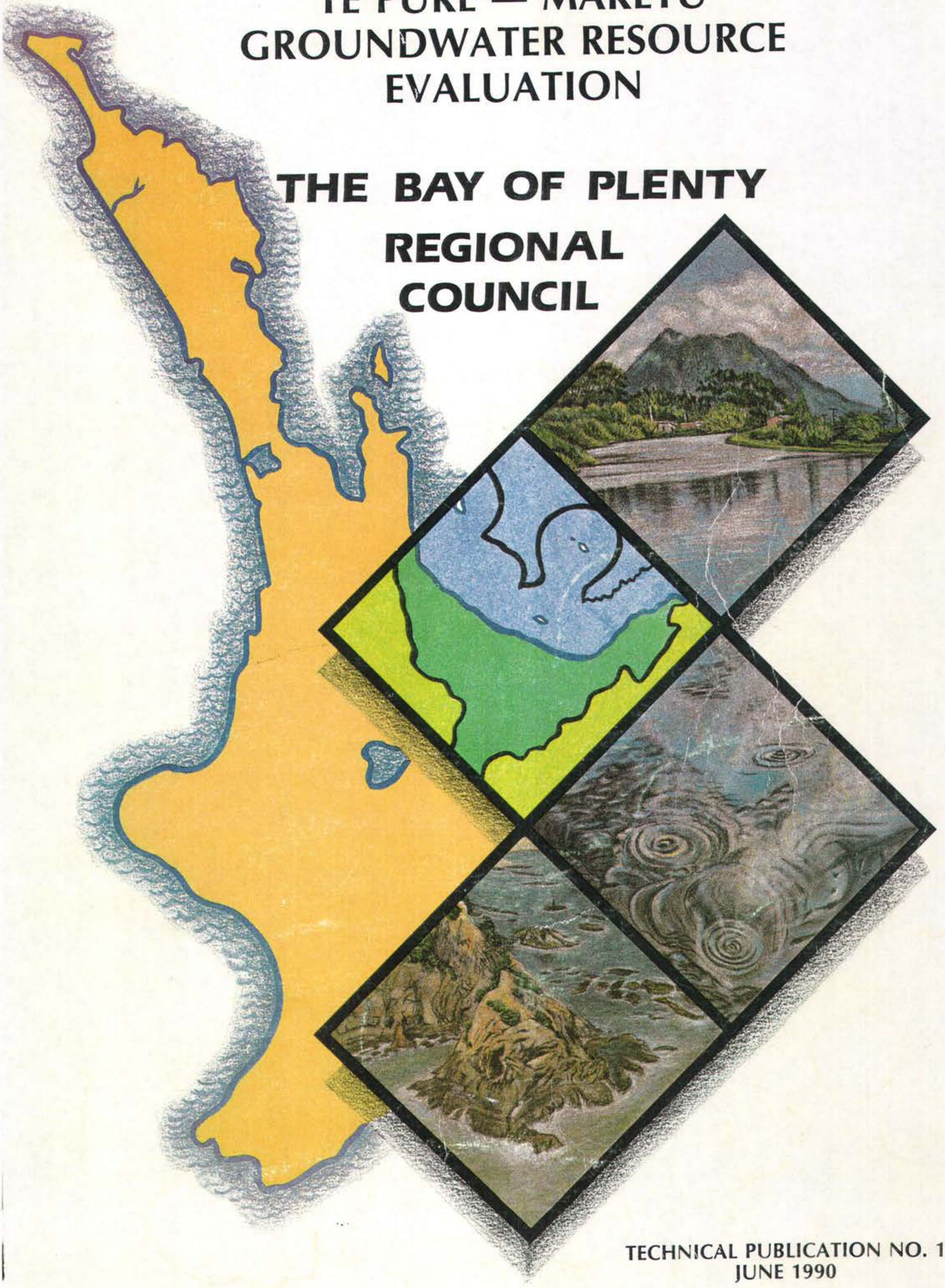
TE PUKE — MAKETU GROUNDWATER RESOURCE EVALUATION

THE BAY OF PLENTY REGIONAL COUNCIL



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GROUNDWATER RESOURCE EVALUATION

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GLOSSARY

alluvium	material deposited, or being transported by rivers or streams
aquifer	a permeable water-bearing formation through which water moves under natural conditions and yields water to wells at a sufficient rate to be a practical source of water supply
artesian	confined aquifer water which is under sufficient pressure to rise above ground surface when penetrated. The term sub-artesian is used to describe wells in which water rises above the ceiling of the confined aquifer, but does not reach ground surface
breccia	a coarse grained clastic rock composed of large (greater than 2mm diameter), angular rock fragments that are cemented together in a finer-grained matrix
confined	water which is isolated from above and below by impermeable layers is called confined water, or water of a confined aquifer
connate	water that is trapped in sediments or rock at the time of deposition or formation
drawdown	the drawdown of static water level in a well due to the influence of pumping
evapotranspiration	water returned to the air through direct evaporation and transpiration by vegetation
greywacke	hard, grey, fine-grained sandstone
hydrograph	a graphical plot of water level observations against time

hydraulic conductivity	a measure of a material's ability to transmit water (permeability)(k): the value of k is dependent on the size, number and interconnections of the inter-granular pore spaces within the material
ignimbrite	the rock formed by the deposition of ash flows and nuee ardentes at high temperatures consisting of layers of tuff material (including pumice, lapilli, crystals, etc)
infiltration	flow of water (often rainfall) into the ground (as distinct from percolation that is flow through earth materials)
lithology	a rock type, classified according to physical characteristics
nuee ardente	a swiftly flowing and turbulent gaseous cloud erupted from a volcano and containing ash and other volcanic debris in its lower part
permeability	a measure of the capacity of an aquifer material to transmit water. It is the amount of flow per unit cross-sectional area under the influence of a unit gradient
potentiometric	the elevation to which water rises in a well that taps a confined surface is called its potentiometric level. Under confined conditions, the potentiometric surface is an imaginary surface coinciding with the hydrostatic pressure level of the water in the aquifer
pumping test	a field procedure in which water is pumped from a well in the aquifer to be tested at a measured rate while observing the drawdown in other wells nearby, to calculate the aquifer characteristics. These include transmissivity, storativity, hydraulic resistance, and leakage factor

recharge	the addition of water from other sources to an aquifer, e.g. seepage from rivers, percolation of rainfall
rhyolite	a fine grained volcanic or extrusive rock rich in silica
specific capacity	the discharge achieved per metre of drawdown of a bore: this provides an indication of a particular bore's ability to yield a water supply
specific discharge	a discharge expressed as an equivalent volume/depth derived from a given area: common units are litres/sec/km^2 and mm depth (analogous to rainfall depth)
stratigraphic	time related classification of geologic units based on analysis of relative positions
tephra	all volcanic material ejected during an eruption and transported through the air
transmissivity	the rate of flow of ground water under a unit hydraulic gradient through a cross-section of unit width and extending through the full thickness of saturated aquifer. It is a measure of the aquifers' ability to transmit water
unconfined	water which is freely connected to the atmosphere and which is free to rise and fall in the saturated zone is called unconfined water, or water of an unconfined aquifer, or water under water-table conditions
water-table	see unconfined

CHAPTER ONE

INTRODUCTION

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INTRODUCTION

1.1 BACKGROUND

This report presents the results of a groundwater resource data review and evaluation in the areas of Papamoa, Te Puke, Paengaroa, Maketu, Pongakawa, Pukehina and Ohinepanea (Figure 1). At the time of commencement of this study, this was the only remaining area of intensive groundwater use between the Western Bay of Plenty and the Rangitaiki Plains that had not been the subject of a detailed resource evaluation.

The report was prepared by the Bay of Plenty Regional Council (BOPRC) in conjunction with Groundwater Consultants NZ Ltd Consultants (GCNZ). The work was initiated by a data review and evaluation carried out in the BOPRC's offices by GCNZ between September and October 1989. Support for the review was provided by staff of the BOPRC who accessed the data bases, compiled the water use section and edited the report. Final report production was carried out by BOPRC during early 1990.

This report will be used to guide future investigation programmes and to provide an initial understanding of the groundwater systems from which management policies for the study area can be developed.

1.2 OBJECTIVES

The objectives of the study were to:-

- produce a preliminary ground water evaluation of the study area
- identify existing and potential groundwater problems in the study area.

1.3 SCOPE

In order to achieve the above objectives the following tasks were undertaken:

(a) Review of available groundwater and geology reports.

(b) Examination of water right data to determine the extent of current groundwater and streamwater usage.

(c) Examination of borelog data and the production of maps and sections showing the extent and vertical distributions of aquifers.

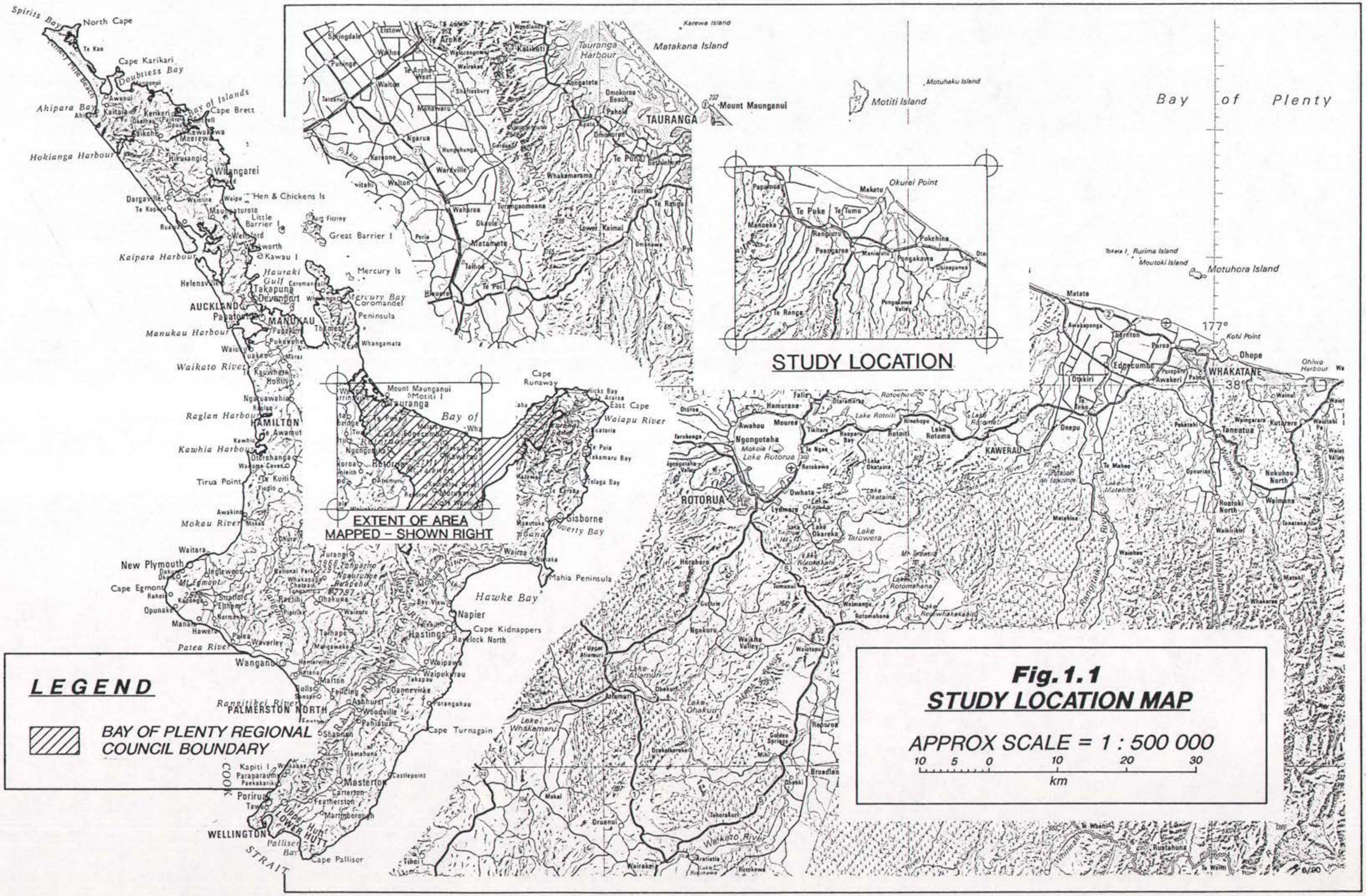


Fig. 1.1
STUDY LOCATION MAP

(d) Examination of available groundwater chemistry and determination of the extent and vertical distribution of selected chemical components.

(e) Separation of groundwater into types based on major component chemistry and correlation of groundwater types with geology, aquifer type and aquifer depth.

(f) Utilisation of topographic and water level data to produce a composite map of the groundwater potentiometric surface.

(g) Estimation of throughflow from groundwater gradient and hydraulic conductivity and estimation of storage from consideration of the nature of the aquifer materials.

(h) Examination of stream flow data to determine base flows and to check throughflow estimates.

(i) Development of an initial conceptual groundwater model.

(j) Indication of areas where problems such as yield or quality in groundwater usage exist and identification of areas where problems may develop.

1.4 PROCEDURE

The study was undertaken jointly between a groundwater consultancy firm (GCNZ) and the Bay of Plenty Regional Council.

Data from the review was obtained principally from the Bay of Plenty Regional Council computer data base "Weldat" file and from drillers bore logs. Additional ground water chemical data was obtained from a hard copy data base of compiled water rights and special purpose analyses.

Geological, streamflow and hot water well data was obtained from internal reports or from published papers and maps. These sources of data are referenced where appropriate.

As a means of making the data available to the public various summaries are provided in the Appendices.

<u>Appendix 1</u> - contains well construction details.

<u>Appendix 2</u> - contains information on aquifer locations, nature, production capacity and chemistry.

<u>Appendix 3</u> - provides some detailed water chemistry data.

<u>Appendix 4</u> - contains information on the location and nature of existing water uses.

The report has been structured in a manner intended to lead the reader to an understanding of the groundwater systems and their inter-relationship with each other and with stream flows and rainfall. Practical aspects of groundwater usage and management are addressed throughout the report.

The first technical section of the report (Chapter 2) describes the geology which sets the scene for the groundwater discussions.

Details on well construction, yield and aquifer characteristics are provided in Chapter 3.

Groundwater levels and flow direction are addressed in Chapter 4, groundwater chemistry is discussed in Chapter 5 and the hot water resource is discussed in Chapter 6.

In Chapter 7 the relationships between recharge and discharge are examined and following this the conceptual hydrological model is presented.

Groundwater usage is discussed in Chapter 8, and the report is summarised in Chapter Nine.

CHAPTER TWO

GEOLOGICAL ASSESSMENT

CHAPTER TWO

GEOLOGICAL ASSESSMENT

2.1 General Geology

The geology of the study area is shown in Figure 2.1 (Healey et al 1964). The geology essentially consists of a fault-bound basin filled with volcanic materials from rhyolitic eruptions. These include rhyolitic domes, lava flows, ash flows (ignimbrite), ash fall deposits, fluviatile and coastal sediments derived from the volcanics. Older indurated sandstones and mudstones (greywackes) outcrop on the eastern boundary of the study area.

The stratigraphy relevant to Figure 2.1 is shown in Table 2.1 below:-

TABLE 2.1 : Stratigraphy

Unit	Thickness (metres)	Age (years)
Alluvium		<10 Ky
Terrace Deposits (Younger)		>10 Ky
Rotoiti Breccia	50	42 Ky
Terrace Deposits (Older)		?
Mamaku Ignimbrite	130	170 Ky
Haparangi Rhyolite		?
Minden Rhyolite		>500 Ky
Papamoa Ignimbrite		840 Ky
Te Puke Breccias		>2 Ma
Beesons Island Volcanics	>150	>2 Ma
Urewera Greywacke	Basement	100 - 130 Ma

Ky = Thousand
Ma = Million

2.2 Lithologic Units

The major lithologic units in the region from oldest to youngest are:-

Urewera Greywacke
This is the basal rock unit for the region. It outcrops south of Ohinepanea. The Urewera Greywacke is a hard indurated fractured rock. It consists of banded argillite, alternating siltstones and sandstones, conglomerates and some fine-grained volcanic rocks.

Beesons Island Volcanics
These rocks which form the western boundary of the study area, (Figure 2.1) are also hard and fractured where fresh. They comprise weathered andesite lavas and breccias which have been hydrothermally altered and mineralised in part.

Te Puke Beccias
These rocks are also exposed in the hills west of Te Puke. They consist of white to pale brown pumice breccias and tuff with interbedded freshwater siltstones and sandstones occasionally interbedded with andesite lava flows.

Papamoa Ignimbrite
This overlies the Te Puke breccias on the western upland. The rock is a dark grey highly welded dacitic or andesitic ignimbrite with a lenticular (flattened particle) texture. Upper portions are less welded.

Minden Rhyolites
These rocks are described as spherulitic and lithic (rocky) slightly weathered rhyolite. They form slightly eroded domes which have not been deeply buried by other sediments. They outcrop on the western edge of the study area.

Haparangi Rhyolite
These rocks are described as spherulitic and lithic slightly weathered rhyolite. They form slightly eroded domes which have not been deeply buried by other sediments. They outcrop close to the western edge of the study area. Pumiceous and blocky near the surface they change to glassy then hard lithic highly jointed rhyolite which forms the bulk of the dome.

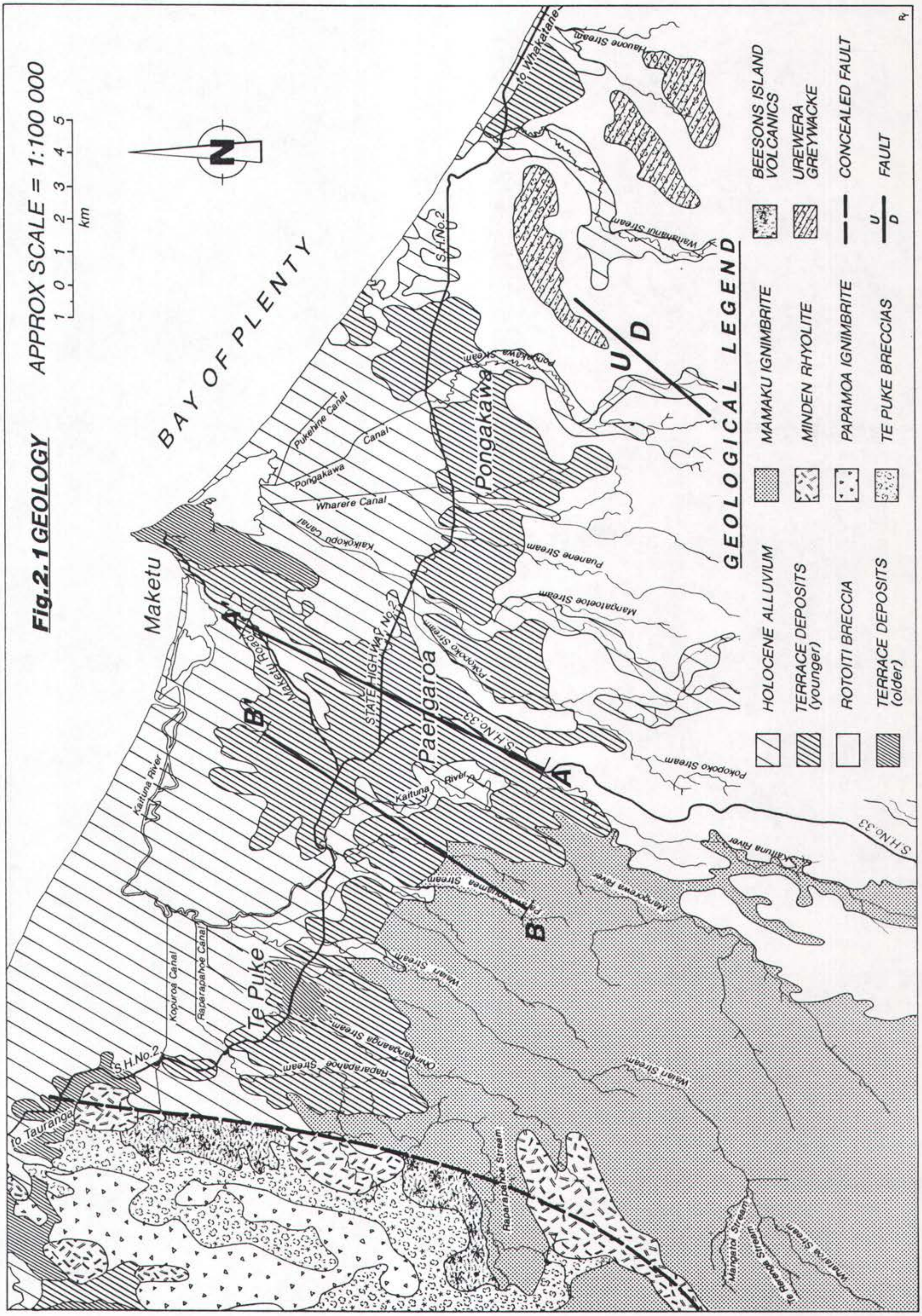


Fig.2.1 GEOLOGY

Mamaku Ignimbrite

This rock is exposed in the southwest and underlies much of the study area. It is a massive, soft, pink to grey coloured deposit with conspicuous soft pumice up to 30mm or more in length and flattened subhorizontally.

Considerable vertical variation is recorded. At depth the Mamaku Ignimbrite becomes progressively harder and pumice become harder and flatter. Near the base the pumice become lenticular (flattened fragments) with parallel faces about 3mm to 12mm apart. The lenticular zone grades downwards rapidly into a basal sand layer up to 6m thick. Harder layers are well jointed vertically but the basal sand layer is tight. Available reports indicate little lateral variation. However drill hole records suggest that welding reduces and disappears towards the coast.

Terrace Deposits Older

These materials are reported from the Headland. They are compacted to partially cemented fluviatile silts, sands, gravels with interbedded pumiceous tuffs underlying terraces at 30m and 70m above mean sea level.

Rotoiti Breccia

This material is exposed on the southeastern part of the study area. It is described as an upper member of loosely compacted, roughly stratified pumice with minor rhyolite breccia and sand. Typically beds are unsorted and up to 6m thick. The breccia contains rounded to subangular rhyolitic pumice up to 50mm in diameter and fragments of dark grey rhyolite up to 40mm in diameter in a matrix of pumice and quartz. Breccia members may be separated by brown volcanic ash. The lower breccia unit is up to 9m thick and consists of finely pumiceous slightly compacted sandstone, tight siltstone and basal brown ash.

Terrace Deposits (Younger)

These materials separate the outcropping volcanic materials from the coastal alluvium. These fluvial terrace deposits consist of silts, sands and gravels.

Holocene Alluvium
Alluvium, sands and peats lie between the younger terrace deposits and the coast. Much of the alluvium is undifferentiated but close to the coast fixed and moving dune cover occurs. The peats have formed in hollows behind the dunes.

2.3 Physiography

The volcanic rocks form plateaux which dip gently (1 to 2 degrees) seawards. These plateaux have been widely to closely dissected. Valley sides are steep but streams are long with flat gradients. The plateaux remain as broad interfluves of accordant levels.

Towards the coast the volcanic plateaux give way to marine terraces up to 45m amsl. These terraces in turn give way coastwards to low coastal swamps and alluvial plains, bounded at the coast by fixed and moving dunes.

On the western side of the study area the older volcanics form a small north-trending range. This dissected range is closely dissected with short streams of steep grade.

2.4 Structure

Figure 2.2 is a conceptualisation of the main structural features of the study area. A north north-east trending fault (Figure 2.2) separates the older volcanics on the west from the younger volcanics of the study area. A significant fault is inferred to separate basement greywackes which outcrop on the eastern part of the study area from the younger volcanics. It is probable that this fault is aligned in a similar manner to that on the west.

The area between these two faults has been down-faulted. Rock units which outcrop on the western upland probably lie at depth below the Mamaku Ignimbrite.

The area between the faults lies within a trough between two gravity anomaly highs to the east and west. The low gravity values in the basin indicate a substantial thickness of rhyolitic material.

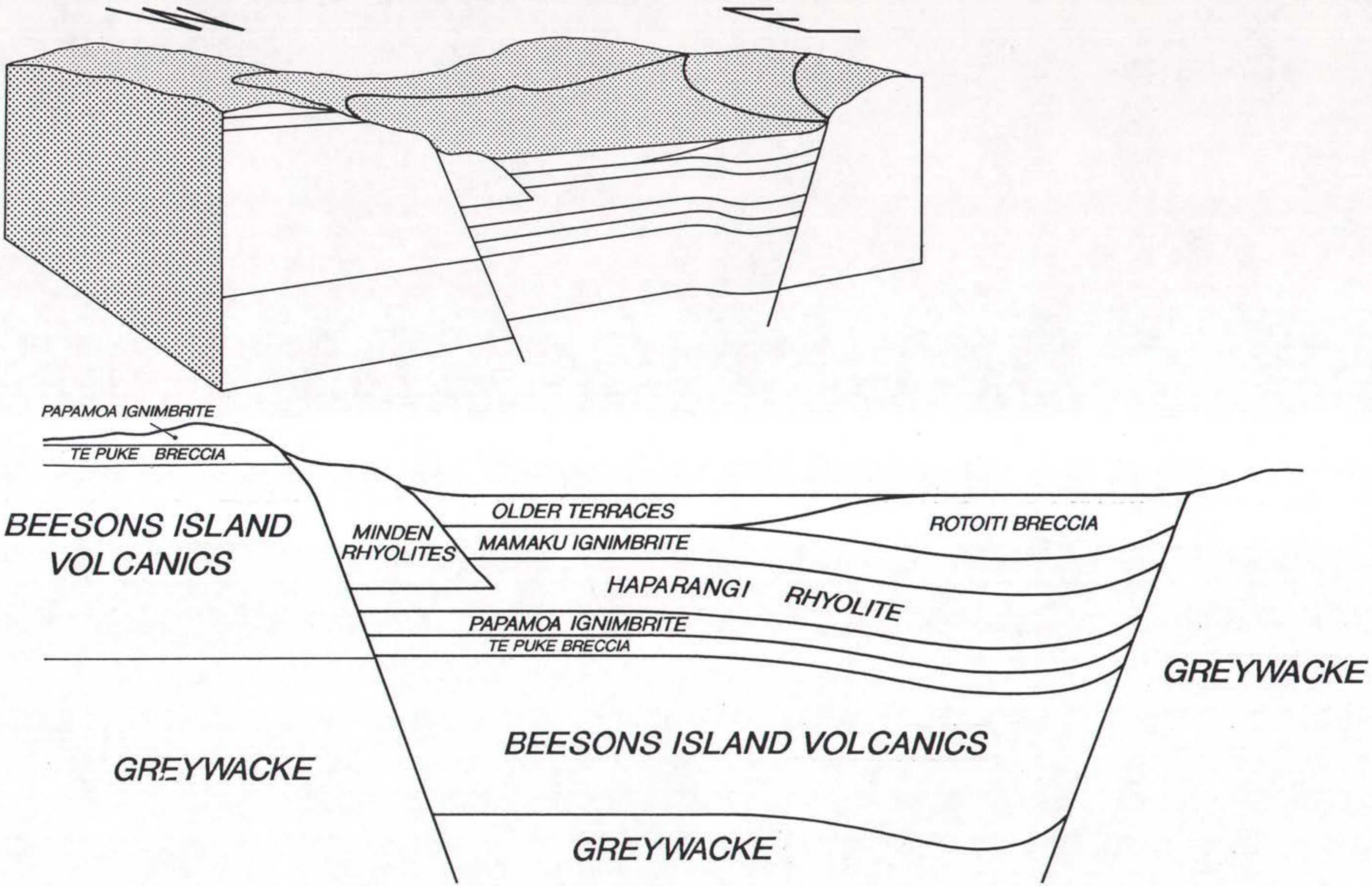


Fig.2.2

CONCEPTUAL GEOLOGICAL STRUCTURE

Thompson (1968) describes a downwarping of the Mamaku Ignimbrite to form a shallow north-plunging syncline with its axis close to the Pongakawa Stream. This syncline is partly filled with Rotoiti Breccia.

Elsewhere, the Mamaku ignimbrite dips gently seawards with a surface slope of 0° 55′ to 1° 34′ (Soons et al 1982).

CHAPTER THREE

OCCURRENCE AND DISTRIBUTION

3.1 Well Details

The location of all known wells in the study area as at October 1989 is shown in Figure 3.1 and 3.2. Appendices 1 and 2 provide data on well construction and yields. Well construction is variable but wells are generally constructed using single casing and are unscreened (Drill op end sgl cas in Appendix 1). A number of wells are multicased (Drill. op. end.mul.cas.) Screening where present is either stainless steel wound wedgewire, slotted PVC or slotted steel casing. In some holes screens have been placed beyond the casing leaving a substantial portion of the hole open.

Figure 3.3 shows the distribution of well depths. Well depths range from 9m to 542m with 80% less than 140m deep. The largest group is between 60m and 140m depth.

3.2 Well Yields/Specific Capacities

Well yields are presented in Appendix 2 and range from 25 to 1965m^3/day. Well yields are not an indication of aquifer yield as they are generally related to usage, not production potential.

Specific capacities derived from the drillers log sheets are provided in Appendix 2. Specific capacity provides an estimate of potential well yield. It is a function of both aquifer permeability and well construction, and is defined as the discharge per unit drawdown of the water level in a well. Specific capacity for well 1687 was 160m^3/d/m. This is about half the value of transmissivity derived by a pump test on the same well. Transmissivity provides an estimate of the aquifers ability to transmit water. Specific capacity therefore underestimates transmissivity by up to about 2 to 3 times.

Specific capacities from Appendix 2 are shown in Figure 3.4. Coverage of the area is reasonable but no patterns are apparent. Figure 3.5 shows the variation of specific capacity with depth. No trends are indicated - the apparent concentration of higher values between 80m to 150m depth is a consequence of the number of wells in this interval. A check of well logs for deep holes with low specific capacities (Appendix 2) shows large open areas or screens set below the casing and not attached to it. Low specific capacities under such conditions are anomalous. It is possible that well collapse may have reduced the extent of production zones in some of these wells.

Figure 3.6 shows the frequency distribution of specific capacity values. Fifty percent of the values are above $100m^3/d/m$. This implies transmissivities of $200-300m^3/d$ or more. Transmissivities of this magnitude indicate a good potential for groundwater production.

3.3 Aquifer Characteristics

Appendix 1 lists aquifer types. These descriptions are based on the details provided by drillers on the drillers borelog forms. Examination of the logs suggests that different drillers use the terms "Rhyolite" and "Ignimbrite" in different ways. In the absence of qualifiers such as "soft", "hard" or "compacted" on the logs the nature of the aquifers, i.e. porous or fractured, can not be determined.

Figures 3.7 and 3.8 are cross sections showing summarised log data. The locations of these sections are shown on Figure 2.1. Aquifers are variable, ranging from gravels and sands through sandy pumices, pumices, moderately hard rocks to hard fractured rocks. Shell beds are occasionally encountered near the coast.

In Figures 3.7 and 3.8 the projected gradients of the Mamaku Ignimbrite surface are shown. The existence of peats (Well Nos.1700 and 952) indicates that the steeper gradient may be more reliable. Above this line wells will be tapping tephras or alluvium. Below this line in addition to the tephras and alluvium wells may tap aquifers in ignimbrite.

A transmissivity of $350m^2/d$ was derived from a pumping test in Well No.1687 (Figure 3.2). This well is 116m in depth and penetrates a "uniform, well rounded cemented pumice". Another pump test was conducted on well No.1535 and a value of $700m^2/d$ was obtained for transmissivity. The aquifer zone screened between 19.5 and 31.5 meters comprised sands and pumices.

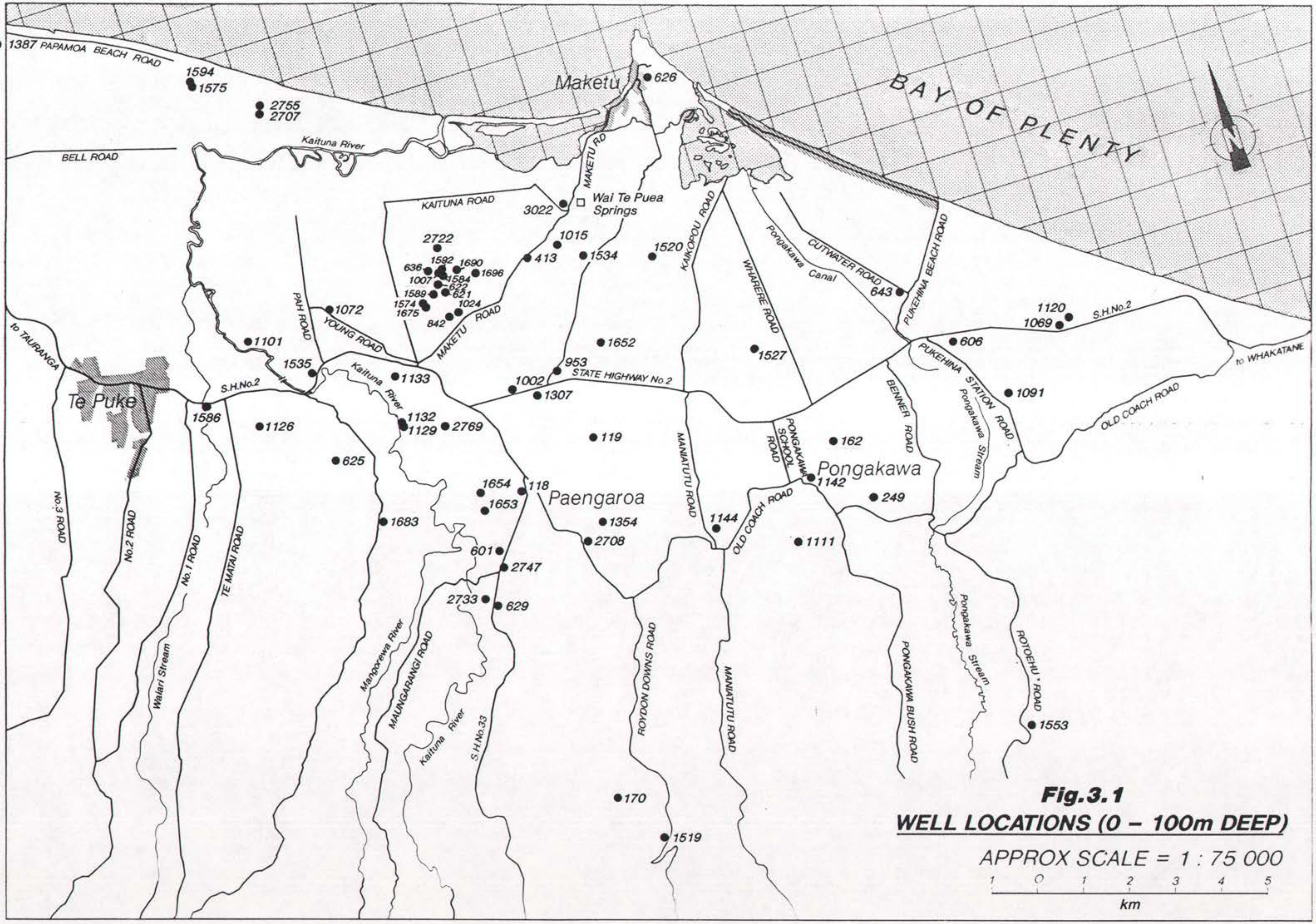


Fig.3.1
WELL LOCATIONS (0 – 100m DEEP)
APPROX SCALE = 1 : 75 000

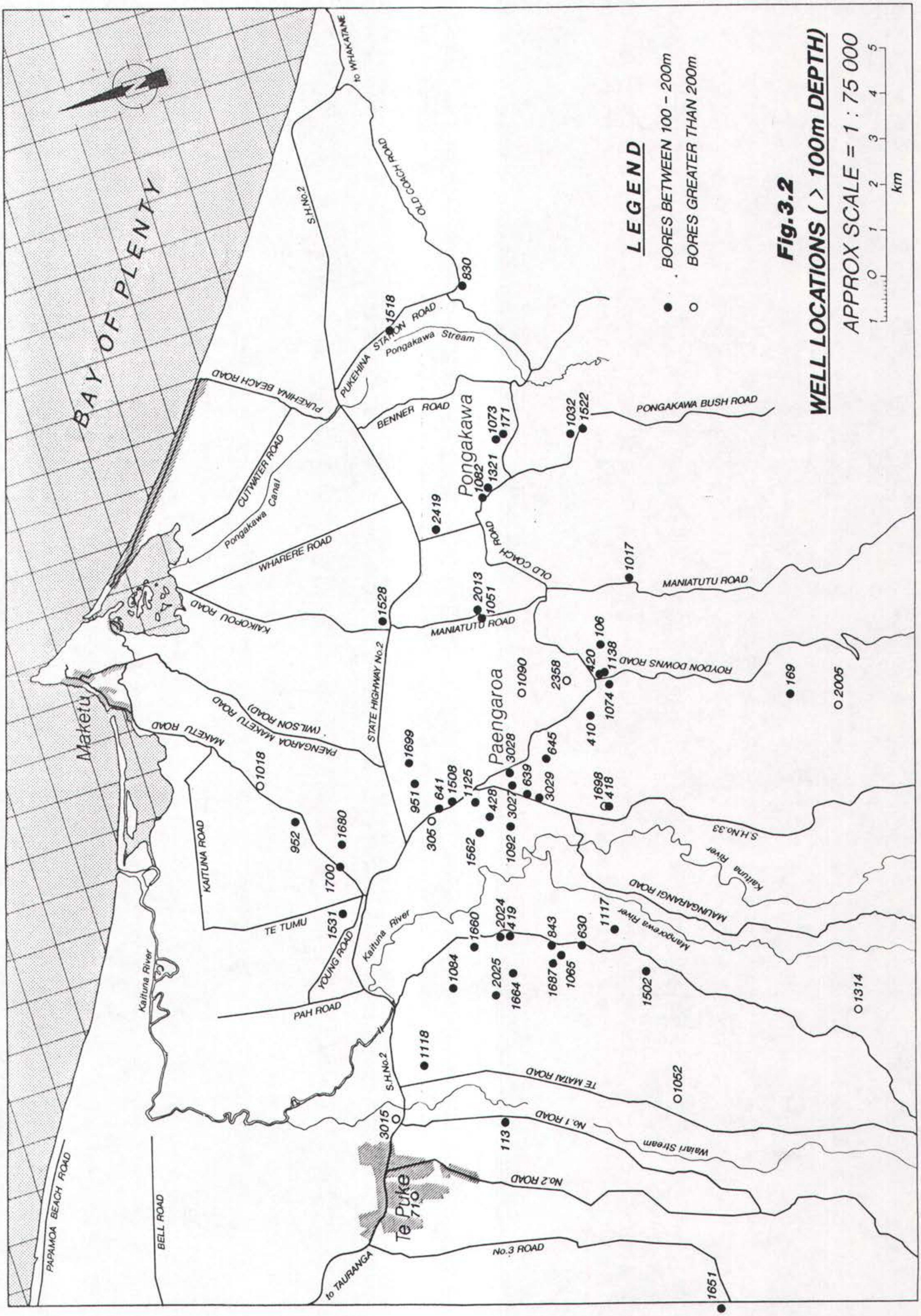


Fig.3.2

WELL LOCATIONS (> 100m DEPTH)

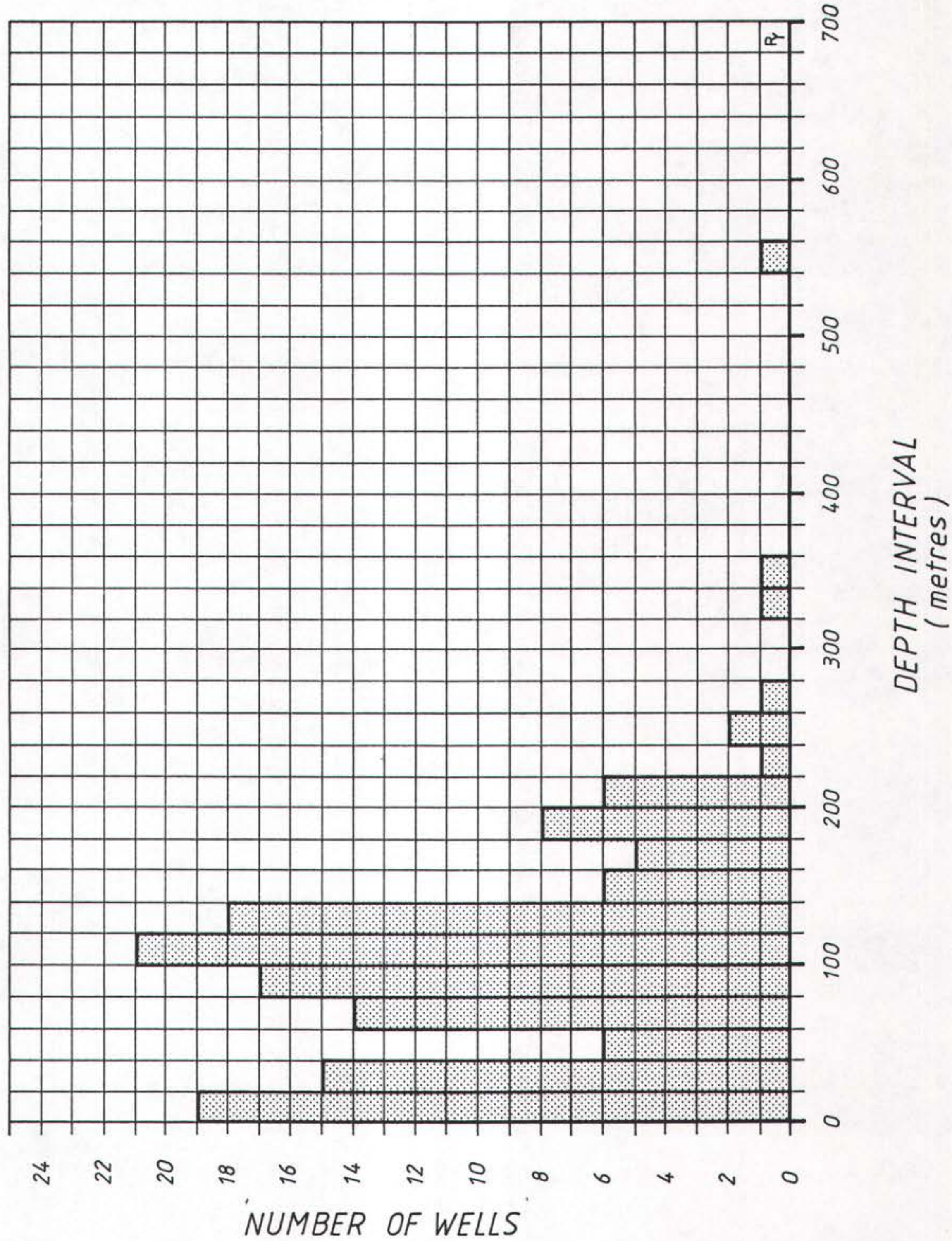


Fig.3.3 DISTRIBUTION OF WELL DEPTHS

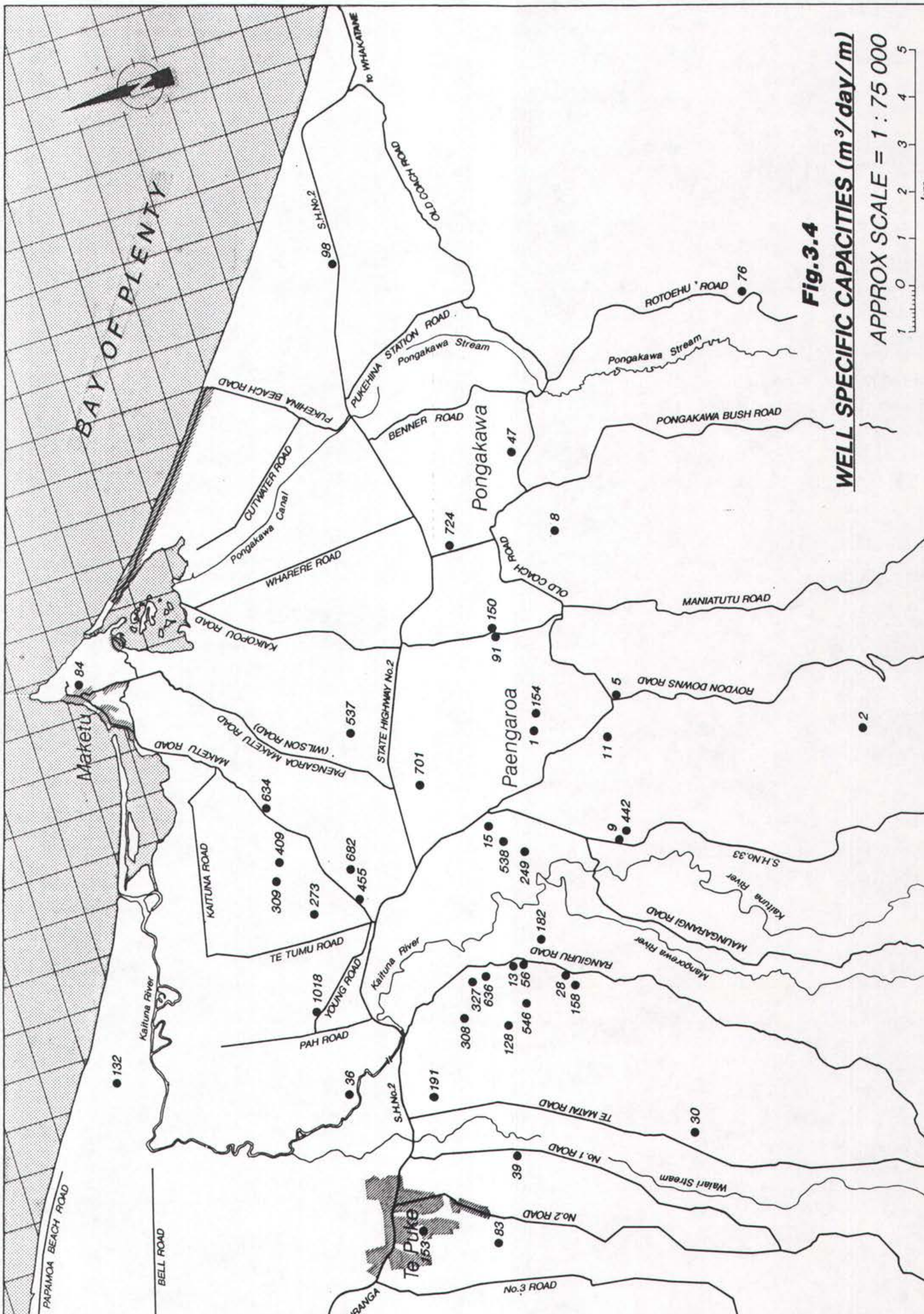


Fig.3.4

WELL SPECIFIC CAPACITIES ($m^3/day/m$)

APPROX SCALE = 1 : 75 000

0 1 2 3 4 5 km

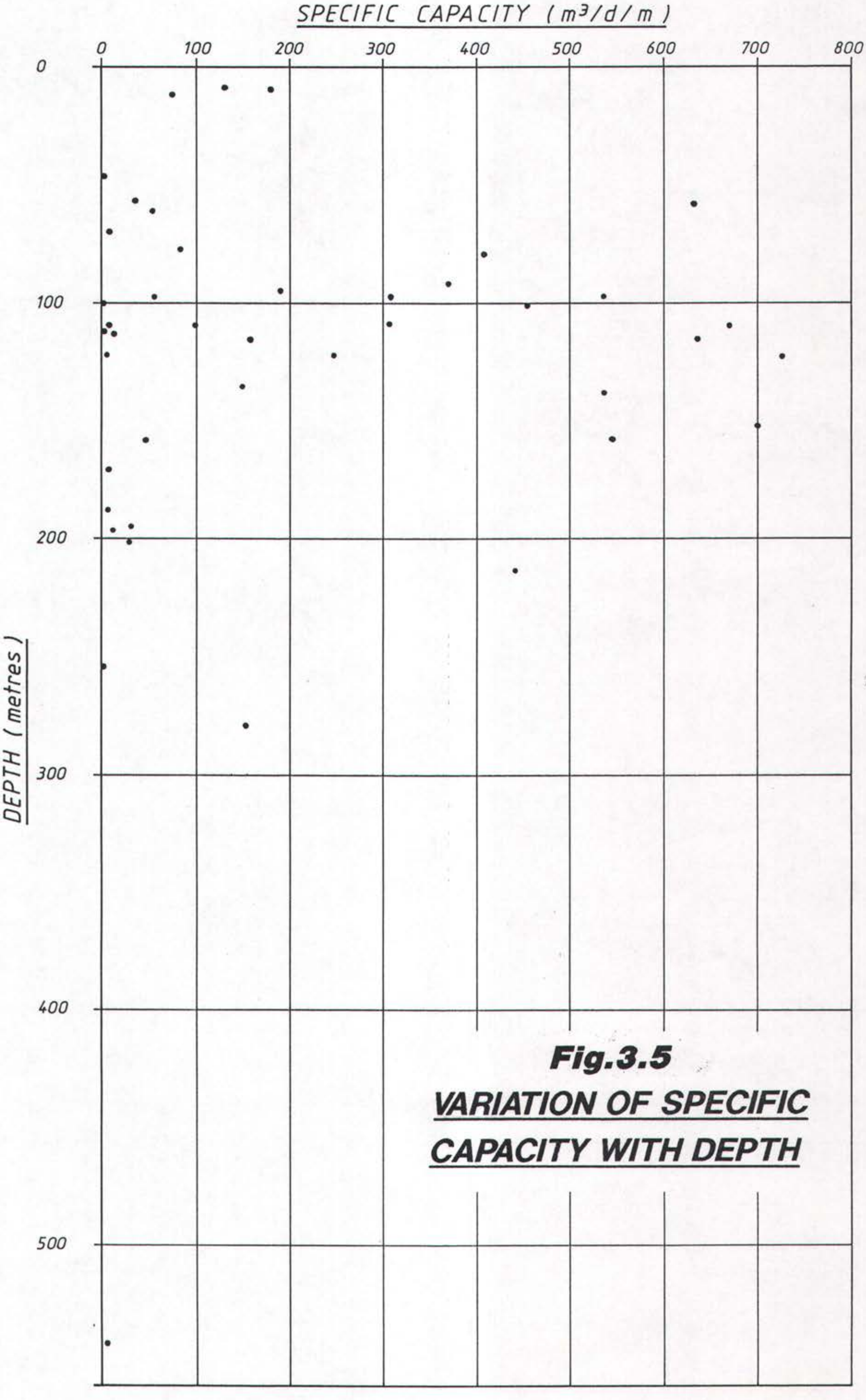


Fig.3.5

VARIATION OF SPECIFIC CAPACITY WITH DEPTH

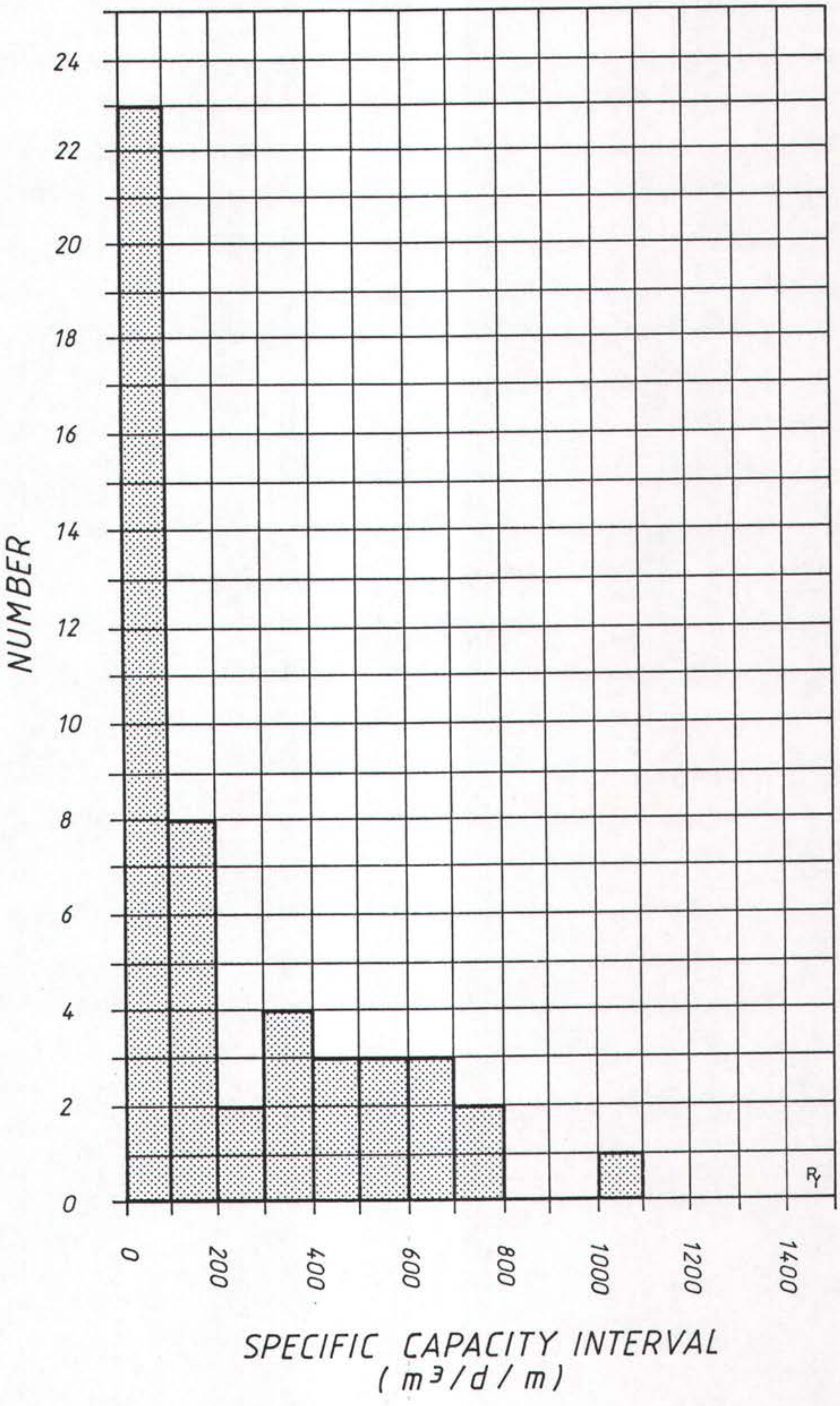


Fig.3.6

DISTRIBUTION OF SPECIFIC CAPACITY

Fig.3.7

SURMISED GEOLOGICAL SECTION A – A'

(See Figure 2.1)

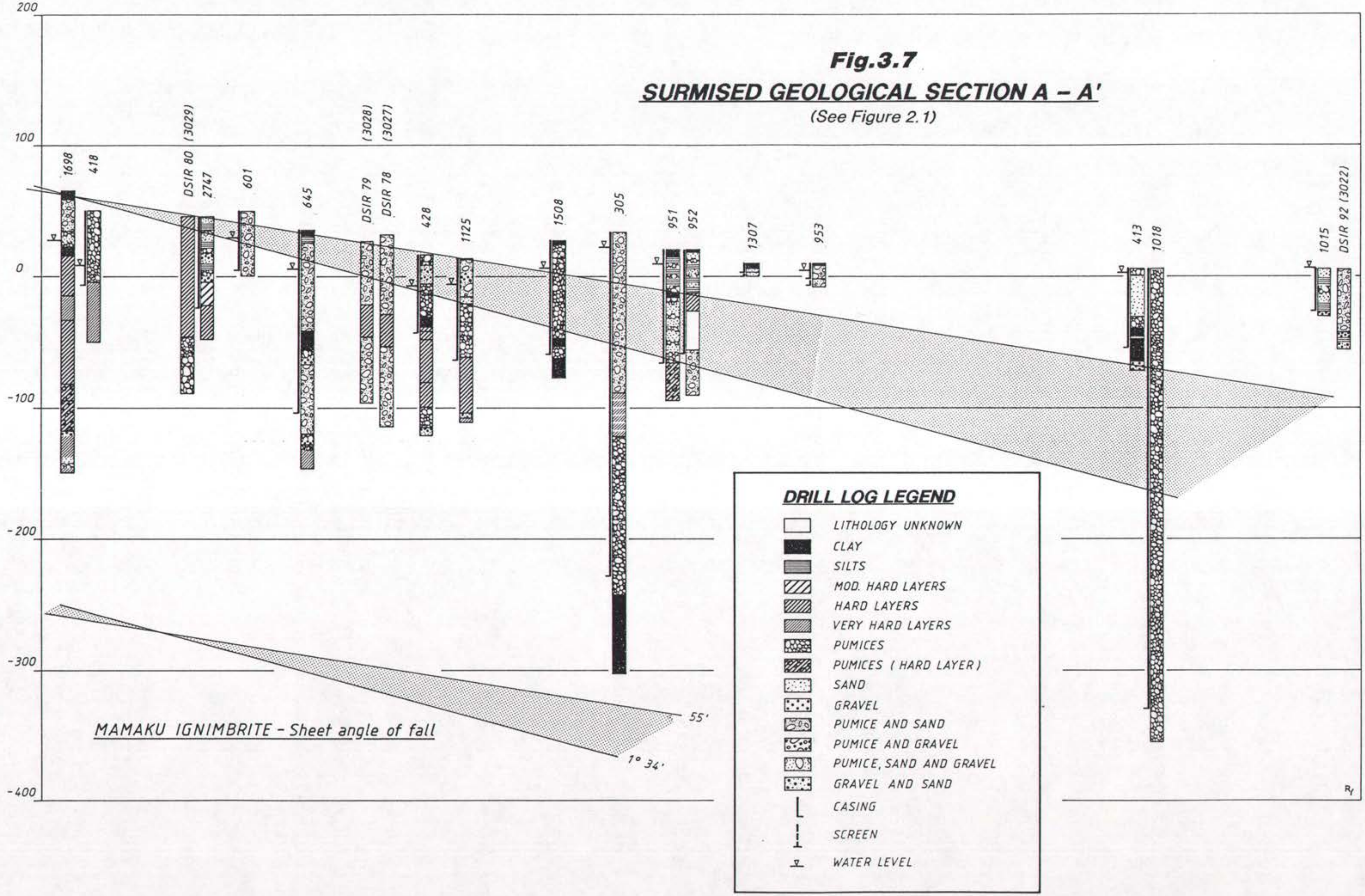
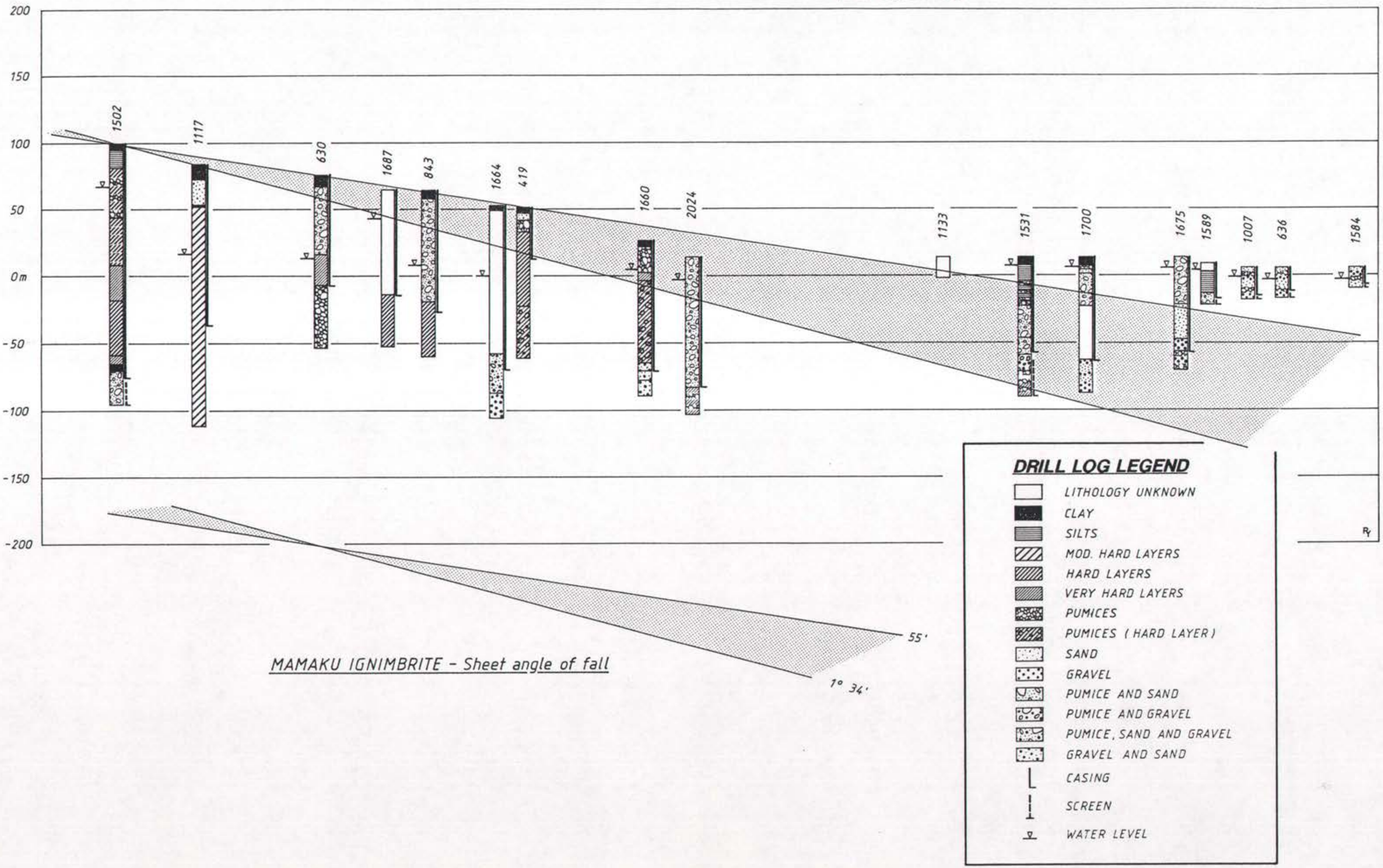


Fig.3.8

SURMISED GEOLOGICAL SECTION B – B'

(See Figure 2.1)



CHAPTER FOUR

WATER LEVELS

CHAPTER FOUR

WATER LEVELS

4.1 Monitoring Records

Few water level monitoring readings are available for the study area. The only continuous records are for four coastal wells at Papamoa which were monitored monthly during the period October 1979 to May 1984. The wells are all shallow, monitoring the water table aquifer in sands and shallow sediments along the Papamoa coast. They are all located to the north-west of the area shown on Figure 4.2. Figure 4.1 shows water levels in the four wells over the monitored interval. The response of the wells is similar suggesting that they tap the same aquifer system. The differences in the levels above mean sea level suggests a fall in groundwater to both the north and the east. This is consistent with the expected groundwater gradients in the area.

4.2 Records From Drill Log Data

Water levels recorded by well drillers after the completion of drilling (depth to groundwater below ground surface) are shown in Figures 3.7 and 3.8. In the hinterland groundwater levels are generally some distance below ground level (up to 70m) and frequently are consistent with river levels. This implies highly permeable material in the upper parts of the ignimbrite.

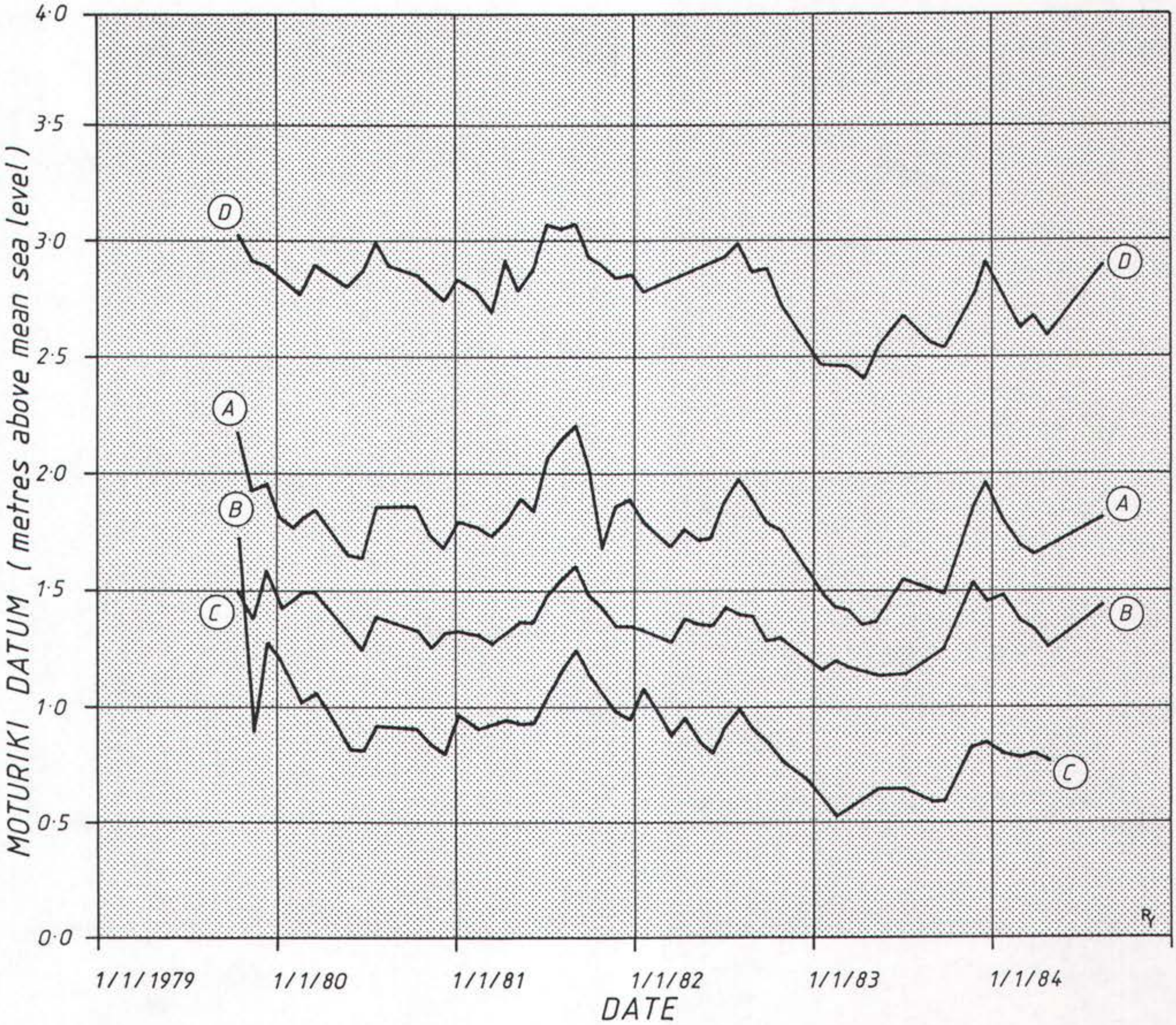
Towards the coast water levels are much shallower. Flowing artesian wells (i.e. groundwater level above ground level) occur at Maketu and Paengaroa.

4.3 Inferred Potentiometric Surface

Figure 4.2 shows the inferred potentiometric surface. The potentiometric surface can be defined as an imaginary surface representing the level to which water level rises throughout the aquifer. It has been constructed by intersection of contours with the main river systems. The general pattern shown is of inward flow to the basin. Steep gradients on the basin northwestern sector are due to less permeable older volcanics across a north trending fault.

The steep gradients in the southwest sector are within Mamaku Ignimbrite. A change in gradient is shown at the 80m contour. Major spring discharges occur about or above this level. In the central area the groundwater gradient flattens towards the coast with the gradient changing from about 0.020 inland to about 0.002 from the 20m contour to the coast. In the east, outcropping greywacke basement imposes steep gradient on the potentiometric surface.

It is probable that groundwater in the terrace deposits stands above that in the underlying volcanic materials. This would form a separate potentiometric surface. However insufficient data is available to adequately define such a surface at this stage.



LEGEND

A: Partons Road South

B: Intersection Partons Road / Beach Road

C: Eastern end of Beach Road

D: Papamoa Domain

Fig.4.1

HYDROGRAPH, PAPAMOA MONITORING BORES

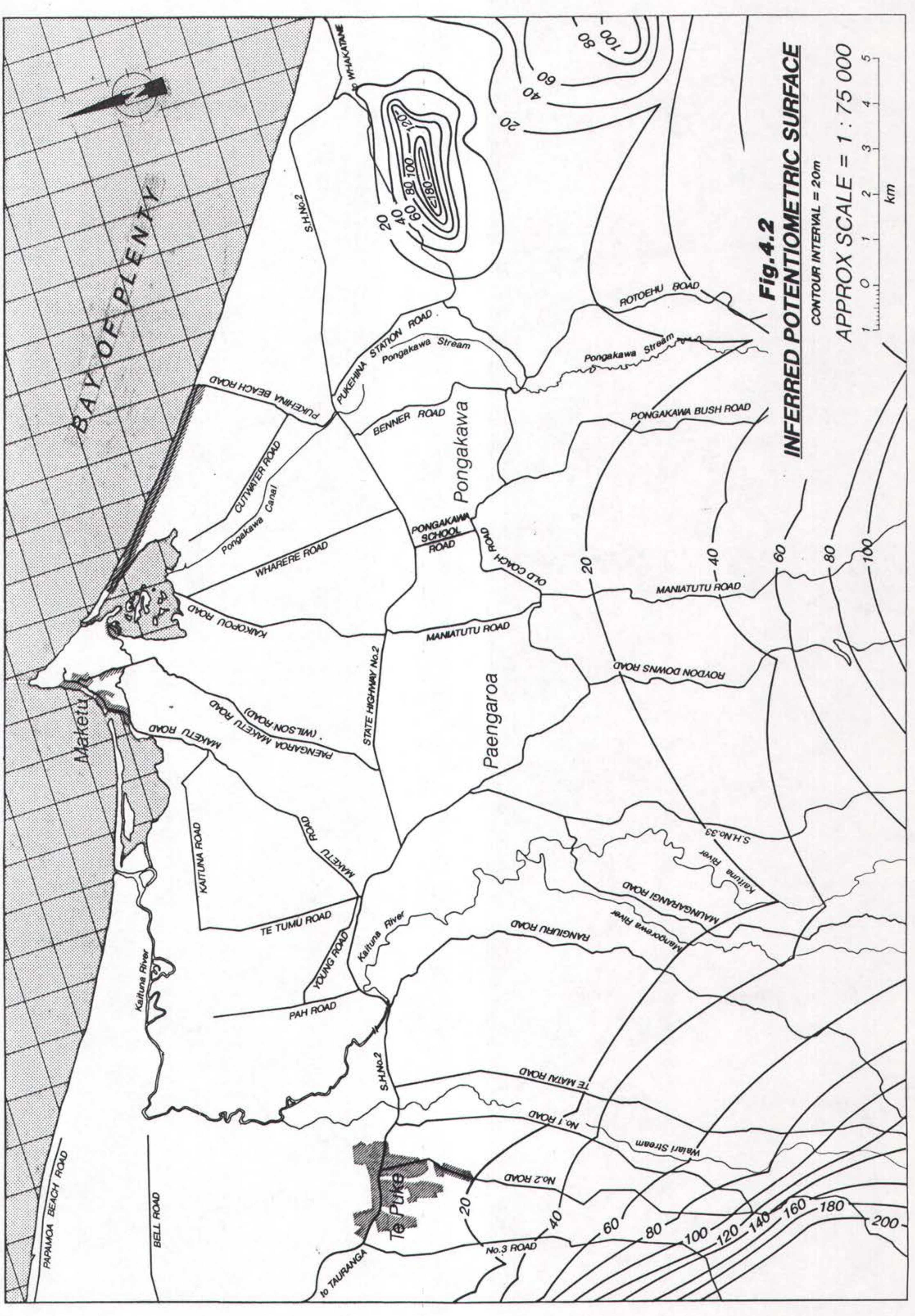


Fig.4.2

INFERRED POTENTIOMETRIC SURFACE

CHAPTER FIVE

GROUNDWATER CHEMISTRY

CHAPTER FIVE

WATER CHEMISTRY

5.1 Data Source

Water quality data for the area has been obtained from the following sources.

- Bay of Plenty Regional Council Laboratory. The Bay of Plenty Regional Council has analysed waters from a number of wells in the area to check for saline contamination in coastal aquifers.

- Water Right Files. Analyses have been provided in fulfilment of water right conditions or in support of water right applications. Most of the analyses have been carried out in other laboratories. The number of parameters analysed vary and are often insufficient to determine the water type.

- Laboratories in the Bay of Plenty. Various laboratories have supplied the Bay of Plenty Regional Council with analytical data. As for the above source, parameters analysed are variable and often incomplete.

- Existing Publications. A number of analyses have been reported in published reports, particularly those describing the hot water systems.

The chemistry data, where able to be matched to a well, has been included in Appendix 2. When full analyses are available, these have been used in Appendix 3 to type the waters.

5.2 Chemical Constituents

Values for pH, conductivity, chloride, iron and boron are given in Appendix 2. pH values range from 5.4 to 8.3. This range indicates moderately acid to moderately alkaline water. Figure 5.1 shows the distribution of conductivity values which range from 80 mS/m to 1260mS/m. Fifty-four percent are below 300mS/m and 87% below 500mS/m. Conductivity values equate to Total Dissolved Solids (TDS) generally by a factor between 0.55 and 0.70 (APHA 1985). Therefore 54% of water samples have calculated TDS value below the 165-250 g/m^3 range and 87% of samples have calculated values below the 275-350 g/m^3.

Figure 5.2 shows the distribution of chloride values. Sixty-five percent of the values fall below $40g/m^3$ and 93% below $100g/m^3$ hence, salinity is low. Figure 5.3 shows the distribution of chloride values with depth. As for specific capacity no trends are apparent. High and low values occur at all depths. The apparent concentration of sample points at about 100m depth is a consequence of the well depths. Figure 5.4 shows chloride concentrations across the study area. The highest chloride concentrations occur in wells adjacent to the Maketu estuary.

The iron values range from 0.1 to $28.0g/m^3$. This wide variation of values is likely to have resulted from particulate iron as well as dissolved iron being analysed. Figure 5.5 shows iron concentrations. From Appendix 2, 34% of iron values lie below $0.3g/m^3$ and 57% below $1.0g/m^3$. High iron levels often appear to be associated with organic horizons within aquifers. An area of high iron concentration at Paengaroa is seen in Figure 5.5.

Boron values are also included in Appendix 2. Seventy-eight percent of the values lie below $0.5g/m^3$ (toxicity concentration for most crops). No value greater than $0.93g/m^3$ has been reported. This indicates that deep groundwater from greywacke rocks or groundwater from hydrothermal systems are absent from the system.

5.3 Ion Balance

Few analyses were sufficiently complete to provide the components needed for an ion balance. Appendix 3 provides ion balances and ion ratios of these analyses. The greater proportion of the analyses in Appendix 3 do not balance. Generally the anion sum (HCO3 + CL + SO4) exceeds the cation sum (Na + K + Mg) as milliequivalents/litre, even in the absence of sulphate determinations. As high silica contents are common in groundwaters from pumice, ignimbrite and rhyolite material, it is probable that silica may in some way be responsible for high alkalinity values which result in the elevated anion sums. Silica in a set of analyses from Maketu (Wells TGW, 38, 39,49,51,52) ranged from $103g/m^3$ to $175g/m^3$ SiO_2 (Simpson and Stewart, 1987).

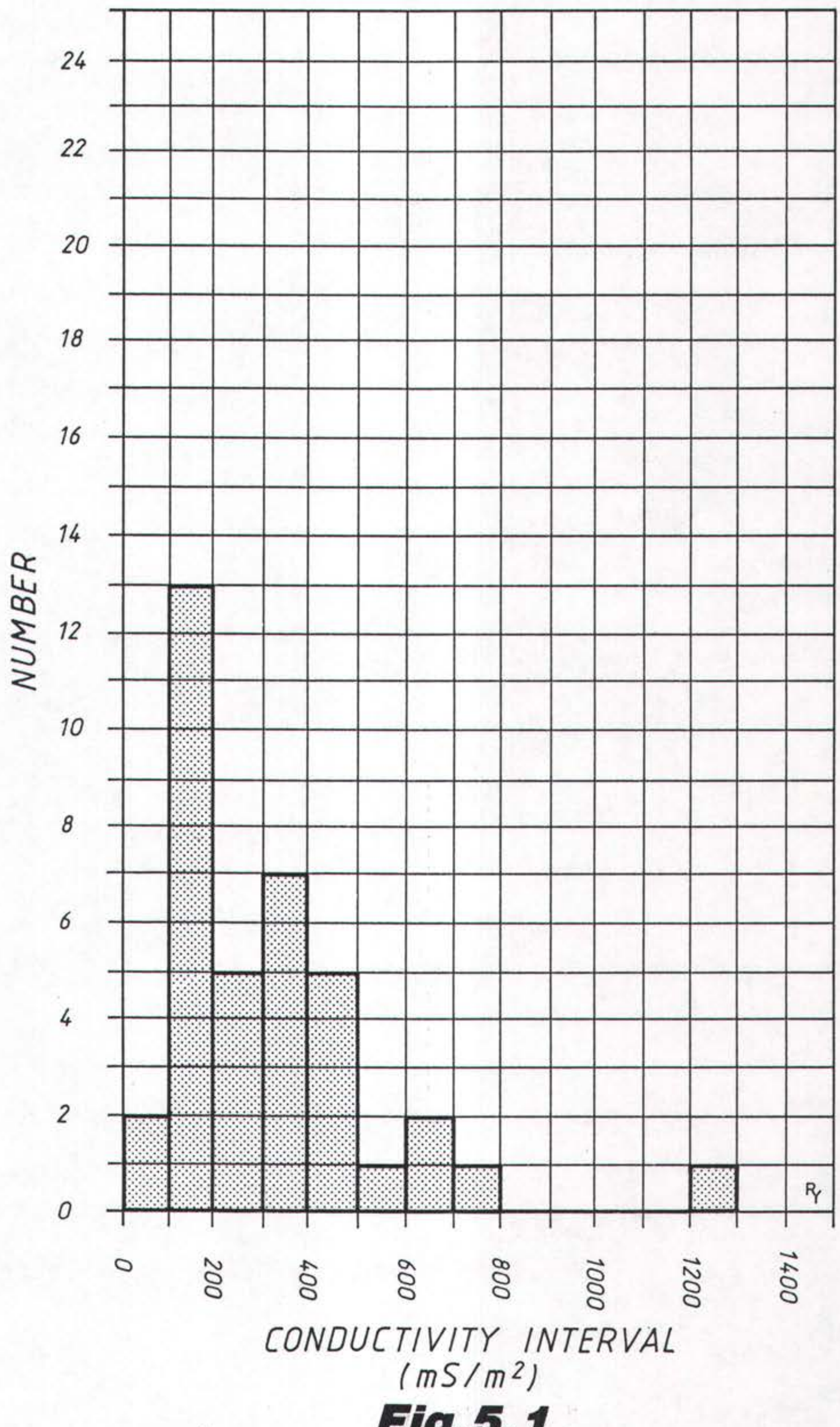
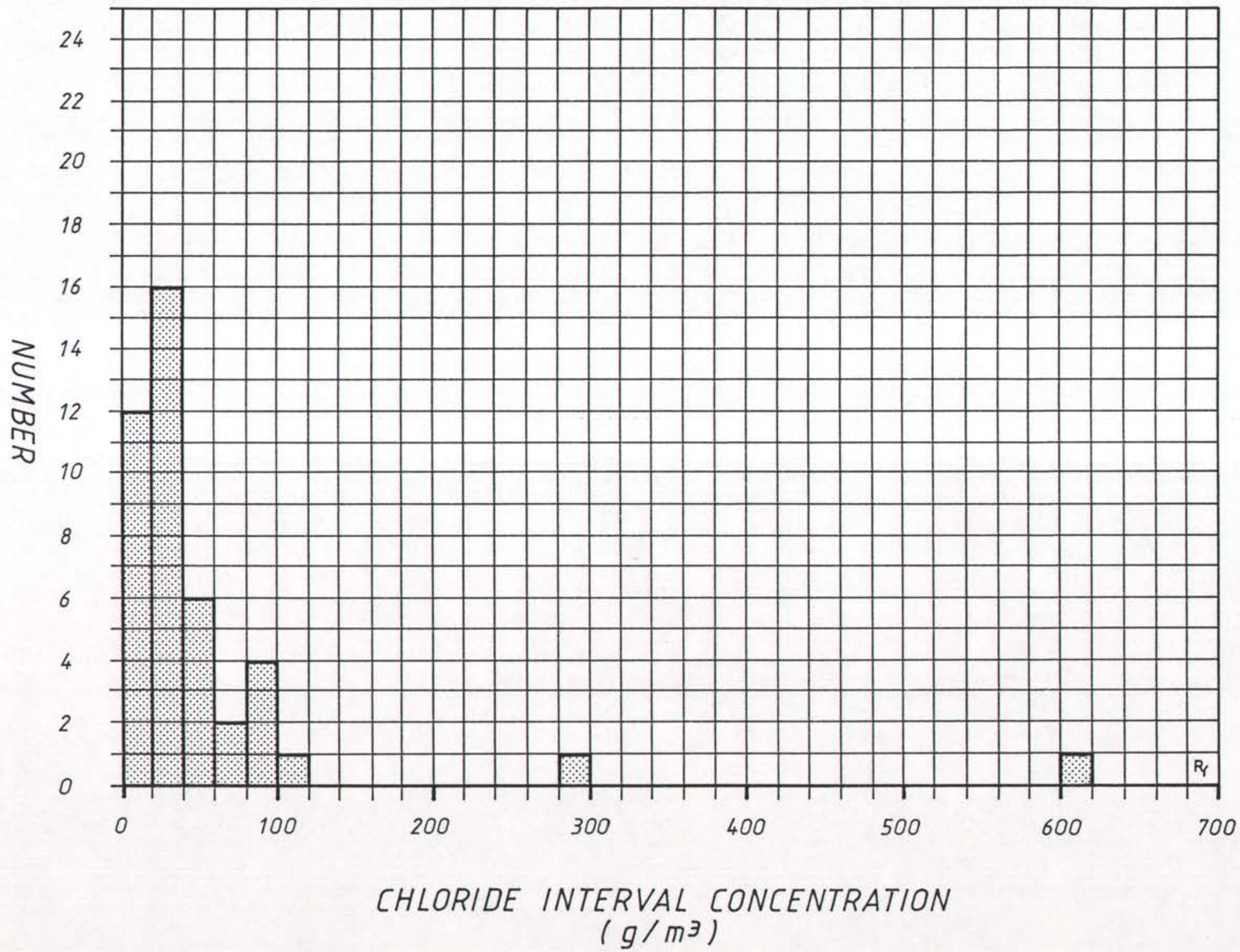


Fig.5.1

DISTRIBUTION OF CONDUCTIVITY VALUES

Fig.5.2

DISTRIBUTION OF CHLORIDE VALUES



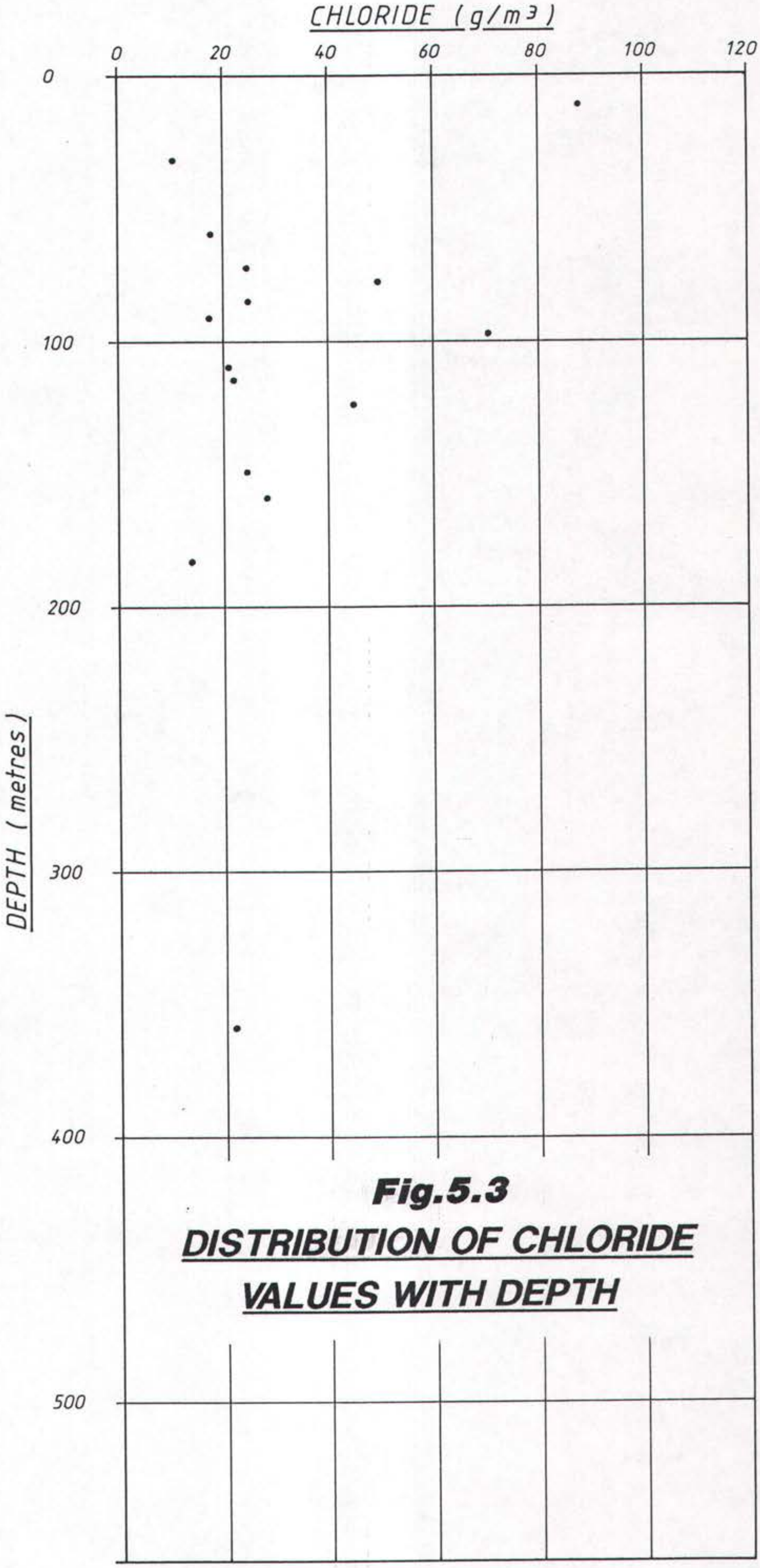


Fig.5.3

DISTRIBUTION OF CHLORIDE VALUES WITH DEPTH

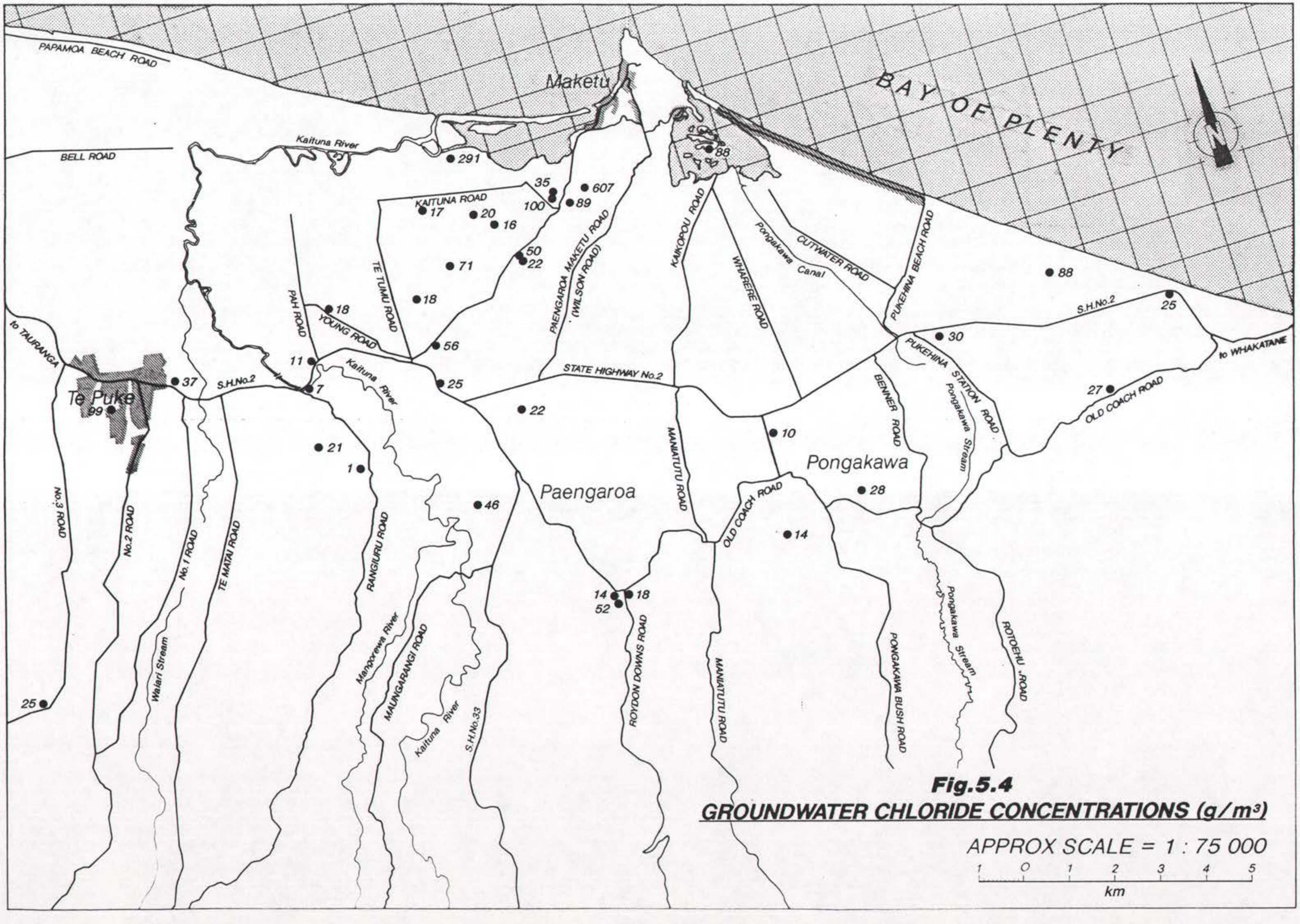


Fig.5.4

GROUNDWATER CHLORIDE CONCENTRATIONS (g/m³)

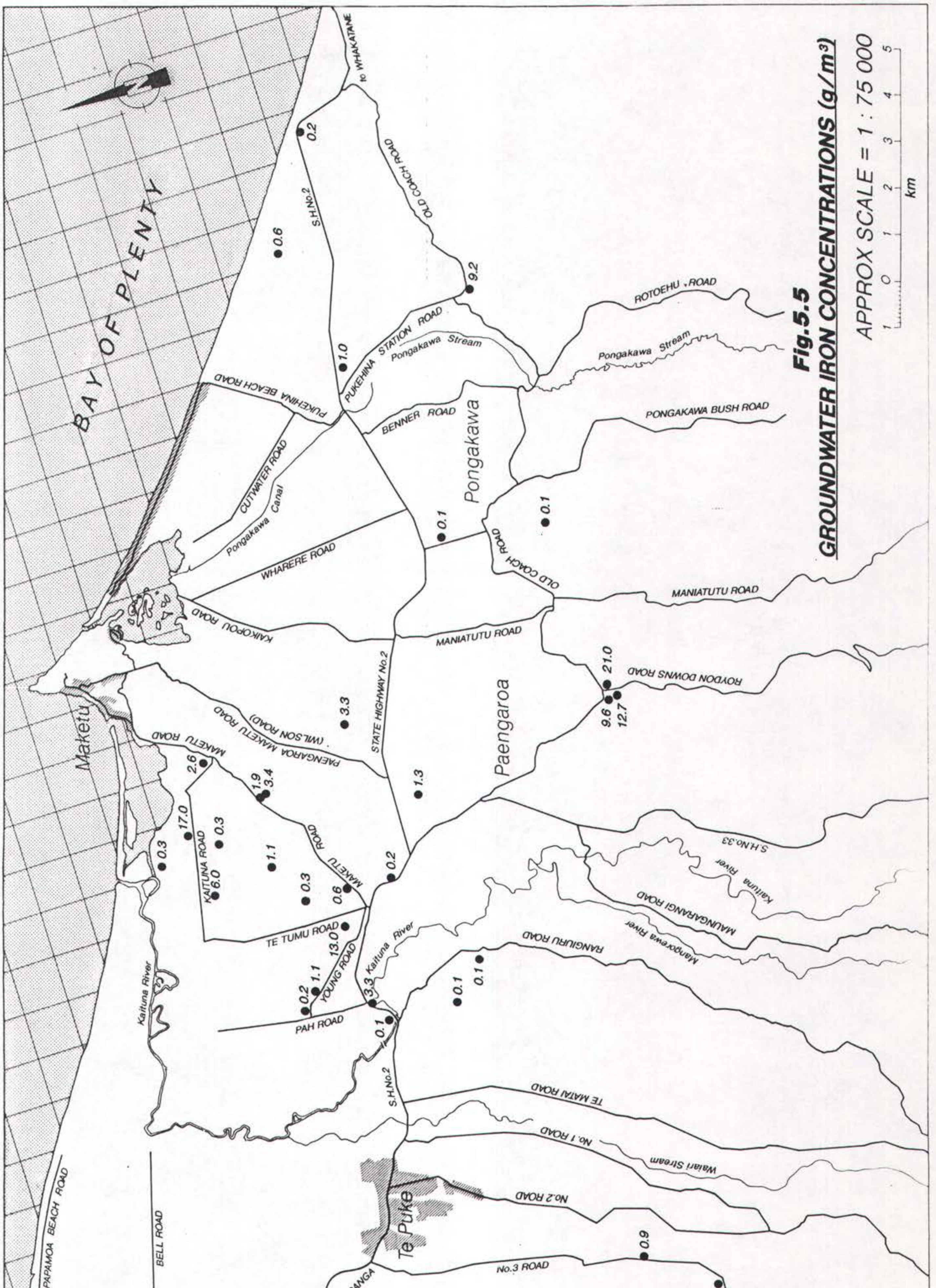


Fig.5.5
GROUNDWATER IRON CONCENTRATIONS (g/m³)
APPROX SCALE = 1 : 75 000

The analytical results from a set of samples at Maketu (Wells TGW 38, 39, 40, 41, 42) in Appendix 3 were analysed by the DSIR (Wairakei). Bicarbonate was measured directly and not calculated from alkalinity (Mr M Cramp, pers comm). The ion balances of these analyses are acceptable despite the high silica contents (see above).

In Appendix 3 the anion ratios have been adjusted by generally recalculating the bicarbonate value. The impact on the anion ratios from the uncertainty of the bicarbonate value is apparent. Data from Appendix 3 shows that groundwaters are predominantly of the bicarbonate type, but a large proportion are also sodium chloride type.

5.4 <u>Sodium Adsorption Ratios and Corrosion Indices</u>

Sodicity is an important factor that may limit the irrigation potential of groundwaters. The sodium hazard is measured by the Sodium Adsorption Ratio (SAR). Sodicity becomes a problem when the proportion of sodium ions is significantly greater than that of calcium and magnesium combined. Excessive sodium results in a deterioration in soil structure and reduced infiltration and permeability rates. A level of 9 has been set as the upper limit of low alkali hazard (Ayers, 1975).

The Ryznar Stability Index is a measure of corrosion or scale-forming potential. Calcium carbonate scale formation is indicated at an index between 6 and 6.5 and becomes increasingly heavy as the index decreases. Increasing corrosion is indicated above an index of 7.5.

Table 5.1 provides the calculated sodium adsorption ratios (SAR) and Ryznar Indices for those analyses from Appendix 3 which have acceptable ion balances. Comparison of Table 5.1 with cation values and cation sums from Appendix 3 suggests that most groundwaters have low SAR values.

TABLE 5.1 : SODIUM ADSORPTION RATIOS

Bore	Well Number	SAR	Ryznar Stability Index
Cornucopia Orchard	3004	0.763	11.6
Mangatawa Orchard	3011	0.915	11.4
Yangtao Orchard	1138	2.511	9.9
Murrey	3010	0.192	
Manson	3016	0.392	
DSIR Maketu 61m	3023	22.750	
DSIR Maketu 130m	3023	18.330	
TGW 38 Te Puke		2.349	
TGW 39 Maketu		15.120	
TGW 40 Maketu		28.780	
TGW 41 Maketu		38.170	
TGW 42 Maketu		9.330	

Few Ryznar Stability Indices have been plotted as most of the alkalinity values examined are considered unreliable. The values in Table 5.1 are likely to be representative of most groundwaters. Table 5.2 shows component limitations for water use. Only those parameters for which analyses were available in the study area are included in the Table. Except for iron the parameters analysed are within the limits set for potable supplies.

The waters, except those with elevated iron, chloride and SAR values (hot water wells at Maketu) have analysed parameters within the limits set for irrigation. Boron levels observed are not a significant problem either for irrigation or for stock watering.

The elevated Ryznar values indicate a potential for corrosion. The potential is likely to be greater in the west with more saline groundwater.

TABLE 5.2
COMPONENT LIMITATIONS FOR WATER USE

USE	POTABLE		IRRIGATION			STOCK	REACTION	
COMPONENT	MAXIMUM ACCEPTABLE	MAXIMUM ALLOWABLE	NO PROBLEM	INCREASING PROBLEM	SEVERE PROBLEM		CORROSIVE	ENCRUSTING
pH	7 - 8·5							
TDS	500	1500						
Cl	200	600						
Fe	0·3	1·0						
Mn	0·1	0·5						
SO_4	200	400						
SALINITY TDS			< 480	480 - 1920	> 1920			
DEFLOCCULATION OF CLAYS TDS			> 320	< 320	< 128			
SAR			< 6	6 - 9	> 9			
ION TOXICITY								
B			0·5	0·5 - 2	2 - 10			
Na (leaf)			< 69	> 69				
Cl (roots)			< 142	142 - 355	< 355			
Cl (leaf)			< 106	> 106				
QUALITY HCO_3 (as $CaCO_3$)			< 75	75 425	> 425			
TDS						3000		
B						5		
pH							< 7	> 7·5
Rhyznar INDEX							> 7	< 7
TDS							> 1000	
Cl							500	
Carbonate Hardness								> 300
Iron								> 0·5
Mn								> 0·2

5.5 Seawater Contamination

Some wells show elevated chloride levels. Table 5.3 shows ratios of selected components of seawater, groundwater and of the elevated salinity groundwaters.

TABLE 5.3 : IONIC RATIOS OF SEAWATER AND GROUNDWATER

	Na	Cl	Na/K	Na/Ca	Cl/B	Ca/Mg
Seawater	10561	18980	47.2	46.0	1258	0.19
Holster (1013)	28.3	88.13	5.9	9.2	0.33	0.24
TPSC (71)	98.5	99	26.1	286	-	2.50
Brain (3009)	170	291	16.1	2.3	-	3.79
DSIR Maketu @ 61m	410	697	15.8	15.5	332	0.78
DSIR Maketu @ 130m	330	602	13.7	8.1	375	0.73
TGW 41	498	607	22.2	19.1	206	0.89

The ratios indicate that seawater intrusion at least at shallow depth is not taking place. The elevated values of sodium chloride may result from mixing of entrapped sea water in sediments with groundwater moving through the sediments, or from discharging groundwaters approaching the sea water - groundwater interface at depth.

CHAPTER SIX

HOT WATER RESOURCE

CHAPTER SIX

HOT WATER RESOURCE

6.1 Resource Definition

The coastal part of the study area forms part of a broad warm groundwater resource extending between Waihi in the west to Maketu in the east. The warm resource is arbitarily defined to be tapped by those wells discharging at a temperature of 30 degrees celsius or greater. Data concerning this resource is available from a number of sources.

- Hot water from wells and springs at Maketu and Te Puke as described in Simpson et al (1987) and Simpson (1987).

- A number of warm wells in the area have been logged by the DSIR and temperature profiles run.

- A third source of data is the Bay of Plenty Regional Councils WELDAT database which provides production temperature data recorded by the welldriller after completion of the well.

6.2 Physical Characteristics

The hottest temperature recorded is 53°C from the 542m deep well supplying the Te Puke Swimming Club. Other temperatures range from 26 to 40°C in wells 97.5 to 335m deep (Appendix 2). Aquifers are variable being gravels, pumices, ignimbrite and broken rock. At Maketu one artesian well (well No.1015) produces 40°C water from a well 35m deep into gravels. It is understood that wells at Maketu noted in Simpson et al (1987) are also shallow. Hot water also discharges at the Maketu (Wai-Te-Puia) Hot Springs. Hot groundwater near Maketu is obtained at a much shallower depth (0-60m) than at Te Puke (>300m). Water from hot wells is predominantly of sodium bicarbonate type. Few wells are of sodium chloride type. Boron values in the hot groundwater are low (Appendix 2). This suggests that the thermal waters are not rising from basement greywackes.

Based on chemistry, isotope ratios and dating of groundwaters, Simpson et al (1987) concluded that:-

- The hot groundwaters have not encountered the high temperatures typical of geothermal reservoirs

- The hot groundwaters are not recharged in their immediate vicinity but are a mixture of groundwaters from various sources

- Water originating from the highest elevation occurs nearest the coast.

These observations showed that the hot groundwaters resulted from recharge at the highest elevations, circulating to greatest depth within a rhyolitic (ignimbritic) rock mass and rising at the coast, the furtherest distance from the recharge point.

The scope of this study is not sufficient to clearly define the extent and nature of the hot water system.

CHAPTER SEVEN

RECHARGE DISCHARGE AND GROUNDWATER FLOW

CHAPTER SEVEN

RECHARGE DISCHARGE AND GROUNDWATER FLOW

7.1 Rainfall

Mean annual rainfalls range from less than 1400mm at the coast to about 2500mm in the upland areas. The mean annual rainfall at Te Puke is 1682mm (Quayle, 1984). Annual rainfall totals vary in relation to the terrain changes. Rainfall occurs throughout the year with greater rainfall in winter than summer.

7.2 Water Balance

Water balance data for the study area is given in Quayle (1984). Study area water balance data probably correlate closely with data from Tauranga (TGA) and Kawerau (KEU) for coastal and hinterland areas respectfully. Data for these sites is given in Table 7.1 Upland water balance data would involve greater rainfall, lesser deficit and greater runoff than in the coastal and hinterland zones.

TABLE 7.1 : WATER BALANCE DATA (mm)

		Coastal (TGA)	Hinterland (KEU)
Potential Evapotranspiration	(PE)	949	716
Rainfall	(RR)	1363	1801
Deficit	(DE)	220	45
No. of Days of Deficit	(ND)	60	17
Runoff (Water Surplus)	(RO)	633	1134
No. of Days of Runoff	(NR)	50	63

NOTE: TGA = Tauranga
KEU = Kawerau

7.3 Recharge

Recharge to aquifers within the study area is predominantly from rainfall infiltration. Mamaku Ignimbrite and Rotoiti Breccia have water levels at depths of up to 50m below ground surface. This indicates permeable materials with substantial unsaturated zones beneath the relatively flat interfluves. Rainfall infiltration on these areas is expected to be high with rapid movement to the water table. In the upland areas blind valleys occur i.e. depressions with no stream outlet, and these assist in maximising recharge.

The terraces and alluvium toward the coast appear to be less permeable and water tables are much closer to the ground surface. There is therefore less opportunity for recharge to take place.

7.4 Discharge

Data from the Bay of Plenty Regional Council's low flow gauging records and from MWD gaugings was examined. Low flows range from zero to 4149 litres/second. Flow in the Kaituna River is lake fed and controlled.

Figure 7.1 shows specific discharges (flow divided by catchment area) calculated for sectors of the catchments (areas between gauging sites). Specific discharges range from zero to 292 $l/s/km^2$. The upper range of values (>10 - 15 $l/s/km^2$) indicates areas with significant spring discharges. Generally this takes place at elevation between 20 and 100 metres above sea level. The precise locations of the main spring zones are unknown. In the lower sector of the Waiari Catchment specific discharge is 272 $l/s/km^2$ while in the upper Waiari zero discharges occur. Catchments with zero discharge are taken to indicate catchments where the water table has fallen below stream levels. Water movement is therefore through the groundwater system and emerges as springs further down the catchment. A small amount of discharge takes place at the coast or to streams and swamps near the coast. Although large amounts of groundwater flow are occurring above the springs the limited groundwater gradient below the springs indicates limited flow.

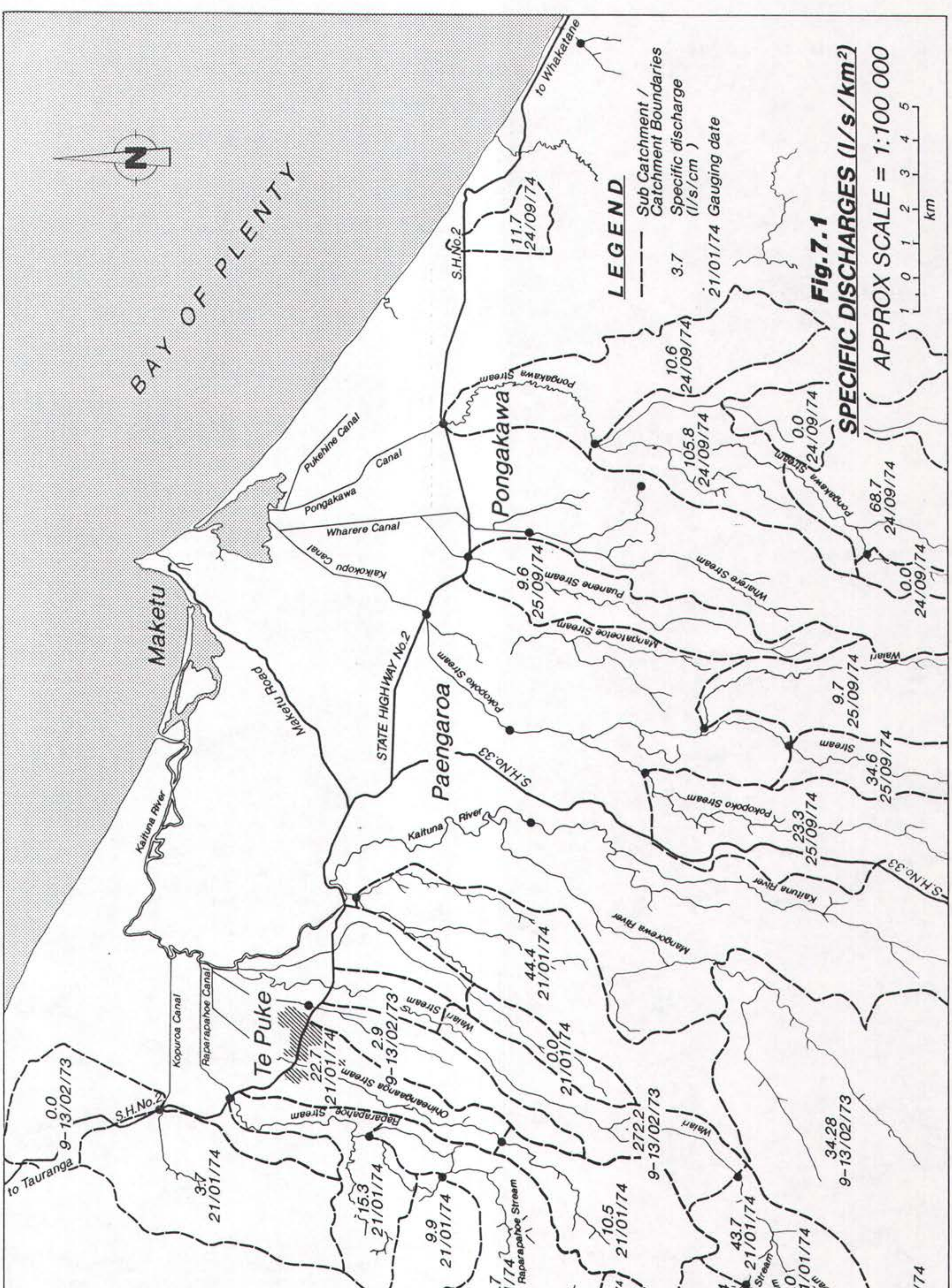


Fig.7.1
SPECIFIC DISCHARGES (l/s/km²)

Figure 7.2 shows a hydrograph of river flow in the Waiari catchment. A feature of this hydrograph is the large base flow with little variation. Storm runoff is shown as short sharp peaks with flow returning to "normal" after a few days of fine weather. This flow behaviour indicates large catchment storage in highly permeable materials. It is a feature of the Mamaku Ignimbrite and Rotoiti Breccia. Catchments in alternative geological materials which have lesser storage and lower permeability have lower and less sustained baseflows. An example of this is the catchments draining the older volcanic rocks forming the uplands immediately to the west of the study area.

7.5 <u>Groundwater Budget</u>

An examination of the surface flow characteristics shows that there is very much more water available for recharge than the groundwater system can cope with. Large spring discharges result from this.

An estimate of the groundwater through-flow (Q) for the area above the spring discharge has been derived from

$Q = Tiw$

where T = transmissivity
i = groundwater gradient
w = width of groundwater flow system

For T = 1000 m^2/d (2 x upper range of specific capacity)
i = 0.02 (from Figure 4.2 specific capacity)
w = 25000m (width of study area)

<u>$Q = 182,500,000\ m^3/year$</u>

For comparison the 1 in 5 year low flow in the Waiari (at Muttons gauging site) is approximately 102,800,000 m^3/year (3.26 m^3/s) and in the Mangorewa (Saunders Farm site) is approximately 138,800,000 (4.3 m^3/s). Even without the inclusion of the remaining stream flow data, it is apparent that the throughflow estimate given above is at variance with the much larger stream base flows. The variance indicates a wider catchment area than the study area and/or a greater transmissivity (higher permeability and/or greater thickness) than utilised in the calculation.

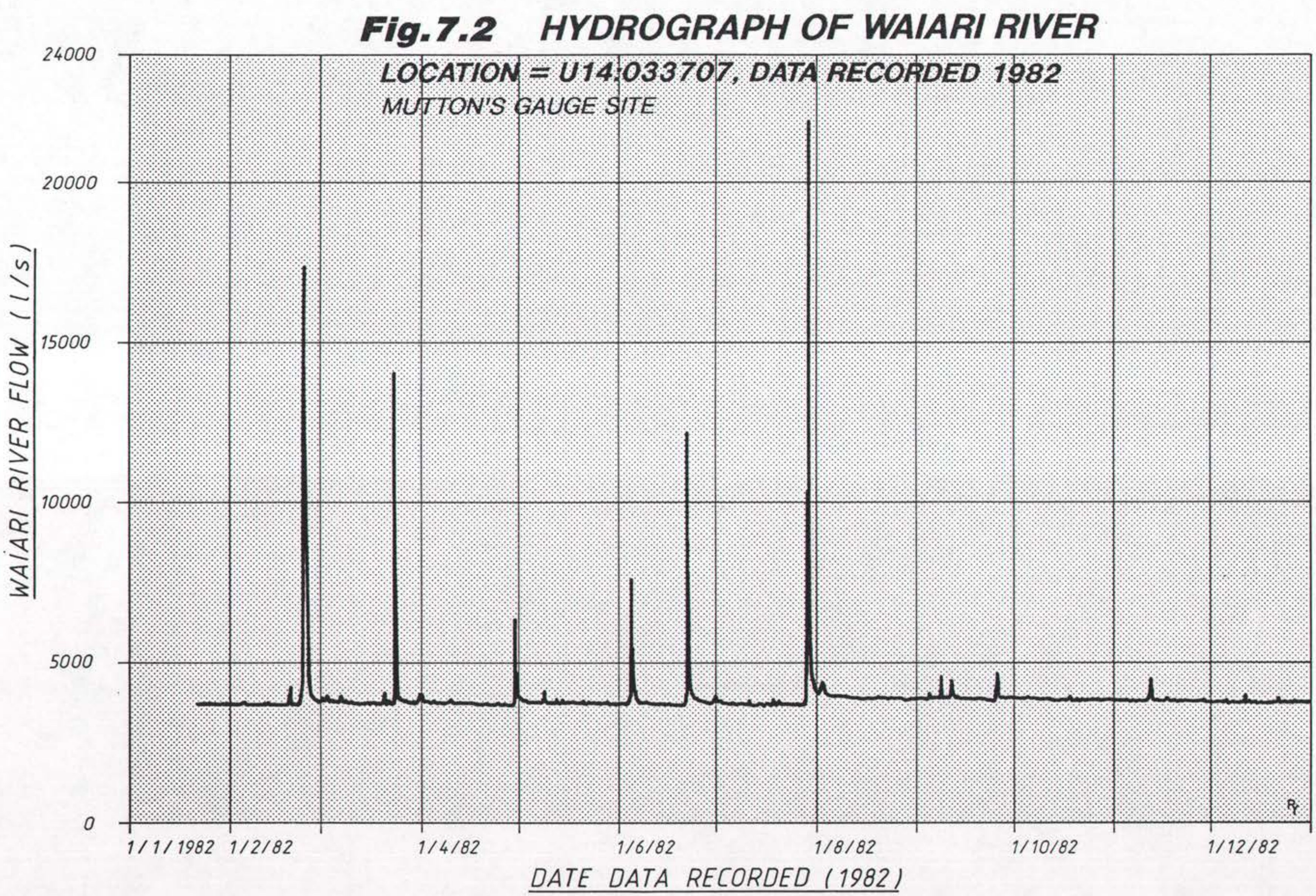


Fig.7.2 HYDROGRAPH OF WAIARI RIVER
LOCATION = U14:033707, DATA RECORDED 1982
MUTTON'S GAUGE SITE
24000
20000
15000
10000
5000
0
WAIARI RIVER FLOW (l/s)
1/1/1982
1/2/82
1/4/82
1/6/82
1/8/82
1/10/82
1/12/82
DATE DATA RECORDED (1982)

An estimate of through-flow for the coastal section assuming:-

$T = 1000\ m^2/d$
$i = 0.002$ (from figure 4.2)
$w = 25,000m$
Yields $Q = 18,250,000\ m^3/year$

This figure may also underestimate the actual throughflow but it demonstrates that much less groundwater is moving seawards of the spring zone than inland of the spring zone.

Another key factor in understanding the groundwater system is the amount of groundwater "stored" in the subsurface.

An estimate of the quantity held in storage is

$Q = B \times W \times D \times S$
where B = 15000m (distance to wells furtherest inland)
W = 25000m (width of study area)
D = 500m (Drillable depth of system)
S = 0.1 - 0.2 (storage co-efficient)
$Q = 1.875 \times 10^{10}$ to $3.75 \times 10^{10}\ m^3$
or 3.75×10^{7} to $7.5 \times 10^{7}\ m^3$/metre change in head

7.6 Conceptual Hydrogeological Model

Figure 7.3 is a schematic representation of the conceptual hydrogeological model. It provides an overall picture of the groundwater system as it is currently understood.

Rainfall recharging near the head of the basin moves deep into the mass of rhyolitic materials. This water is heated by conduction and/or convection processes.

Near the coast this deep and now warm water rises, mixing with a small amount of connate or slow intruding seawater. The rate of rise is slow allowing sufficient time for the chemistry of the sea water mixture to react with the mainly pumiceous materials. At the coast movement is restricted by stratified low permeability materials. Leakage has however taken place and discharge occurs as small hot springs. Where the ground has not permitted springs to form pressurised conditions have developed giving rise to flowing artesian conditions.

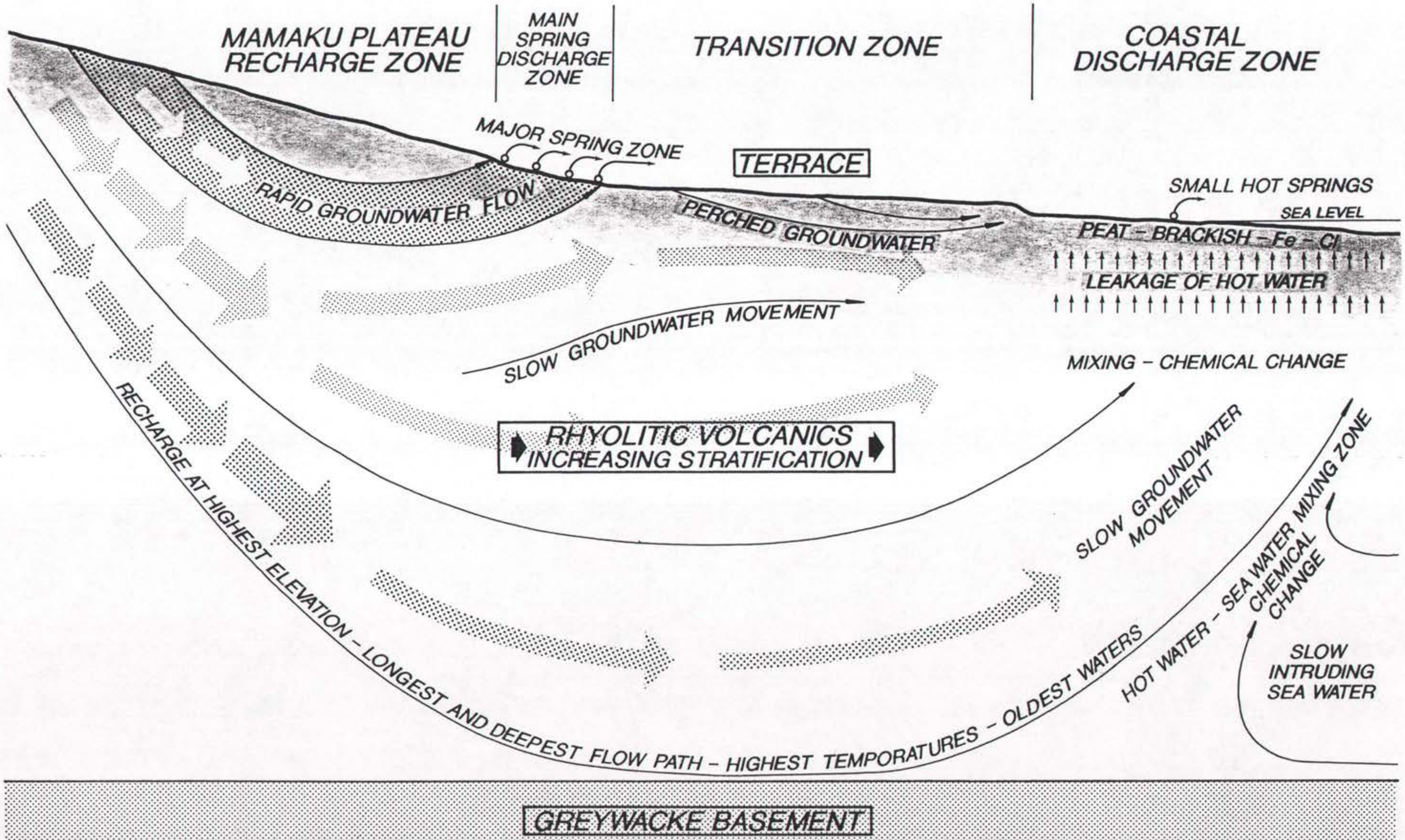


Fig.7.3 CONCEPTUAL HYDROLOGICAL MODEL

A Transition Zone exists between the recharge and discharge zones where groundwater is neither descending or ascending but is moving sub horizontally.

Rainfall recharging further down the catchment moves to shallower depth and rises to discharge at the main spring zone. Further coastwards movement is restricted by low permeability stratified layers in the alluvium. Some leakage to the alluvium however takes place from the underlying volcanic deposits.

Rainfall onto the terrace materials infiltrates and recharges a separate groundwater system that is perched above the underlying volcanic system. Groundwater in this system discharges to drains and swamps on the lowlands.

In summary the inferred potentiometric surface implies inward flowing groundwater to the basin from the surrounding elevated areas. The predominant feature is seaward flow.

CHAPTER EIGHT

WATER USE

CHAPTER EIGHT

WATER USE

8.1 Water Rights

There are currently 324 water rights held in the study area. Of these 4 are rights to dam; 26 are to discharge (to either water or land); and 6 are to divert. There are 184 rights to take from groundwater and 104 rights to take from surface resources. Details of all Water Rights are given in Appendix 4.

The largest use of water in the area is for the irrigation of horticultural crops with 90,385 m^3/day allocated almost equally from surface and groundwater resources. This is sufficient for the irrigation of up to 3,347 ha of horticultural crops. Another major use is for public water supplies for which 79,643 m^3/day is allocated (of which 77,500 m3/day is from the Waiari Stream). Industrial use of water is predominantly from surface supplies, the Auckland Farmers Freezing Co-operative at Rangiuru and Bay Milk Products at Te Puke being the major users. A small amount of water has been allocated for swimming and spa pool purposes.

Table 8.1 below sets out quantities allocated via water rights to various uses from both surface and groundwater resources.

TABLE 8.1 : TAKE WATER RIGHTS

		m^3/day	
	Groundwater	Surface Water	Total
Irrigation	44,339	46,046	90,385
Public Water Supply	1,161	78,482	79,643
Industry	1,130	37,119	38,249
Recreational	408	0	408
TOTAL	47,038	161,647	208,685

8.2 Existing Use Rights

No detailed survey of existing use water rights has been carried out. The majority of these rights are for minor quantities of water associated with stock watering or dairy shed/piggery wash down. Most major uses of water are now the subject of water rights. The Tauranga District Council holds two Existing Use notices to abstract stream water for public water supply purposes in the study area.

8.3 Farm and Domestic Use

The quantity of water used by farm and domestic supplies has not been determined and lies outside the scope of this study. The quantity used by the 220 dairy farms in the study area can be estimated. Ministry of Agriculture figures recommend a combined volume of 140 litre per cow per day (Mr Rowan Kyle, pers comm.) This equates to a total figure of 5293m^3/day for the 37,810 dairy cows in the area. The proportion of this quantity abstracted from Groundwater is unknown.

8.4 Future Water Use

The largest potential water user in the area is the horticultural industry. With reduced activity and growth in this industry the application rate for new take water rights in the study area and in the Bay of Plenty generally has been very low. Between 1 January 1988 and 31 December 1989 there have been only six new take water right applications. A low application rate is also expected for the near future unless there is a significant change in activity associated with this industry.

Demand for water for industrial and public water supply in the area is expected to increase in future but at a gradual rate. The study area lies within the boundaries of the Te Puke and Maketu Wards which returned a total population of 12,126 in the 1986 census. No projected population figures for the combined Wards are available.

8.5 Availability and Groundwater Demand

In terms of the allocated groundwater resource 94% or 44339m^3/day is to irrigation right holders. Given an irrigation season of 100 days then approximately 4.4 Mm^3/year would be abstracted from groundwater if every right holder was taking the maximum authorised quantity. (Where 1 Mm^3 equals one million cubic metres). A further 0.1 Mm^3 is abstracted annually by other right holders. Quantities taken for farm supply and domestic use have not been established but are not likely to be greater than a further 2 Mm^3/year. Therefore it is estimated that total annual abstraction from groundwater is approximately 6.5 Mm^3/year in the study area.

A conservative estimate for throughflow is around 18 Mm^3/year across the coastal section.

Initial calculations indicate that the groundwater resource is large and is capable of meeting current and projected water requirements. The only proviso to this is that during drought periods irrigation demand may be in excess of available throughflow. If storage is drawn upon then the potential for lowering the water table to sea level or below may exist. It is considered more likely however that any significant lowering of the water table would be accompanied by concomitant recharge from baseflow.

CHAPTER NINE

SUMMARY

CHAPTER NINE

SUMMARY

This report presents the results of a resource data review and evaluation of the groundwater resources in the areas of Papamoa, Te Puke, Paengaroa, Maketu, Pongakawa, Pukehina and Ohinepanea.

The geology of the area essentially consists of a fault bound basin filled with volcanic materials from rhyolitic eruptions. Volcanic rocks form plateaux inland which are steeply dissected by streams and which give way coastward to alluvial plains, low coastal swamps and finally fixed and moving dunes.

Well depths in the study area range from 9m to 542m with 80% less than 140m. The largest group tap aquifers between 60m and 140m depth. Aquifers are variable ranging from gravels and sands through sandy pumices, pumices, moderately hard rocks to hard fractured rocks. Hydraulic characteristics of the aquifers indicate a good potential for groundwater production in at least fifty percent of all known wells.

Groundwater levels inland have been measured up to 70m below ground surface while at the coast much shallower levels are present. Some flowing artesian wells occur at Maketu and Paengaroa but heads are not high. Groundwater gradients are approximately 0.020 inland decreasing to about 0.002 from the 20m contour to the coast.

Water chemistry data indicates a general suitability for irrigation of horticultural crops. Eighty seven percent of all analysis have Conductivity and Total Dissolved Solid Values below 300 mS/m and 275 - 350 $g.m^3$ respectively. Salinity is low with 93% of chloride values below 100 g/m^3. Fifty-seven percent of iron values lie below 1.0 g/m^3. Higher iron levels are evident near Paengaroa and generally higher iron levels tend to be associated with organic horizons within aquifers. Sodicity and boron do not present water quality problems for most groundwaters in the area but Ryznar Values indicate a potential for corrosion of metal fittings. Ionic ratios indicate that seawater intrusion of fresh groundwater is not occurring at least at shallow depth.

Warm groundwaters up to 53°C have been located in the study area. Generally temperatures range from 26°C to 40°C in wells greater than 100m depth although warm water is present at much shallow depths near Maketu. Warm water is predominantly of sodium bicarbonate type and boron values are low suggesting that the thermal waters are not rising from basement greywackes and are probably circulating within a rhyolitic rock mass.

Specific discharges calculated from low flow gauging data are extremely variable ranging from zero to 272 litres/second. Specific discharges greater than 10-15 $l/s/km^2$ are associated with significant spring discharges. Typical catchments in the study area indicate large catchment storage in highly permeable materials and more surface water is available for recharge than the groundwater system can accept. A conceptual hydrogeological model for the area indicates a three tiered system based on rainfall recharge at different levels with groundwater moving into the basin and towards the coast.

Total annual abstraction from the groundwater resource has been estimated at around 6.5 million cubic metres/year while a conservative estimate of the available resource in terms of annual throughflow is around 18 million cubic metres/year. The study overall indicates a significant groundwater resource capable of meeting current and projected water requirements. Potential for salt water contamination however may exist in heavily utilised coastal zones.

REFERENCES

REFERENCES

Ayers, R S 1975 Quality of water for irrigation. Proceedings of Irrigation Drainage Division, Specialty Conference, American Society of Civil Engineers August 13-15, Logan, Utah pp.24-56

Bay of Plenty Catchment Commission March 1983 File 18/6 - Groundwater Surveys. Unpublished Report on Maketu Groundwater.

Beca Carter Hollings and Ferner Ltd 1981 Water Resource Studies in the Mount Maunganui-Papamoa-Te Puke area, Interim Report, Volumes 1 and 2, for Bay of Plenty Catchment Commission and Regional Water Board.

Freestone, H J 1975 Coldwater Springs of the Bay of Plenty. Unpublished paper presented to New Zealand Hydrological Society Composium Auckland.

Healey, J, Schofield, J, and Thompson, B N 1964 Sheet 5 Rotorua (1st edition). Geological Map of New Zealand 1:250,000. DSIR Wellington.

MAFTECH 1988 Kaituna Basin Agricultural Potential. Ministry of Agricultural and Fisheries Report. Tauranga.

Ministry of Works and Development Bay of Plenty Low Flow Water Resources, November 1982 Unpublished Report.

Quayle, A M 1984 The Climate and Weather of the Bay of Plenty. New Zealand Meterological Service. Misc. Pub. 115(1) 2nd Edition.

Simpson, B, and Stewart M K, 1987 Geochemical and Isotope Identification of Warm Groundwaters in Coastal Basin near Tauranga, New Zealand. Journal of Chemical Geology, 64: 67-77.

Soons, J M, Selby, M J (Editors) 1982 Landforms of New Zealand. Longman Paul. Chapter 9. Central Volcanic Region.

Thompson, B N 1970 Bay of Plenty Catchment Commission. Kaituna River Major Scheme. Lower Kaituna River Vol. II. Appendices. Appendix No.3 Geology of the Kaituna River Catchment.

APPENDICES

APPENDICES

Appendix 1 shows well location, construction and aquifer type details. It also relates well number to Water Rights, where held, and gives predominant water use where known. Map grid references are to the NZMS 260 1:50,000 series.

Appendix 2 gives hydrogeological details including static water level, thickness of the aquifer zone, well yields, drawdown at that yield and specific capacity values. Basic water chemistry details including conductivity (in mS/m at 25°C), pH, temperature, chloride, iron and boron.

Appendix 3 presents ion balance data for these wells for which full analyses have been completed. This data is expressed as mg/l, meq/l and as a percentage.

Appendix 4 presents water right data for the study area including water right number, map reference, water right type, quantity allocated and area. This data is derived directly from the Council's water rights database WATERS.

APPENDIX 1: WELL DETAILS

LOG	MAP REF.	CONSTRUCTION DETAILS	AQUIFER TYPE	RIGHT WATER USE	CASING (mm)	DEPTH (m)
71	U14:023740	Drill.op.end.sgl.cas	N.F.art.ignimbrite	1017 Commercial Heating	.150	542.54
106	V15:127674	Drill.op.end.mul.cas	N.F. artesian sand	1629 Irrigation	.150	192.00
113	U14:033714	Drill.op.end.sgl.cas	N.F.art.rhyolite	367 Investigation Bore	.100	110.00
118	V15:104696	Drill.scr.singl.cas.	W.T. aquifer gravel		.100	24.40
119	V14:122703	Drill.scr.singl.cas.	W.T. aquifer gravel		.100	24.40
162	V15:172687	Drill.scr.singl.cas.	W.T aqf.undif.alluv.		.100	26.50
169	V15:103625	Drill.op.end.mul.cas	N.F. artesian sand	Unused	.100	106.70
170	V15:103624	Drill.scr.singl.cas.	N.F. artesian sand		.100	81.10
171	V15:177670	Drill.op.end.mul.cas	N.F.art.pumic.materl	479 Irrigation	.150	121.90
249	V15:177672	Drill.scr.multi.cas.	W.T aqf.undif.alluv.	1343 Irrigation	.150	32.00
305	V14:101711	Drill.op.end.mul.cas	N.F.art.ignimbrite	796 Commercial Heating	.100	335.00
410	V15:112670	Drill.op.end.sgl.cas	N.F.art.pumic.materl	1474 Irrigation	.100	196.60
413	V14:120746	Drill.op.end.sgl.cas	N.F. artesian gravel	1594 Irrigation	.150	77.72
418	U15:092672	Drill.op.end.sgl.cas	N.F.art.undif.vol.rk	935 Irrigation	.100	100.60
419	U14:071701	Drill.op.end.sgl.cas	N.F.art.rhyolite		.100	112.80
420	V15:120666	Drill.op.end.sgl.cas	N.F. artesian gravel		.100	187.50
428	U15:098698	Pit	N.F.art.pumic.materl	2139 Irrigation	.150	135.94
601	U15:095685	Drill.op.end.sgl.cas	N.F. artesian sand		.100	48.00
606	V14:203700	Drill.scr.singl.cas.	N.F.art.undif.alluv.		.100	24.00
621	V14:102746	Drill.op.end.sgl.cas	N.F.art.undif.alluv.		.100	54.00
622	U14:100747	Drill.scr.singl.cas.	W.T. aquifer gravel	1796 Irrigation	.100	15.00
624	U14:982833	Drill.op.end.sgl.cas	N.F.art.pumic.materl		.100	24.00
625	U14:066716	Drill.scr.singl.cas.	N.F.art.pumic.materl	1976 Irrigation	.100	48.00
626	V14:156777	Drill.scr.singl.cas.	W.T aqf.undif.alluv.	408 Public Water Supply	.150	77.50
629	U15:090674	Drill.op.end.sgl.cas	N.F.art.rhyolite	1882 Irrigation/Domestic	.100	98.00
630	U15:065686	Drill.scr.singl.cas.	N.F.art.undif.alluv.	1354 Irrigation/Domestic	.100	130.00
632	U14:976831	Drill.scr.singl.cas.	N.F. artesian sand		.100	28.00
636	U14:098749	Drill.scr.singl.cas.	W.T aqf.undif.alluv.	1505 Irrigation	.100	23.00
637	V15:188669	Drill.op.end.sgl.cas	N.F.art.undif.alluv.	2138 Irrigation	.150	0.00
639	U15:100689	Drill.op.end.mul.cas	N.F.art.rhyolite		.150	164.00
641	V14:104707	Drill.op.end.mul.cas	N.F.art.undif.alluv.	1161 Irrigation	.100	114.00
643	V14:195715	Drill.scr.singl.cas.	W.T aquifer sand		.100	9.00
701	U14:997716	Drill.op.end.sgl.cas		821 Irrigation		109.70
645	V15:106682	Drill.op.end.sgl.cas	N.F.art.pumic.materl		.100	180.00
830	V15:211668	Drill.op.end.sgl.cas	N.F. artesian gravel	1024 Irrigation/Domestic		109.70
842	U14:100738	Drill.scr.singl.cas.	W.T aqf.undif.alluv.	1499 Irrigation	.100	26.50
843	U15:067694	Drill.op.end.sgl.cas	N.F.art.rhyolite	1506 Irrigation		124.00
951	V14:110712	Drill.scr.singl.cas.	N.F.art.rhyolite	944 Irrigation	.100	114.30
952	V14:110712	Drill.scr.singl.cas.	N.F.art.rhyolite	944 Irrigation	.100	109.70
953	V14:118720	Drill.scr.singl.cas.	N.F. artesian sand	986 Irrigation	.100	18.30
1002	V14:108719	Drill.scr.singl.cas.	N.F. artesian gravel	1988 Irrigation	.100	12.00
1003	V15:259681	Drill.scr.singl.cas.	N.F.art.undif.alluv.		.100	47.20
1007	V14:101748	Drill.scr.singl.cas.	N.F.art.undif.alluv.	1796 Irrigation	.100	22.90
1011	U14:009801	Drill.scr.singl.cas.	N.F. artesian sand	1857	.100	31.10
1013	V14:232706	Drill.scr.singl.cas.	N.F.art.undif.alluv.	1858 Unused	.100	10.40
1014	U14:979804	Drill.op.end.sgl.cas	N.F.art.ignimbrite		.150	181.40
1015	V14:127757	Drill.scr.singl.cas.	F. artesian sand	1804 Domestic Heating	.100	35.00
1017	V15:138652	Drill.op.end.sgl.cas	N.F.art.ignimbrite		.100	137.00

N.F.art - non flowing artesian
W.T. - water table

LOG	MAP REF.	CONSTRUCTION DETAILS	AQUIFER TYPE	RIGHT	WATER USE	CASING (mm)	DEPTH (m)
1018	V14:120746	Drill.op.end.mul.cas	N.F.art.ignimbrite	1967	Irrigation	.100	359.00
1024	V14:104739	Drill.scr.singl.cas.	N.F.art.undif.alluv.	889	Irrigation	.150	85.00
1032	V15:173655	Drill.scr.singl.cas.	N.F.art.undif.alluv.			.100	128.00
1040	U14:990823	Drill.scr.singl.cas.	N.F.art.undif.alluv.			.100	27.00
1051	V15:140686	Drill.op.end.sgl.cas	N.F.art.ignimbrite	1518	Irrigation	.100	109.70
1052	U15:026675	Drill.op.end.sgl.cas	N.F.art.ignimbrite		Commercial	.150	201.20
1054	U14:014722	Drill.op.end.sgl.cas	N.F.art.ignimbrite	1640	Irrigation	.150	249.90
1065	U15:064692	Drill.scr.multi.cas.		1504	Irrigation	.150	117.30
1069	V15:227696	Drill.scr.singl.cas.	N.F.art.pumic.materl	1866	Irrigation	.100	11.60
1072	U14:075747	Drill.op.end.sgl.cas	N.F.art.undif.alluv.	1046	Irrigation	.100	91.44
1073	V15:177671	Drill.op.end.sgl.cas	N.F.art.ignimbrite	1713	Irrigation/Domestic	.100	158.50
1074	V15:117664	Drill.op.end.sgl.cas	N.F.art.ignimbrite	814	Irrigation	.100	195.10
1082	V15:166678		N.F.art.pumic.materl				172.21
1084	U14:065716	Drill.scr.singl.cas.	N.F. artesian gravel	1998	Irrigation	.150	109.73
1090	V15:121684	Drill.op.end.mul.cas	N.F.art.undif.vol.rk			.150	278.89
1091	V15:121685	Drill.op.end.sgl.cas	N.F.art.pumic.materl			.100	73.15
1092	U15:095694	Drill.op.end.mul.cas	N.F. artesian gravel	1836	Irrigation	.100	121.92
1101	U14:056745	Drill.scr.singl.cas.	N.F.art.pumic.materl	670	Irrigation	.100	57.00
1111	V15:158668	Drill.scr.multi.cas.	N.F. artesian sand	1699	Irrigation	.150	78.00
1117	U15:065678	Drill.op.end.sgl.cas	N.F.art.rhyolite			.100	196.00
1118	U14:050729	Drill.op.end.mul.cas	N.F. artesian sand			.100	164.60
1119	V15:238691	Drill.op.end.sgl.cas			Unused	.100	9.10
1120	V15:229698	Drill.op.end.sgl.cas			Unused		64.00
1125	V15:102700	Drill.op.end.sgl.cas	N.F.art.ignimbrite		Irrigation	.100	124.00
1126	U14:053727	Drill.op.end.sgl.cas	N.F. artesian sand	1987	Irrigation	.100	95.00
1129	U14:094719	Drill.scr.singl.cas.		2082		.100	12.10
1132	U14:094719	Drill.scr.singl.cas.		2082		.100	12.20
1133	U14:085729				Domestic Water Sup.		15.20
1134	V15:136593	Drill.op.end.sgl.cas					32.00
1138	V15:120666	Drill.op.end.sgl.cas		1454	Irrigation/Domestic		193.50
1142	V15:165680	Drill.scr.singl.cas./Grav	N.F.art.pumic.materl	1280	Irrigation	.100	91.40
1144	V15:141675	Drill.op.end.sgl.cas	N.F.art.pumic.materl	1536	Irrigation	.100	82.00
1146	V14:239700	Drill.op.end.sgl.cas	N.F. artesian sand			.100	67.10
1307	V14:113717	Drill.scr.singl.cas.	N.F.art.pumic.materl			.100	9.00
1314	U15:032633	Drill.op.end.sgl.cas	N.F.art.rhyolite	1334	Irrigation/Domestic	.100	204.20
1321	V15:167677	Drill.op.end.sgl.cas	N.F.art.pumic.materl	1280	Irrigation	.100	124.00
1354	V15:118685	Drill.scr.singl.cas.	N.F.art.pumic.materl			.100	46.30
1387	U14:006826	Drill.op.end.sgl.cas	N.F. artesian sand	649	Irrigation	.100	61.00
1388	U14:005827	Drill.op.end.sgl.cas	N.F. artesian sand	744	Irrigation	.100	61.00
1502	U15:055675	Drill.scr.singl.cas.	N.F. artesian sand			.100	195.10
1503	U14:991762	Drill.scr.singl.cas.	F.art.rhyolite			.100	120.40
1505	U15:974681	Drill.op.end.sgl.cas	N.F.art.rhyolite		Irrigation	.100	185.90
1508	V14:104705	Drill.scr.singl.cas.	N.F.art.pumic.materl	1383	Irrigation	.150	103.60
1513	U15:978681	Drill.op.end.sgl.cas	N.F.art.rhyolite		Irrigation	.100	128.00
1518	V15:207688	Drill.scr.singl.cas.	N.F. artesian sand			.100	140.20
1520	V14:147738	Drill.scr.singl.cas.	N.F. artesian gravel	625		.100	74.00
1522	V15:172652	Drill.scr.singl.cas.	N.F.art.undif.alluv.	1390	Irrigation	.100	122.00
1527	V14:161711	Drill.scr.singl.cas.	F.art.pumic.materl			.100	72.54
1528	V14:146708	Drill.op.end.sgl.cas	F.art.rhyolite			.100	144.48
1531	U14:088734	Drill.scr.singl.cas.	N.F. artesian sand	1473	Irrigation	.150	103.60
1532	U14:091733			1473	Irrigation	.150	0.00
1533	U14:091733	Drill.scr.singl.cas.	N.F. artesian sand	1472	Water Sup./Irrigation	.100	91.40
1534	V14:132742	Drill.scr.singl.cas.	N.F.art.pumic.materl		Irrigation	.100	90.00
1535	U14:068736	Drill.op.end.sgl.cas	N.F. artesian sand			.100	32.00
1551	U15:998694			1213	Irrigation	.100	60.96
1553	V15:194614	Drill.scr.singl.cas.	N.F.art.undif.alluv.			.100	12.00
1562	U14:096701	Drill.op.end.sgl.cas	N.F.art.rhyolite	767		.150	138.70

N.Fart - non flowing artesian

W.T. - water table

LOG	MAP REF.	CONSTRUCTION DETAILS	AQUIFER TYPE	RIGHT	WATER USE	CASING (mm)	DEPTH (m)
1574	U14:096743	Drill.scr.singl.cas.	N.F.art.undif.alluv.	1503	Irrigation	.100	85.30
1575	U14:061805	Drill.scr.singl.cas.	N.F.art.undif.alluv.			.100	9.50
1584	V14:101748	Drill.scr.singl.cas.	N.F.art.undif.alluv.		Irrigation	.100	15.00
1586	U14:043735	Drill.scr.singl.cas.	N.F.art.undif.alluv.		Irrigation	.100	30.50
1589	U14:098744	Drill.scr.singl.cas.	N.F. artesian sand			.100	30.50
1591	V15:110613	Drill.scr.singl.cas.	N.F.art.undif.alluv.	1926	Irrigation	.100	12.20
1592	V14:101749	Drill.scr.singl.cas.	N.F.art.undif.alluv.		Irrigation	.150	15.50
1594	U14:061806	Drill.scr.singl.cas.				.100	9.00
1651	U15:980681	Drill.op.end.sgl.cas	N.F.art.undif.vol.rk	1603	Irrigation	.100	170.70
1652	V14:130723	Drill.op.end.sgl.cas	N.F. artesian gravel	1667	Irrigation	.100	97.50
1653	U15:095694	Drill.op.end.sgl.cas	N.F.art.ignimbrite	1836	Irrigation/Domestic	.100	79.20
1654	U15:095696	Drill.op.end.sgl.cas	N.F.art.ignimbrite			.100	97.50
1660	U14:072710	Drill.op.end.sgl.cas	N.F. artesian gravel		Irrigation	.150	115.80
1664	U14:063703	Drill.op.end.sgl.cas	N.F. artesian gravel		Irrigation	.150	158.50
1666	U15:002675			1252	Irrigation	.150	213.36
1667	U15:009697			1302	Irrigation	.150	219.45
1671	U14:974831	Drill.op.end.sgl.cas	N.F.art.ignimbrite	1800	Irrigation	.100	109.70
1675	U14:096742	Drill.op.end.sgl.cas	N.F. artesian gravel	1919	Irrigation	.100	85.30
1680	V14:102731	Drill.op.end.sgl.cas	N.F. artesian sand	1615	Irrigation	.150	109.70
1683	U15:072699	Drill.op.end.sgl.cas	N.F.art.ignimbrite	1524	Irrigation/Domestic	.100	97.50
1687	U15:064692	Drill.op.end.mul.cas	N.F.art.undif.alluv.	1504	Irrigation	.150	115.80
1690	V14:105747	Drill.op.end.sgl.cas	N.F.art.ignimbrite	1287	Irrigation	.150	97.50
1696	V14:109746	Drill.op.end.sgl.cas	N.F.art.undif.alluv.	1558	Irrigation	.150	79.20
1698	U15:092672	Drill.op.end.mul.cas	N.F.art.ignimbrite	935	Irrigation/Agri.	.150	213.40
1699	V14:115712	Drill.op.end.sgl.cas	N.F. artesian gravel	944	Irrigation	.100	152.00
1700	U14:098733	Drill.op.end.sgl.cas	N.F. artesian gravel	1651	Irrigation	.150	100.60
2005	U15:098616	Drill.scr.singl.cas.	N.F.art.ignimbrite	1835	Irrigation	.100	254.50
2012	U14:012797			1439	Irrigation	.100	190.00
2013	V15:142687	Drill.scr.singl.cas.	N.F.art.undif.alluv.	1611	Irrigation	.150	135.00
2024	U14:072713	Drill.op.end.sgl.cas	N.F.art.ignimbrite	1994	Irrigation/Domestic	.125	118.50
2025	U14:060708	Drill.op.end.sgl.cas	N.F.art.ignimbrite	1995	Irrigation	.100	148.00
2340	U14:990830	Drill.op.end.sgl.cas	N.F.art.ignimbrite		Irrigation		416.05
2341	U14:998813	Drill.scr.singl.cas.	N.F. artesian gravel			.075	54.86
2358	V15:121672	Drill.op.end.sgl.cas	N.F.art.ignimbrite	1895	Irrigation/Domestic	.100	204.22
2361	U15:997622	Drill.op.end.sgl.cas	N.F.art.ignimbrite		Domestic Water Sup.	.100	283.46
2410	U14:985816	Drill.scr.singl.cas.	N.F.art.ignimbrite		Domestic Water Sup.	.120	100.00
2411	U14:988813	Drill.scr.singl.cas.	N.F. artesian sand		Domestic Water Sup.	.120	122.00
2419	V15:161690	Spring	F.art.rhyolite	935	Domestic/Irrigation	.120	122.50
2707	U14:076795	Drill.scr.singl.cas.	W.T. aquifer gravel		Irrigation	.150	10.00
2708	V15:114681	Drill.op.end.sgl.cas				.100	60.00
2722	V14:102754	Drill.scr.singl.cas.	W.T. aquifer gravel		Irrigation	.100	13.50
2733	U15:089675	Drill.op.end.sgl.cas	N.F.art.rhyolite	1322	Irrigation	.100	78.00
2747	U15:095681	Drill.op.end.sgl.cas	N.F.art.rhyolite		Irrigation	.100	93.00
2755	U14:075795	Drill.scr.singl.cas.	W.T aquifer sand		Commercial	.100	9.00
2769	U14:092714	Drill.scr.singl.cas.	N.F. artesian gravel		Irrigation	.100	18.00
2819	U14:022751		N.F.art.pumic.materl	85	Commercial	.250	80.47
2820	U15:056695	Drill.op.end.sgl.cas	N.F. artesian gravel	707	Irrigation		115.82
2821	U15:056695	Drill.scr.multi.cas.	N.F. artesian gravel	707	Irrigation		158.50
2822	V15:162681			1041	Irrigation		121.92
2823	V14:109714	Drill.op.end.mul.cas	N.F. artesian gravel	2074	Irrigation	.150	24.99
2824	U14:054727	Drill.op.end.sgl.cas	N.F.art.undif.alluv.	1677	Irrigation		95.00
2825	U14:047728	Drill.op.end.sgl.cas	N.F.art.ignimbrite	1678	Irrigation		95.70
2826	U15:007690	Drill.scr.singl.cas.	N.F.art.pumic.materl	1336	Irrigation	.100	169.81
2827	U15:998694	Drill.scr.singl.cas.	N.F.art.pumic.materl	1213	Irrigation		219.46
2828	U15:996688	Drill.scr.singl.cas.	N.F.art.pumic.materl	1178	Irrigation		219.46
3004	V15:161685						0.00
3005	V14:117764						0.00

N.F.art - non flowing artesian

W.T. - water table

LOG	MAP REF.	CONSTRUCTION DETAILS	AQUIFER TYPE	RIGHT	WATER USE	CASING (mm)	DEPTH (m)
3006	U14:005837						
3007	Neureuter, R.						10.00
3008	U15:956687						
3009	V14:112771						0.00
3010	V14:102762						0.00
3011	U14:958842						
3012	V15:236676						0.00
3013	U14:045714						0.00
3014	U14:034745						0.00
3015	U14:038741						0.00
3016	V14:112758						0.00
3022	V14:131755	Drill.op.end.sgl.cas		27	Pool Heating		36.50
3023	V14:109767	Drill.op.end.mul.cas	N.F. artesian sand		Investigation Bore		132.44
3027	V15:103693				Irrigation		146.30
3028	V15:106691						122.00
3029	V15:100682						134.20
3030	V14:127762						61.00
TGW 38	U14:038741						
TGW 39	V14:131756						
TGW 40	V14:134755						
TGW 41	V14:138757						
TGW 42	V14:166756						
WR 27	V14:131755			27	Pool Heating		
WR 407	V15:104700			407	County Supply		33.50
WR 408	V14:155776			408	County Supply		75.00
WR 749	U15:069697			749	Irrigation		91.40
WR 908	V15:187672			908	Irrigation		146.00
WR 910	V15:158678			910	Irrigation		134.11
WR 917	V15:208699			917	Irrigation		61.00
WR 936	V15:115676			936	Irrigation		152.40
WR1112	U14:094744			1112	Irrigation		60.96
WR1127	U15:007678			1127	Irrigation		201.00
WR1178	U15:996688			1178	Irrigation		170.69
WR1380	U15:987681			1380	Irrigation		149.35
WR1489	U14:065732			1489			
WR1567	U14:072750			1567	Irrigation		7.62
WR1679	U14:095733			1679	Irrigation		
WR1831	V15:117665			1831	Irrigation		183.00
WR1891	V15:255694			1891	Irrigation		73.20
WR1929	U14:094723			1929	Irrigation		54.86

N.F.art - non flowing artesian

W.T. - water table

APPENDIX 2: HYDROGEOLOGICAL AND WATER CHEMISTRY DETAILS

BORE	MAP. REF.	DEPTH m	CASING m	S.W.L.	PRODUCTION ZONE Top	Base	ZONE Thickness	DISCHARGE m^3/day	DRAWDOWN m	S.C m^2/day	CONDUCTI -	P.H. -	TEMP °C	Cl g/m^3	IRON g/m^3	BORON g/m^3
71	U14:023740	542.54	292.61	13.72	292.61	542.54	249.93	1638.14	10.70	153.10	469	7.2	53.0	99.0	0	
106	V15:127674	192.00	186.00	9.20	186.00	192.00	6.00	151.20								
113	U14:033714	110.00	99.23	72.20	99.23	110.00	10.77	98.50	2.50	39.40						
118	V15:104696	24.40	19.50		19.50	22.50	3.00	27.65								
119	V14:122703	24.40	19.50		19.50	24.40	4.90									
162	V15:172687	26.50	22.50		22.50	26.50	4.00	65.66								
169	V15:103625	106.70	98.06		98.06	106.70	8.64									
170	V15:103624	81.11	73.13		73.13	77.00	3.87	32.83								
171	V15:177670	121.90	53.32	24.00	53.32	121.90	68.58	163.30								
249	V15:177672	32.00	26.00		26.00	32.00	6.00	273.02								
305	V14:101711	335.00	262.10	9.10	262.10	335.00	72.90						40.0			
410	V15:112670	196.60	118.00	67.10	118.00	196.60	78.60	327.46	30.50	10.74						
413	V14:120746	77.72	58.98	3.05	58.98	77.72	18.74	1965.60	3.10	634.06	696	6.8		49.6	3.4	
418	U15:092672	100.60	57.00	41.15	57.00	100.60	43.60	327.46	35.05	9.34						
419	U14:071701	112.80	39.62	32.00	39.62	112.80	73.18	414.72	32.00	12.96						
420	V15:120666	187.50	111.25	42.10	111.25	187.50	76.25	273.02	55.47	4.92						
428	U15:098698	135.94	59.01	22.58	59.01	135.94	76.93	1641.60	3.05	538.23						
601	U15:095685	48.00	45.00	18.00	45.00	48.00	3.00	218.59								
606	V14:203700	24.00	21.00	12.00	21.00	24.00	3.00	108.86								
621	V14:102746	54.00	54.00	8.50	54.00	54.00		756.00								
622	U14:100747	15.00	12.00	9.00	12.00	15.00	3.00									
624	U14:982833	24.00	19.50	5.00	19.50	24.00	4.50	259.20								
625	U14:066716	48.00	45.50	21.00	45.50	48.00	2.50	324.00								
626	V14:156777	77.51	73.50	61.50	73.50	77.51	4.01	756.00	9.00	84.00						
629	U15:091674	98.00	51.00	27.00	51.00	98.00	47.00	129.60								
630	U15:065686	130.00	83.00	63.00	83.00	130.00	47.00	259.20								
632	U14:976831	28.00	22.00	9.00	22.00	28.00	6.00	216.00								
636	U14:098749	23.00	17.50	9.00	17.50	23.00	5.50									
637	V15:188669	90.00	90.00	31.00	90.00	90.00		540.00								
639	U15:100689	164.00	87.00	24.00	87.00	164.00	77.00	1296.00								
641	V14:104707	114.00	68.00	14.00	68.00	114.00	46.00	224.64								
643	V14:195715	9.00	7.00	1.00	7.00	9.00	2.00	108.00								
645	V15:106682	180.00	138.00	30.00	138.00	180.00	42.00	259.20								
701	U14:997716	109.70				109.70		273.02								
830	V15:211668	117.40	110.50	39.20	110.50	117.40	6.90								9.2	
842	U14:100738	26.50	21.00		21.00	26.50	5.50	218.59								
843	U15:067694	124.00	91.00	56.00	91.00	124.00	33.00									
951	V14:110712	114.31	86.30	10.40	86.30	114.31	28.01	273.02			480	8.0		22.0	1.3	.18
952	V14:110712	109.71	78.30	8.50	78.30	98.10	19.80	261.79								
953	V14:118720	18.30	12.80	4.60	12.80	18.30	5.50	44.06								
1002	V14:108719	12.00	9.00	4.00	9.00	12.00	3.00	436.32								
1003	V15:259681	47.20	42.00	27.00	42.00	46.00	4.00	54.43								
1007	V14:101748	22.90	22.00	8.30	22.00	22.00		196.13								
1011	U14:009801	31.10	25.50	9.00	25.50	30.00	4.50	54.43								
1013	V14:232706	10.40	8.00	1.20	8.00	10.40	2.40	327.46			313	5.5		88.1	.6	.70
1014	U14:979804	181.40	120.00	4.00	120.00	181.40	61.40	546.05								
1015	V14:127757	35.00	32.50	+1.50	32.50	35.00	2.50	245.38								
1017	V15:138652	137.00	111.30	77.70	111.30	137.00	25.70	76.03								
1018	V14:120746	359.00	182.90	3.35	182.90	359.00	176.10	196.13			583	6.8		22.0	1.9	.55
1024	V14:104739	85.01	78.50	9.00	79.00	85.01	6.01	1632.96								
1032	V15:173655	128.00	114.00	24.00	114.00	128.00	14.00	217.73								
1040	U14:990823	27.00	22.00	10.50	22.00	27.00	5.00	130.46								
1051	V15:140686	109.70	86.00		86.00	109.70	23.70	273.02	3.00	91.01						
1052	U15:026675	201.20	161.20	116.40	161.20	201.20	40.00	785.38	25.90	30.32						
1054	U14:014722	249.90				249.90		174.53	2.10	83.11						

S.C. - Specific Capacity

Conductivity Units mS/m at 25° centigrade

BORE	MAP. REF.	DEPTH m	CASING m	S.W.L.	PRODUCTION ZONE Top	Base	ZONE Thickness	DISCHARGE m^3/day	DRAWDOWN m	S.C m^2/day	CONDUCTI -	P.H. -	TEMP °C	Cl g/m^3	IRON g/m^3	BORON g/m^3
1065	U15:064692	117.30		22.90		117.30		982.37	34.80	28.23						
1069	V15:227696	11.58		4.70		10.80		490.75	5.00	98.15						
1072	U14:075747	91.44		4.57		91.44		1088.64	1.07	1017.42	193	7.2		17.7	1.1	
1073	V15:177671	158.50		18.00		158.50		327.46	7.00	46.78	290	8.3		28.2		
1074	V15:117664	183.00	148.70	44.80	148.70	183.00	34.30	261.79			345	6.6		52.0	12.7	.25
1082	V15:166678	172.21				172.21										
1084	U14:065716	109.73	86.87	27.13	103.63	109.73	6.10	1313.28	4.27	307.56	121	6.8		21.1	.1	
1090	V15:121684	278.89	275.84		275.84	278.89	3.05	982.37	6.40	153.50			26.0			
1091	V15:121685	73.15		16.76		73.15										
1092	U15:095694	121.92	118.87	1.60	118.87	121.92	3.05	436.32	1.75	249.33	290	6.0		45.8		.50
1101	U14:056745	57.00	13.00		13.00	16.20	3.20	196.13	5.50	35.66						
1111	V15:158668	78.00	64.75	26.90	64.75	70.00	5.25	263.52	31.50	8.37	94	6.1		14.00	.10	.24
1117	U15:065678	196.00	102.40	67.10	102.40	196.00	93.60									
1118	U14:050729	164.60	117.30		117.30	164.60	47.30									
1119	V15:238691	9.10	6.60		6.60	9.10	2.50									
1120	V15:229698	64.00	58.80		58.80	64.00	5.20									
1125	V15:102700	124.00	77.70	19.20	77.70	124.00	46.30	108.86								
1126	U14:053727	95.00	80.80	60.20	80.80	95.00	14.20	381.89	2.00	190.95						
1129	U14:094719	12.10	7.50		10.00	12.10	2.10	98.50								
1132	U14:094719	12.20	8.50		10.20	12.20	2.00	576.29								
1133	U14:085729	15.20				15.20										
1138	V15:120666	193.50	144.80		144.80	193.50	48.70				315	6.7		18.0	21.0	.3
1142	V15:165680	91.41	71.90		71.90	72.55	.65									
1144	V15:141675	82.00	44.00	10.00	44.00	82.00	38.00									
1146	V14:239700	67.10	57.90		57.90	67.10	9.20	283.39								
1307	V14:113717	9.00	7.50		7.50	9.00	1.50	131.33								
1314	U15:032633	204.20	194.50		194.50	204.20	9.70	88.99								
1321	V15:167677	124.00	79.20		79.20	124.00	44.80	327.46								
1354	V15:118685	46.30	40.23	24.40	40.23	46.30	6.07	15.55	12.19	1.28						
1387	U14:006826	61.00	32.00	1.20	32.00	61.00	29.00	181.44	3.40	53.36						
1388	U14:005827	61.00	44.00	2.40	44.00	61.00	17.00	294.62	5.50	53.57						
1502	U15:055675	195.10	175.26	105.00	175.26	192.00	16.74									
1503	U14:991762	120.41	98.45		98.45	120.41	21.96	163.30								
1505	U15:974681	185.90	123.14	60.00	123.14	185.90	62.76	136.51								
1508	V14:104705	103.61	85.65	18.90	85.65	103.61	17.96	327.46								
1513	U15:978681	128.00	77.72		77.72	128.00	50.28	108.86								
1518	V15:207688	140.20	122.23		122.23	140.20	17.97	273.02								
1520	V14:147738	74.01	50.00	21.20	50.00	67.70	17.70	261.79								
1522	V15:172652	122.01	80.16	48.80	80.16	120.40	40.24	163.30								
1527	V14:161711	72.54	45.72		45.72	72.54	26.82	327.46								
1528	V14:146708	144.48	104.24	102.11	104.24	144.48	40.24	44.06								
1531	U14:088734	103.61	71.90	7.90	71.90	76.20	4.30	872.64			80	7.1			13.0	.40
1532	U14:091733	128.02				128.02										
1533	U14:091733	91.41	74.50		74.50	80.70	6.20	388.80								
1534	V14:132742	90.00	39.00	2.00	39.00	47.95	8.95	872.64								
1535	U14:068736	32.00	19.81		19.81	32.00	12.19	196.13			170	7.3		11.0	3.3	.10
1551	U15:998694	60.96				60.96										
1553	V15:194614	12.00	12.00	3.50	9.00	12.00	3.00	381.89	5.00	76.38						
1562	U14:096701	138.70	71.00	23.00	71.00	138.70	67.70	1309.82								
1564	U15:014689	225.50				225.50		131.33								
1574	U14:096743	85.31	76.00	8.00	76.00	85.31	9.31	273.02								
1575	U14:061805	9.50	6.70	5.30	6.70	9.50	2.80	381.89								
1584	V14:101748	15.00	13.00	9.00	13.00	15.00	2.00	44.06								
1586	U14:043735	30.50	28.00	6.00	28.00	30.50	2.50	131.33								
1589	U14:098744	30.50	27.00	4.00	27.00	29.00	2.00	98.50								
1591	V15:110613	12.20	11.00	2.00	11.00	11.00		131.33								
1592	V14:101749	15.50	14.00	9.00	14.00	15.50	1.50									

S.C. - Specific Capacity

Conductivity Units mS/m at 25° centigrade

BORE	MAP. REF.	DEPTH m	CASING m	S.W.L.	PRODUCTION ZONE Top	Base	ZONE Thickness	DISCHARGE m^3/day	DRAWDOWN m	S.C m^2/day	CONDUCTI -	P.H. -	TEMP °C	Cl g/m^3	IRON g/m^3	BORON g/m^3
1594	U14:061806	9.00	6.20		6.20	9.00	2.80	436.32								
1651	U15:980681	170.70	136.60	73.20	136.60	170.70	34.10	196.13	27.40	7.16						
1652	V14:130723	97.50	84.40	2.30	84.40	97.50	13.10	654.91	1.22	536.81		6.1	30.0		3.3	
1653	U15:095694	79.20		3.00		79.20		327.46								
1654	U15:095696	97.50		6.10		97.50		25.92								
1660	U14:072710	115.80	97.50	20.70	97.50	115.80	18.30	1145.66	1.80	636.48						
1664	U14:063703	158.50	123.40	51.80	123.40	158.50	35.10	1145.66	2.10	545.55						
1666	U15:002675	213.36				213.36		786.24								
1667	U15:009697	219.45				219.45		818.21								
1671	U14:974831	109.70	92.70	12.20	92.70	109.70	17.00	250.56	33.50	7.48						
1675	U14:096742	85.30	71.30	9.10	71.30	85.30	14.00	327.46	1.20	272.88						
1680	V14:102731	109.70	97.50	1.10	97.50	109.70	12.20	1227.74	1.80	682.08						
1683	U15:072699	97.50	78.90	41.80	78.90	97.50	18.60	273.02	4.90	55.72						
1687	U15:064692	115.80	78.60	22.90	109.00	115.80	6.80	1200.10	7.60	157.91						
1690	V14:105747	97.50	72.50	3.00	72.50	97.50	25.00	1021.25	3.30	309.47	424	6.8		70.5	1.1	
1696	V14:109746	79.20	71.60	3.70	71.60	79.20	7.60	490.75	1.20	408.96						
1698	U15:092672	213.40		39.00		213.40		927.94	2.10	441.88						
1699	V14:115712	152.00	115.80	5.40	115.80	152.00	36.20	490.75	.70	701.07						
1700	U14:098733	100.60	78.00	9.70	78.00	100.60	22.60	1091.23	2.40	454.68						
2005	U15:098616	254.50	106.40	67.00	224.00	254.50	30.50	158.11	80.20	1.97						
2012	U14:012797	190.00				190.00		261.79								
2013	V15:142687	135.00	92.00	26.50	121.00	131.00	10.00	976.32	6.50	150.20						
2024	U14:072713	118.50	98.00	17.30	98.00	118.50	20.50	327.46	1.00	327.46						
2025	U14:060708	148.00	135.00	44.20	135.00	148.00	13.00	267.84	2.10	127.54						
2340	U14:990830	154.84	115.82	1.83	115.82	154.84	39.02	524.45	.50	1048.90						
2341	U14:998813	54.86	36.27	11.28	39.62	54.86	15.24	118.37	14.90	7.94						
2358	V15:121672	204.22	91.44	17.09	91.44	204.22	112.78	491.62								
2361	U15:997622	283.46	215.49	141.73	215.49	283.46	67.97	87.26								
2410	U14:985816	100.00	61.00	7.50	61.00	100.00	39.00	78.62	42.50	1.85						
2411	U14:988813	122.00	38.00	33.50	38.00	122.00	84.00	131.33	27.50	4.78						
2419	V15:161690	122.50	99.50	5.80	99.50	122.50	23.00	434.59	.60	724.32						
2707	U14:076795	10.00	8.00	4.50	8.00	10.00	2.00	546.05	3.00	182.02						
2708	V15:114681	60.00	60.00		60.00	60.00										
2722	V14:102754	13.50	11.00	7.00	11.00	13.50	2.50	98.50								
2733	U15:089675	78.00	72.00	39.00	72.00	78.00	6.00	327.46								
2747	U15:095681	93.00	69.00	33.00	69.00	93.00	24.00	273.02								
2755	U14:075795	9.00	6.20	2.70	6.20	9.00	2.80	434.59	3.30	131.69						
2769	U14:092714	18.00	15.00	11.00	15.00	18.00	3.00	44.06								
2819	U14:022751	80.47		13.11		80.47										
2820	U14:072710	115.82	97.50	20.70	97.50	115.82	18.32					5.9		.5	.1	
2821	U15:056695	158.50		51.80		158.50										
2822	V15:162681	121.92	104.85	7.62	104.85	121.92	17.07									
2823	V14:109714	24.99	19.50	8.53	19.50	24.99	5.49	129.60								
2824	U14:054727	95.00		60.00		95.00						6.60				
2825	U14:047728	95.70	71.00	56.00	71.00	95.70	24.70	349.06								
2826	U15:007690	169.81	124.08		124.08	169.81	45.73	131.33								
2827	U15:998694	219.46				219.46						6.4		14.0	.9	
2828	U15:996688	219.46	115.82		115.82	219.46	103.64	210.82								71
3004	V15:161685										125	7.0		10.0	.1	.10
3005	V14:117764											6.3		16.2	17.0	
3006	U14:005837										100	5.4		21.0	.4	.35
3007											231	7.0		49.3	2.6	.10
3008	U15:956687										400	6.9			28.0	.10
3009	V14:112771										1280	7.3		291.0	.3	
3010	V14:102762										153	6.0		16.8	6.0	
3011	U14:958842										168	6.8		18.0	.3	.10
3012	V15:236676										250	6.6		27.0	.1	.10

S.C. - Specific Capacity

Conductivity Units mS/m at 25° centigrade

BORE	MAP. REF.	DEPTH m	CASING m	S.W.L.	PRODUCTION ZONE Top	Base	ZONE Thickness	DISCHARGE m^3/day	DRAWDOWN m	S.C m^2/day	CONDUCTI -	P.H. -	TEMP °C	Cl g/m^3	IRON g/m^3	BORON g/m^3
3013	U14:045714	10.00				10.00					267	6.1		57.00	.10	0
3014	U14:034745										153	7.2		67.0	.3	.28
3015	U14:038741											7.3	38.9	34.0	.1	
3016	V14:112758										163	6.0		20.2	.3	
3017											194	6.7		10.6	.1	.05
TGW 38	U14:038741													37.00		.40
TGW 39	V14:131756													35.00		.70
TGW 40	V14:134755													89.00		.80
TGW 41	V14:138757													607.00		.90
TGW 42	V14:166756													88.00		.40
WR 27	V14:131755							196.56				6.5	40.0	100.0	2.6	
WR 407	V15:104700	33.50				33.50		151.20	10.06	15.03						
WR 408	V14:155776	75.00				75.00		1002.24	62.23	16.11						
WR 749	U15:069697	91.40				91.40		240.19				7.0				
WR 908	V15:187672	146.00				146.00		273.02								
WR 910	V15:158678	134.11				134.11		436.32				6.6				
WR 917	V15:208699	61.00									600	6.6		30.0	1.0	.30
WR 917	V15:208699	61.00				61.00						6.8				
WR 936	V15:115676	152.40				152.40		327.46				6.2				
WR1112	U14:094744	60.96				60.96					400	6.9		18.0	.3	.10
WR1127	U15:007678	201.00				201.00						6.3				
WR1178	U15:996688	170.69				170.69										
WR1380	U15:987681	149.35				149.35					124	7.2		24.8	.2	
WR1489	U14:065732										790	7.2		7.0	.1	.10
WR1567	U14:072750	7.62				7.62		567.65				6.9			.2	
WR1679	U14:095733										390	7.0		56.40	.60	.93
WR1831	V15:117665	183.00				183.00		273.02			360	6.9		14.0	9.6	
WR1891	V15:255694	73.20				73.20					382	7.6		24.8	.2	
WR1929	U14:094723	54.86				54.86					158	6.4		25.0	.2	.06

TGW - sourced from water rights database
WR - from Barbara Simpson *et al*, 1987

S.C. - Specific Capacity

Conductivity Units mS/m at 250 centigrade

APPENDIX 3

ION BALANCE AND RATIOS

	1013 mg/l	me/l	Percent	3017 mg/l	me/l	Percent	WR 1112 mg/l	me/l	Percent	3011 mg/l	me/l	Percent
Na	28.30	1.231	.58	10.80	.470	.47	53.00	2.305	.55	17.00	.739	.52
K	8.09	.207	.10	8.80	.225	.23	6.00	.153	.04	4.40	.113	.08
Ca	2.68	.134	.06	2.30	.115	.12	18.00	.898	.21	5.50	.274	.19
Mg	6.91	.568	.27	2.20	.181	.18	10.00	.823	.20	3.60	.296	.21
Sum		2.140			.991			4.179			1.422	
HCO_3	50.00	1.000	.29	26.00	.520	.63	87.00	1.740	.77	47.00	.940	.65
Cl	88.13	2.486	.71	10.60	.299	.37	18.00	.508	.23	18.00	.508	.35
SO_4		.000			.000			.000			.000	
Sum		3.486			.819			2.248			1.448	

	413 mg/l	me/l	Percent	WR 1891 mg/l	me/l	Percent	Neureuter, R. mg/l	me/l	Percent	WR 1380 mg/l	me/l	Percent
Na	45.00	1.957	.61	52.40	2.279	.72	27.10	1.179	.81	11.10	.483	.67
K	6.40	.164	.05	8.05	.206	.06	4.31	.110	.08	3.80	.097	.13
Ca	7.60	.379	.12	3.70	.185	.06	1.41	.070	.05	.80	.040	.06
Mg	8.70	.716	.22	6.20	.510	.16	1.15	.095	.07	1.20	.099	.14
Sum		3.216			3.180			1.454			.719	
HCO_3	300.00	6.000	.88	200.00	4.000	.85	130.00	2.600	.65	50.00	1.000	.59
Cl	25.00	.705	.10	24.80	.700	.15	49.35	1.392	.35	24.80	.700	.41
SO_4	4.00	.083			.000			.000			.000	
Sum		6.788			4.700			3.992			1.700	

	WR 917 mg/l	me/l	Percent	1072 mg/l	me/l	Percent	3005 mg/l	me/l	Percent	3008 mg/l	me/l	Percent
Na	103.00	4.480	.69	35.40	1.540	.92	19.60	.853	.47	5.50	.239	.72
K	6.80	.174	.03	2.50	.064	.04	.76	.019	.01	1.76	.045	.14
Ca	13.00	.649	.10	.60	.030	.02	8.50	.424	.23	.46	.023	.07
Mg	15.00	1.234	.19	.60	.049	.03	6.50	.535	.29	.32	.026	.08
Sum		6.537			1.683			1.831			.333	
HCO_3	290.00	5.800	.87	100.00	2.000	.80	72.00	1.440	.70	20.00	.400	.34
Cl	30.00	.846	.13	17.70	.499	.20	16.20	.457	.22	28.00	.790	.66
SO_4		.000			.000		7.00	.146	.07		.000	
Sum		6.646			2.499			2.043			1.190	

	1111			WR 1679			1138			3009		
	mg/l	me/l	Percent	mg/l	me/l	Percent	mg/l	me/l	Percent	mg/l	me/l	Percent
Na	11.00	.478	.81	64.00	2.784	.72	32.00	1.392	.51	170.00	7.395	.59
K	1.60	.041	.07	5.43	.139	.04	4.00	.102	.04	18.00	.460	.04
Ca	.70	.035	.06	1.54	.077	.02	9.20	.459	.17	64.10	3.199	.26
Mg	.40	.033	.06	10.30	.847	.22	9.70	.798	.29	16.90	1.390	.11
Sum		.587			3.847			2.751			12.444	
HCO_3	40.00	.800	.57	280.00	5.600	.78	141.00	2.820	.85	162.00	3.240	.26
Cl	14.00	.395	.28	56.40	1.591	.22	18.00	.508	.15	291.00	8.209	.66
SO_4	10.00	.208			.000			.000		50.00	1.041	.08
Sum		1.403			7.191			3.328			12.490	

	3010			3016			DSIR Maketu 30m			DSIR Maketu 61m		
	mg/l	me/l	Percent	mg/l	me/l	Percent	mg/l	me/l	Percent	mg/l	me/l	Percent
Na	19.20	.835	.64	20.80	.905	.65	186.00	8.091	.31	410.00	17.835	.83
K	.68	.017	.01	.83	.021	.01	109.00	2.787	.11	44.20	1.130	.05
Ca	4.90	.245	.19	5.10	.254	.18	297.00	14.820	.58	23.00	1.148	.05
Mg	2.60	.214	.16	2.70	.222	.16		.000		17.90	1.472	.07
Sum		1.311			1.402			25.698			21.585	
HCO_3	17.40	.348	.21	22.60	.452	.36	32.79	.656	.11	95.08	1.902	.09
Cl	16.80	.474	.29	20.20	.570	.46	191.00	5.388	.89	697.00	19.662	.91
SO_4	40.00	.833		11.00	.229		1.00	.021		1.50	.031	
Sum		1.655			1.251			6.065			21.595	

	DSIR Maketu 91m			DSIR Maketu 130m			1018			TGW 38		
	mg/l	me/l	Percent	mg/l	me/l	Percent	mg/l	me/l	Percent	mg/l	me/l	Percent
Na	260.00	11.310	.80	330.00	14.355	.73	107.60	4.681	.79	67.00	2.914	.92
K	27.60	.706	.05	41.00	1.048	.05	12.38	.317	.05	6.70	.171	.05
Ca	18.50	.923	.06	35.50	1.771	.09	2.64	.132	.02	1.40	.070	.02
Mg	15.60	1.283	.09	29.50	2.427	.12	9.75	.802	.14	.23	.019	.01
Sum		14.222			19.601			5.932			3.174	
HCO_3		.000		166.48	3.330	.16	289.00	5.780	.90	113.00	2.260	.64
Cl	454.00	12.807	1.00	602.00	16.982	.83	22.00	.621	.10	37.00	1.044	.30
SO_4	2.50	.052		7.00	.146			.000		11.00	.229	.06
Sum		12.859			20.458			6.401			3.533	

	1653			WR 1929			3004			413 (86.07.06)		
	mg/l	me/l	Percent	mg/l	me/l	Percent	mg/l	me/l	Percent	mg/l	me/l	Percent
Na	37.50	1.631	.53	20.00	.870	.69	16.00	.696	.62	88.30	3.841	.72
K	36.30	.928	.30	2.90	.074	.06	2.30	.059	.05	7.30	.187	.03
Ca	1.86	.093	.03	1.60	.080	.06	4.40	.220	.20	4.60	.230	.04
Mg	5.09	.419	.14	2.80	.230	.18	1.80	.148	.13	13.30	1.094	.20
Sum		3.071			1.254			1.123			5.352	
HCO_3	140.00	2.800	.68	60.00	1.200	.55	46.00	.920	.77	280.00	5.600	.80
Cl	45.80	1.292	.32	25.00	.705	.32	10.00	.282	.23	49.60	1.399	.20
SO_4		.000		14.00	.291			.000			.000	
Sum		4.092			2.196			1.202			6.999	

	413 (87.01.30)			413 (86.02.12)			1084			1690		
	mg/l	me/l	Percent	mg/l	me/l	Percent	mg/l	me/l	Percent	mg/l	me/l	Percent
Na	70.00	3.045	.74	83.00	3.610	.73	13.57	.590	.86	56.50	2.458	.70
K	6.90	.176	.04	7.20	.184	.04	3.54	.091	.13	6.23	.159	.05
Ca	2.20	.110	.03	8.50	.424	.09	.06	.003		6.47	.323	.09
Mg	9.70	.798	.19	9.10	.749	.15	.04	.003		6.99	.575	.16
Sum		4.129			4.967			.687			3.515	
HCO_3	300.00	6.000	.83	280.00	5.600	.79	70.00	1.400	.70	215.00	4.300	.68
Cl	43.00	1.213	.17	46.00	1.298	.18	21.15	.597	.30	70.50	1.989	.32
SO_4	2.00	.042		8.00	.167			.000			.000	
Sum		7.255			7.065			1.997			6.289	

	WR 1489			71			3014			3013		
	mg/l	me/l	Percent	mg/l	me/l	Percent	mg/l	me/l	Percent	mg/l	me/l	Percent
Na	9.00	.391	.55	98.50	4.285	.96	16.68	.726	.73	28.00	1.218	.60
K	2.50	.064	.09	6.40	.164	.04	3.89	.099	.10	7.70	.197	.10
Ca	2.90	.145	.21	.30	.015		.20	.010	.01	4.40	.220	.10
Mg	1.30	.107	.15	.07	.006		2.00	.165	.16	4.90	.403	.20
Sum		.707			4.470			1.000			2.038	
HCO_3	19.00	.380	.66	220.00	4.400	.61	60.00	1.200	.39	60.00	1.200	.40
Cl	7.00	.197	.34	99.00	2.793	.39	67.00	1.890	.61	57.00	1.608	.53
SO_4		.000			.000			.000		11.00	.229	.08
Sum		.577			7.193			3.090			3.037	

	TGW 39 mg/l	me/l	Percent	TGW 40 mg/l	me/l	Percent	TGW 41 mg/l	me/l	Percent	TGW 42 mg/l	me/l	Percent
Na	176.00	7.656	.78	243.00	10.571	.88	498.00	21.663	.87	119.00	5.176	.78
K	14.00	.358	.04	18.20	.465	.04	38.20	.977	.04	5.60	.143	.02
Ca	16.20	.808	.08	10.30	.514	.04	22.70	1.133	.05	8.20	.409	.06
Mg	12.20	1.004	.10	5.90	.485	.04	15.40	1.267	.05	11.00	.905	.14
Sum		9.826			12.035			25.040			6.633	
HCO_3	321.00	6.420	.84	437.00	8.740	.76	383.00	7.660	.31	162.00	3.240	.55
Cl	35.00	.987	.13	89.00	2.511	.22	607.00	17.123	.68	88.00	2.482	.42
SO_4	13.00	.271		11.00	.229		15.00	.312	.01	6.00	.125	.02
Sum		7.678			11.480			25.095			5.847	

APPENDIX 4: WATER RIGHT DETAILS

WATER RIGHT	MAP REFERENCE	RIGHT TYPE	QUANTITY m^3/day GW	SW	DIS	AREA
1324/1	U14 / 997 742	DAM				Atuaroa Stream
1212	U14 / 997 741	DAM				Atuaroa Stream
1212/1	V15 / 209 666	DAM				Pongakawa Stream
2186/1	U14 / 997 741	DAM				Kopuaroa Strm
2191	U14 / 034 732	DISCHARGE			0	Managh's Drain
1955	U14 / 042 746	DISCHARGE			1500	Waiari Stream
41/2	U15 / 014 493	DISCHARGE			272	Raparapahoe Stream
337	U15 / 024 751	DISCHARGE			509	Kaituna River
2068	U14 / 025 754	DISCHARGE			80	Ohineangaanga Strm
834	U14 / 048 763	DISCHARGE			950	Kaituna River
197	U14 / 034 750	DISCHARGE			1	Kaituna River
893	U14 / 076 731	DISCHARGE			19120	Kaituna River
1168	U14 / 057 744	DISCHARGE			2183	Kaituna River
625	V14 / 153 733	DISCHARGE			12800	Kaikokopu Canal
170/4	U14 / 067 785	DISCHARGE			1	Kaituna River
1825/2	U14 / 038 771	DISCHARGE			7516	Ohineangaana Str,
192	U14 / 034 750	DISCHARGE			1	Kaituna River
336	U14 / 030 760	DISCHARGE			1	Kaituna River
170/6	U14 / 042 778	DISCHARGE			1	Kaituna River
1804/2	V14 / 134 758	DISCHARGE			83	Kaituna River
170/2	V14 / 109 779	DISCHARGE			1	Kaituna River
87	V14 / 109 774	DISCHARGE			1	Kaituna River
19/2	U14 / 083 735	DISCHARGE			136	Kaituna River
188	U15 / 024 736	DISCHARGE			1	Kaituna River
822/3	U14 / 000 714	DISLAND			100	Raparapahoe Stream
185/2	U14 / 037 739	DISLAND			1818	Cannell Drain
1017/2	U15 / 023 740	DISLAND			269	Ohineangaanga Stm
1794/2	V15 / 277 680	DISLAND			227	Drain
1857/2	U14 / 009 801	DISLAND			34	Kopuaroa Canal
1967/2	V14 / 120 744	DISLAND			90	Maketu
1760/2	U14 / 083 736	DISLAND			15	Kaituna River
1801/2	V15 / 106 690	DISLAND			8	Kaikokopu Strm
1441/2	U15 / 055 684	DISLAND			100	Parawhenuamea
796/2	V14 / 101 711	DISLAND			182	Kaituna River
1840	U14 / 029 746	DIVERT				Trib Ohineangaanga
170/5	U14 / 050 772	DIVERT				Kaituna River
1825/1	U14 / 033 764	DIVERT				Ohineangaanga Str.
170/1	V14 / 015 779	DIVERT				Kaituna River
2038	U14 / 070 734	DIVERT				Kaituna River
170/3	U14 / 056 782	DIVERT				Kaituna River
151	V14 / 152 722	SURFTAKE		1591		Kaikokopu Canal
417	V15 / 128 662	SURFTAKE		295		Mangatoetoe Stream
1969/2	U14 / 025 812	SURFTAKE		630		Drain
1794/1	V15 / 277 680	SURFTAKE		227		Drain
1165	V15 / 118 699	SURFTAKE		416		Blackmore's Spring
1489	U14 / 066 731	SURFTAKE		27		Pakipaki stream
1565	V15 / 143 618	SURFTAKE		872		Wharere tributary

WATER RIGHT	MAP REFERENCE	RIGHT TYPE	QUANTITY m^3/day GW	SW	DIS	AREA
1037/1	V15 / 183 671	SURFTAKE		160		Wharere tributary
539	U15 / 024 696	SURFTAKE		318		Waiari Stream
678	U14 / 029 749	SURFTAKE		299		Waiari Stream
1544	U15 / 085 682	SURFTAKE		43		Kaituna River
324	U14 / 033 708	SURFTAKE		273		Waiari Stream
333	U15 / 009 676	SURFTAKE		273		Waiari Stream
397	U14 / 031 704	SURFTAKE		136		Waiari Stream
410	U15 / 025 695	SURFTAKE		227		Waiari Stream
740	U14 / 069 734	SURFTAKE		68		Kaituna River
1628	U14 / 036 718	SURFTAKE		235		Waiari Stream
1797	U15 / 084 669	SURFTAKE		70		Kaituna River
373	U14 / 033 706	SURFTAKE		131		Waiari Stream
1966	U15 / 082 677	SURFTAKE		80		Kaituna River
1377	U15 / 025 695	SURFTAKE		300		Waiari Stream
1459	U14 / 040 731	SURFTAKE		650		Waiari Stream
177	U15 / 024 696	SURFTAKE		163		Waiari Stream
177/1	U15 / 024 696	SURFTAKE		1136		Waiari Stream
501	U15 / 009 676	SURFTAKE		68		Waiari Stream
383	U14 / 033 706	SURFTAKE		145		Waiari Stream
865	U15 / 077 687	SURFTAKE		65		Mangorewa River
1515	U14 / 056 746	SURFTAKE		114		Kaituna River
1218	U15 / 074 679	SURFTAKE		104		Mangorewa Stream
385	V15 / 153 631	SURFTAKE		91		Un-named spring
767/1	U14 / 096 705	SURFTAKE		260		Un-named spring
1934	U15 / 084 668	SURFTAKE		135		Kaituna River
787	V15 / 171 649	SURFTAKE		227		Un-named Spring
1480	U14 / 041 715	SURFTAKE		140		Un-named springs
321	V15 / 150 651	SURFTAKE		218		Un-named spring
792	U14 / 055 713	SURFTAKE		750		Un-named Spring
322	V15 / 150 651	SURFTAKE		218		Un-named spring
1441/1	U15 / 060 683	SURFTAKE		20		Un-named spring
381	U15 / 094 692	SURFTAKE		123		Un-named spring
433	U14 / 043 719	SURFTAKE		225		Un-named spring
1943	U15 / 057 660	SURFTAKE		280		Mangorewa River
155	U15 / 004 723	SURFTAKE		136		Raparapahoe Stream
723	U15 / 018 754	SURFTAKE		22		Raparapahoe Stream
2079	U15 / 078 687	SURFTAKE		145		Mangorewa River
495	U15 / 075 681	SURFTAKE		227		Mangorewa River
149	U14 / 006 754	SURFTAKE		711		Raparapahoe Stream
39	U15 / 006 745	SURFTAKE		45		Raparapahoe Stream
379	U15 / 094 692	SURFTAKE		164		Kaituna River
605	U15 / 068 672	SURFTAKE		182		Mangorewa River
1205	U15 / 006 751	SURFTAKE		242		Raparapahoe Stream
790	U15 / 074 681	SURFTAKE		2550		Mangorewa River
41/1	U14 / 012 764	SURFTAKE		176		Raparapahoe Stream
2102/2	U15 / 091 688	SURFTAKE		187		Kaituna River
1811	U14 / 093 709	SURFTAKE		200		Kaituna River
2109	U14 / 004 723	SURFTAKE		108		Raparapahoe Stream
1096	U15 / 005 755	SURFTAKE		189		Raparapahoe
179	V14 / 193 730	SURFTAKE		1136		Pukehina Canal
35	U15 / 005 759	SURFTAKE		273		Raparapahoe Stream

WATER RIGHT	MAP REFERENCE	RIGHT TYPE	QUANTITY m^3/day GW	SW	DIS	AREA
621	U14 / 097 746	UNDERTAKE	116			Kaituna River
2000	U14 / 074 751	UNDERTAKE	110			Kaituna River
152	U14 / 092 720	UNDERTAKE	135			Kaituna River
474	U15 / 068 696	UNDERTAKE	87			Mangorewa River
657	U14 / 088 741	UNDERTAKE	140			Kaituna River
1505	U14 / 098 749	UNDERTAKE	105			Kaituna River
1514	U14 / 091 755	UNDERTAKE	112			Kaituna River
1994	U14 / 072 712	UNDERTAKE	100			Kaituna River
407	V15 / 104 700	UNDERTAKE	153			Kaituna River
1162	V14 / 106 719	UNDERTAKE	158			Kaituna River
706	V14 / 104 703	UNDERTAKE	130			Kaituna River
1472	U14 / 091 733	UNDERTAKE	160			Kaituna River
1375	U14 / 091 751	UNDERTAKE	135			Kaituna River
1937	U14 / 089 758	UNDERTAKE	162			Kaituna River
1760/1	U14 / 083 736	UNDERTAKE	15			Kaituna River
1817	U14 / 076 700	UNDERTAKE	162			Kaituna River
1161	V14 / 104 707	UNDERTAKE	170			Kaituna River
1439	U14 / 012 796	UNDERTAKE	162			Kopuaroa Canal
1858	V15 / 227 697	UNDERTAKE	108			Bore
899	V14 / 103 722	UNDERTAKE	136			Kaituna River
2102/3	U15 / 096 687	UNDERTAKE	187			Bore
1895	V15 / 121 672	UNDERTAKE	197			Kopuaroa Canal
1271	V15 / 118 681	UNDERTAKE	130			Kaikokopu Stream
796/1	V14 / 101 711	UNDERTAKE	182			Kaituna River
980	V15 / 237 678	UNDERTAKE	109			Bay of Plenty
1987	U14 / 053 727	UNDERTAKE	290			Parawhenuamea St.
1624	U15 / 026 671	UNDERTAKE	864			Parawhenuamea St.
1504	U15 / 064 692	UNDERTAKE	925			Parawhenuamea St.
1677	U14 / 054 727	UNDERTAKE	180			Parawhenuamea St.
2016	U14 / 087 714	UNDERTAKE	180			Kaituna River
1998	U14 / 065 716	UNDERTAKE	450			Parawhenuamea Str.
636	V14 / 106 745	UNDERTAKE	260			Kaituna River
538	U14 / 093 748	UNDERTAKE	23			Kaituna River
1886	U14 / 094 726	UNDERTAKE	27			Kaituna River
755	U14 / 005 777	UNDERTAKE	95			Kopura Canal
936	V15 / 115 676	UNDERTAKE	260			Kaikokopu Stream
2138	V15 / 188 667	UNDERTAKE	499			Pongakawa Stm
1024	V15 / 211 668	UNDERTAKE	598			Pongakawa Stream
1542	U14 / 098 748	UNDERTAKE	194			Kaituna River
908	V15 / 187 672	UNDERTAKE	382			Pongakawa Stream
542	U14 / 073 711	UNDERTAKE	140			Kaituna River
689	U14 / 089 732	UNDERTAKE	100			Kaituna River
1597/1	V14 / 115 740	UNDERTAKE	900			Maketu Estuary
1041	V15 / 162 681	UNDERTAKE	290			Pongakawa Stream
1670	V14 / 111 743	UNDERTAKE	200			Kaituna River
1667	V14 / 129 717	UNDERTAKE	240			Kaikokopu Stream
2150	V15 / 177 656	UNDERTAKE	189			Pongakawa Stream
758	U14 / 024 829	UNDERTAKE	150			Bay of Plenty
1390	V15 / 172 652	UNDERTAKE	52			Pongakawa Stream
487	U14 / 099 722	UNDERTAKE	205			Kaituna River
420	U15 / 039 693	UNDERTAKE	200			Kaituna River

WATER RIGHT	MAP REFERENCE	RIGHT TYPE	QUANTITY m³/day GW	SW	DIS	AREA
2077	V15 / 133 642	SURFTAKE		108		Puanene Stream
1823/2	V15 / 130 687	SURFTAKE		324		Mangatoetoe Stream
722	V15 / 186 644	SURFTAKE		318		Pongakawa Stream
1597/2	V14 / 122 738	SURFTAKE		680		Maketu Estuary
2011	U15 / 086 682	SURFTAKE		270		Kaituna River
2148	U14 / 078 713	SURFTAKE		375		Kaituna River
1764	V15 / 196 695	SURFTAKE		2511		Pongakawa Stream
845	V15 / 109 686	SURFTAKE		320		Pokopoko Stream
582	V15 / 109 678	SURFTAKE		270		Pokopoko Stream
1935	U15 / 101 656	SURFTAKE		118		Pokopoko Stream
2023	V15 / 118 699	SURFTAKE		208		Pokopoko Stream
2071	U14 / 058 718	SURFTAKE		450		Parawhenuamea Strea
2053	U14 / 017 732	SURFTAKE		150		Ohineanganga Stream
412	U15 / 022 749	SURFTAKE		9600		Ohineangaanga Strm
402	U15 / 023 751	SURFTAKE		299		Ohineangaanga Strm
1482	U14 / 030 703	SURFTAKE		980		Waiari Stream
409	U14 / 031 704	SURFTAKE		77500		Waiari Stream
655	U14 / 042 725	SURFTAKE		36		Waiari Stream
390	U14 / 031 704	SURFTAKE		164		Waiari Stream
1123	U14 / 033 709	SURFTAKE		138		Waiari Stream
1060	V15 / 124 622	SURFTAKE		150		Waiari Stream
432	U15 / 082 697	SURFTAKE		600		Kaituna River
1616	V15 / 204 685	SURFTAKE		25		Pongakawa Stream
877	U14 / 988 708	SURFTAKE		350		Wairapukao stream
380	U15 / 009 710	SURFTAKE		727		Ohineangaanga Strm
2058	U14 / 082 705	SURFTAKE		1400		Kaituna River
320	V15 / 122 623	SURFTAKE		36		Un-named Stream
32	U14 / 005 721	SURFTAKE		227		Raparapahoe Stream
332	U15 / 018 738	SURFTAKE		136		Ohineangaanga Strm
1592	U14 / 005 755	SURFTAKE		300		Raparapahoe Stream
196	U15 / 088 694	SURFTAKE		2062		Kaituna River
37	U15 / 990 675	SURFTAKE		227		Ohui Trib Ohineanga
1128	U15 / 005 755	SURFTAKE		182		Raparapahoe Stream
2065	U14 / 005 760	SURFTAKE		120		Raparapahoe Stm
194/1	U14 / 078 730	SURFTAKE		27270		Kaituna River
2186/2	U14 / 997 741	SURFTAKE		140		Kopuaroa
672	V15 / 202 691	SURFTAKE		1500		Pongakawa Stream
1808	V15 / 188 662	SURFTAKE		6360		Pongakawa Stream
175	U14 / 031 704	SURFTAKE		982		Spring adj.Waiari R
312	V14 / 176 730	SURFTAKE		27		Pongakawa Stream
1967/3	V14 / 117 744	UNDERTAKE	109			Kaituna River
1903	U14 / 095 720	UNDERTAKE	110			Kaituna River
1919	U14 / 096 742	UNDERTAKE	131			Kaituna River
1555	V15 / 124 693	UNDERTAKE	159			Kaikokopu Stream
1878	V15 / 223 691	UNDERTAKE	480			Kopuaroa Canal
1503	U14 / 096 743	UNDERTAKE	185			Kaituna River
1426	U15 / 081 682	UNDERTAKE	120			Kaituna River
1882	U15 / 090 674	UNDERTAKE	108			Kaituna River
1929	U14 / 095 723	UNDERTAKE	108			Kaituna River
2074	V14 / 109 714	UNDERTAKE	108			Kaituna River
1506	U15 / 067 694	UNDERTAKE	116			Kaituna River

WATER RIGHT	MAP REFERENCE	RIGHT TYPE	QUANTITY m^3/day GW	SW	DIS	AREA
1890	U14 / 102 756	UNDERTAKE	300			Kaituna River
2082	U14 / 095 719	UNDERTAKE	324			Kaituna River
1796	U14 / 101 748	UNDERTAKE	330			Kaituna River
892	V15 / 173 695	UNDERTAKE	55			Kaituna River
1313	U14 / 088 715	UNDERTAKE	360			Kaituna River
1928	U14 / 055 796	UNDERTAKE	378			Kaituna River
1286	V14 / 105 747	UNDERTAKE	390			Kaituna River
1499	U14 / 100 738	UNDERTAKE	392			Kaituna River
1988	V14 / 108 719	UNDERTAKE	432			Kaituna River
935	U15 / 092 672	UNDERTAKE	400			Kaituna River
1631	U14 / 101 750	UNDERTAKE	392			Kaituna River
107	U14 / 022 726	UNDERTAKE	455			Waiari River
1678	U14 / 047 728	UNDERTAKE	180			Waiari River
670	U14 / 047 801	UNDERTAKE	220			Kaituna River
1252/1	U15 / 002 675	UNDERTAKE	170			Waiari River
2081	V15 / 116 667	UNDERTAKE	108			Waiari River
1252/2	U15 / 002 675	UNDERTAKE	320			Waiari River
1478	U15 / 014 689	UNDERTAKE	315			Waiari River
1336	U15 / 007 690	UNDERTAKE	106			Waiari River
1558	V14 / 109 746	UNDERTAKE	577			Kaituna River
1285	U14 / 094 747	UNDERTAKE	624			Kaituna River
27	V14 / 131 755	UNDERTAKE	68			Kaituna River
1322	U15 / 096 683	UNDERTAKE	70			Kaituna River
2123	V14 / 110 712	UNDERTAKE	780			Kaituna River
2139	U15 / 098 698	UNDERTAKE	735			Kaituna River
1830	V15 / 109 666	UNDERTAKE	100			Waiari Stream
1969/1	U14 / 027 813	UNDERTAKE	630			Kaituna River
1046	U14 / 075 747	UNDERTAKE	731			Kaituna River
1651	U14 / 098 733	UNDERTAKE	715			Kaituna River
814	V15 / 113 666	UNDERTAKE	320			Waiari Stream
1804/1	V14 / 134 758	UNDERTAKE	83			Kaituna River
1127	U15 / 007 678	UNDERTAKE	125			Waiari Stream
1178	U15 / 996 688	UNDERTAKE	260			Atuaroa Stream
85	U14 / 022 751	UNDERTAKE	910			Kaituna River
1615	V14 / 102 731	UNDERTAKE	1000			Kaituna River
1799	U14 / 0890737	UNDERTAKE	80			Kaituna River
1876	V14 / 108 759	UNDERTAKE	80			Kaituna River
1595	V15 / 114 680	UNDERTAKE	109			Kaikokopu Stream
986	V14 / 118 720	UNDERTAKE	270			Kaikokopu Stream
1831	V15 / 117 665	UNDERTAKE	160			Waiari Stream
1636	U14 / 024 702	UNDERTAKE	400			Waiari Stream
1492	V14 / 120 724	UNDERTAKE	80			Kaituna River
1474	V15 / 112 670	UNDERTAKE	432			Waiari Stream
1801/1	V15 / 106 689	UNDERTAKE	308			Kaikokopu Str.
707/2	U14 / 072 710	UNDERTAKE	225			Bore Lot 2
367	U14 / 024 703	UNDERTAKE	250			Waiari Stream
707/3	U14 / 060 700	UNDERTAKE	700			Bore Lot 14
1018	V15 / 177 669	UNDERTAKE	170			Waihi Estuary
1557	V14 / 122 725	UNDERTAKE	114			Waihi Estuary
654	U14 / 012 744	UNDERTAKE	45			Atuaroa Stream
1885	V15 / 233 679	UNDERTAKE	300			Waitahanui St

WATER RIGHT	MAP REFERENCE	RIGHT TYPE	QUANTITY m^3/day GW	SW	DIS	AREA
273	U14 / 023 826	UNDERTAKE	141			Bay of Plenty
917	V15 / 208 699	UNDERTAKE	200			Pongakawa Stream
2062	V14 / 107 713	UNDERTAKE	45			Kaituna River
298	V15 / 245 680	UNDERTAKE	123			Bay of Plenty
1509	U14 / 088 730	UNDERTAKE	216			Kaituna River
1806	V15 / 141 656	UNDERTAKE	170			Puanene Str.
1847	U15 / 100 695	UNDERTAKE	216			Kaituna River
729	U14 / 094 724	UNDERTAKE	92			Kaituna River
714	V15 / 143 666	UNDERTAKE	227			Puanene Stream
1510	U14 / 089 729	UNDERTAKE	216			Kaituna River
2037	U14 / 071 721	UNDERTAKE	216			Kaituna River
208	U14 / 095 735	UNDERTAKE	218			Kaituna River
839	V15 / 140 667	UNDERTAKE	182			Mangatoetoe Stream
648	V14 / 105 741	UNDERTAKE	240			Kaituna River
2010	U14 / 089 738	UNDERTAKE	240			Kaituna River
1383	V14 / 104 705	UNDERTAKE	173			Kaituna River
1380	U15 / 987 681	UNDERTAKE	155			Raparapahoe Stream
1594	V14 / 120 746	UNDERTAKE	1160			Bay of Plenty
475	U14 / 089 754	UNDERTAKE	227			Kaituna River
1930	U15 / 092 674	UNDERTAKE	220			Kaituna River
1629	V15 / 127 674	UNDERTAKE	350			Mangatoetoe Stream
1240	U14 / 016 821	UNDERTAKE	46			Bay of Plenty
1309	V14 / 106 744	UNDERTAKE	240			Kaituna River
1486	V14 / 112 719	UNDERTAKE	46			Kaituna River
910	V15 / 158 678	UNDERTAKE	260			Raparapahoe Stream
19/1	U14 / 083 735	UNDERTAKE	91			Kaituna River
749	U15 / 069 697	UNDERTAKE	242			Kaituna River
1567	U14 / 072 750	UNDERTAKE	140			Kaituna River
617	U14 / 094 732	UNDERTAKE	20			Kaituna River
1454	V15 / 120 666	UNDERTAKE	300			Kaikokopu Stream
1112	U14 / 094 744	UNDERTAKE	182			Kaituna River
1017/1	U14 / 023 740	UNDERTAKE	269			Kaituna River
	U14 / 014 797	UNDERTAKE	266			Kaituna River
1640	U14 / 014 722	UNDERTAKE	110			Raparapahoe Stream
1679	U14 / 095 733	UNDERTAKE	270			Kaituna River
408	V14 / 155 776	UNDERTAKE	1008			Bay of Plenty
1213	U15 / 998 694	UNDERTAKE	100			Raparapahoe Stream
1302	U15 / 009 697	UNDERTAKE	250			Atuaroa Stream
2026	U14 / 088 750	UNDERTAKE	270			Kaituna River
1874	V14 / 127 760	UNDERTAKE	50			Kaituna River
1341	U15 / 051 667	UNDERTAKE	195			Mangorewa River
1976	U14 / 066 716	UNDERTAKE	270			Kaituna River
1287	V14 / 105 747	UNDERTAKE	364			Kaituna River
2102/1	U15 / 094 692	UNDERTAKE	3			Spring
889	V14 / 102 737	UNDERTAKE	270			Kaituna River
2099	U15 / 089 676	UNDERTAKE	315			Tauranga Harbour
1204	U14 / 014 725	UNDERTAKE	170			Atuaroa Stream
1900	V15 / 145 691	UNDERTAKE	454			Trib.Kaikokopu Can
1524	U15 / 071 699	UNDERTAKE	200			Kaituna River
1939	U14 / 091 754	UNDERTAKE	290			Kaituna River
1967/1	V14 / 120 745	UNDERTAKE	90			Kaituna River

WATER RIGHT	MAP REFERENCE	RIGHT TYPE	QUANTITY m^3/day GW	SW	DIS	AREA
1866	V15 / 227 696	UNDERTAKE	136			Waitahanui Stm
479	V15 / 177 670	UNDERTAKE	162			Well
1251	V15 / 123 666	UNDERTAKE	110			Wharere Canal
1536	V15 / 141 675	UNDERTAKE	540			Wharere Canal
1289	V15 / 166 678	UNDERTAKE	598			Wharere Canal
1288	V15 / 166 677	UNDERTAKE	125			Wharere Canal
1819	V15 / 165 696	UNDERTAKE	270			Wharere Canal
1611	V15 / 140 678	UNDERTAKE	41			Wharere Canal
1518	V15 / 140 686	UNDERTAKE	176			Wharere Canal
468	V15 / 153 682	UNDERTAKE	1087			Wharere Canal
1190	V15 / 143 682	UNDERTAKE	218			Wharere canal
1713	V15 / 177 671	UNDERTAKE	178			Wharere Canal
1343	V15 / 177 672	UNDERTAKE	160			Wharere Canal
1947	V15 / 167 672	UNDERTAKE	200			Wharere Stm
1699	V15 / 155 670	UNDERTAKE	740			Wharere Stream
2142	V15 / 168 679	UNDERTAKE	52			Wharere Stream
1836	U15 / 095 694	UNDERTAKE	265			Kaituna River
1473	U14 / 089 736	UNDERTAKE	34			Kaituna River