Tributary characterization and assessment of tributary impacts on the geomorphic behaviour of Waiau River, Southland, New Zealand

Report submitted to Waiau River Working party as part of the project entitled "Tributary reach analysis of Waiau River" by

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Summary

This report characterizes the primary physical characteristics of tributaries of Waiau River with catchment areas > 10 km^2. This information was compiled from existing reports and field observations made in conjunction with relevant 1:50,000 and 1:63,360 topographic maps, 1:50,000 and 1:250,000 geological maps, and pertinent aerial photographs. The aim of this report is to provide the geomorphic context within which to view tributary impacts on the character of Waiau River in the period post-regulation.

Figure 1 provides a schematic overview of tributary catchments along Waiau River. These are presented geographically in Figure 2. Primary physical characteristics for each tributary catchment > 10 km^2 are summarised in Table 1. Geomorphic impacts at the confluence zone are described for each tributary in Table 2. Maps of each tributary catchment are then presented, along with other physical characteristics and longitudinal profiles. Analysis of this information, evaluated in context of the regional setting and river reach analyses, will form the basis for the Final Report on River character and tributary responses to flow regulation in Waiau Catchment.

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Figure 1: Schematic framework of tributaries along Waiau River

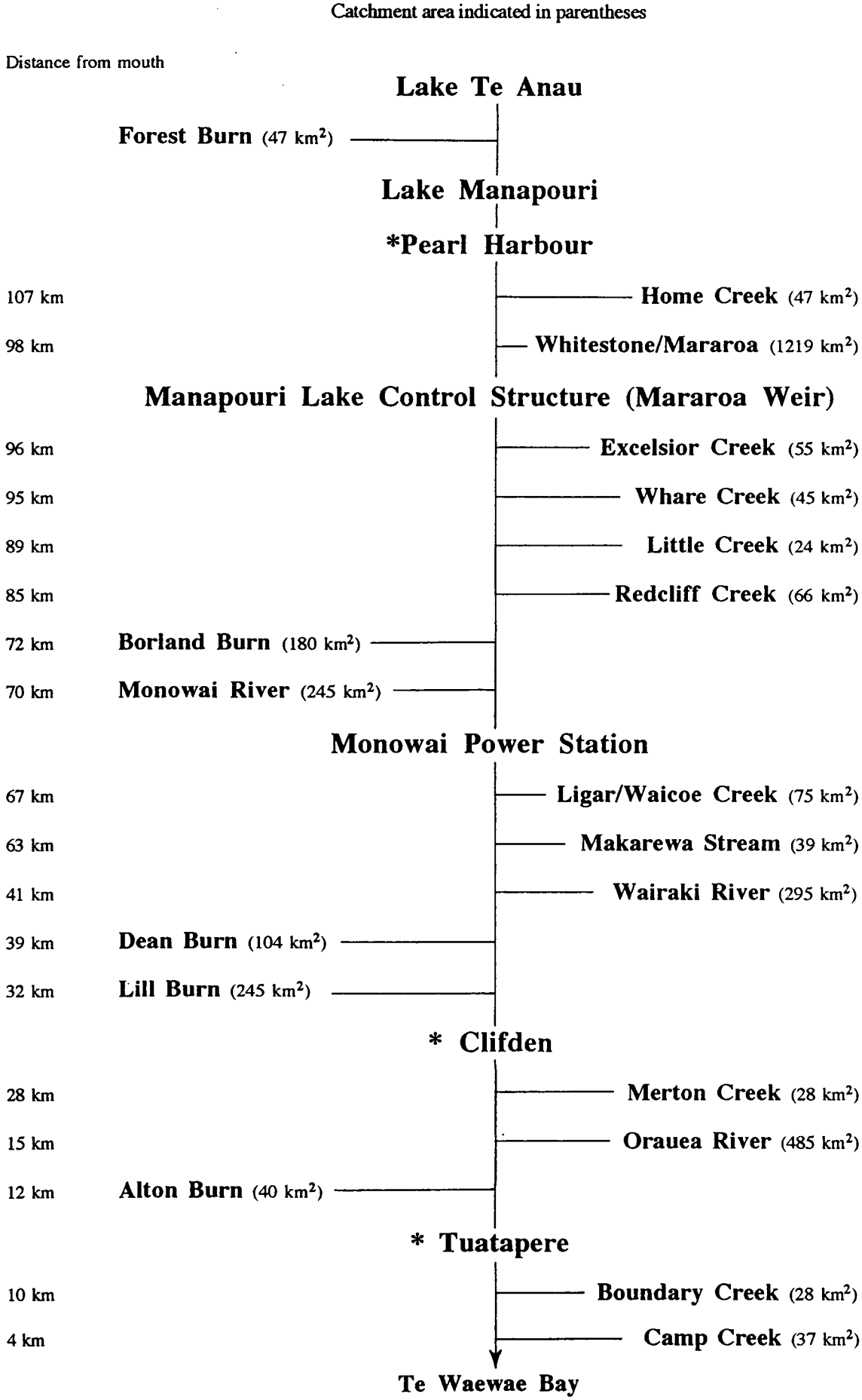


Figure 2: Tributary base map, Waiau River Catchment

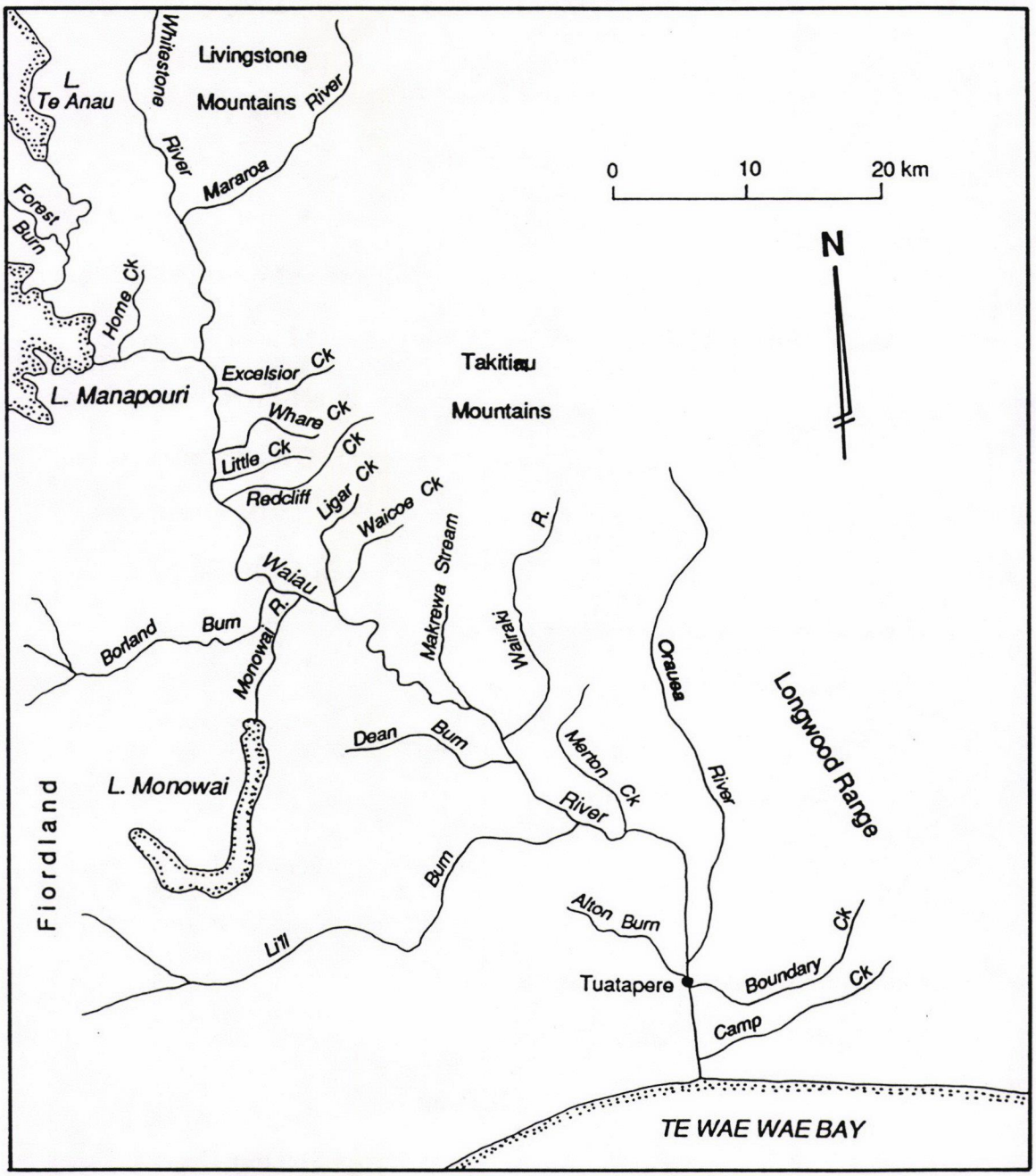


Table 1: Tributary catchment characteristics, Waiau River

Tributary	Area (km^2)	Length (km)	Shape (*1)	Relief (m)	Slope (^{0})	Valley side	Orientation	Vegetation	History (*2)
Forest Burn	47	51	3.4	1152	1.3	Right	NW-SE	indigenous forest	-
Home Creek	45	11	3.3	50	0.7	Left	NE-SW	pasture	1,2,3
Mararoa River	1219	128	8.1	1315	0.8	Left	NE-SW	pasture, indigenous grass	1,2,3
Excelsior Creek	55	20	2.2	1241	3.6	Left	E-W	pasture, indigenous grass	1,2
Whare Creek	45	22	6.1	1141	3.0	Left	E-W	forestry, indigenous forest	1,4
Little Creek	24	15	4.0	1100	4.2	Left	ESE-WNW	indigenous grass	1
Redcliff Creek	66	24	5.2	1401	3.3	Left	E-W	indigenous grass	1
Borland Burn	180	31	2.5	1094	2.0	Right	NW-SE	indigenous forest	1
Monowai River	245	9	2.3	58	0.4	Right	WSW-ENE	indigenous forest, grass	1,3
Ligar/Waicoe	75	61	2.5	1482	2.8	Left	E-W	forestry, indigenous forest	1,2,4
Makarewa Stream	39	19	3.0	1380	2.0	Left	E-W	forestry, indigenous grass	1,4
Wairaki River	295	54	3.5	1390	1.5	Left	ENE-WSW	pasture, indigenous grass	1,2,3
Dean Burn	104	23	2.5	791	2.0	Right	NW-SE	indigenous forest, grass	1
Lill Burn	245	55	3.3	1094	1.1	Right	W-E	pasture	1,2
Merton Creek	28	19	6.3	210	0.6	Left	N-S	pasture	1,2
Orauea River	485	44	2.9	300	0.4	Left	ENE-WSW	pasture, indigenous forest	1,2,3
Alton Burn	40	20	4.9	380	1.1	Right	NW-SE	indigenous forest, forestry	4
Boundary Creek	20	20	6.9	700	2.0	Left	E-W	indigenous forest, grass	-
Camp Creek	37	17	3.6	720	2.4	Left	E-W	indigenous forest, grass	-

1) Catchment shape is determined by dividing the squared length of the catchment by its area (i.e. $S = L^2/A$, where S = shape, L = length and A = area). Small S values indicate circular catchments whereas large values indicate long, thin catchments.

2) History
- 1 Direct or indirect evidence of past glacial activity (predominantly recorded by the presence of a significant number of terraces covering a large percentage of the catchment area)
- 2 Deforestation for agricultural purposes
- 3 Human impacts other than vegetation change
- 4) Development of forestry

Tributary impacts on Waiau River character

Field observations wer used along with and 1:50,000 or 1:63,360 topographic maps and aerial photographs to determine tributary impacts at the Waiau River confluence zone (**Table 2**).

Table 2: The nature of tributary impacts at Waiau River confluence zone

Tributary	Impacts on Waiau River
Forest Burn	none
Home Creek	delta formation, flow constriction
Mararoa River	delta and bar formation, flow constriction
Excelsior Creek	delta formation and flow constriction
Whare Creek	delta formation
Little Creek	none
Redcliff Creek	delta formation and flow constriction
Borland Burn	delta formation
Monowai River	none
Ligar/Waicoe Creek	delta formation and flow constriction
Makarewa Stream	none
Wairaki River	delta formation, flow deflection and constriction
Dean Burn	none
Lill Burn	delta and bar formation, flow deflection and constriction
Merton Creek	none
Orauea River	none
Alton Burn	none
Boundary Creek	none
Camp Creek	none

Geomorphic impacts of catchments > 10 km^2 on the character of Waiau River can be explained as follows, moving in downstream sequence:

Home Creek has created an extensive delta of sand-sized material at Waiau confluence, as Home Creek reworks former lake-bed deposits in its incised pathway down to Waiau River. Sand accumulation also reflects the inability of Waiau River to remove these deposits, given the low flow velocity of Waiau River, which minimises erosive competence.

Mararoa River has created a delta and numerous bars at its confluence, in addition to restricting flow width. Mararoa River maintains a high, steady sediment discharge given its catchment area and elevated headwaters/tributaries from the Takitimu's, aided by factors such as the high sustained water discharges, extensive deposits of unconsolidated material, vegetation clearance and channelisation (particularly of lower Whitestone River).

Extensive deposits of unconsolidated material stored in terraces, steep slopes, short channel lengths and small catchment areas are responsible for the small delta and mid-channel bars located at the confluences of **Whare Creek, Redcliff Creek** and **Makarewa Stream.**

The apparent delta at **Borland Burn** confluence is no more than a thin, single clast veneer of sediment. Persistence of this 'delta' is probably a result of regulating water discharges from the Waiau River, rather than conditions in Borland Burn catchment.

Of all tributaries investigated, **Wairaki River** displayed the most pronounced impacts on Waiau River, with delta and bar formation, flow constriction and deflection. The cause of these impacts is a high sediment discharge, resulting from a large catchment area, elevated headwaters and extensive deposits of unconsolidated sediments, ie. a similar explanation to that given for Mararoa River. Further to this explanation are conditions within Waiau River itself. At Wairaki confluence, the Waiau has a considerable flow width, following its release from confinement through Blackmount-Mangapiri reach. A consequence of increasing flow width is decreasing competence and erosive power, thereby enhancing the impacts of Wairaki River.

The elevated headwaters and steep slopes in the upper reaches of **Dean Burn** allow erosion of the extensive deposits of unconsolidated sediment in its lower course, thus producing enough sediment to facilitate mid-channel bar formation. The apparent flow deflection and constriction of flow width are a consequence of the upstream influences of Wairaki River, rather than conditions created by Dean Burn.

For much of its course **Lill Burn** is a gently meandering stream, incapable of transporting the vast quantities of sediment necessary to create the impacts observed at its confluence. It is only in lower reches, where Lill Burn flows over sediment deposited by Waiau River, that the tributary becomes braided, eroding and transporting material of a calibre similar to that found at the confluence. This indicates that Lill Burn's upper catchment is not presently responsible for supplying the material which is being deposited at the confluence. The condition of Waiau River at the confluence zone also facilitated delta and bar formation, as Waiau River is expanding its flow width following confinement through Motu Bush. Also, a local base level, which prevents downward erosion, exists at Clifden. Both of these factors reduce the erosive power of Waiau River, allowing sediment accumulation.

Mid-channel bars at **Orauea River** confluence are only partly consequent upon sediment from the Orauea catchment, where the dominant control is a local base level imposed by a resistant band of sandstone. This reduces the Waiau's erosive power, facilitating sediment accumulation.

Nine further tributaries make no detectable impact on the geomorphic character of Waiau River. The negligible impact of these tributaries can be explained by:

- Catchments with low gradients, low elevated headwaters and small areas (eg Merton Creek and Little Creek) are unable to produce sustained water discharges capable of eroding and transporting the volumes of sediment required to impact on Waiau River.

- Small catchments with steep slopes (eg Excelsior Creek and Whare Creek) have flashy discharges which are responsible for rapid removal of easily erodible material from their catchments.

- Lake Monowai acts as a sediment trap preventing large sediment discharge from Monowai River.

- Dense vegetation cover in Forest Burn and Alton Burn retards erosion, reducing sediment discharges such that these tributary streams exert negligible impact on Waiau River.

- Restricted availability of unconsolidated sediment in Camp Creek restricts tributary impacts on Waiau River.

Summary

The following factors appear to have the greatest influence in determining tributary impacts on Waiau River.

(i) Catchment size

Large catchments are able to produce higher, sustainable sediment discharges than the smaller catchments which have smaller, spasmodic sediment discharges.

(ii) Availability of unconsolidated sediment

The greater the availability of unconsolidated sediment, in combination with the ability to erode and transport it, greatly influences tributary impacts on Waiau River.

(iii) Conditions in Waiau River.

Tributaries which flow into Waiau River in confined reaches have little or no effect on the trunk stream. However, tributaries flowing into less confined reaches have greater potential to modify the geomorphic behaviour of Waiau River.

Inevitably, it is the combination of these factors which brings about greatest modification in the upstream and downstream behaviour of Waiau River adjacent to the confluence zone.

Appendices

In the following appendices a range of standard procedures have been employed to characterise tributary catchments of Waiau River. The following procedures have been used consistently for each catchment:

Catchment area was determined from planimeter measurements of catchment boundaries interpolated from 1:50,000 map sheets.

Catchment shape was measured using the US Army Corps of Engineers approach, namely:

$$\text{Shape}(S)=\text{Length}^2/\text{Area}.$$

Catchment orientation was interpreted from 1:50,000 map sheets.

Strahler Number refers to an ordering system for rivers, in which tributary streams are Order 1 streams, and when two first order streams combine the next stream segment is an Order 2 stream. When two Order 2 stream combine, an Order 3 stream is described. Hence, the higher the Strahler Number, the greater the complexity of streams within a catchment. In general stream order increases in a regular manner with catchment area.

Max channel length was determined from the catchment maps produced from the 1:50,000 topographic sheets.

Maximum channel rise is a measure of catchment relief, determined by the highest point within each tributary catchment in which a channel course has been plotted on the 1:50,000 topographic map.

Catchment slope was determined from standard topographic maps as channel length / channel rise (in degrees (^{o})).

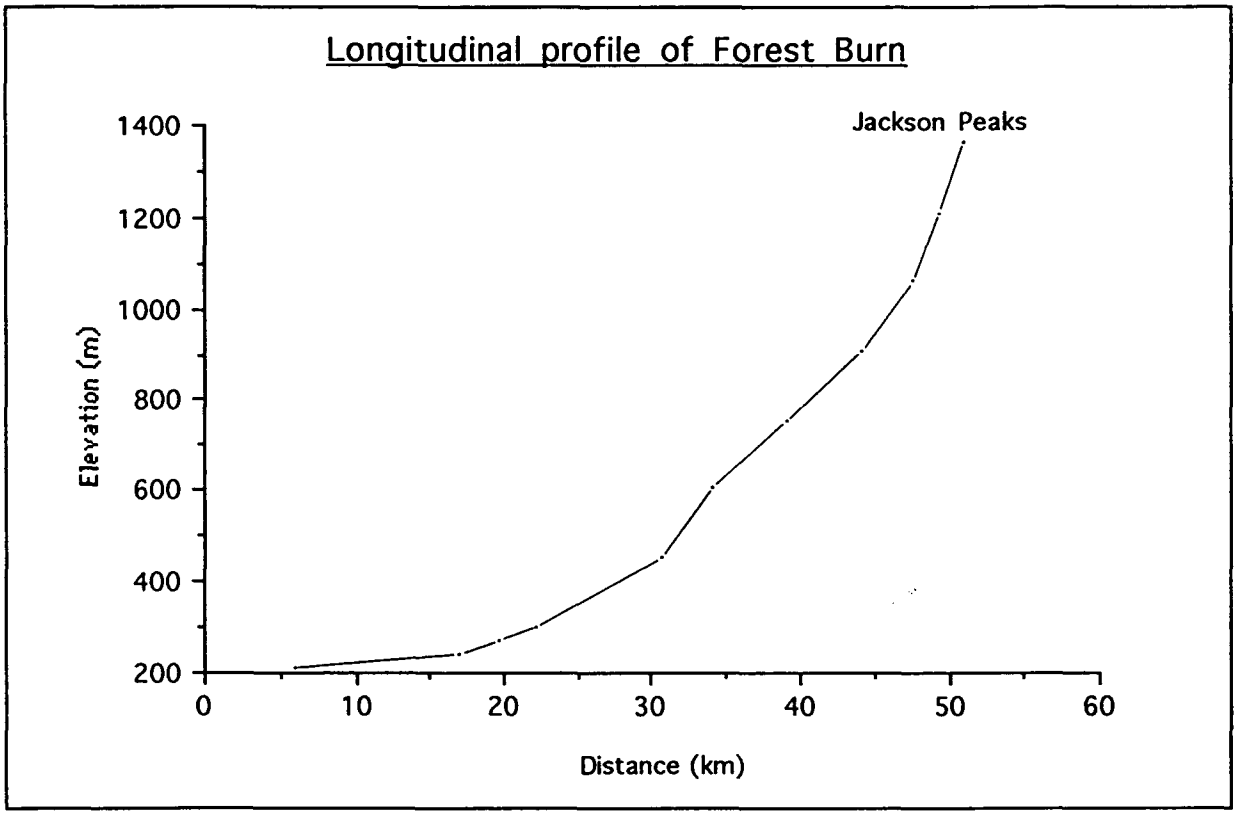
Longitudinal profile was plotted using Cricket Graph from 1:50,000 or 1:63,360 topographic maps

Proportional catchment geology was determined from 1:250,000 Geology and Surficial geology maps.

Proportional catchment soils was determined from 1:250,000 soil maps. Note that yellow-brown earths form in moderate-strong leaching environments which are humid, usually under a cover of forest or tall tussock.

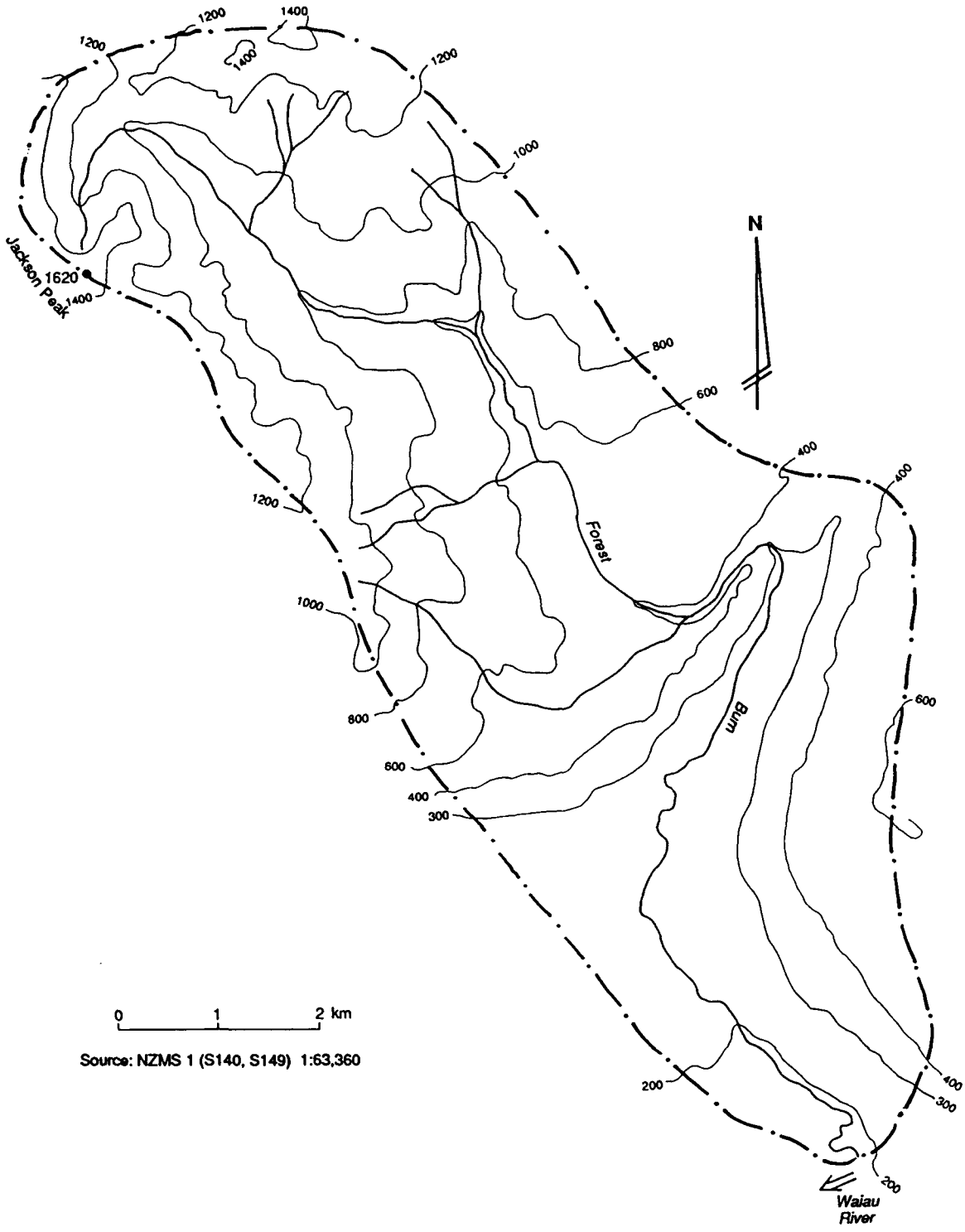
Forest Burn

Catchment area (km^2):	47
Catchment shape	3.7
Catchment orientation:	NW-SW, right bank
Strahler number:	3
Max channel length (km):	51
Max. channel rise (m):	1152
Catchment slope (degrees):	1.3



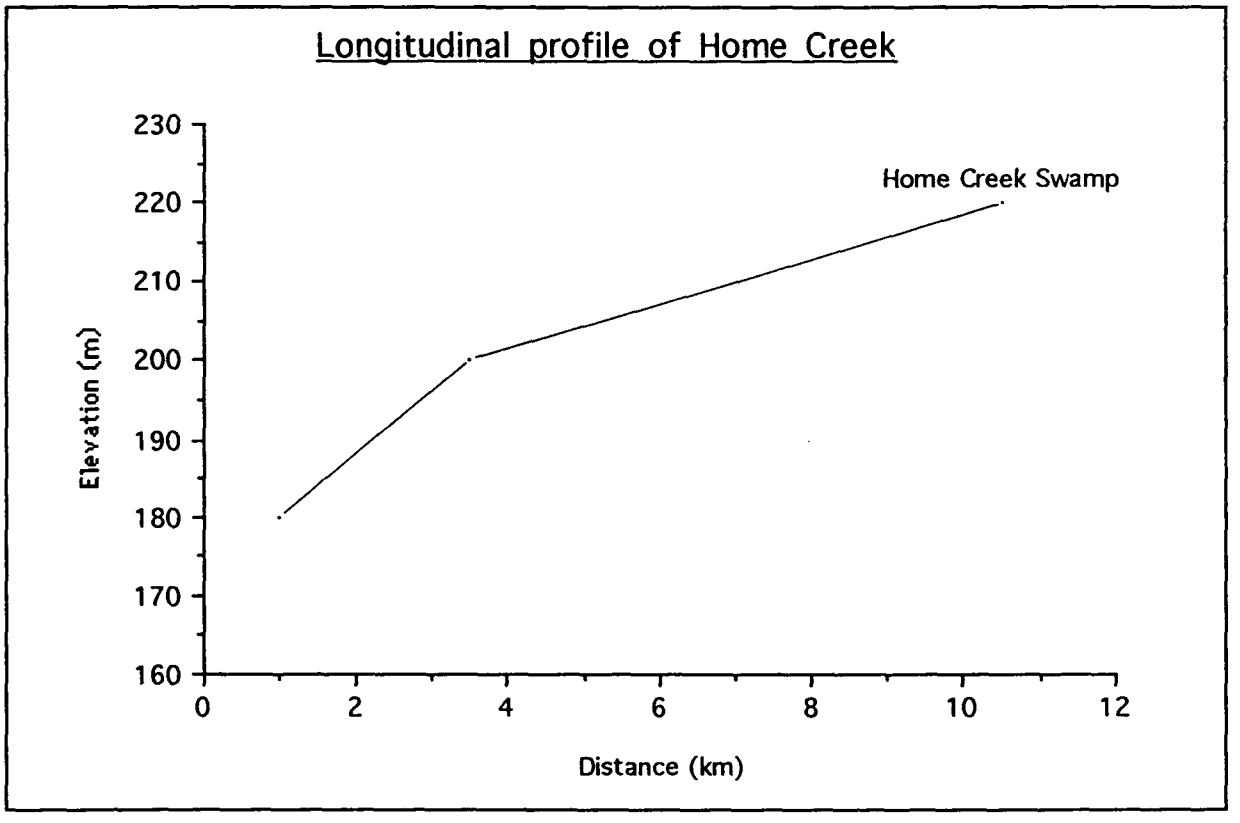
Catchment Geology (%)	Sedimentary	20	
	Metamorphic	40	
	Quaternary	40	
Catchment Soils (%)	Lowland yellow-brown earths		10
	Upland and high-country podzolized yellow-brown earths and podzols		40
	Yellow-brown loams		50

FOREST BURN CATCHMENT BASE MAP



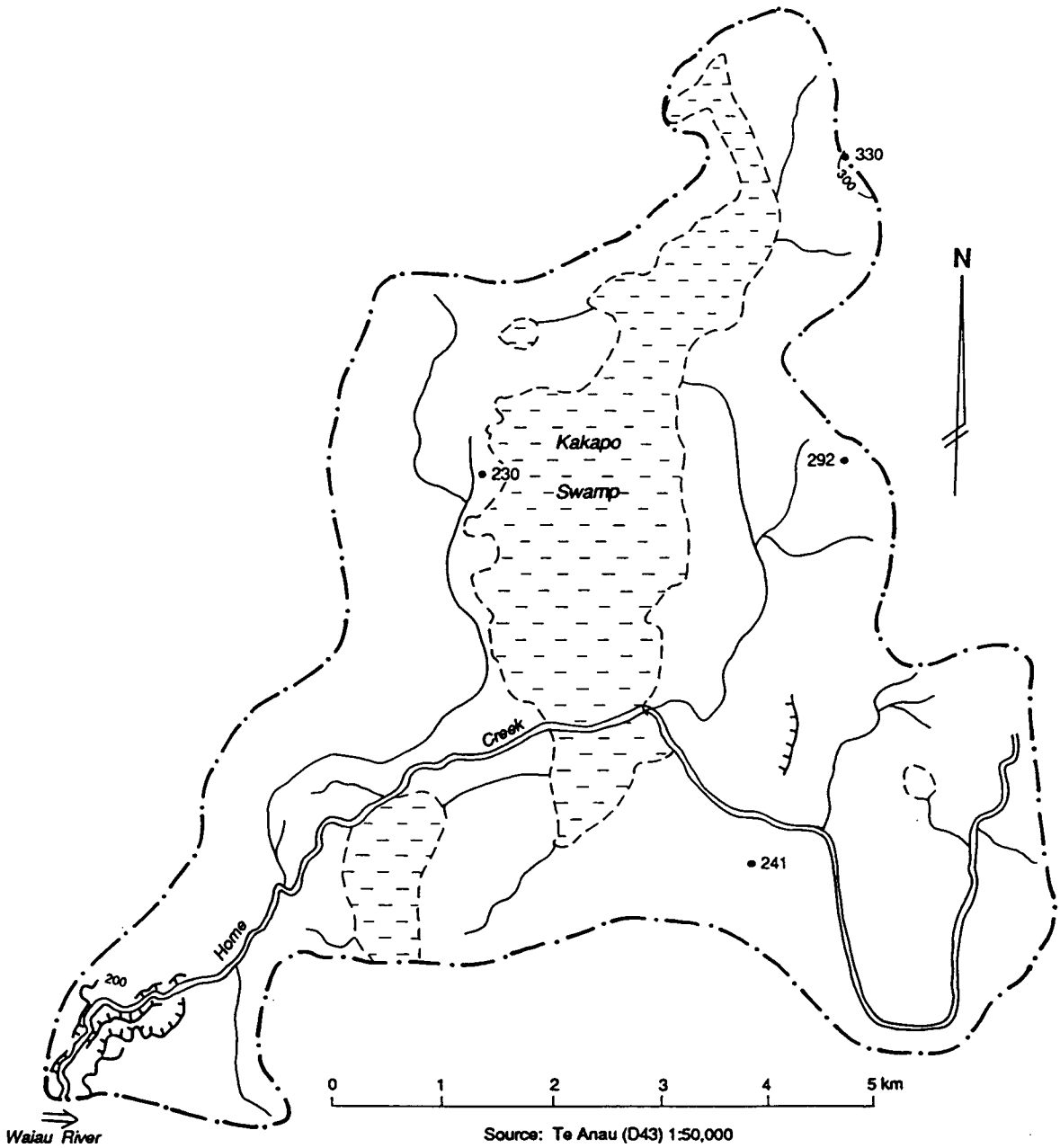
Home Creek

Catchment area (km^2):	47
Catchment shape:	3.3
Catchment orientation:	NE-SW, left bank
Strahler number:	3
Max. channel length (km):	11
Max. channel rise (m):	50
Catchment slope (degrees):	0.7, convex up



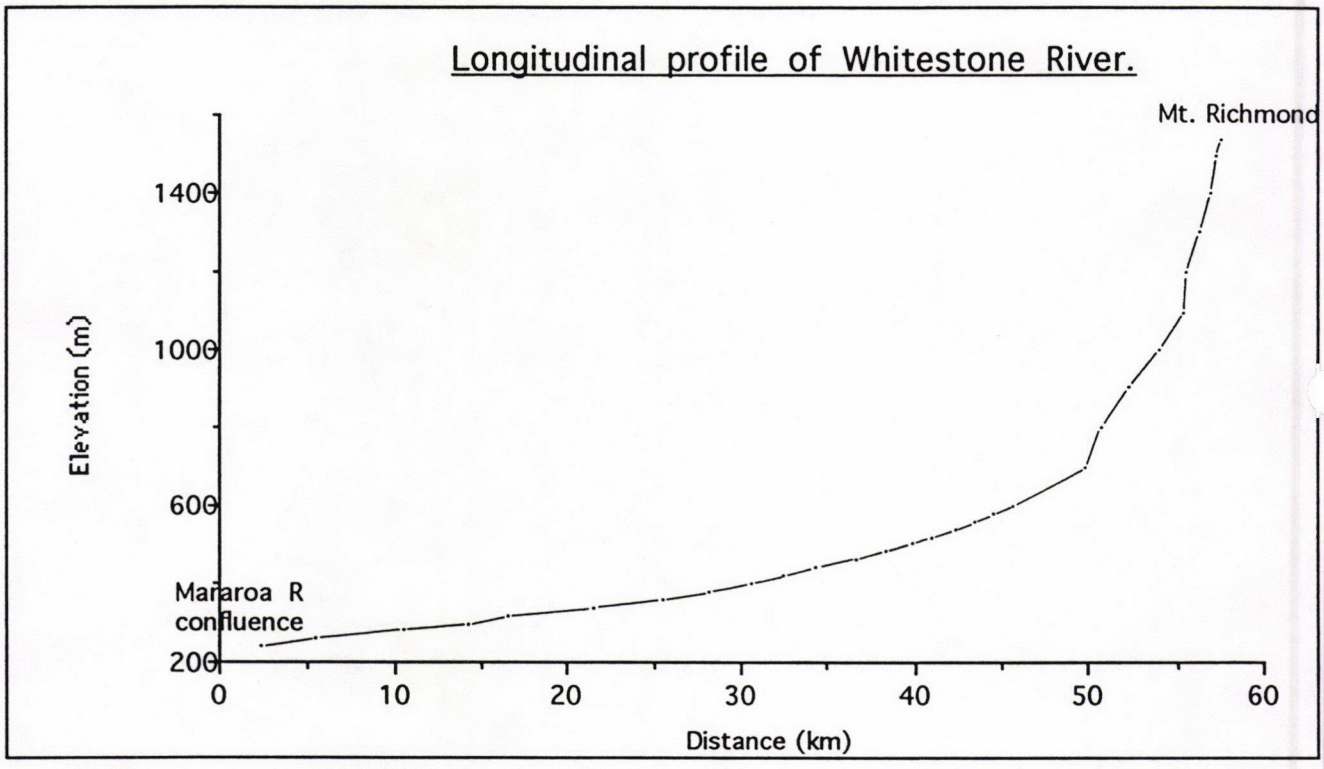
Catchment Geology (%):	Quaternary	100
Catchment Soils (%):	Yellow-brown loams	20
	Gley soils	80

HOME CREEK CATCHMENT BASE MAP



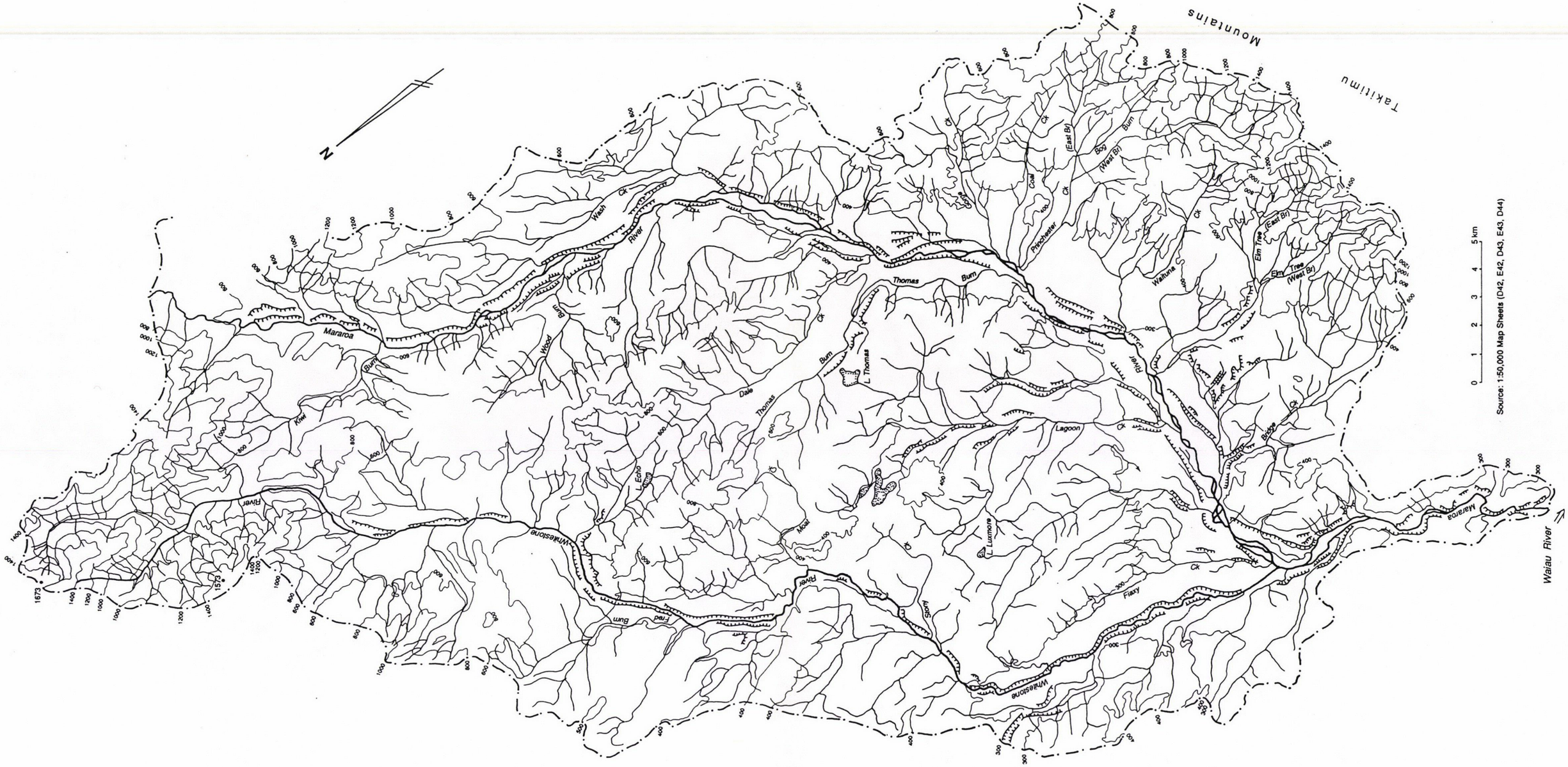
Whitestone River

Catchment area (km^2):	290
Catchment shape:	7.1
Catchment orientation:	NE-SW, left bank
Strahler number:	4
Max. channel length (km):	58
Max. channel rise (m):	1152
Catchment slope (degrees):	1.3



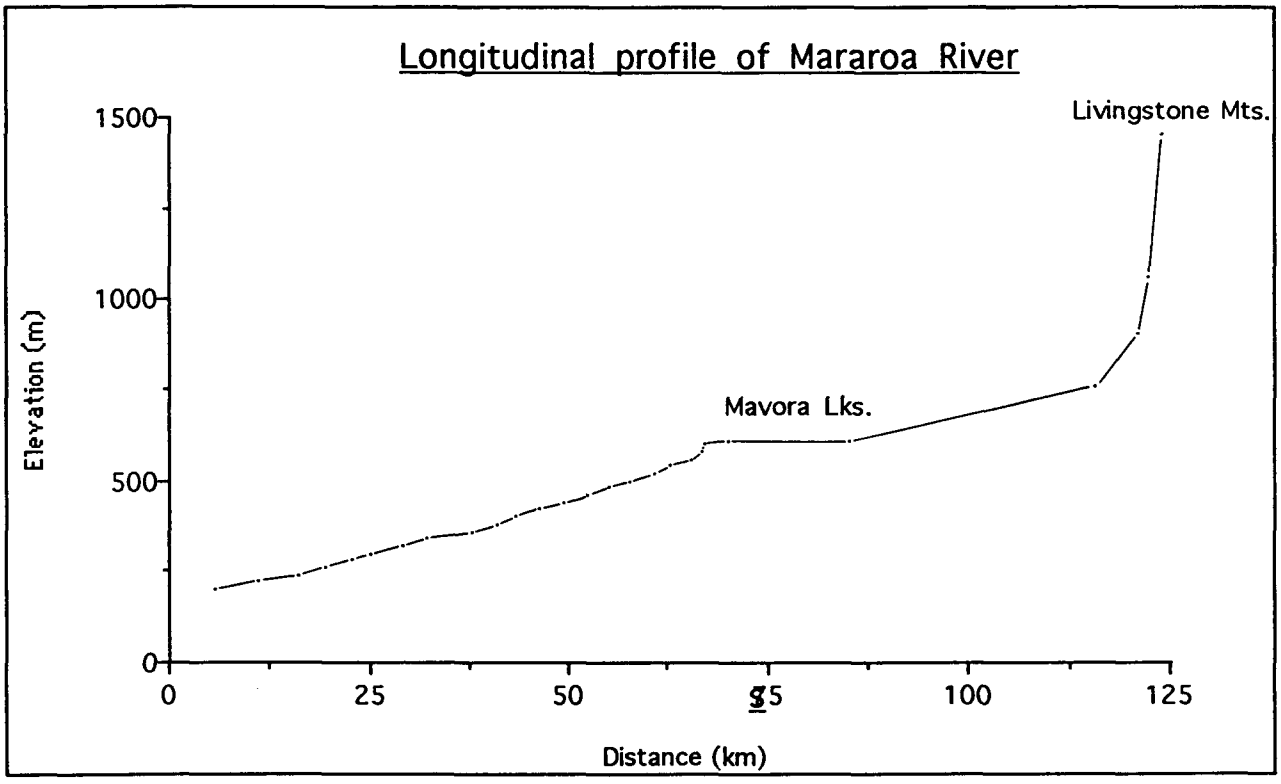
Catchment Geology (%):	Sedimentary	16
	Igneous	4
	Quaternary	80
Catchment Soils (%):	Lowland yellow-brown earths	11
	Upland and high country yellow-brown earths	32
	Yellow-brown earth intergrade	25
	Yellow-brown loams	15
	Gley soils	2
	Recent soils	15

WHITESTONE/MARAROA RIVER CATCHMENT BASE MAP



Mararoa River

Catchment area (km^2):	929
Catchment shape:	8.4
Catchment orientation:	NE-SW, left bank
Strahler number:	6
Max. channel length (km):	70
Max. channel rise (m):	1300
Catchment slope (degrees):	0.4

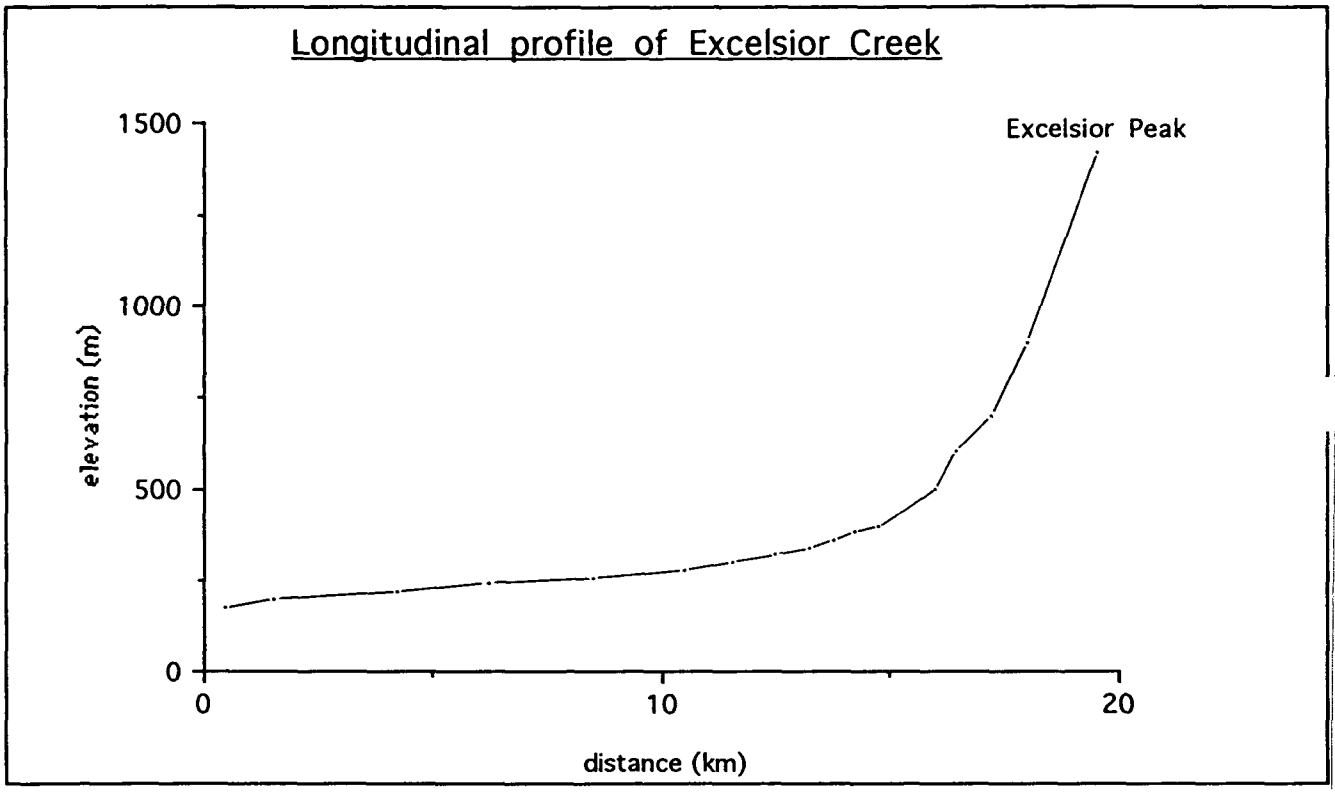


Catchment Geology (%):	Sedimentary	5
	Igneous	20
	Quaternary	75
Catchment Soils (%):	Lowland yellow-brown earths	11
	Upland and high country yellow-brown earths	32
	Yellow-brown earth intergrade	25
	Yellow-brown loams	15
	Gley soils	2
	Recent soils	15

(For base map, see page 15)

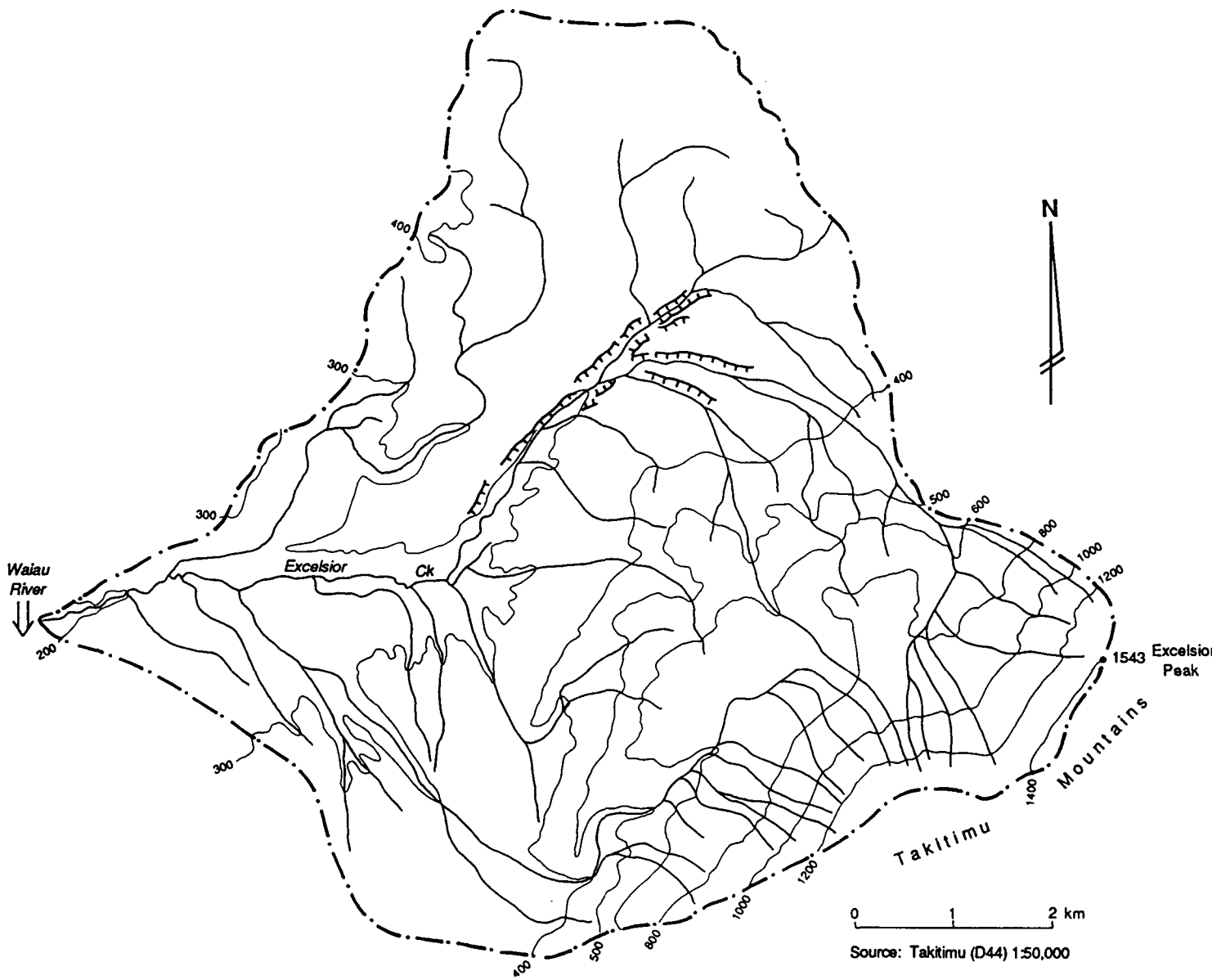
Excelsior Creek

Catchment area (km^2):	55
Catchment shape:	2.2
Catchment orientation:	E-W, left bank
Strahler number:	4
Max. channel length (km):	20
Max. channel rise (m):	1241
Catchment slope (degrees):	3.6



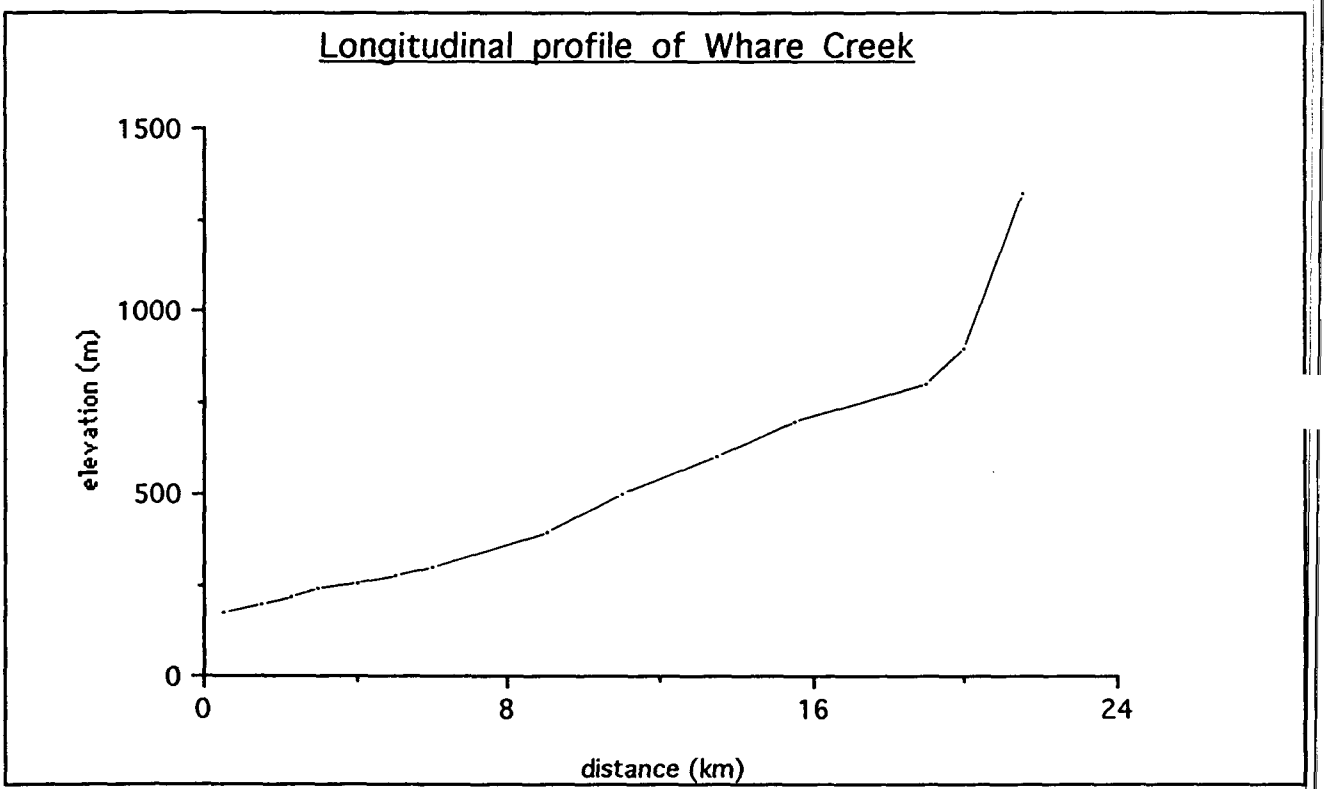
Catchment Geology (%):	Sedimentary	30
	Igneous	4
	Quaternary	65
Catchment Soils (%):	Lowland yellow-brown earths	40
	Yellow-brown earths intergrade	30
	Recent soils	30

EXCELSIOR CREEK CATCHMENT BASE MAP



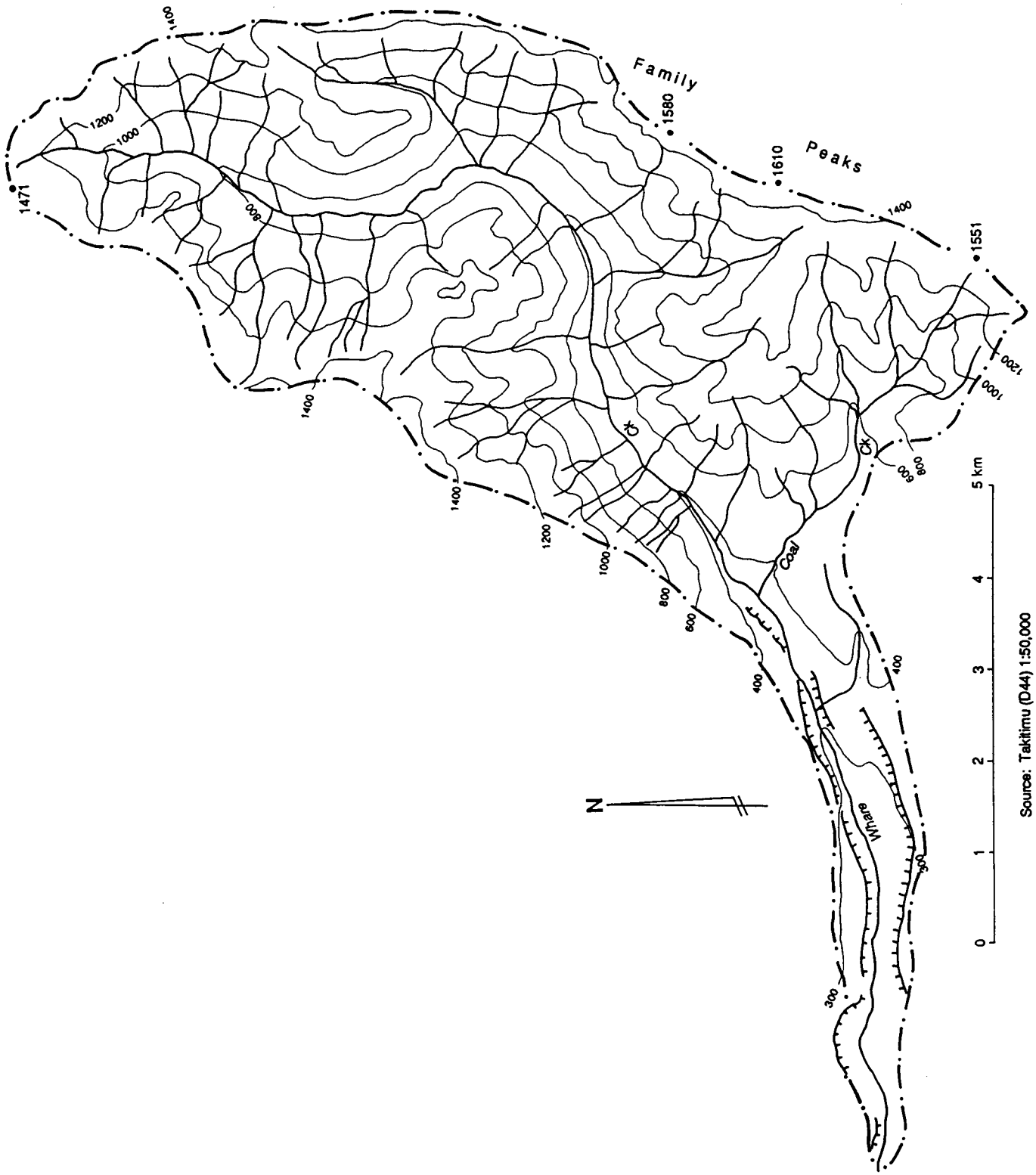
Whare Creek

Catchment area (km^2):	45
Catchment shape:	6.1
Catchment orientation:	E-W, left bank
Strahler number:	4
Max. channel length (km):	22
Max. channel rise (m):	1141
Catchment slope (degrees):	3.0



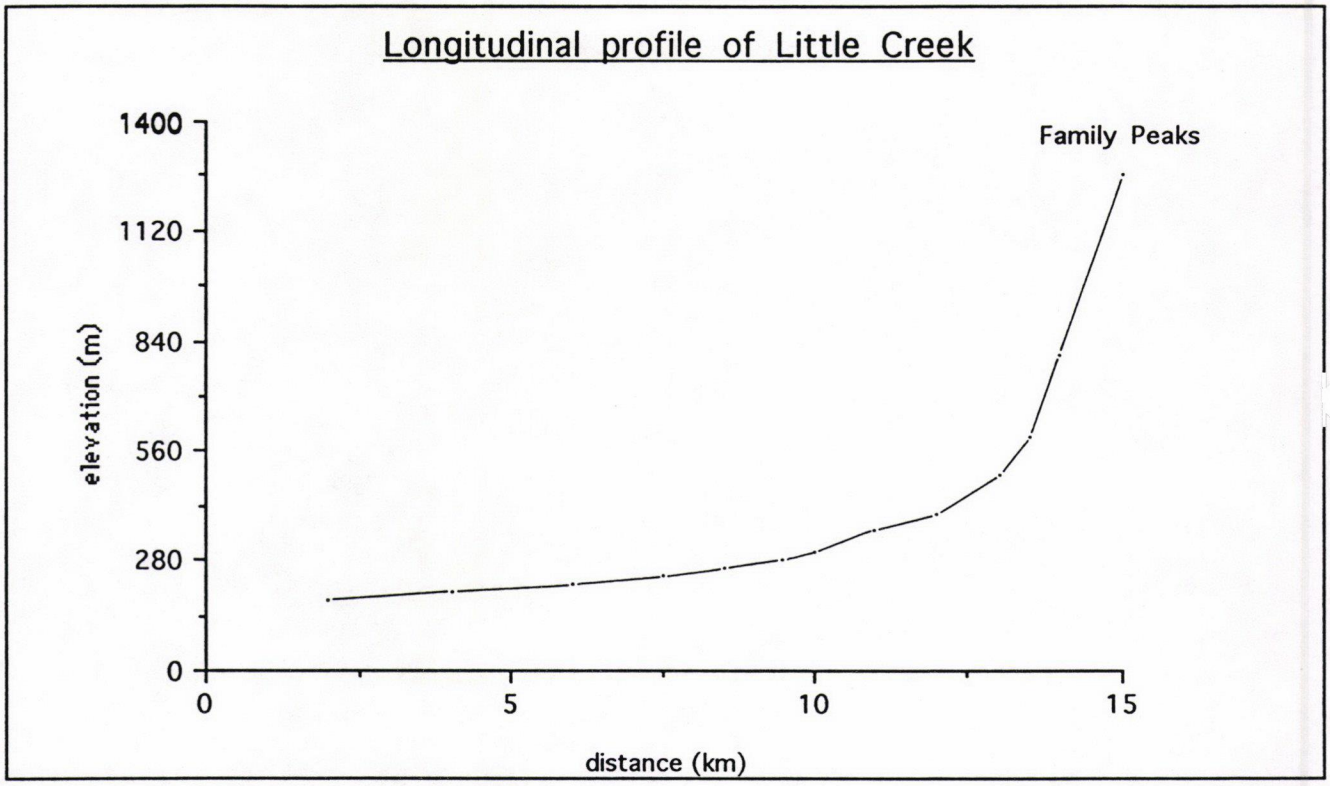
Catchment Geology (%):	Igneous	60
	Quaternary	40
Catchment Soils (%):	Yellow-brown earth intergrade	60
	Recent soils	40

WHARE CREEK CATCHMENT BASE MAP



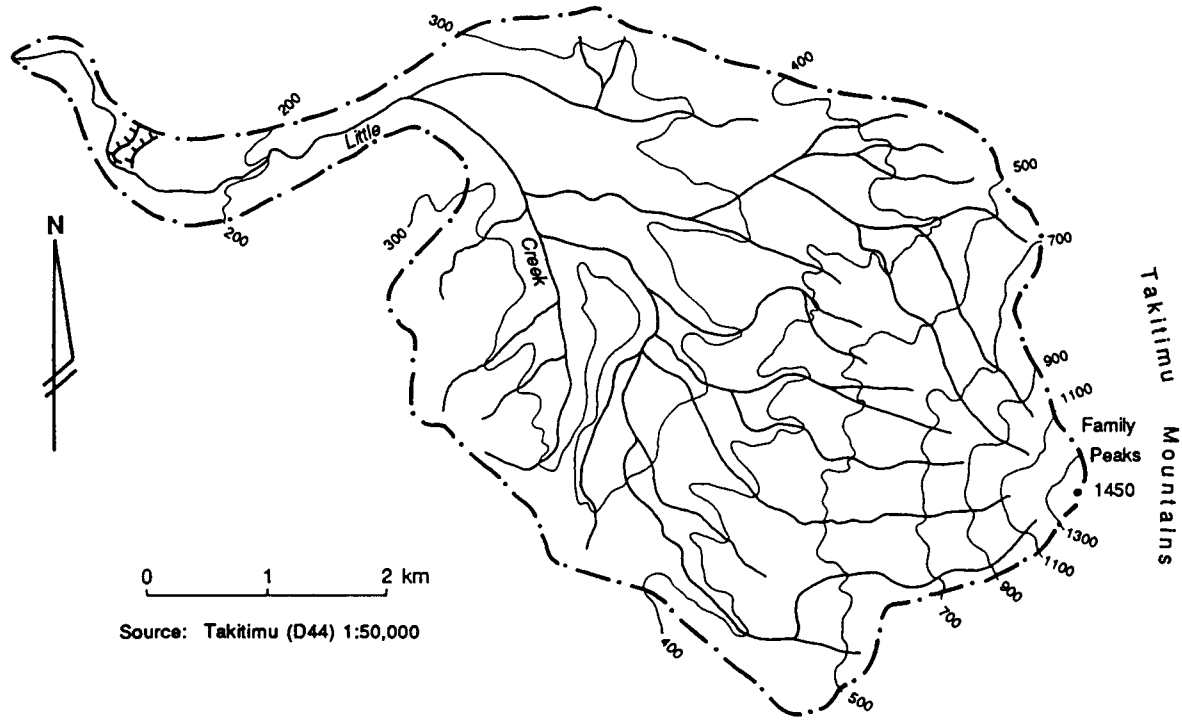
Little Creek

Catchment area (km^2):	24
Catchment shape:	4.0
Catchment orientation:	ESE-WNW, left bank
Strahler number:	4
Max. channel length (km):	15
Max. channel rise (m):	1100
Catchment slope (degrees):	4.2



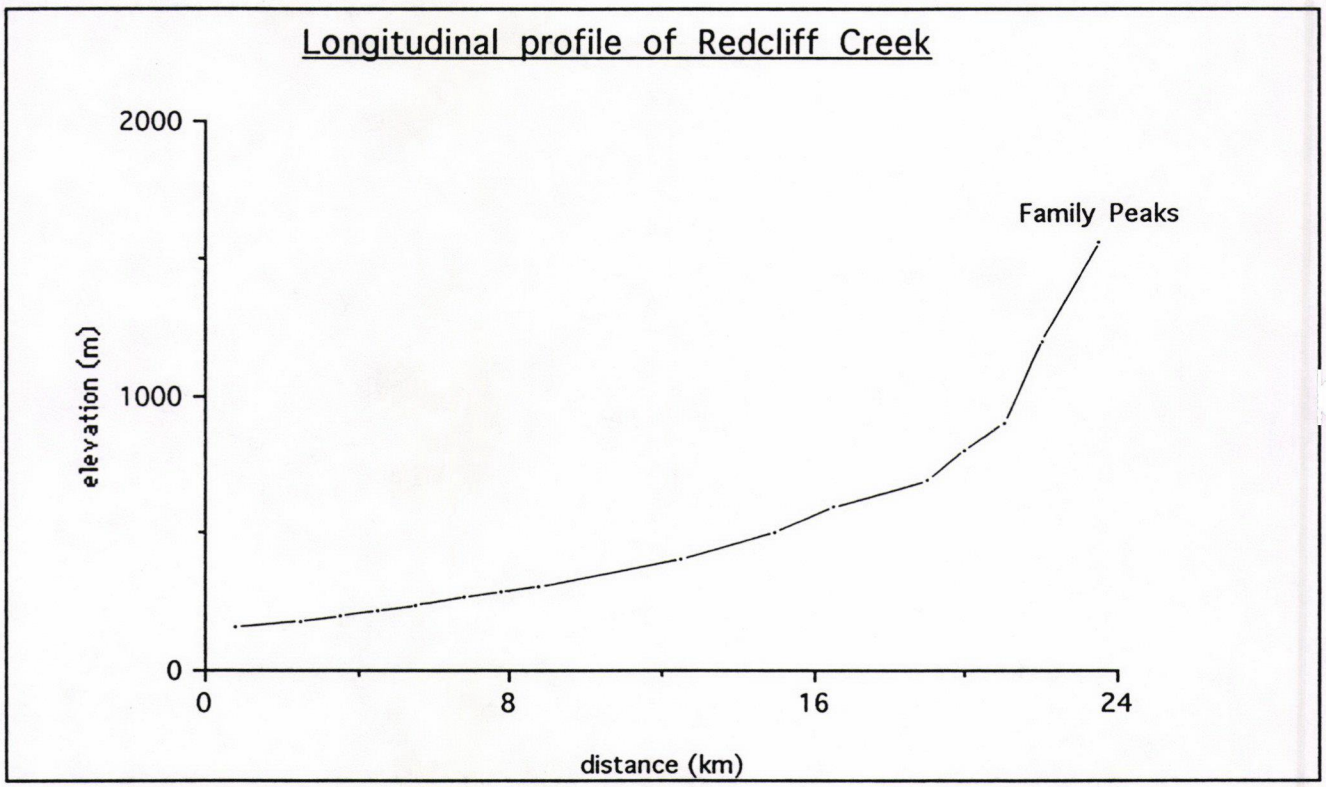
Catchment Geology (%):	Sedimentary	5
	Igneous	10
	Quaternary	85
Catchment Soils (%):	Lowland yellow-brown earths	10
	Yellow-brown earth intergrade	40
	Recent soils	50

LITTLE CREEK CATCHMENT BASE MAP



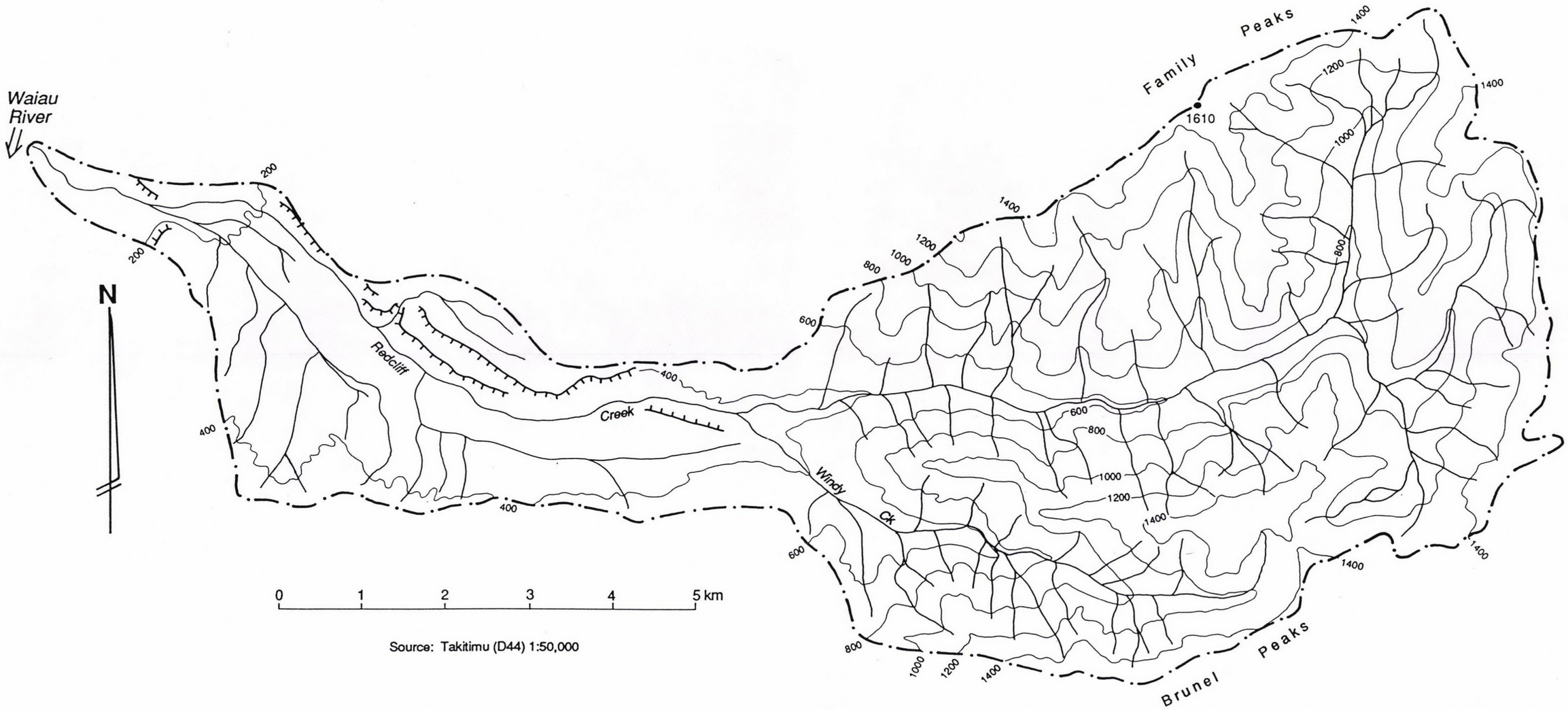
Redcliff Creek

Catchment area (km^2):	66
Catchment shape:	5.2
Catchment orientation:	E-W, left bank
Strahler number:	4
Max. channel length (km):	24
Max. channel rise (m):	1401
Catchment slope (degrees):	3.3



Catchment Geology (%):	Sedimentary	5
	Igneous	50
	Quaternary	45
Catchment Soils (%):	Lowland yellow-brown earths	15
	Yellow-brown earth intergrade	5
	Recent soils	80

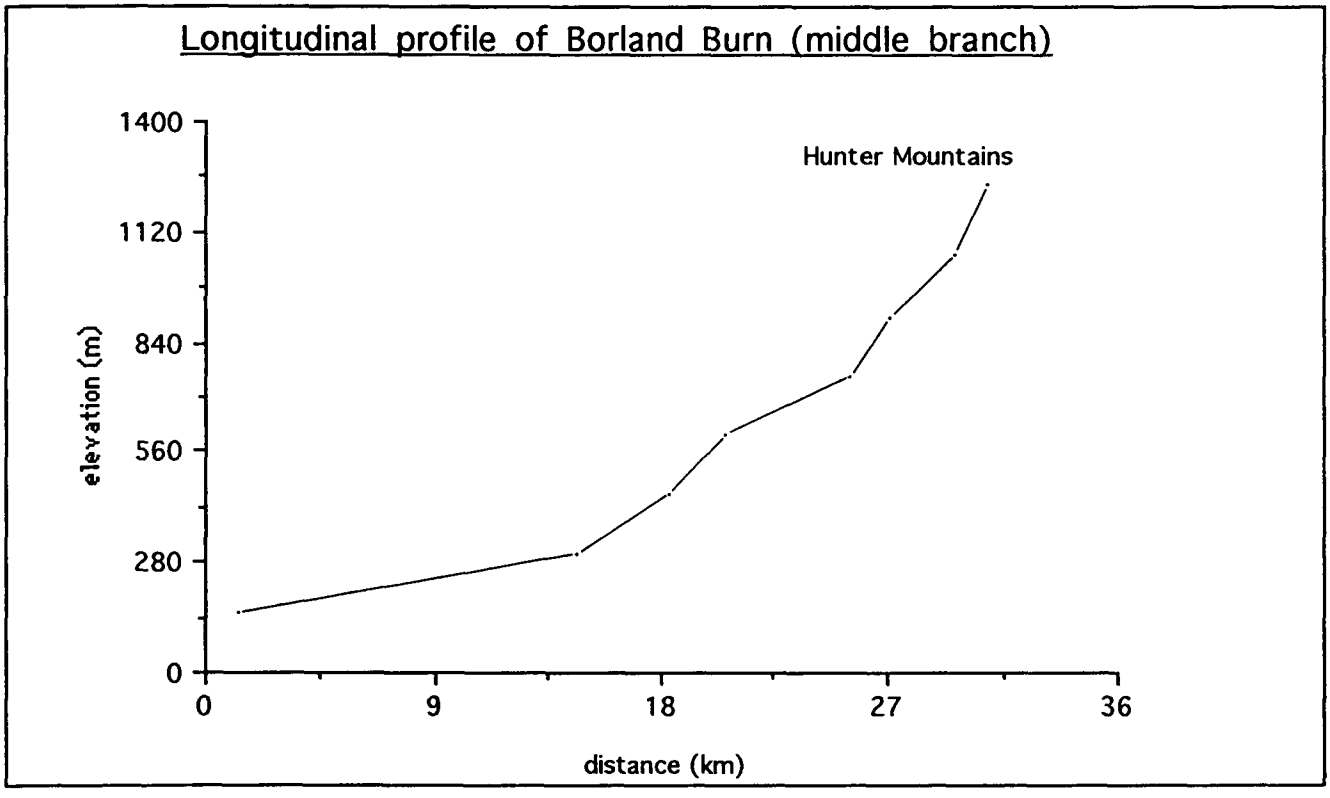
REDCLIFF CREEK CATCHMENT BASE MAP



Source: Takitimu (D44) 1:50,000

Borland Burn

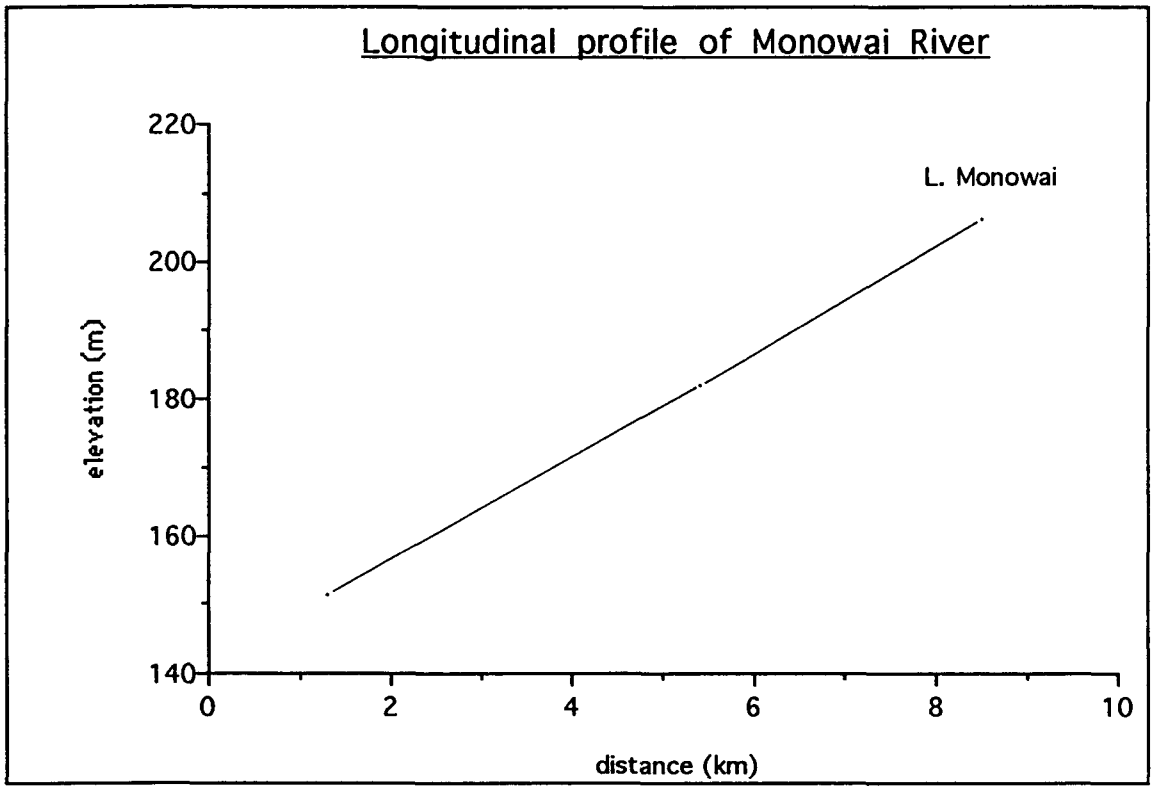
Catchment area (km^2):	180
Catchment shape:	2.5
Catchment orientation:	NW-SE, right bank
Strahler number:	4
Max. channel length (km):	31
Max. channel rise (m):	1094
Catchment slope (degrees):	2.0



Catchment Geology (%):	Sedimentary	11
	Metamorphic	70
	Quaternary	19
Catchment Soils (%):	Lowland yellow-brown earth	5
	Upland and high country podzolized yellow-brown earths and podzols	70
	Yellow-brown loams	10
	Recent soils	5

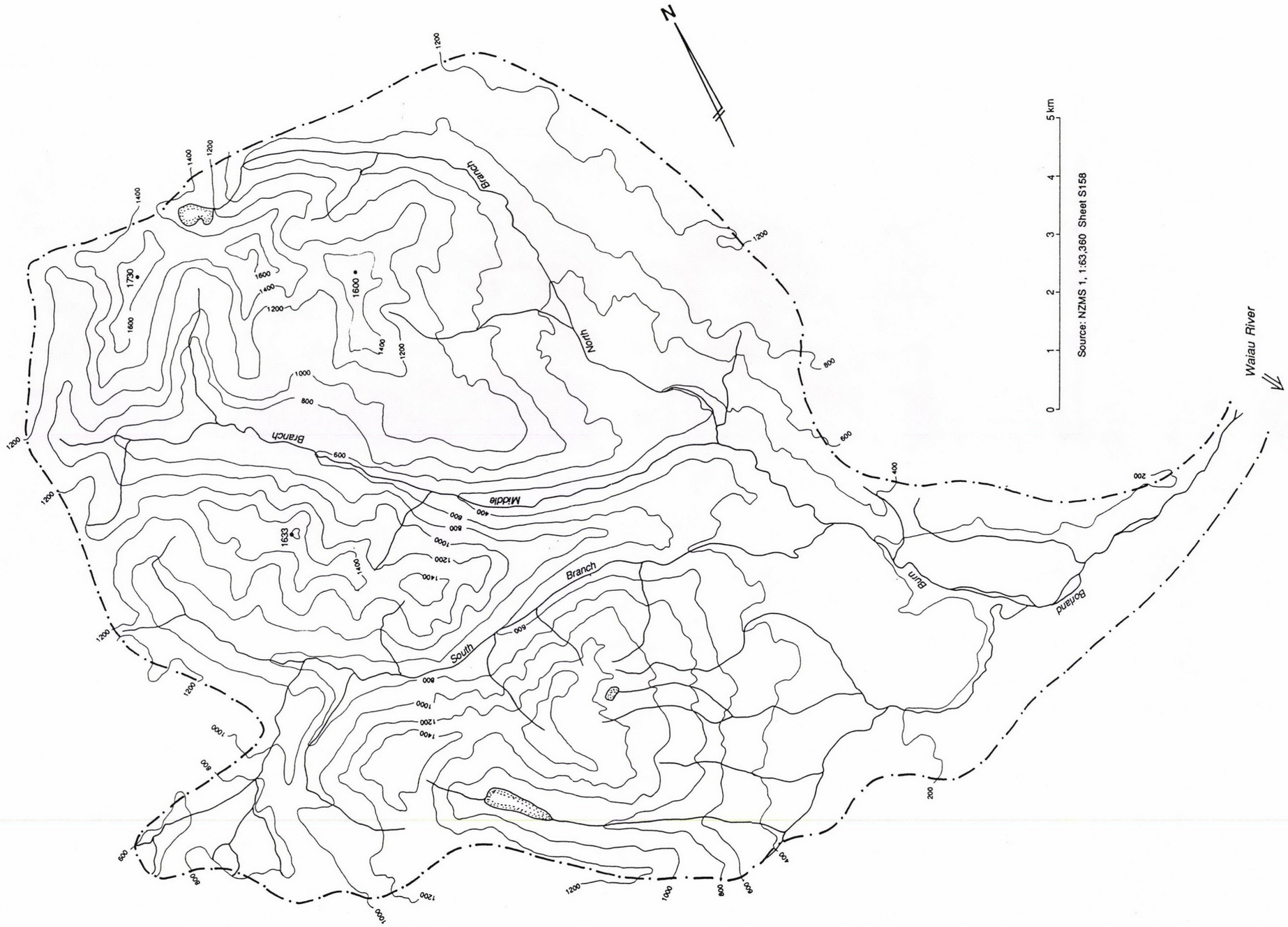
Monowai River

Catchment area (km^2):	245
Catchment shape:	2.3
Catchment orientation:	WSW-ENE, right bank
Strahler number:	3
Max. channel length (km):	9, Lake Monowai exclusive
Max. channel rise (m):	58
Catchment slope (degrees):	0.4

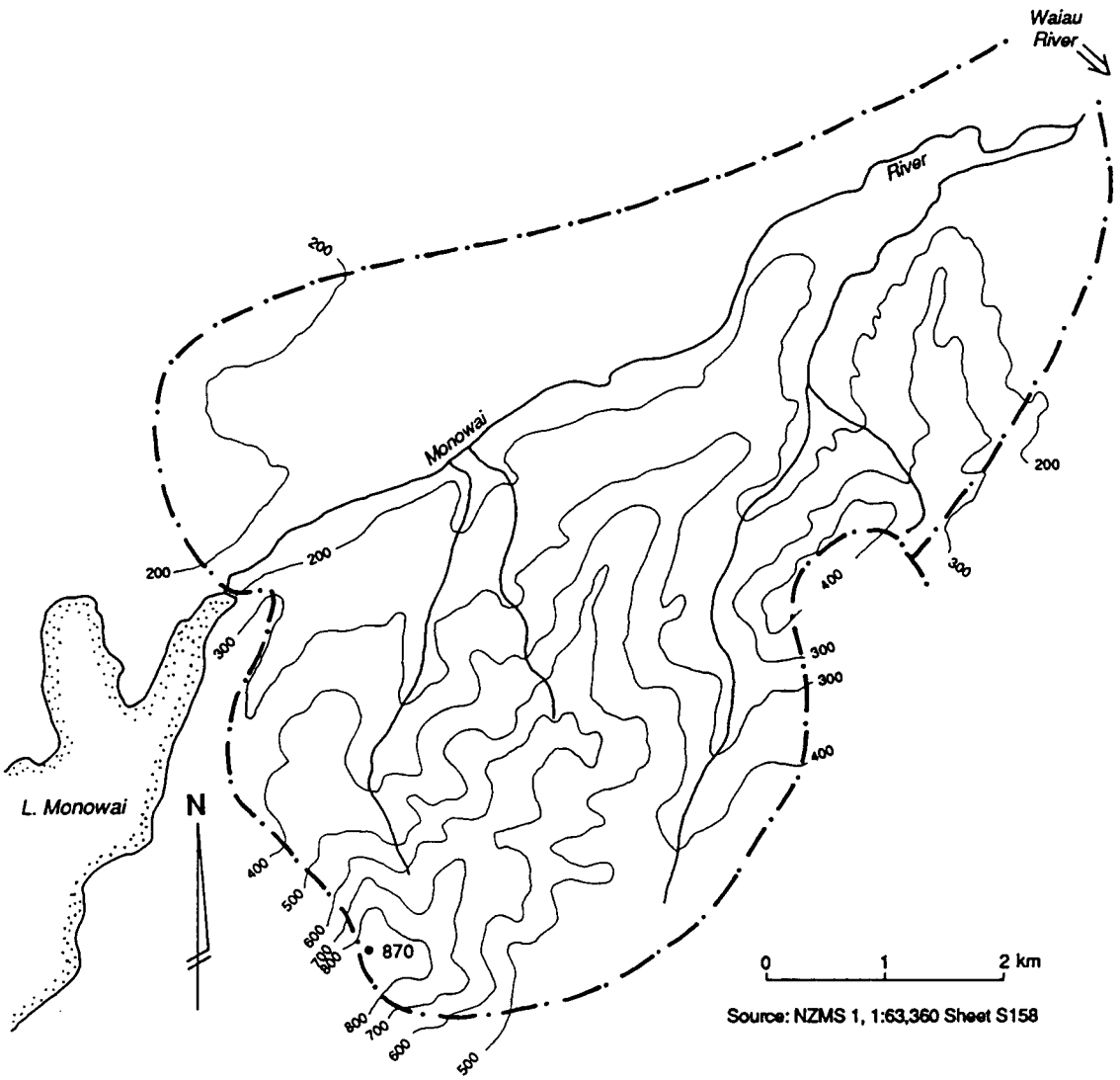


Catchment Geology (%):	Quaternary	100
Catchment Soils (%):	Lowland yellow-brown earths	50
	Yellow-brown earth	50

BORLAND BURN CATCHMENT BASE MAP

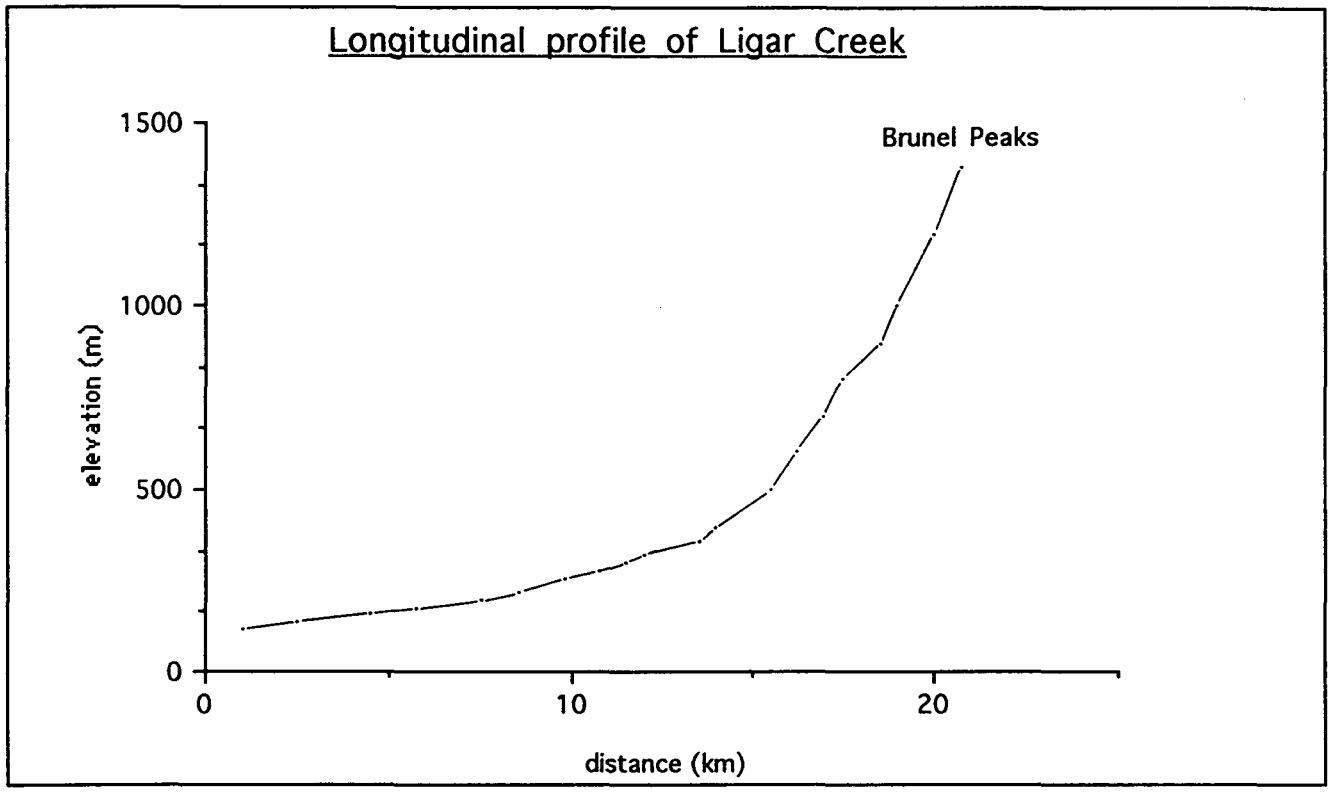


MONOWAI RIVER CATCHMENT BASE MAP



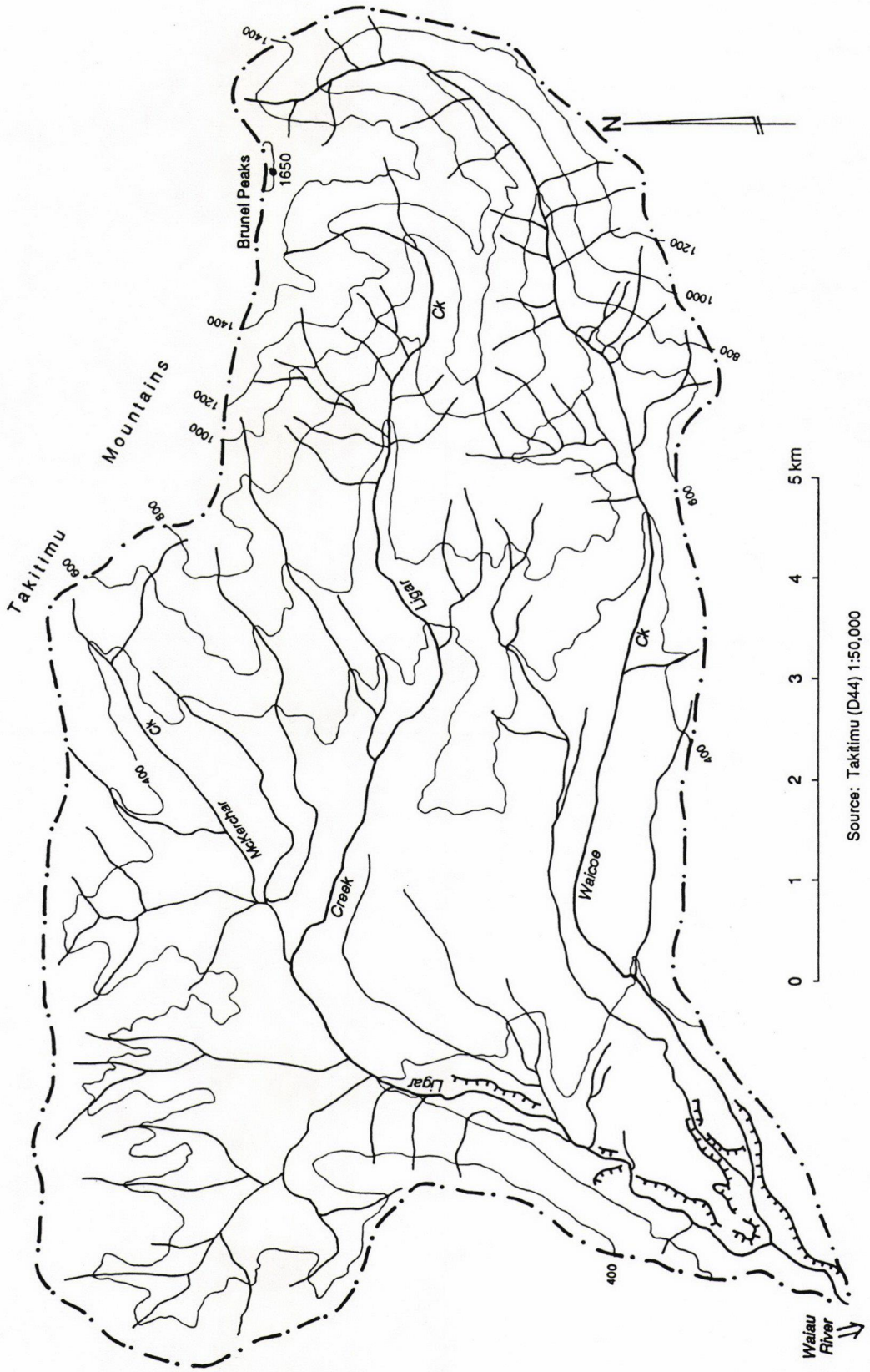
Ligar Creek

Catchment area (km^2):	50
Catchment shape:	3.1
Catchment orientation:	ENE-WSW, left bank
Strahler number:	4
Max. channel length (km):	42
Max. channel rise (m):	1262
Catchment slope (degrees):	1.7



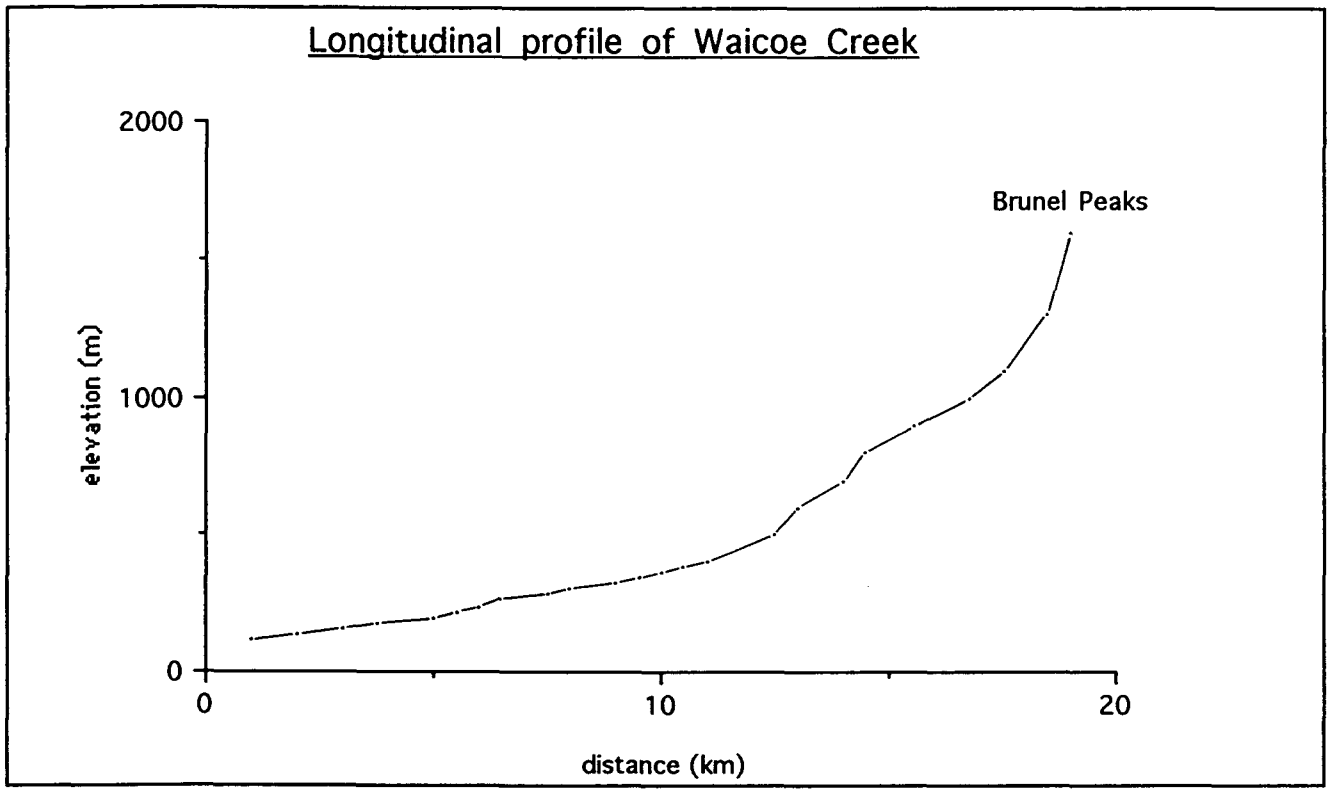
Catchment Geology (%):	Sedimentary	5
	Igneous	15
	Quaternary	80
Catchment Soils (%):	Lowland yellow-brown soils	5
	Yellow-brown earth intergrade	35
	Recent soils	60

LIGAR/WAICOE CATCHMENT BASE MAP



Waicoe Creek

Catchment area (km^2): 25
Catchment shape: 7.6
Catchment orientation: E-W, left bank
Strahler number: 3
Max. channel length (km): 19
Max. channel rise (m): 1482
Catchment slope (degrees): 4.5

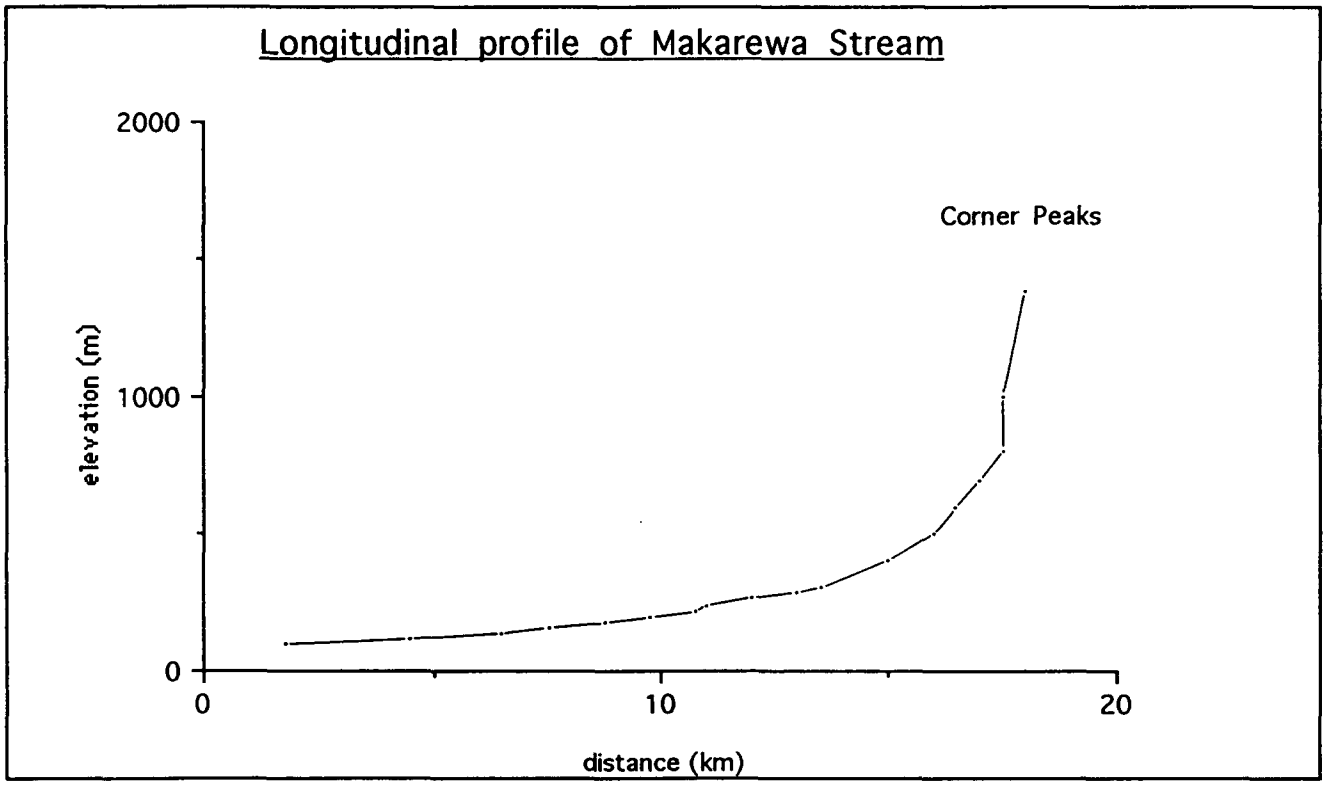


Catchment Geology (%):	Sedimentary	30
	Igneous	20
	Quaternary	50
Catchment Soils (%):	Yellow-brown earths	20
	Yellow-brown earth intergrade	30
	Recent soils	50

(For base map see page 30)

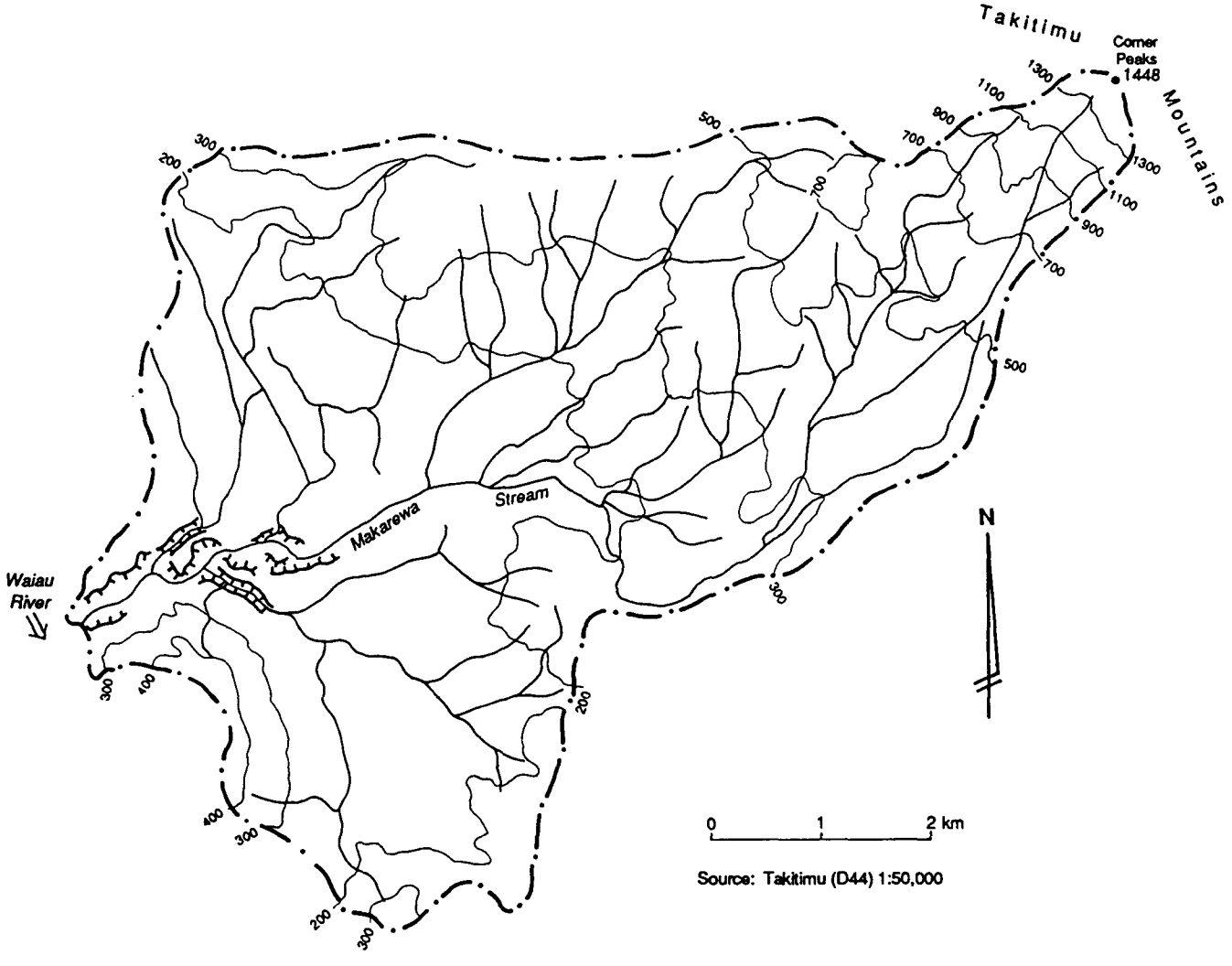
Makarewa Stream

Catchment area (km^2):	39
Catchment shape:	3.0
Catchment orientation:	E-W, left bank
Strahler number:	4
Max. channel length (km):	19
Max. channel rise (m):	1380
Catchment slope (degrees):	2.0



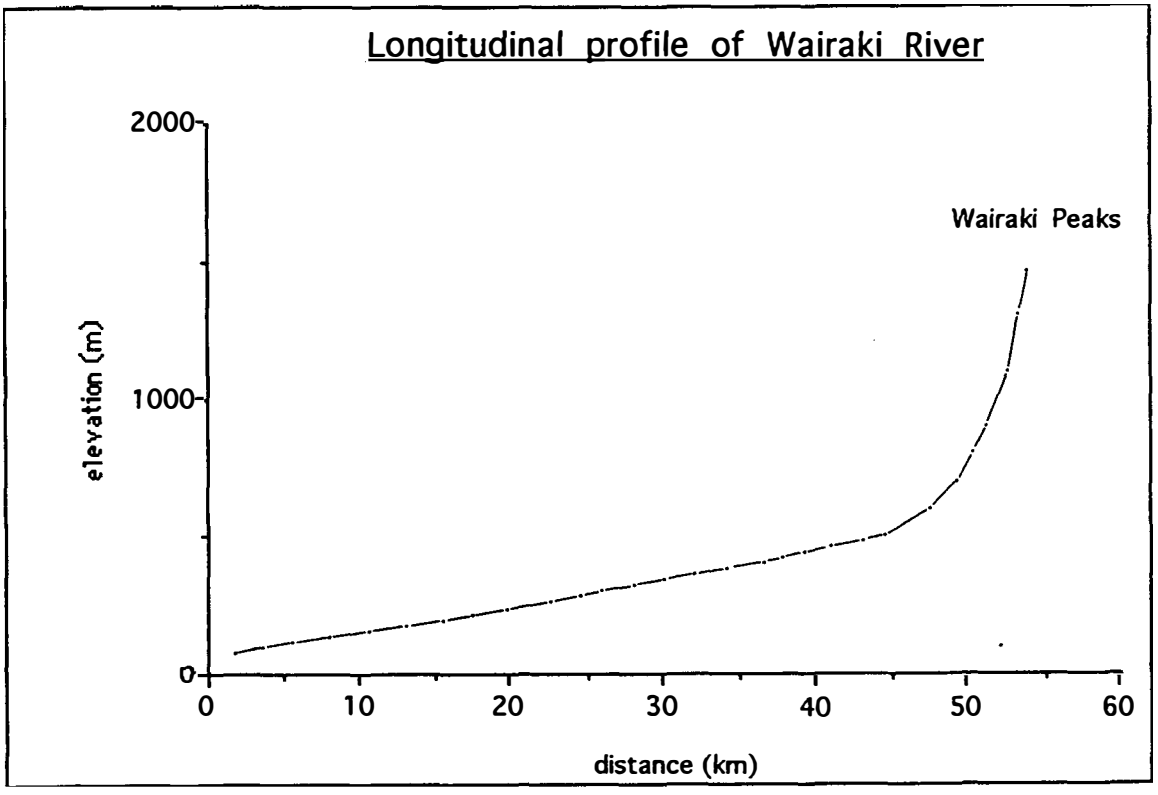
Catchment Geology (%):	Sedimentary	40
	Quaternary	60
Catchment Soils (%):	Lowland yellow-brown earth	65
	Gley recent soils	35

MAKAREWA STREAM CATCHMENT BASE MAP



Wairaki River

Catchment area (km^2):	295
Catchment shape:	3.5
Catchment orientation:	ENE-WSW, left bank
Strahler number:	6
Max. channel length (km):	54
Max. channel rise (m):	1390
Catchment slope (degrees):	1.5



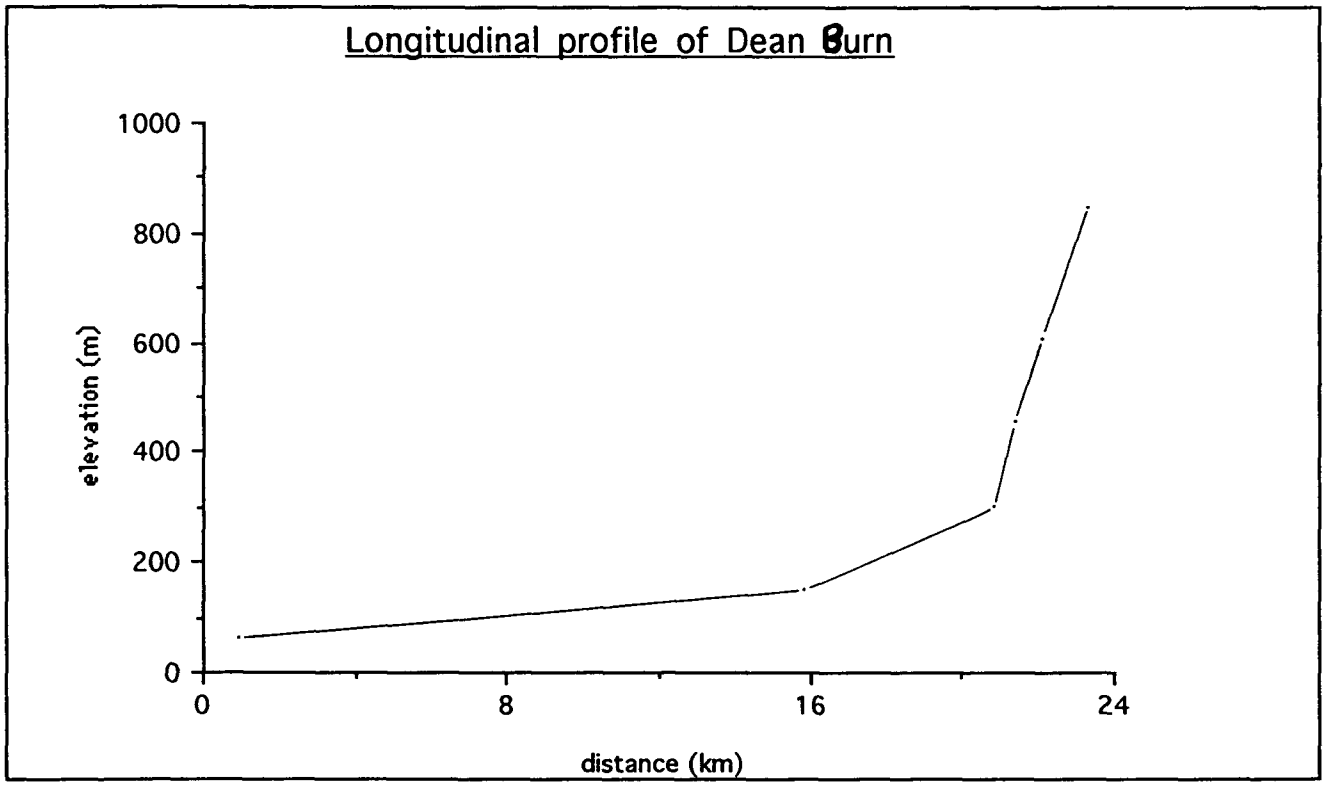
Catchment Geology (%):	Sedimentary	35	
	Igneous	50	
	Quaternary	15	
Catchment Soils (%):	Yellow-brown earth		15
	Upland and high country yellow-brown earth		20
	Brown granular loams and clays		30
	Yellow-brown earth intergrade		20
	Yellow-brown loam		10
	Recent soils		5

WAIRAKI RIVER CATCHMENT BASE MAP



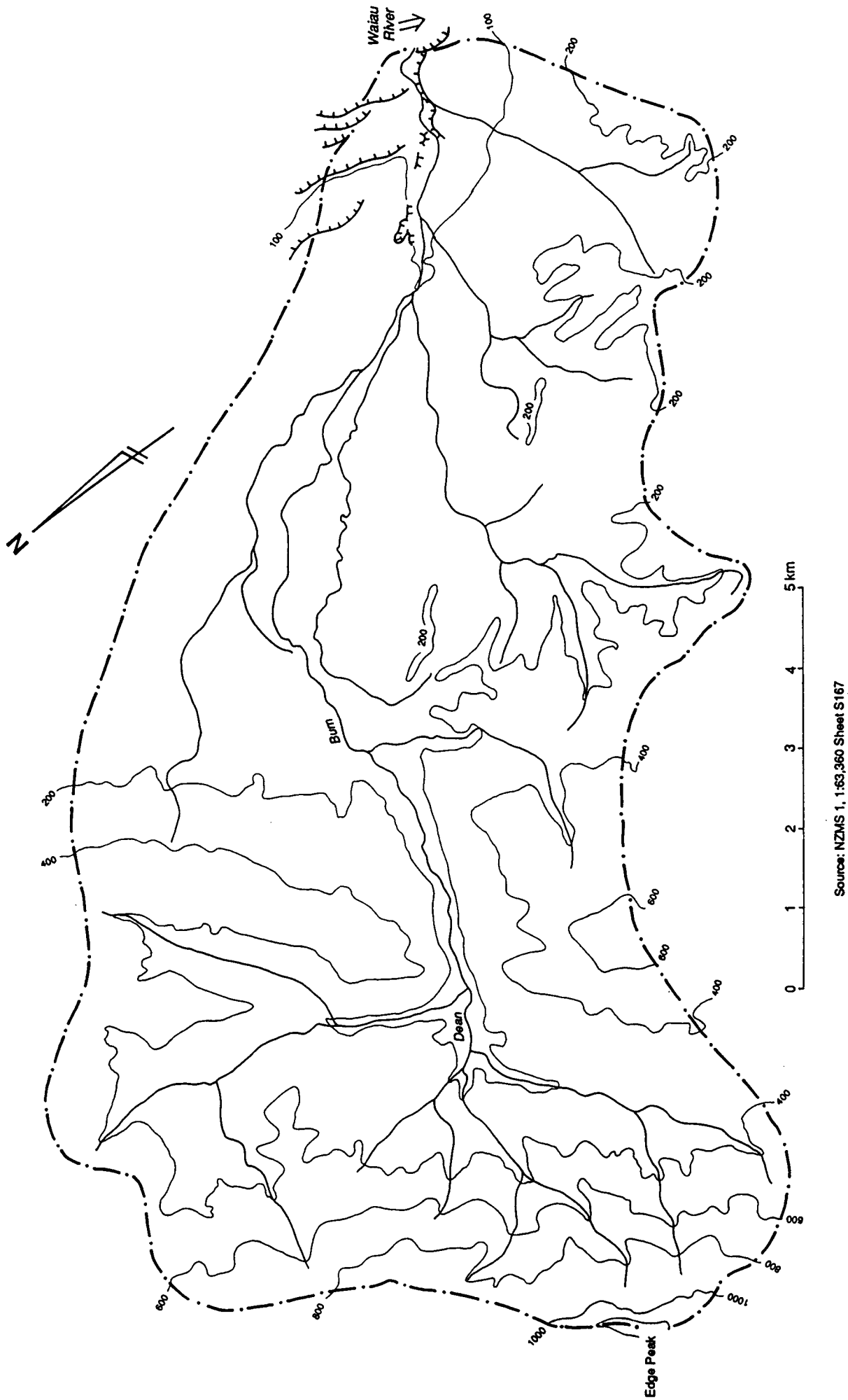
Dean Burn

Catchment area (km^2):	104
Catchment shape:	2.5
Catchment orientation:	NW-SE, right bank
Strahler number:	3
Max. channel length (km):	23
Max. channel rise (m):	791
Catchment slope (degrees):	2.0



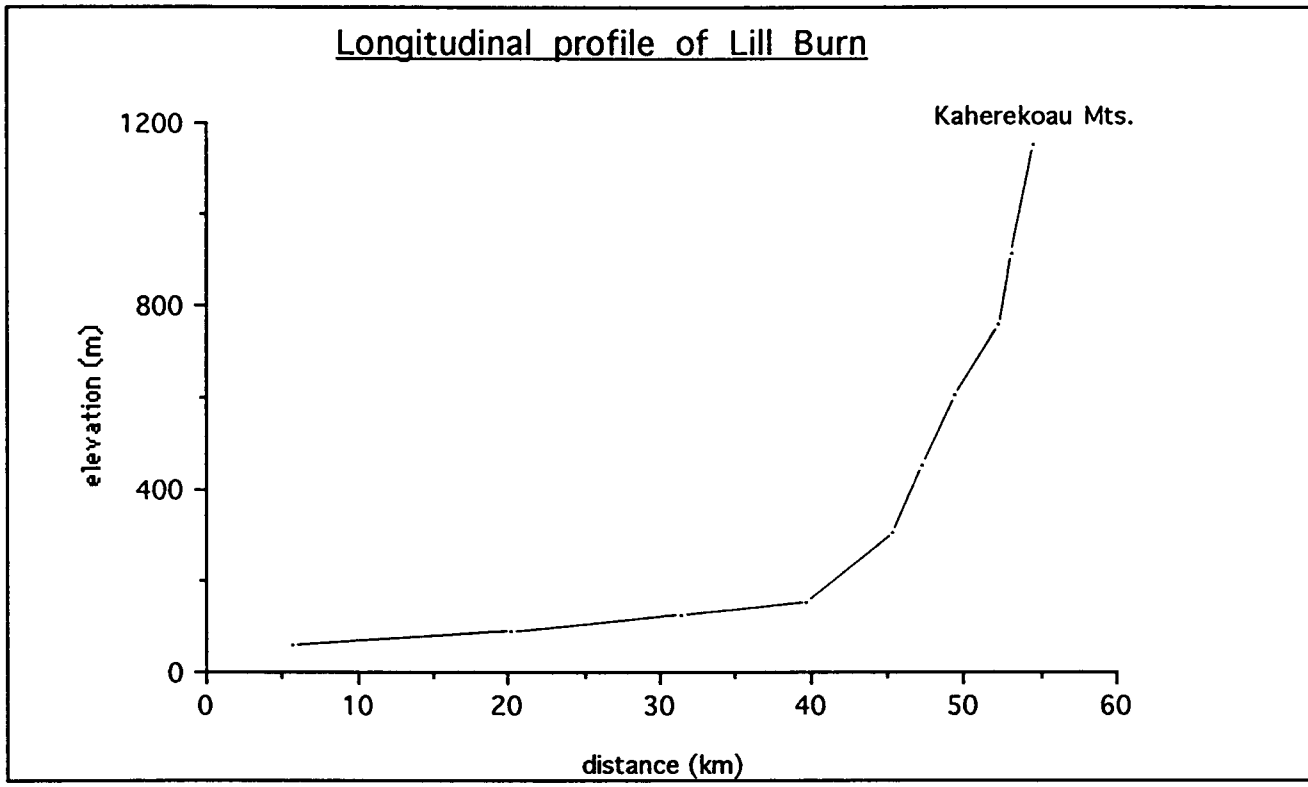
Catchment Geology (%):	Sedimentary	70
	Quaternary	30
Catchment Soils (%):	Lowland yellow-brown earth	75
	Organic soils	5
	Gley recent soils	20

DEAN BURN CATCHMENT BASE MAP



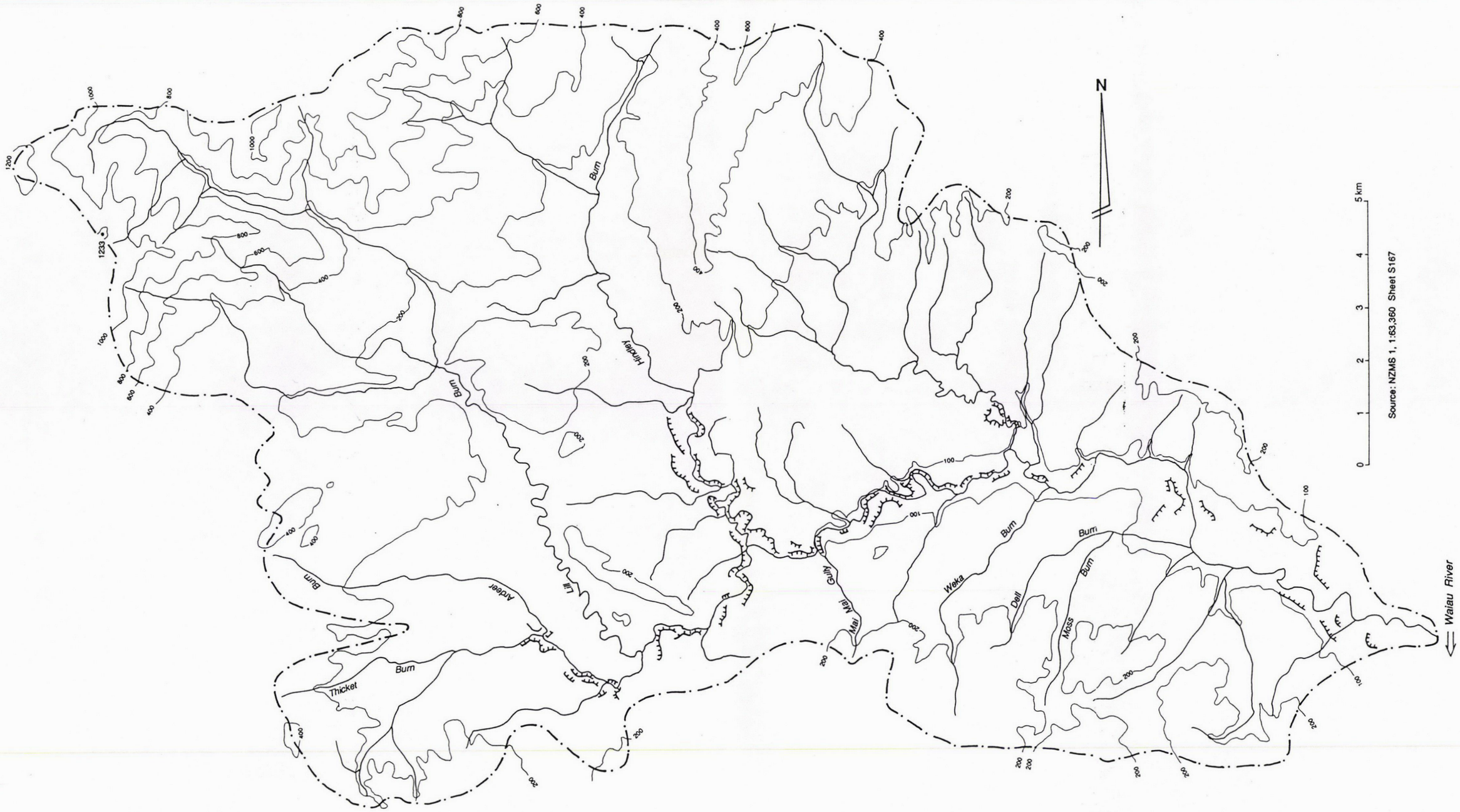
Lill Burn

Catchment area (km^2):	245
Catchment shape:	3.3
Catchment orientation:	W-E, right bank
Strahler number:	4
Max. channel length (km):	55
Max. channel rise (m):	1094
Catchment slope (degrees):	1.1



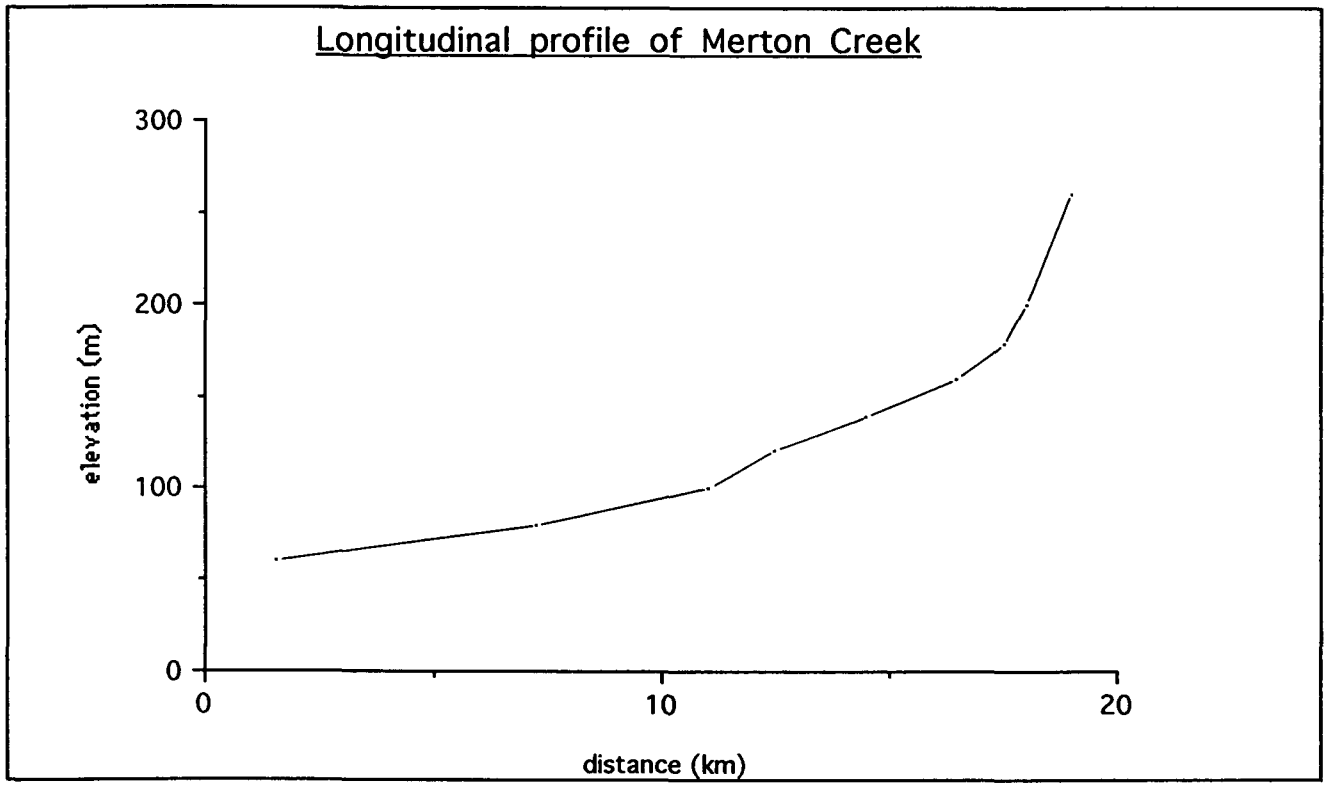
Catchment Geology (%):	Sedimentary	70
	Metamorphic	5
	Quaternary	25
Catchment Soils (%):	Lowland yellow-brown earth	80
	Gley recent soils	20

LILL BURN CATCHMENT BASE MAP



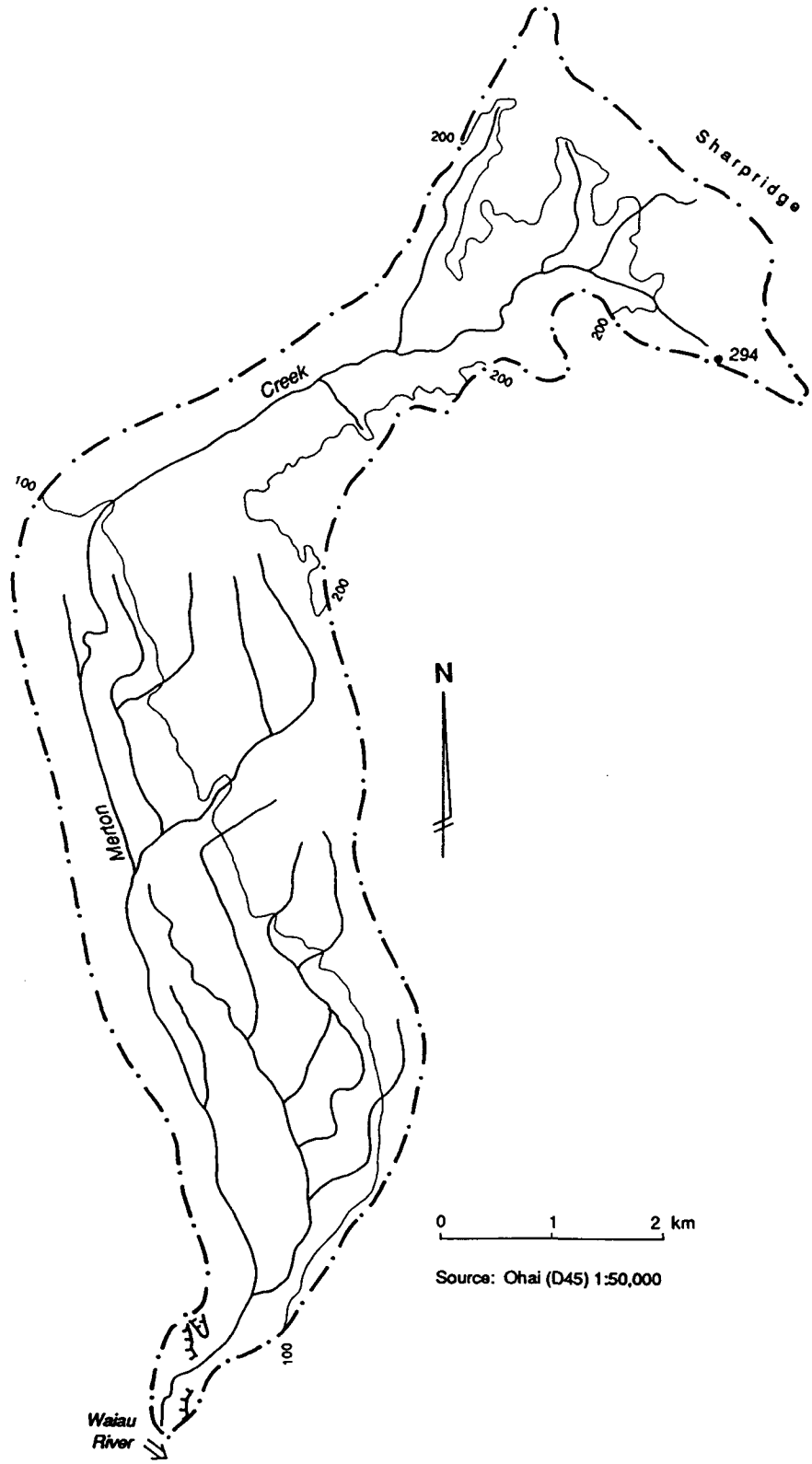
Merton Creek

Catchment area (km^2):	28
Catchment shape:	6.3
Catchment orientation:	N-S, left bank
Strahler number:	4
Max. channel length (km):	19
Max. channel rise (m):	210
Catchment slope (degrees):	0.6



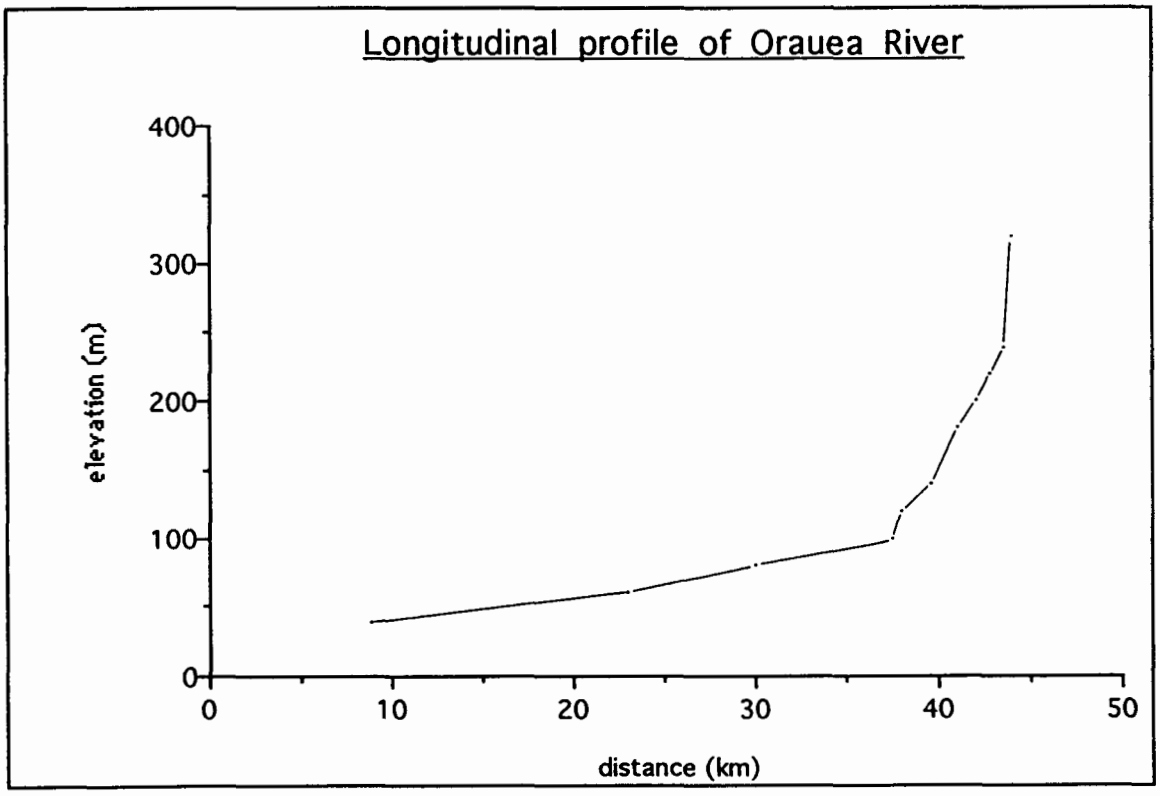
Catchment Geology (%):	Quaternary	100
Catchment Soils (%):	Lowland yellow-brown earth	20
	Yellow-brown earth intergrade	80

MERTON CREEK CATCHMENT BASE MAP



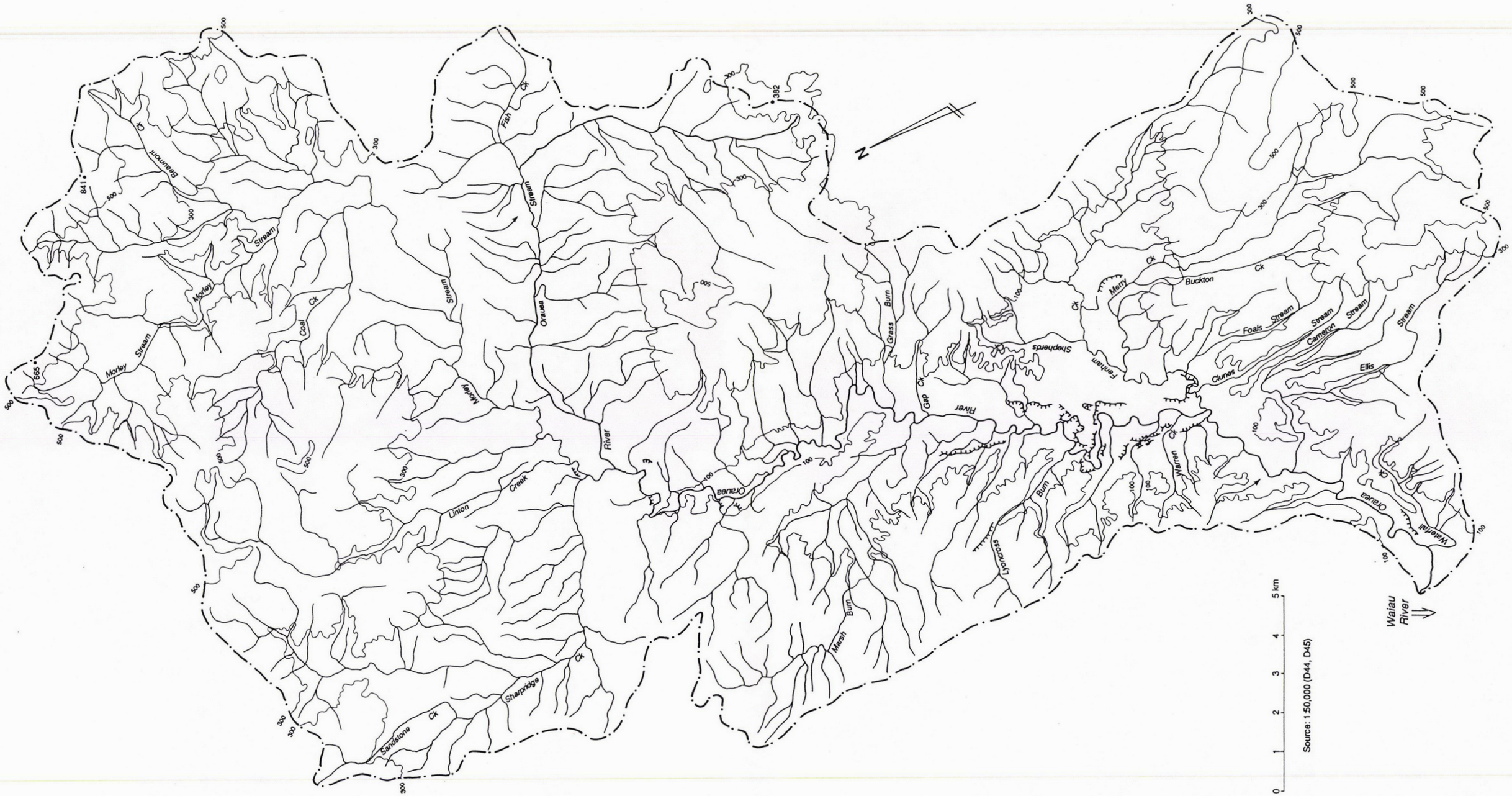
Orauea River

Catchment area (km^2):	485
Catchment shape:	2.9
Catchment orientation:	ENE-WSW, left bank
Strahler number:	5
Max. channel length (km):	44
Max. channel rise (m):	300
Catchment slope (degrees):	0.4



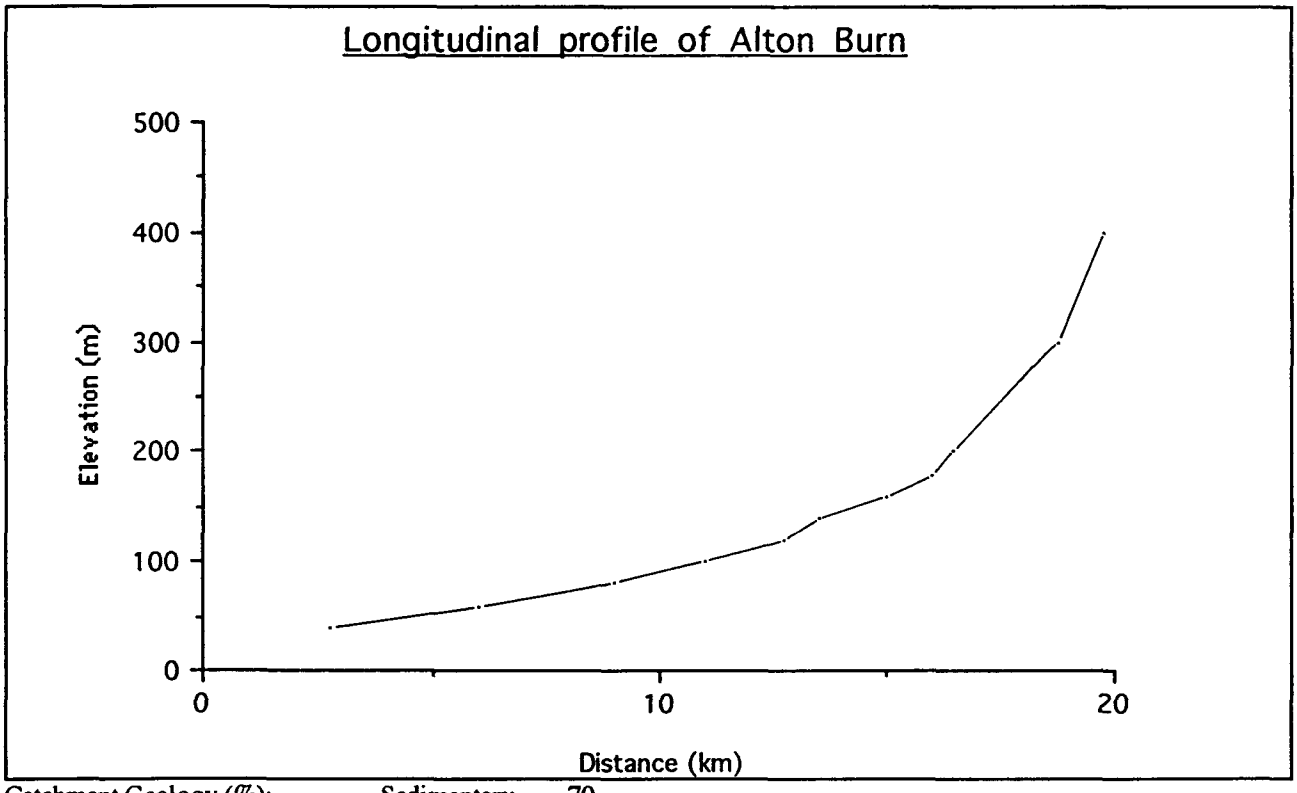
Catchment Geology (%):	Sedimentary	40
	Igneous	30
	Quaternary	30
Catchment Soils (%):	Lowland yellow-brown earth	50
	Lowland podzolized yellow-brown earths and podzols	20
	Brown granular loams and clays	20
	Yellow-brown earths intergrade	5
	Recent soils	5

ORAUEA RIVER CATCHMENT BASE MAP



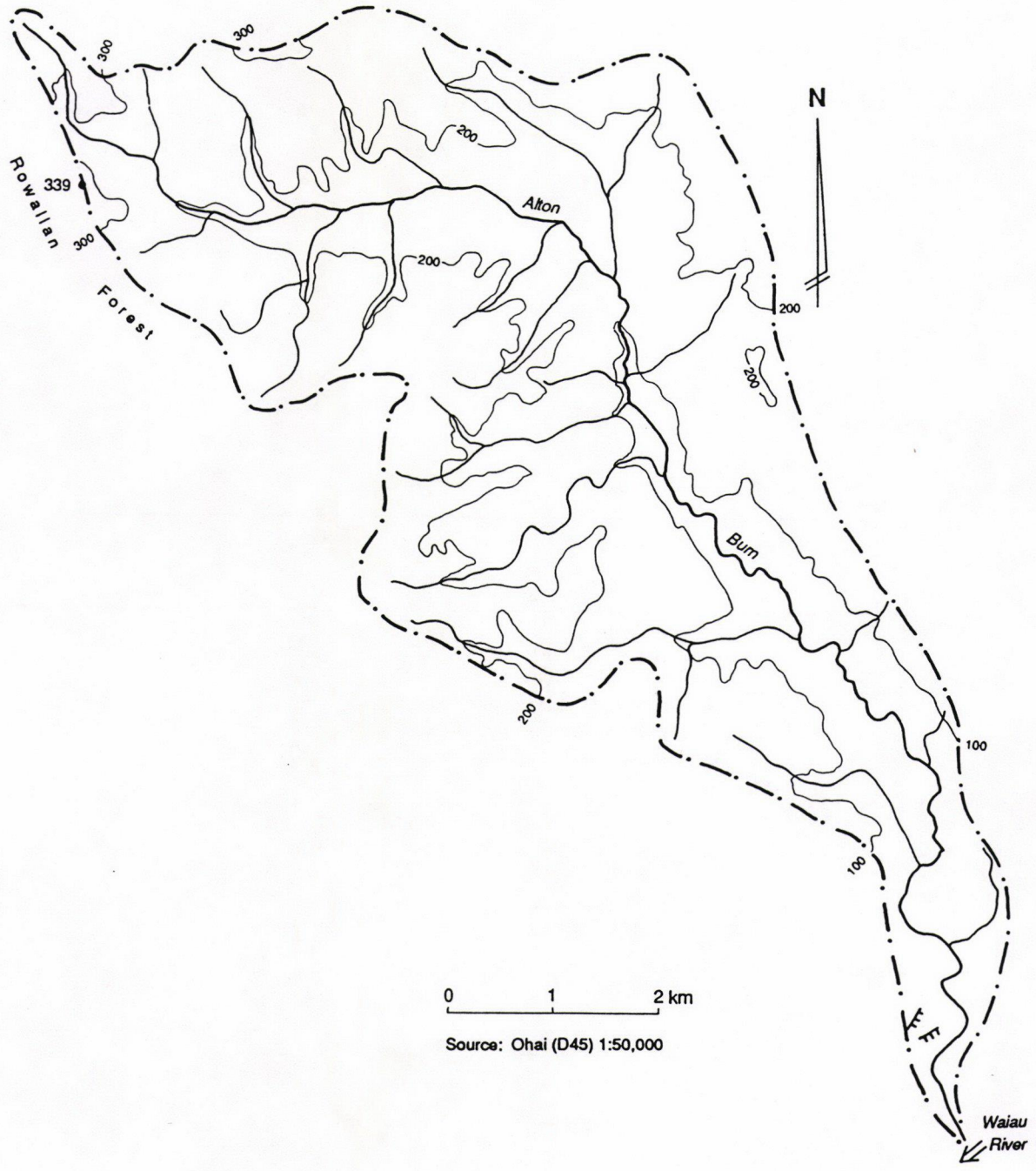
Alton Burn

Catchment area (km^2):	40
Catchment shape:	4.9
Catchment orientation:	NW-SE, right bank
Strahler number:	3
Max. channel length (km):	20
Max. channel rise (m):	380
Catchment slope (degrees):	1.1



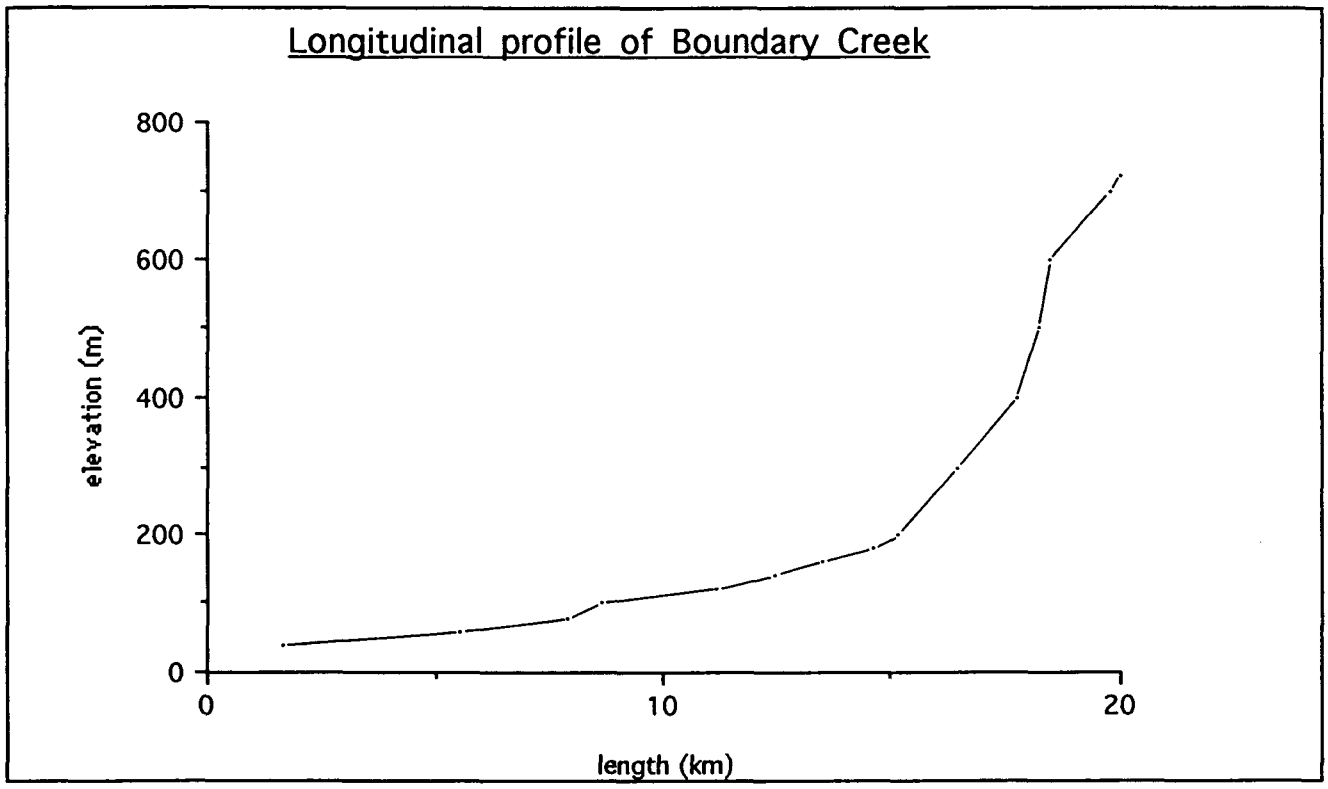
Catchment Geology (%):	Sedimentary	70
	Quaternary	30
Catchment Soils (%):	Lowland yellow-brown earths	65
	Rendzina and related soils (limestone)	5
	Yellow-brown earths intergrade	10
	Gley recent soils	20

ALTON BURN CATCHMENT BASE MAP



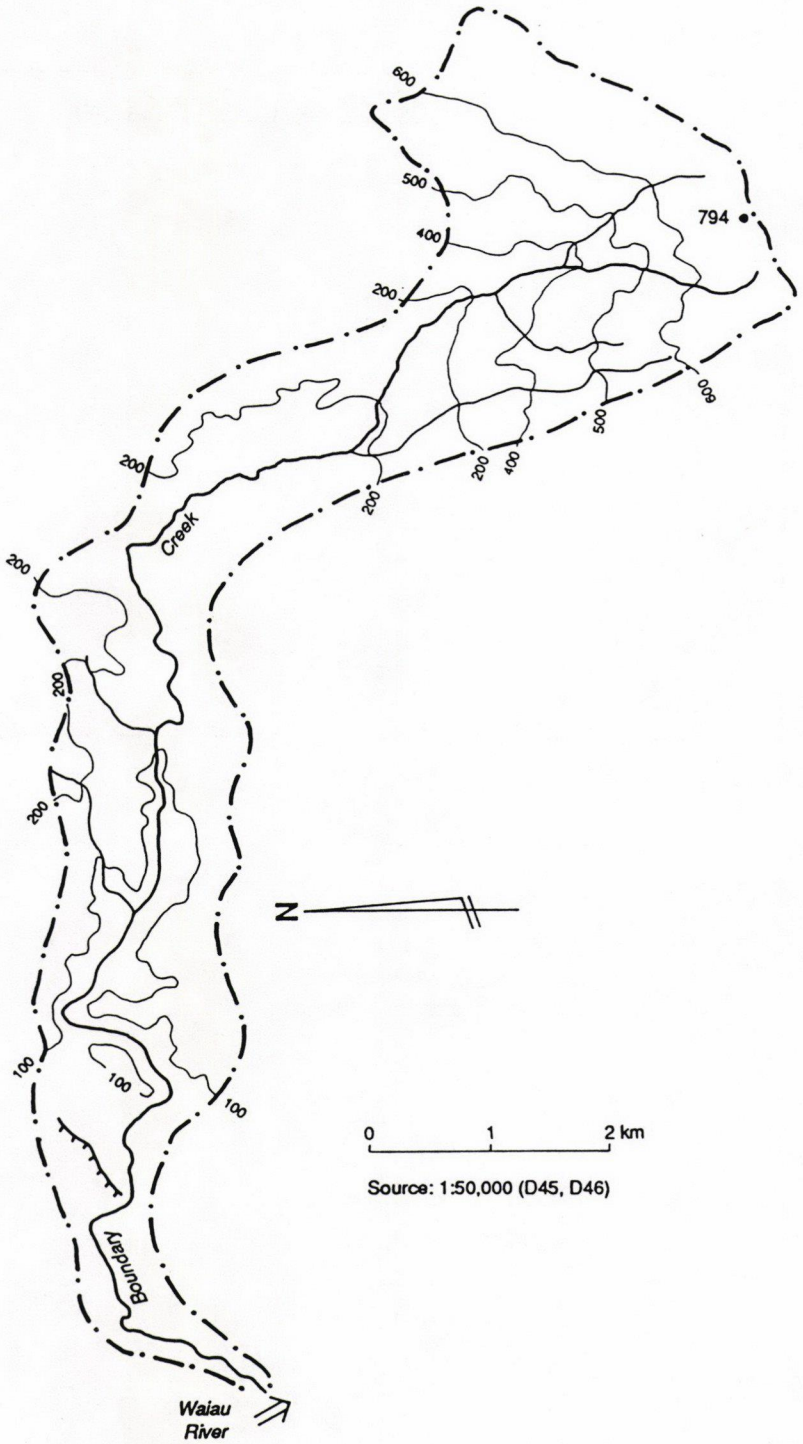
Boundary Creek

Catchment area (km^2):	20
Catchment shape:	6.9
Catchment orientation:	E-W, left bank
Strahler number:	2
Max. channel length (km):	20
Max. channel rise (m):	700
Catchment slope (degrees):	2.0



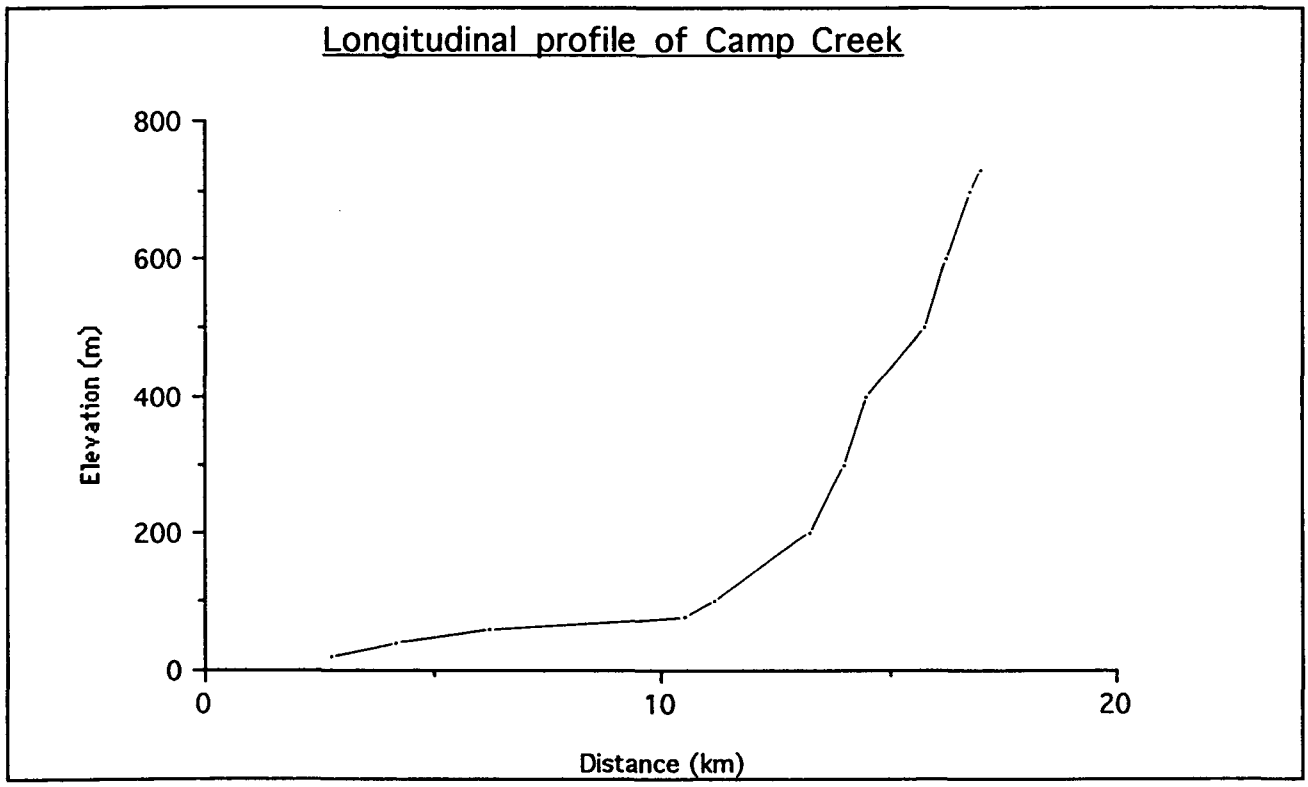
Catchment Geology (%):	Sedimentary	50
	Igneous	25
	Quaternary	25
Catchment Soils (%):	Lowland yellow-brown earths	80
	Yellow-brown earths intergrade	20

BOUNDARY CREEK CATCHMENT BASE MAP



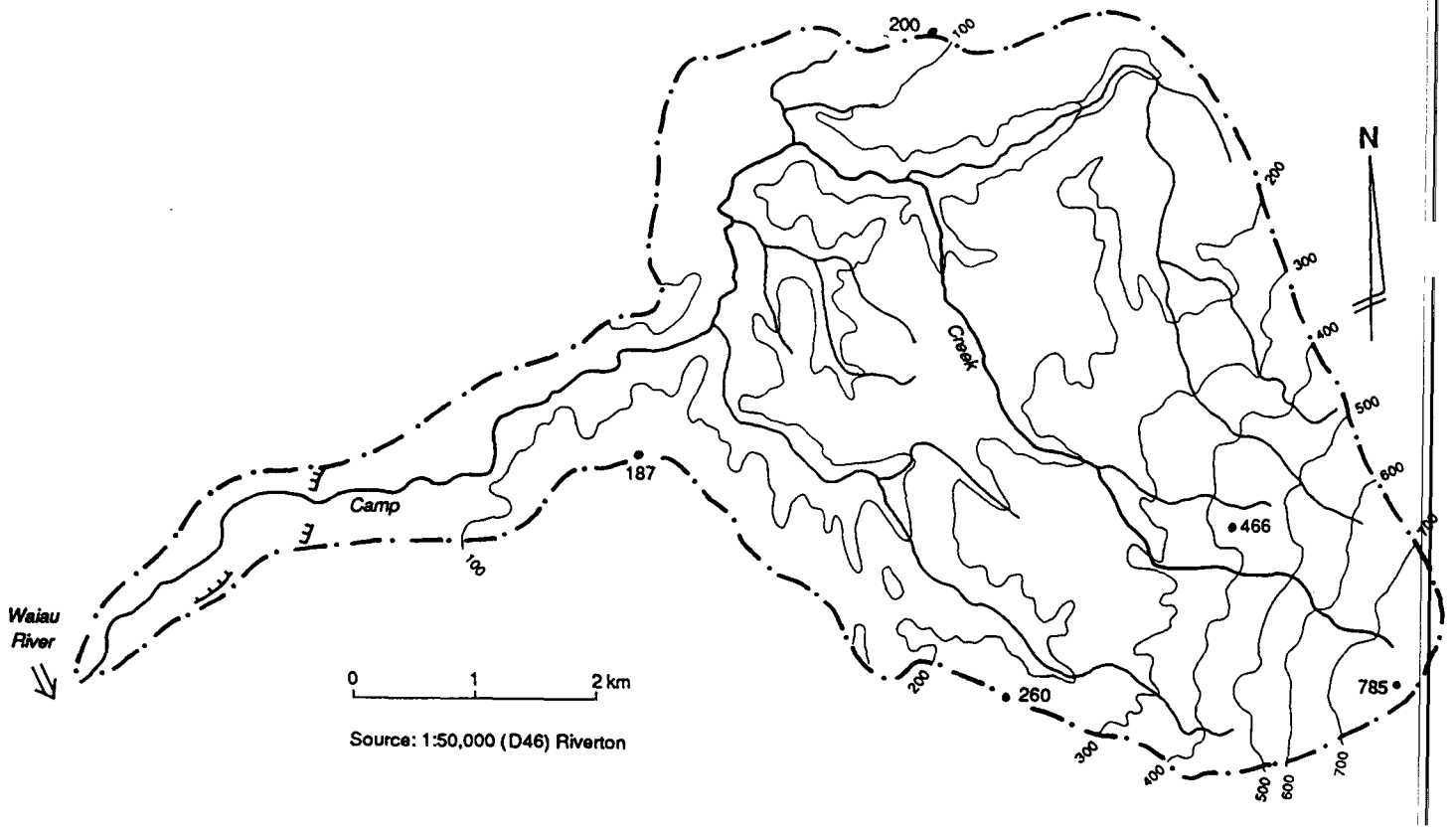
Camp Creek

Catchment area (km^2):	37
Catchment shape:	3.6
Catchment orientation:	E-W, left bank
Strahler number:	3
Max. channel length (km):	17
Max. channel rise (m):	720
Catchment slope (degrees):	2.4



Catchment Geology (%):	Sedimentary	50
	Quaternary	50
Catchment Soils (%):	Lowland yellow-brown earths	50
	Yellow-brown earths intergrade	20
	Recent soils	30

CAMP CREEK CATCHMENT BASE MAP



Source: 1:50,000 (D46) Riverton