993	Nov 1993			60	
Top Run in Pakuratahi	HBRC	963815	V20:409021	Jan 1994			360	
Waipatiki in Waipatiki	HBRC	962910	W20:519048	Jun 1996			200	
Te Poi (No. 2) in Esk	HBRC	962610	V20:277086	Dec 1994			370	
Paritu Loop in Kopuawhara	HBRC	970810	Y19:306319	Mar 1981			22	
Waihau in Mangatutu	HBRC	963512	V20:162958	Dec 1984			350	

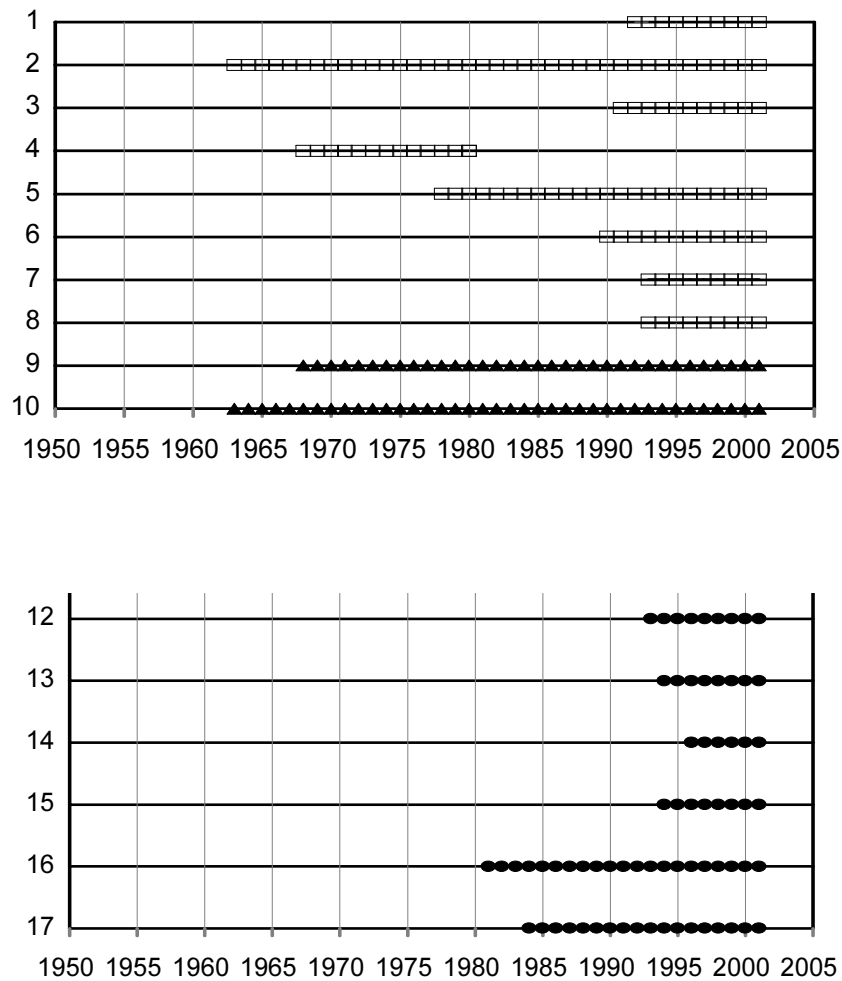


Fig. 12 Periods of record for stations in the Wairoa suite. Streamflow sites are: 1 Esk @ Berry Road; 2 Esk @ Waipunga Bridge; 3 Tutaekuri @ Ngaroto Rd; 4 Tutaekuri @ Puketapu; 5 Tutaekuri @ Puketapu F/W; 6 Mangaone @ Rissington; 7 Tamingimingi @ Top Ford; 8 Pakuratahi @ Forest Glade; 9 Ngahere @ Ngahere Weir; 10 Ngaruroro @ Kuripapango. Rainfall sites are: 11 Tangoio in Esk; 12 Fishers in Pakuratahi; 13 Top Run in Pakuratahi; 14 Waipatiki in Waipatiki; 15 Te Poi (2) in Esk; 16 Paritu Loop in Kopuawhara; 17 Waihau in Mangatutu.

3.7 Manawatu-Wanganui Region

Mangaetoroa Suite

The Mangaetoroa Suite (Table 14, Fig. 13) is located to the west of Mt Ruapehu. The Mangaetoroa River has about 40% exotic forest but full comparisons with the other two sites (Makotuku and Manganui-o-te-ao Streams) may not be valid as geological differences could have a significant influence on yields as they drain

the slopes of Mount Ruapehu.

Table 14 Manawatu-Wanganui Region: Mangaetoroa suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Mangaetoroa @ School	NIWA	33115	S20:017932	Dec 1968		33.2		Exotic + pasture
Makotuku @ SH49A	NIWA	33117	S20:103011	Feb 1968		20.8		Native + pasture
Manganui-o-te-ao @ Ashworths	NIWA	33309	S20:003082	Aug 1961	Aug 1980	332		Native + pasture
Rainfall								
F Trig in Makotuku	NIWA	953510	S20:254061	Nov 1968			1266	
Scarrows in Mangaetoroa	HMW	954210	S20:014957	May 1968				
Gauging Site @ Makotuku	NIWA	953511	S20:103011	Sep 1968	Jan 1980		610	

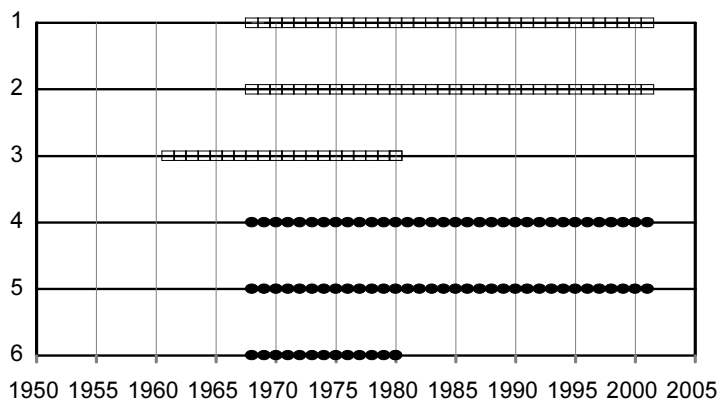


Fig. 13 Periods of record for stations in the Mangaetoroa suite. Streamflow sites are: 1 Mangaetoroa @ School; 2 Makotuku @ SH49A; 3 Manganui-o-te-ao @ Ashworths. Rainfall sites are: 4 F Trig in Makotuku; 5 Scarrows in Mangaetoroa; 6 Gauging Site @ Makotuku

Tokiahuru Suite

These catchments are to the south of Mt Ruapehu (Table 15, Fig. 14). In the Tokiahuru suite, streamflow measurements for catchments with pines may be limited. Water-tightness of the catchments may also be an

issue with the volcanic regions surface boundaries not being the hydrologic boundaries. Whangaehu River and Tokiahura Stream may have had established forests before streamflow measurements began. Control catchments may be the Waitangi Stream and Mangawhero River.

Table 15 Manawatu-Wanganui Region: Tokiahuru suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Mangawhero @ Ore Ore	NIWA	33111	S21:045794	May 1962		506		Pasture + native
Whangaehu @ Karioi	NIWA	33107	S21:218864	Nov 1962		492		Exotics + pasture+ native
Tokiahuru @ Whangaehu Junction	NIWA	33112	S21:217871	Aug 1979	Jan 1994	220		Native + exotics + pasture
Waitangi @ Tangiwai	NIWA	33114	T21:316886	Nov 1967	Jan 1994	63.5		Pasture
Rainfall								
Gauging Station in Waitangi	NIWA	954510	T21:316886	Jun 1968	Jan 1980		671	
Gravel Pit in Waitangi	NIWA	954611	T20:413935	Aug 1967	Jan 1994		869	

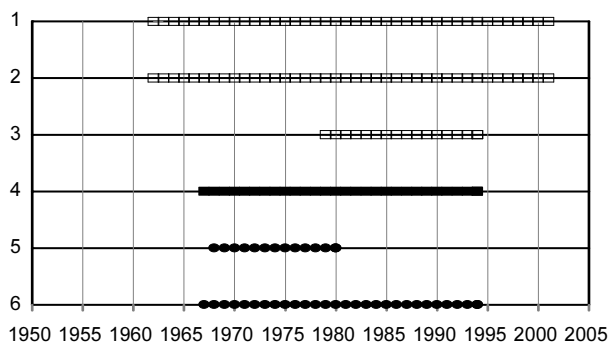


Fig. 14 Periods of record for stations in the Tokiahuru suite. Streamflow sites are: 1 Mangawhero @ Ore Ore; 2 Whangaehu @ Karioi; 3 Tokiahuru @ Whangaehu Junction; 4 Waitangi @ Tangiwai. Rainfall sites are: 5 Gauging Station in Waitangi; 6 Gravel Pit in Waitangi.

3.8 Wellington Region

Hutt Suite

Catchments with small amounts of plantation forest have been identified north of Wellington and centred about Upper Hutt (Table 16, Fig. 15). Plantations in the Whakatiki River catchment are mainly in the Wainui Stream sub-catchment which enters below the Whakatiki River streamgauging station so this site is useful as a control for Akatarawa River. The second catchment with plantations is the Pakuratahi River. Most catchments suitable as control catchments have native forest cover.

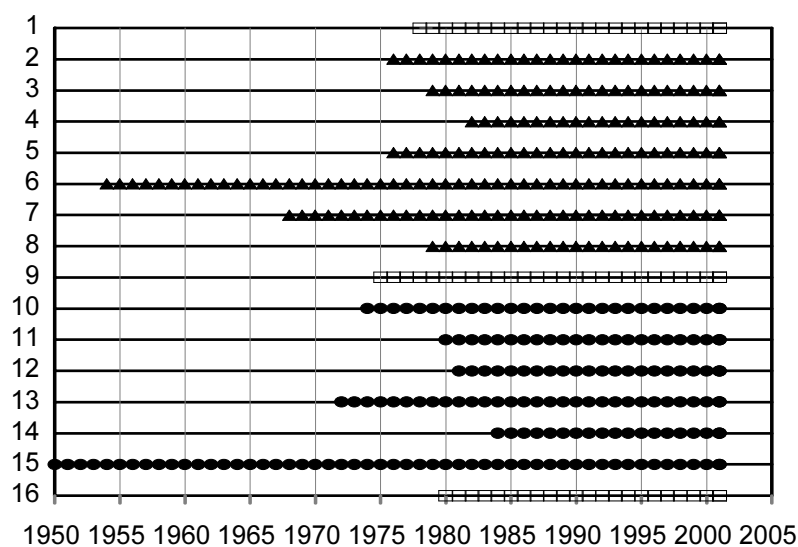


Fig. 15 Periods of record for stations in the Hutt suite. Streamflow sites are: 1 Pakuratahi @ Truss Bridge; 2 Whakatiki @ Dude Ranch; 3 Orongorongo @ Upper Dam; 4 Wainuiomata @ Manuka Track; 5 Tauherenikau @ Gorge; 6 Waiohine @ Gorge; 7 Hutt @ Kaitoke; 8 Akatarawa @ Cemetery; 9 Pauatahanui @ Gorge. Rainfall sites are: 10 Angle Knob in Waingawa; 11 Warwicks in Akatarawa; 12 Blue Gum Spur in Whakatiki R; 13 Phillips in Hutt; 14 Centre Ridge in Pakuratahi; 15 Reservoir in Wainuiomata; 16 Orongo Swamp in Orongorongo.

Table 16 Wellington Region: Hutt suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Pakuratahi @ Truss Bridge	WRC	29843	S27:937069	May 1978		37.2		Native + exotics
Whakatiki @ Dude Ranch	WRC	29841	R26:806119	Sep 1976		46		Native
Orongorongo @ Upper Dam	WRC	29503	R27:825927	Feb 1979		7.1		Native
Wainuiomata @ Manuka Track	WRC	29606	R27:786924	Jun 1982		27.1		Native
Tauherenikau @ Gorge	WRC	29251	S26:080129	Mar 1976		112		Native
Waiohine @ Gorge	WRC	29224	S26:117183	Dec 1954		180		Native
Hutt @ Kaitoke	NIWA	29808	S26:942150	Dec 1967		88.84		Native
Akatarawa @ Cemetery	WRC	29844	R26:863112	Feb 1979		113.5		Native + exotics
Pauatahanui @ Gorge	NIWA	30802	R27:715082	May 1975		39.2		Native + pasture
Rainfall								
Angle Knob in Waingawa	WRC	58403	S26:144376	Dec 1974			1200	
Warwicks in Akatarawa	WRC	59007	R26:848256	Jan 1980			345	
Bull Mound in Tauherenikau	WRC	59310	S26:053227	May 1976			483	
Blue Gum Spur in Whakatiki	WRC	150010	S26:797156	Oct 1981			335	
Phillips in Hutt	NIWA	150210	S26:967158	May 1972			300	
Centre Ridge in Pakuratahi	WRC	151202	S27:946059	Apr 1984			510	
Reservoir in Wainuiomata	WRC	142904	R27:767912	1945			125	
Orongo Swamp in Orongorongo	WRC	152010	R27:825937	Oct 1980			420	

3.9 Tasman District

A number of catchments have been identified and allocated to two areas: Nelson North (Fig.16, Table 17) and Nelson South (Table 18, Fig. 17). In addition, the Moutere catchments operated by NIWA (Table 19, Fig. 18) and the Donald Creek catchments operated by Landcare Research (Table 20, Fig. 19) are listed separately. References to publications produced from the Moutere, Donald Creek, and the Nelson South catchment studies can be found in Rowe et al. (2001a, 2001b, 2001c).

Most catchments have had plantations established before flow recordings began and, therefore, reflect the mature forest estate rather than following through a process of afforestation. The Nelson North suite does not seem to have a suitable control catchment against which comparisons can be made with forested catchments. Some stations, e.g., Stanley Brook, are affected by extraction for irrigation in the low-flow season.

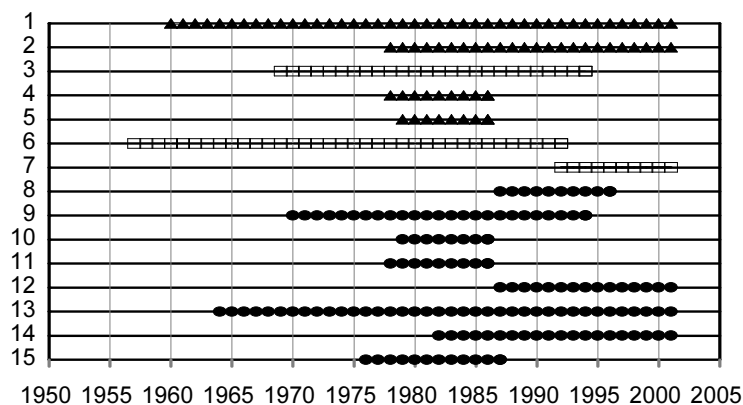


Fig. 16 Periods of record for stations in the Nelson North suite. Streamflow sites are: 1 Collins @ Drop Structure; 2 Wakapuaka @ Hira; 3 Stanley Brook @ Barkers; 4 South Pigeon tributary @ Bradleys; 5 North Pigeon tributary @ Sharpes; 6 Wairoa @ Gorge; 7 Wairoa @ Irvines. Rainfall sites are: 8 Oakleys in Collins; 9 Malcolms in Stanley Brook; 10 Forks in Pigeon; 11 Pah Road in Wakapuaka; 12 Gorge in Motueka; 13 Blue Glen in Motueka; 14 Little Ben in Wairoa; 15 Blunder Ridge in Collins.

Table 17 Nelson Region: Nelson North suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Collins @ Drop Structure	TDC	58301	O27:547052	Jan 1960		17.61		80% exotic + scrub
Wakapuaka @ Hira	TDC	58101	O27:431991	Aug 1978		41.93		65% exotic + scrub
Stanley Brook @ Barkers	NIWA	57014	N27:949877	Dec 1969	May 1994	81.6		70% exotics + pasture
South Pigeon tributary @ Bradleys	NIWA	57505	N27:098812	Dec 1978	Jul 1986	1.29		100% exotics
North Pigeon tributary @ Sharpes	NIWA	57506	N27:116832	Apr 1979	Jul 1986	1.19		100% exotics
Wairoa @ Gorge	TDC	57502	N28:211791	Nov 1957	Dec 1992	464		Exotics + native + scrub/pasture
Wairoa @ Irvines	TDC	57521	N28:210782	Mar 1992		462		Exotics + native + scrub/pasture
Rainfall								
Oakleys in Collins	NIWA	131516	O27:555800	Oct 1987	Apr 1996		260	
Malcolms in Stanley Brook	NIWA	123810	N27:954873	Sep 1970	Jan 1994		116	
Forks in Pigeon	NIWA	133019	N27:119810	Oct 1979	May 1986		120	
Pah Road in Wakapuaka	TDC	131436	O27:476042	Sep 1978	Oct 1986		20	
Gorge in Motueka	TDC	157008	N28:028526	Oct 1987			380	
Blue Glen in Motueka	TDC	126942	N28:023530	Dec 1964			366	
Little Ben in Wairoa	TDC	134001	N28:178711	May 1982			427	
Blunder Ridge in Collins	TDC	131515	O27:560041	May 1976	Dec 1987		215	

Table 18 Nelson Region: Nelson South suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Long Gully @ Meads Road	NIWA	57016	N28:970619	Aug 1973	Mar 1983	2.31		Native + exotics
Roughns @ Weir	NIWA	57020	N28:980555	Jul 1976	Jun 1986	3.22		100% exotics
Graham Creek @ Weir	NIWA	57021	N29:959497	Mar 1977	Jun 1986	4.74		95% exotic
Hunters @ Weir	NIWA	57022	N29:988479	Apr 1977		5.02		Native
Kikiwa @ Weir	NIWA	57023	N28:979502	Jun 1977	Jun 1986	2.85		Pasture
Rainfall								
Long Gully in Golden Downs	NIWA	125842	N28:963596	Jan 1976	Mar 1983		722	
Greens Road in Roughns	NIWA	126810	N28:974537	Nov 1976	Jun 1984		533	
Weir in Graham Creek	NIWA	126844	N29:958496	Nov 1981	Jun 1998		455	
Weir in Hunters	NIWA	126845	N28:979502	Feb 1989	Apr 1996		457	
Forks in Kikiwa	NIWA	127910	N29:976486	Jul 1977	Nov 1981		518	

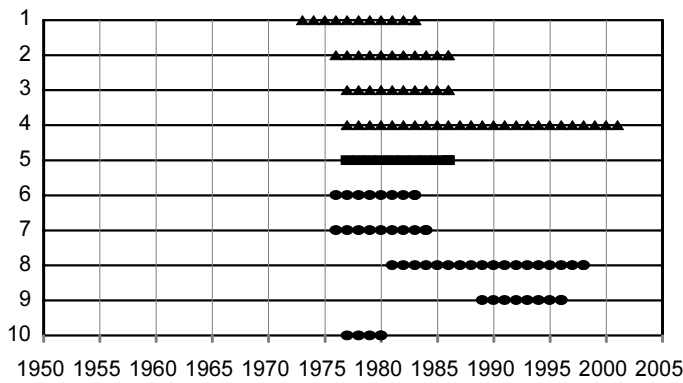


Fig. 17 Periods of record for stations in the Nelson South suite. Streamflow sites are: 1 Long Gully @ Meads Road; 2 Roughns @ Weir; 3 Graham Creek @ Weir; 4 Hunters @ Weir; 5 Kikiwa @ Weir. Rainfall sites are: 6 Long Gully in Golden Downs; 7 Greens Road in Roughns; 8 Weir in Graham Creek; 9 Weir in Hunters; 10 Forks in Kikiwa.

The small Moutere catchments were established to investigate the effects of farming and afforestation practices on the streamflow regime. All stations ceased to be monitored in early 1988 but some were re-established in 1991 for 2 years to appraise the effects of forest harvesting on streamflow. Duncan (1980, 1995) has reported on some of the changes that have taken place to the streamflow regime.

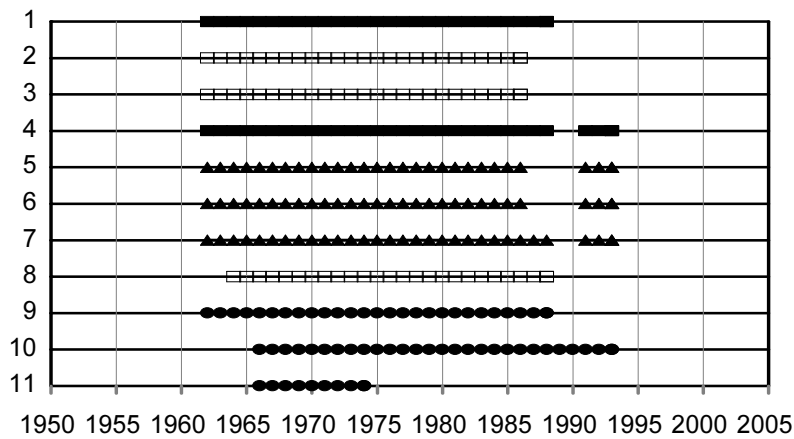


Fig. 18 Periods of record for stations in the Moutere suite. Streamflow sites are: 1 Moutere 2; 2 Moutere 3; 3 Moutere 4; 4 Moutere 5; 5 Moutere 8; 6 Moutere 13; 7 Moutere 14; 8 Moutere 15. Rainfall sites are: 9 Moutere 5 (site 133011); 10 Moutere 5 (site 133054); 11 Moutere 14.

Table 19 Nelson Region: Moutere suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Moutere 2	NIWA	57402	N27:169837	Jan 1962	Jan 1988	0.04		Pasture
Moutere 3	NIWA	57403	N27:166833	May 1962	Jul 1986	0.03		Pasture + exotics
Moutere 4	NIWA	57404	N27:165831	Apr 1962	Jul 1986	0.04		Pasture + exotics
Moutere 5	NIWA	57405	N27:164831	Apr 1962	Jul 1993	0.07		Pasture
Moutere 8	NIWA	57408	N27:171828	Apr 1962	Jul 1993	0.04		Exotic
Moutere 13	NIWA	57413	N27:163839	Apr 1962	Jul 1993	0.08		Exotic
Moutere 14	NIWA	57414	N27:161842	Apr 1962	Jul 1993	0.04		Exotic
Moutere 15	NIWA	57415	N27:160843	Jan 1964	Jan 1988	0.03		Pasture + exotics
Rainfall								
Moutere 5	NIWA	133011	N27:165827	May 1962	Jan 1988		135	
Moutere 5	NIWA	133054	N27:165827	Oct 1966	Jul 1993		135	
Moutere 14	NIWA	133016	N27:162839	Mar 1966	May 1974		138	

The Donald Creek catchments were established by Landcare Research (then, the New Zealand Forest Research Institute) in the 1970s to investigate the consequences of conversion of native forest to exotic plantations and of selection harvesting of native forests. Donald Creek 1 and 4 were converted to plantation while Donald Creek 3 was selection logged. Monitoring is continuing.

Table 20 Nelson Region: Donald Creek suite

Site	Data Source	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow							
Donald Creek 1	LCR	M28:	1976		0.09		Exotic
Donald Creek 2	LCR	M28:	1976		0.05		Native
Donald Creek 3	LCR	M28:	1976		0.08		Native
Donald Creek 4	LCR	M28:	1976		0.219		Exotic
Rainfall							
Upper Donald	LCR	M28:	1976				

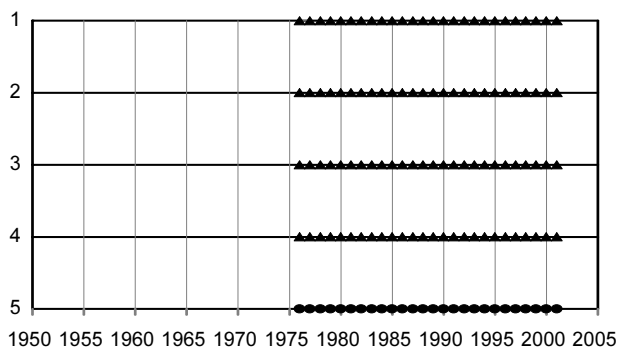


Fig. 19 Periods of record for stations in the Donald Creek suite. Streamflow sites are: 1 Donald Creek 1; 2. Donald Creek 2; 3 Donald Creek 3; 4 Donald Creek 4. Rainfall site is: 5 Upper Donald.

3.10 West Coast Region

Landcare Research has operated a set of very small experimental catchments north-west of Reefton from 1974. Information on these catchments is listed in Table 21 and the periods of record are shown in Fig. 20. These catchments were established to investigate the effects of conversion of native forest to exotic plantations. Another set of three small catchments was established in Larry River to investigate the conversion of scrub to plantation on pakihi land. As this was a very short-term experiment, these will not be considered further.

Table 21 West Coast Region: Maimai suite

Site	Data Source	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow							
Maimai M05	LCR	L30:103021	Apr 1974	Feb 1993	0.02		Exotic
Maimai M06	LCR	L30:104021	May 1974	Feb 1993	0.02		Native
Maimai M07	LCR	L30:106020	Mar 1976	Jan 1988	0.04		Exotic
Maimai M08	LCR	L30:109018	Jul 1974	May 1988	0.04		Exotic
Maimai M09	LCR	L30:112016	Feb 1979	Jan 1989	0.08		Exotic
Maimai M13	LCR	L30:116014	Jul 1974	Aug 1995	0.04		Exotic
Maimai M14	LCR	L30:118013	Aug 1974	Apr 1998	0.05		Exotic
Maimai M15	LCR	L30:119012	Sep 1974		0.03		Native
Rainfall							
Lower Maimai	LCR	L30:105018	Mar 1974			290	
Upper Maimai	LCR	L30:120011	Apr 1974			310	

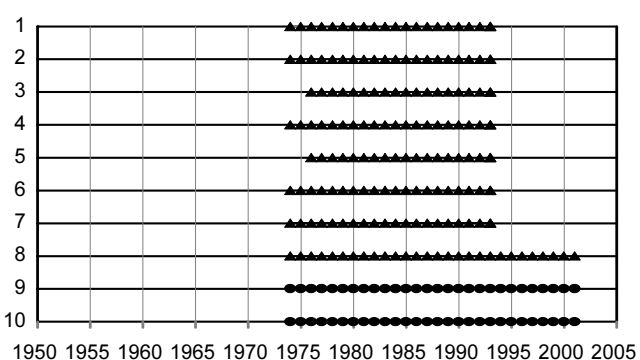


Fig. 20 Periods of record for stations in the Maimai suite. Streamflow sites are: 1 Maimai M05; 2 Maimai M06; 3 Maimai M07; 4 Maimai M08; 5 Maimai M09; 6 Maimai M13; 7 Maimai M14; 8 Maimai M15. Rainfall sites are: 9 Lower Maimai; 10 Upper Maimai.

3.12 Canterbury Region

NIWA and Landcare Research have both monitored catchments at Ashley Forest in North Canterbury (Table 22, Fig. 21). The Ashley catchments provide a snapshot of water yields from a drier environment with mature pine trees and there is a small pasture catchment for a comparative control. Harvesting the Landcare Research pine catchment took place in 1985 which provides another dimension to the data from here. Data is also available for catchments at, and adjacent to, Kakahu Forest near Geraldine (Table 23, Fig. 22). A gap of 10 years duration is in the records for both Mitchell's and Turnbull's weirs.

Table 22 Canterbury Region: Ashley suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Stony Creek @ Forbes Road	NIWA	66207	M34:768748	Dec 1979	Aug 1986	6.07		Exotic +?
Stony Creek South @ Sawbench Road	NIWA	66208	M34:756754	Jun 1979	Feb 1987	2.6		Exotic
Stony Creek North @ Stony Creek Road	NIWA	66209	M34:757756	Jun 1979	Aug 1986	1.82		Exotic
Ashley Pines	LCR	API	M34:755754	Oct 1980	Aug 1989	##		Exotic
Ashley Pasture	LCR	APA	M34:747746	Jan 1981	Apr 1987	##		Pasture
Rainfall								
Lawrence Road in Stony Creek	NIWA	322614	M34:749771	Oct 1983	Oct 1986		305	
Stony Creek Road in Stony Creek	NIWA	322610	M34:747764	Feb 1980	Oct 1983		180	
Ashley Pines	LCR	API	M34:755754	Oct 1980	Apr 1987			
Ashley Pasture	LCR	APA	M34:747746	May 1981	Apr 1987			

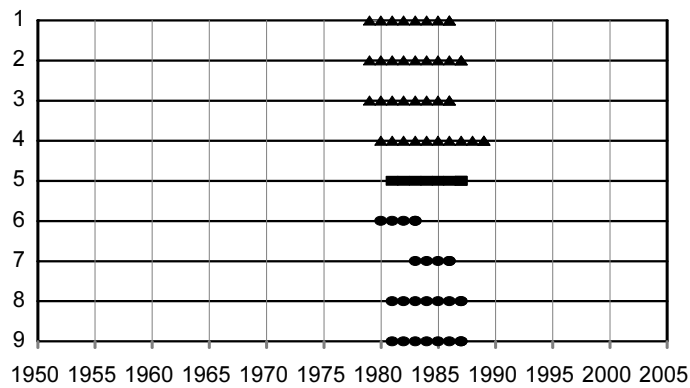


Fig. 21 Periods of record for stations in the Ashley suite. Streamflow sites are: 1 Stony Creek @ Forbes Road; 2 Stony Creek South @ Sawbench Road; 3 Stony Creek North @ Stony Creek Road; 4 Ashley Pines; 5 Ashley Pasture. Rainfall sites are: 6 Lawrence Road in Stony Creek; 7 Stony Creek Road in Stony Creek; 8 Ashley Pines; 9 Ashley Pasture.

Table 23 Canterbury Region: Kakahu suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Kakahu @ Mitchell's weir 9	EC	69633	J38:518795	Nov 1980		2.75		Exotic
Kakahu @ Turnbull's weir 10	EC	69634	J38:536777	Nov 1980		4.55		Pasture
Kakahu @ Mulvihills	EC	69645	J38:538739	Dec 1983		43.7		Exotics + pasture
Te Moana	EC	69644	J37:583834	Dec 1983		77.8		Pasture
Rainfall								
Geraldine Forest in Opuha	EC	410010	J37:508811	Oct 1986			792	

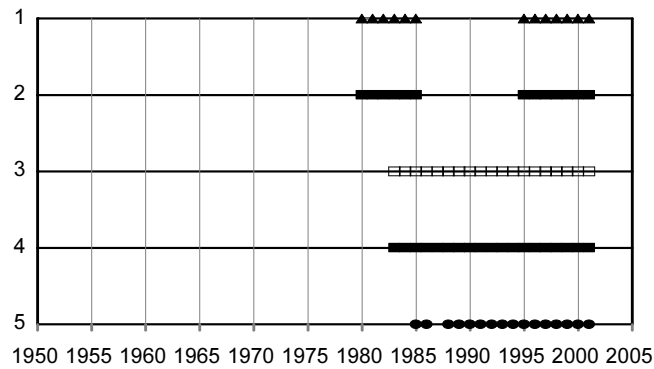


Fig. 22 Periods of record for stations in the Kakahu suite. Streamflow sites are: 1 Kakahu @ Mitchell's 9; 2 Kakahu @ Turnbull's 10; 3 Kakahu @ Mulvihills; 4 Te Moana. Rainfall site is: 6 Geraldine Forest in Opuha.

3.12 Otago Region

Berwick Suite

One significant set of data in the Otago Region is in, and adjacent to, Berwick Forest (Table 24; Fig 23). Smith (1987) reported a comparison of flows from these catchments, two in plantation and two in pasture.

Table 24 Otago Region: Berwick suite

Site	Data Source	Site Number	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow								
Storm Creek @ Storm Road	NIWA	74362	H45:790659	Jul 1978	Jul 1987	1.14		Exotic
Jura Creek @ Jura Road	NIWA	74361	H45:774652	Jun 1978	May 1987	1.92		Exotic
Vollweillerburn @ Berridale	NIWA	74364	H45:763606	May 1980	May 1987	1.63		Pasture
Kintore Creek @ Berridale	NIWA	74360	H45:762607	Sep 1979	Jan 1994	2.92		Pasture
Rainfall								
Jura Road in Taeri	NIWA	509010	H45:774651	June 1980	Jul 1987		215	
Kintore Creek Weir in Kintore	NIWA	690912	H45:762606	Feb 1978	Jan 1994		245	

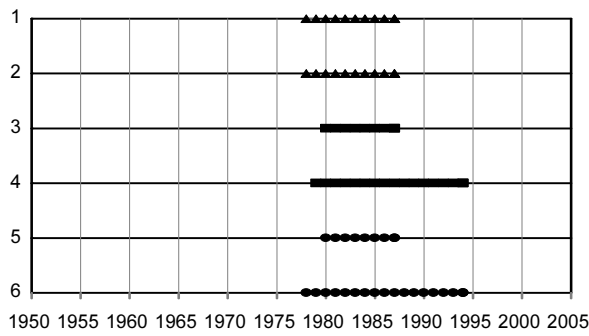


Fig. 23 Periods of record for stations in the Taieri suite. Streamflow sites are: 1 Storm Creek @ Storm Road; 2 Jura Creek @ Jura Road; 3 Vollweillerburn @ Berridale; 4 Kintore Creek @ Berridale. Rainfall sites are: 5 Jura Road in Taieri; 6 Kintore Creek Weir.

Glendhu Suite

The Glendhu catchments near Lawrence are operated by Landcare Research (Table 25, Fig. 24). One has been maintained in the native tussock grassland and the other (GH2) was planted after a 3-year calibration period in 1982

Table 25 Otago Region: Glendhu suite

Site	Data Source	Grid Reference	Start	End	Area (km ²)	Altitude (m)	Land Cover
Streamflow							
Glendhu 1	LCR	H44:554815	1979		2.18		Tussock
Glendhu 2	LCR	H44:563813	1979		3.07		Exotic
Rainfall							
Glendhu Met	LCR	H44:558806	1979			630	

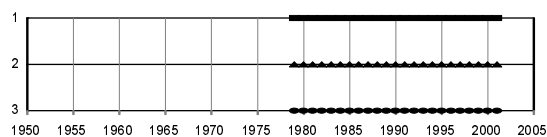


Fig. 24 Periods of record for stations in the Glendhu suite. Streamflow sites are: 1 Glendhu 1; 2 Glendhu 2. The rainfall site is: 3. Glendhu Met.

3.13 Other Regions

Taranaki Regional Council, Marlborough District Council, and Environment Southland advised there were no catchments in their areas identified as being suitable for this project.

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