10 Auckland Central Water Resource Area

10.1 Introduction

Auckland Central is a predominantly urban and peri-urban area. It comprises Auckland and Manukau Cities, the majority of Papakura District and a small part of Waitakere City (fig. 10.1). Much of the Auckland isthmus topography is formed from volcanic lava flow and airfall deposits. The numerous basaltic cones, and their associated lava flow deposits and tuff rings, is a distinctive part of Auckland's landscape (Searle, 1981). The volcanic materials are also an important aquifer system, stormwater receptor and source of aggregate for the inner city. Outside the isthmus, in the eastern suburbs and Manukau, surface geology comprises predominantly Waitemata Group, Pleistocene age sediments and, to a lesser extent greywacke. Waitemata Group forms the cliffs around the Eastern Bays, underlie much of East Tamaki and Manukau and form the ridge that runs south-west from Pakuranga to Ardmore. In low-lying areas south of Otahuhu Pleistocene sediments, predominantly alluvium, veneer Waitemata rocks to varying thicknesses.

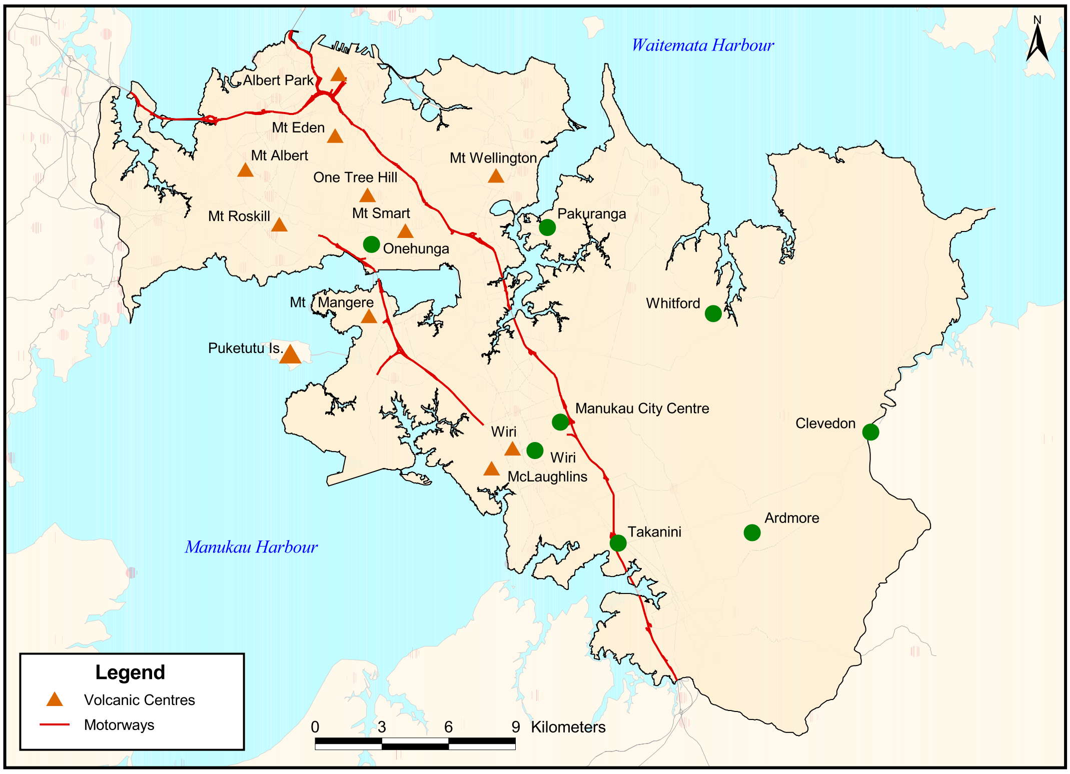

Figure 10.1: Location map for the Auckland Central water resource reporting area.

Most of Auckland's population lives and works within the Auckland Central area. As Auckland's population continues to grow the area will become more intensely urbanised. More of the land area will likely be covered by impervious surfaces. These surfaces limit infiltration of water to aquifers. Urban catchment hydrology is generally very different from rural catchments. The most notable changes in hydrology result from increased imperviousness e.g. from buildings, roads, and soil compaction during and after development. Increased imperviousness alters catchment hydrology in two distinct ways. Firstly rain falling in the catchment rapidly becomes concentrated flow (whereas in the past it may have flowed across a broader area) and peak flows in streams will be greater than pre-development. Secondly increased imperviousness may significantly increase or decrease recharge to aquifers from rainfall. This depends on whether stormwater is directed into ground (e.g. volcanic areas of Auckland City) or out of the catchment (e.g. Manukau). Where aquifer recharge is decreased the catchment water balance will adjust, generally by lowering groundwater levels. This may have a significant effect on stream baseflows that sustain stream flow during dry periods of the year. Increased aquifer recharge to an aquifer may result in localised flooding and will increase aquifer discharge.

Quantifying changes to catchment hydrology is difficult as landuse within catchments continues to change. However, quantification of water resources is necessary to enable sustainable allocation to water users. Within the Auckland isthmus most water demand is met through groundwater abstraction from volcanic aquifers in Onehunga, Mt Wellington and Western Springs. Manukau City water users abstract water from the Waitemata Aquifer and from streams.

10.2 Rainfall

The ARC monitors three automatic rainfall recorder sites within the Auckland Central area: Rowe Street, Onehunga (649723), Sunnyhills Village, Pakuranga (649820) and Botanic Gardens, Manurewa (740815) (fig. 10.2). These automatic sites are complemented by 8 manual rainfall sites; six sites within the Auckland CBD, including Albert Park (648701) which has a record since 1850; one site at Beachlands (658011), and one site in the Papakura Catchment, at the Water Treatment Plant (750012). ARC rainfall monitoring sites are shown in figure 10.2. The NZ Meteorological Service operates a climate site at Auckland Airport (C74082).

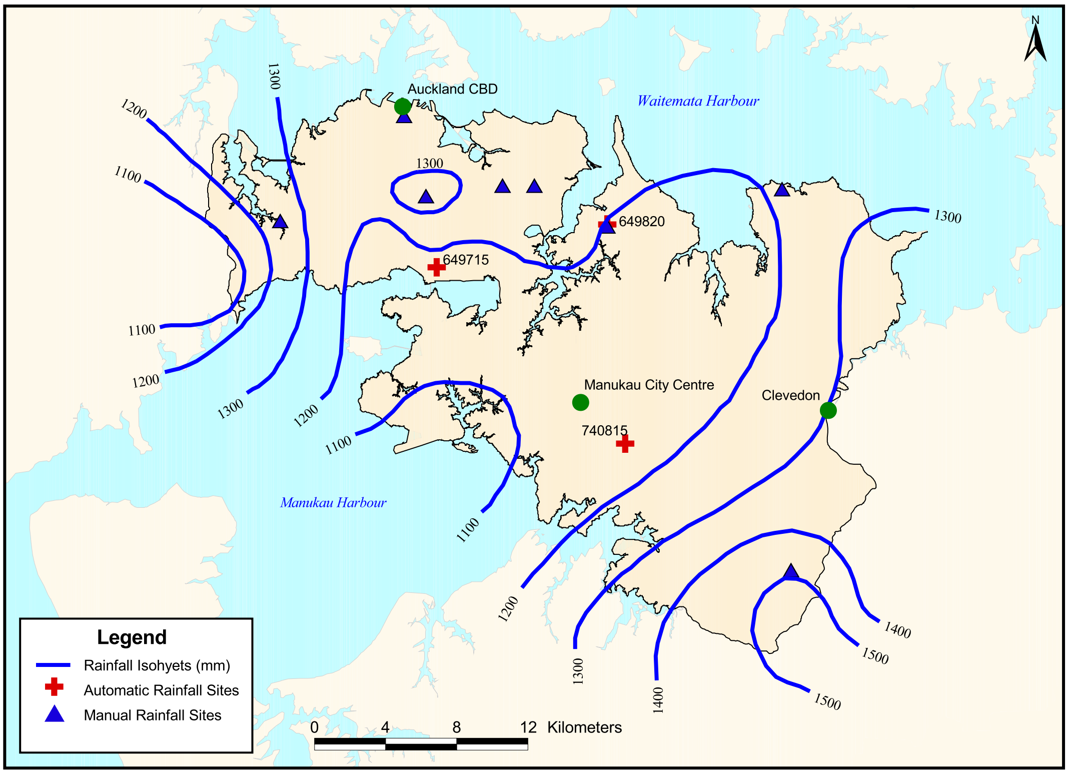

Figure 10.2: Auckland Central area rainfall monitoring sites and mean annual rainfall isohyets.

Average annual rainfall across Auckland Central varies between 1,030mm and 1,300 mm, with generally more rainfall in the east than the west (fig. 10.2). A cyclical annual rainfall trend is definable from manual records at Remuera Golf Course (648813) (fig. 10.3). Two distinct periods of low rainfall during 1982-1983 and 1993-1994 coincide with strong El Nino phases. Periods of higher rainfall are most notable periods between 1988-1992 and 1995-1996.

The seasonal rainfall pattern is shown in mean monthly rainfall values in at Remuera Golf Course and Botanic Gardens in Manurewa. On average July and August are the wettest months of the year at the Golf Course with 154 and 147mm per year for the period between 1980 and 1998. Similarly at the Botanic Gardens in Manurewa, mean rainfall for these months is 160mm and 139mm between 1987 and 1998. The driest months are January and February in which mean monthly rainfall decreases to 59mm and 57mm, and 84mm and 71mm for the respective months.

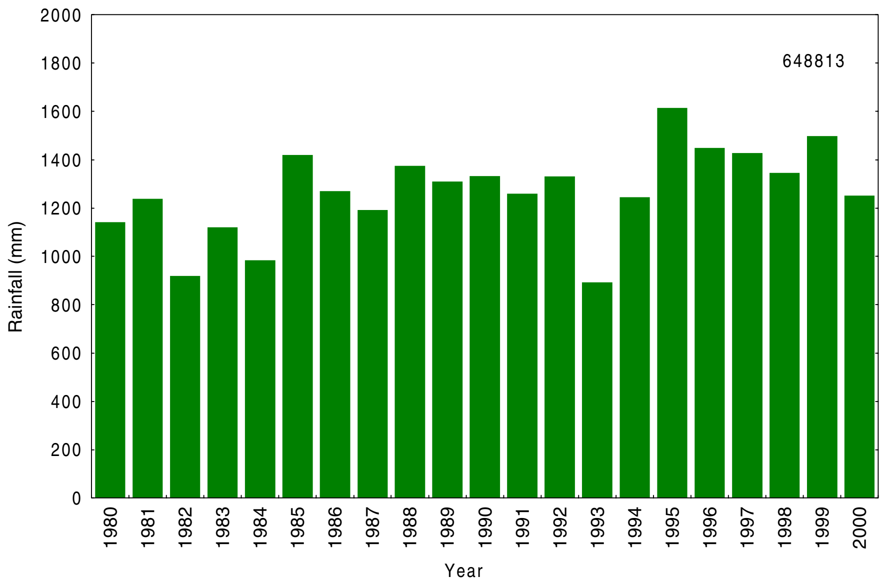

Figure 10.3: Rainfall records at Remuera Golf Course (648813)

10.3 Hydrology

There are seven major surface water catchments in the Auckland Central Region; the Puhinui, Papakura, and Hays/Waihoihi catchments, that drain into the Manukau Harbour; the Pakuranga and Otara Streams, that drain into the Tamaki Estuary; and Meola and Motions Creeks, that drain into the Waitemata Harbour (fig. 10.4). Seven automatic flow recorder sites are monitored in these catchments.

Urbanisation has a significant affect on the timing, duration and intensity of stream discharges. Impervious surfaces are believed to increase the magnitude and reduce the duration of peak flow discharges. In simplistic terms, water velocities are increased. Apart from anthropogenic impacts upon hydrology, stream flows in urban areas continue to exhibit seasonal patterns. A seasonal cycle of high flows occurs during winter months and low flows during summer months. Stream discharges reach a maximum during July and August and a minimum during January, February or March. A typical seasonal example is shown below in figure 10.5.

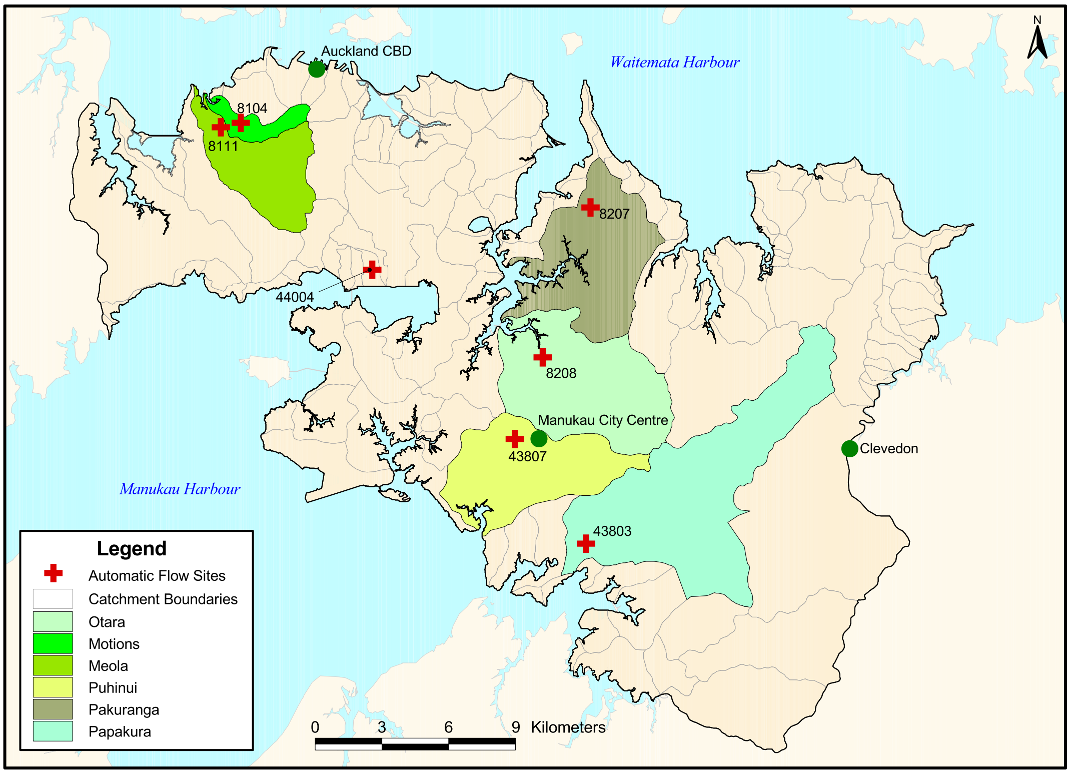

Figure 10.4: Surface water catchments and flow monitoring sites in the Auckland Central area. The six key surface water catchments are indicated.

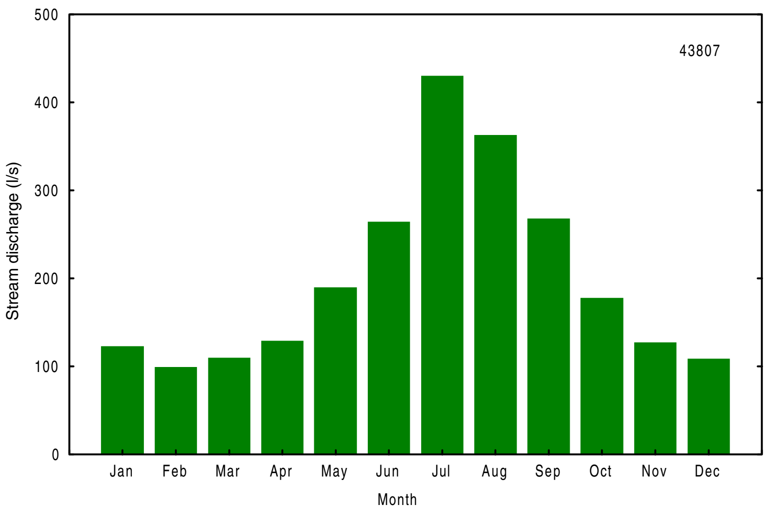

Figure 10.5: Mean monthly stream flows at Puhinui Stream (43807) flow monitoring site.

Low flow duration curves for the Puhinui, Papatoetoe and Otara streams are typical for streams underlain by Waitemata Group geology (fig. 10.6). The Pakuranga stream is also underlain by Waitemata Group sediments but has baseflow contributions from the volcanic rocks in the upper catchment. This has the effect of ameliorating low flow conditions compared with the other 3 streams.

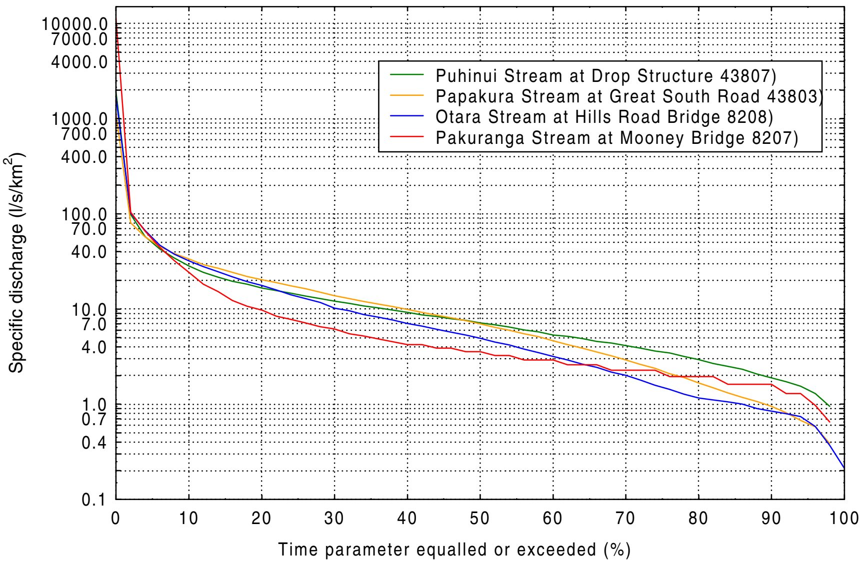

Figure 10.6: Flow duration curves for four Auckland Central area surface water catchments..

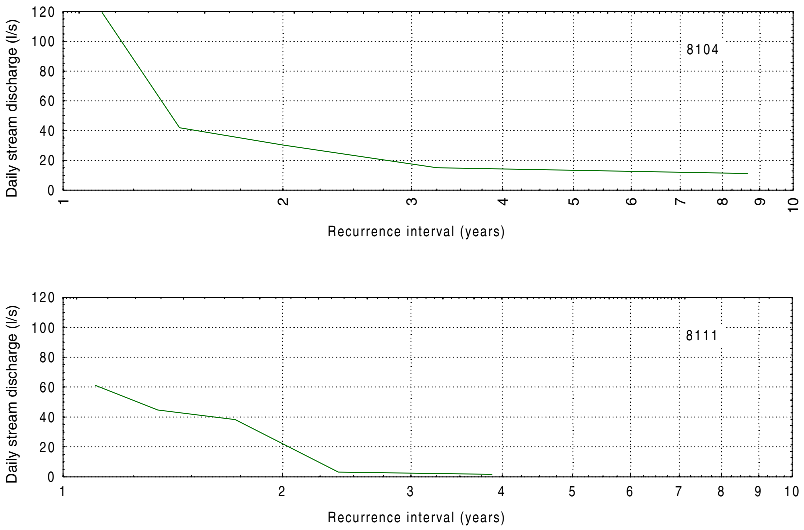

Figure 10.7: Low flow frequency plots at Motions (8104) and Meola (8111) flow monitoring sites.

Three automatic flow recorder sites measure flow from catchments fed from volcanic aquifer springs. While both the Meola and Motions Stream catchments are spring fed low flow frequency curves for the sites are quite different (fig. 10.7). This difference is due to lake storage at Western Springs (upstream on of the Motions flow recorder site), which limits low flow conditions during drier periods. Four ARC automatic flow recorder sites measure flow from catchments with predominantly Waitemata Group geology. Some Waitemata catchments have Tauranga Group sediments in their lower reaches. Table 10.1 tabulates flow data for these sites.

Table 10.1: Flow data for six Auckland Central flow monitoring sites.

Site Number	Catchment	Geology	Catchment area (km^2)	$Q_{2.3}$ l/s	Q_5	$SD_{2.3}$ l/s/km^2	SD_5
8104	Motions	Volcanic	7.5	25	14	3.33	1.86
8111	Meola	Volcanic	12.9	3	2	0.23	0.16
8208	Otara	Waitemata	18.9	7.0	5.4	0.37	0.29
43807	Puhinui	Waitemata	11.6	13.5	11.5	1.16	0.99
8207	Pakuranga	Waitemata	3.1	3.6	3.12	1.17	1.01
43803	Papakura	Waitemata	51.6	30	22	0.58	0.43

The Otara and Papakura sites are at the bottom of their respective catchments and represent total catchment flow while Puhinui and Pakuranga are in the upper catchments. The Papakura low flow values are natural flows corrected for pumping effects.

The Otara and Papakura catchments are still largely rural. The Q_5 low flow specific discharges of 0.29 and 0.43 l/s/km^2 respectively for the catchments are typical of Waitemata upper catchments with alluvial lower catchments. The catchment upstream of the Pakuranga site is fully urbanised, while the catchment upstream of the Puhinui is partially urbanised. The Q_5 low flow specific discharges of 1.01 and 0.99 l/s/km^2 respectively are 2.5-3 times that of the adjacent rural catchments.

10.4 Hydrogeology

Basalt aquifers are the dominant hydrogeological unit in the northern part of the Auckland Central area. In the Central and southern part of the area the Waitemata Aquifer dominates. However, the Kaawa Aquifer, at Mangere and Otahuhu, is also an important local source of groundwater. The greywacke rocks underlying the area are not highly used aquifers. In areas around Ardmore and Brookby high groundwater flows have been found at the contact between basal Waitemata Group rocks and greywacke. This zone is sometimes targeted during drilling when flows in the Waitemata Group are low or high yields are sought. The key aquifers in the Auckland Central area are discussed in the following sections.

10.4.1 Auckland Volcanics

The main basaltic aquifers in the Auckland Region are Onehunga, Mt Wellington, Western Springs, Mt Richmond and to a lesser extent Mt Eden/Epsom and Auckland Domain (fig. 10.8). The lateral extent of Auckland Volcanic aquifers is easily defined by the surface geology. Groundwater movement is dominantly fracture flow and aquifer properties vary considerably over short distances, both horizontally and vertically. Aquifer thickness, transmissivity and contributing volcanic centres for the main volcanic aquifers are presented in table 10.2. Bore yields may vary considerably depending on the nature of the materials encountered. Scoriaceous and heavily fractured zones yield higher rates of flow than tuffaceous and dense, less fractured zones. Groundwater flow direction is strongly controlled by the paleotopography of the underlying low permeability Waitemata Group. Groundwater generally flows down Waitemata paleovalleys that have subsequently been infilled by basaltic lava flows.

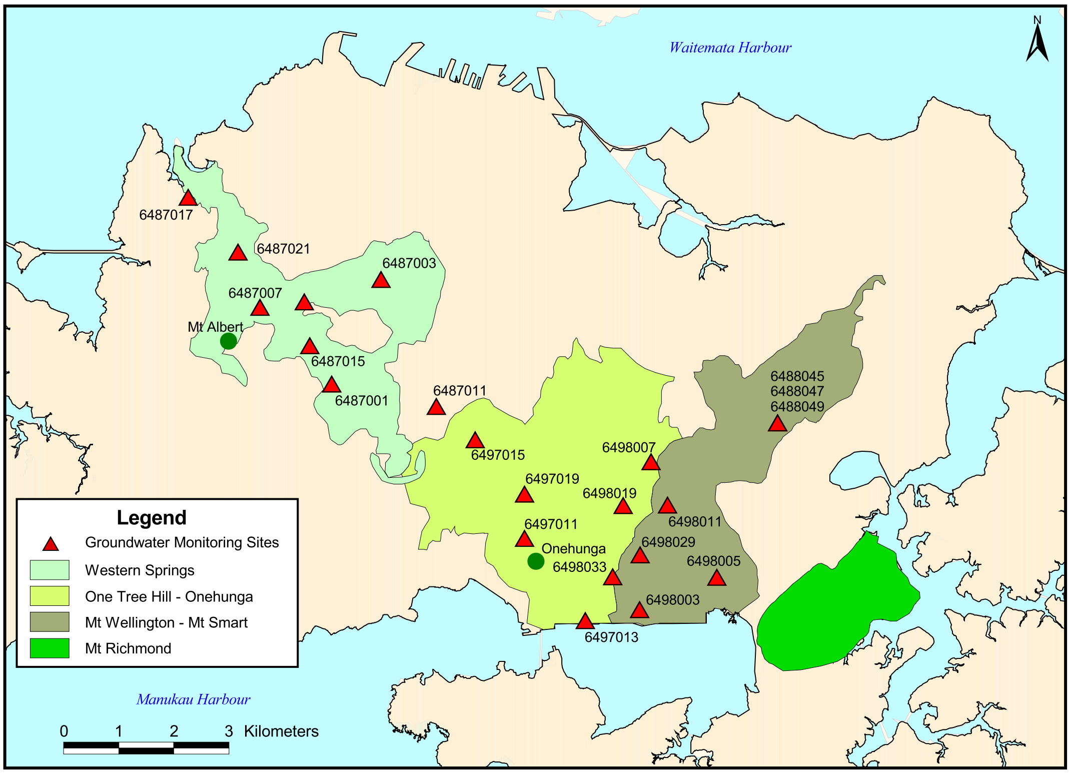

Figure 10.8: Location of Volcanic Aquifers and Volcanic groundwater monitoring sites in the Auckland Central area.

Table 10.2: Auckland Central volcanic aquifers' origin, transmissivity and thickness.

Aquifer Name	Contributing volcanic centres	Transmissivity m^2/day	Aquifer thickness m
One Tree Hill- Onehunga	One Tree Hill,	142-2,656	< 60
Mt Wellington-Mt Smart	Mt Smart, Mt Wellington	111-1,637	
Western Springs	One Tree Hill, Three Kings, Mt Albert	103-7,800	< 50
Mt Richmond	Mt Richmond	260 (tuff) – 1,500 (rock)	< 45
McLaughlins Mtn / Wiri Mtn	McLaughlins Mtn / Wiri Mtn	NA	< 30

Most aquifer recharge is from rainfall and infiltration of stormwater via soak holes. To a lesser extent pipe leakage, both municipal water supply and wastewater, recharges the aquifers. Groundwater levels in the volcanic aquifers respond rapidly to rainfall events (within 20 minutes in some monitoring bores). Groundwater hydrographs for automatically monitored bores show many sharp peaks, in response to recharge events imposed on an underlying seasonal water level record (fig. 10.9). Automatic water level recorders are installed in 6 volcanic groundwater monitoring bores; 33 additional bores are monitored monthly. The location of ARC groundwater monitoring sites is illustrated in figure 10.8.

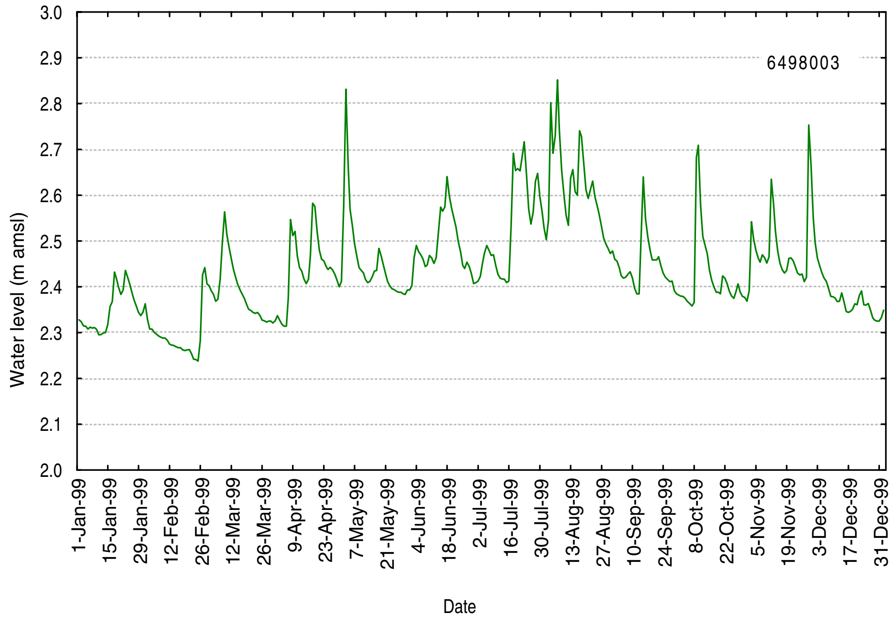

Figure 10.9: 1999 groundwater levels at Angle Street (6498003) showing the rapid response to recharge events.

Groundwater availability has been calculated using the water balance approach and some estimates have been substantiated through the application of numerical models. Present recharge is considerably greater (as much as 3 times) than pre-urban development due to the increased input of stormwater directly into the aquifer from a greater volume of runoff from larger areas of impervious surfaces (Viljevac & Smaill, 1999).

Groundwater in the basalt aquifers is generally low in dissolved constituents, as shown by conductivities below 30 mS/m with low total alkalinity and silica concentrations, and slightly acidic pH (~6.5). It is some of the highest quality groundwater in the region. Contamination from stormwater may show as elevated concentrations of sulphate, potassium, bicarbonate and total hardness. Elevated nitrate, in the order of 2-4 g/m^3, is a result of leaky sewers, stormwater input or landuse practices e.g. horticultural or pastoral.

10.4.2 Waitemata Aquifer

The Waitemata Aquifer is an important source of groundwater in Manukau/Wiri and Clevedon (fig. 10.10). On the isthmus few bores have been drilled to the Waitemata Aquifer, with preference given to abstraction from the overlying volcanic aquifer. Transmissivities, aquifer thicknesses and recharge for Waitemata Aquifers are presented in table 10.3.

Table 10.3: Aquifer properties & recharge in key Waitemata Aquifers in Auckland Central.

Aquifer	Aquifer thickness m	Transmissivity m^2/day	Recharge m^3/year
Manukau/Wiri	>500m	2-21	660,000
East Tamaki	Up to 420m	NA	1,820,600
Clevedon east	Up to 230m	1-8	379,400
Clevedon west	Up to 300m	15-61, 360	964,400

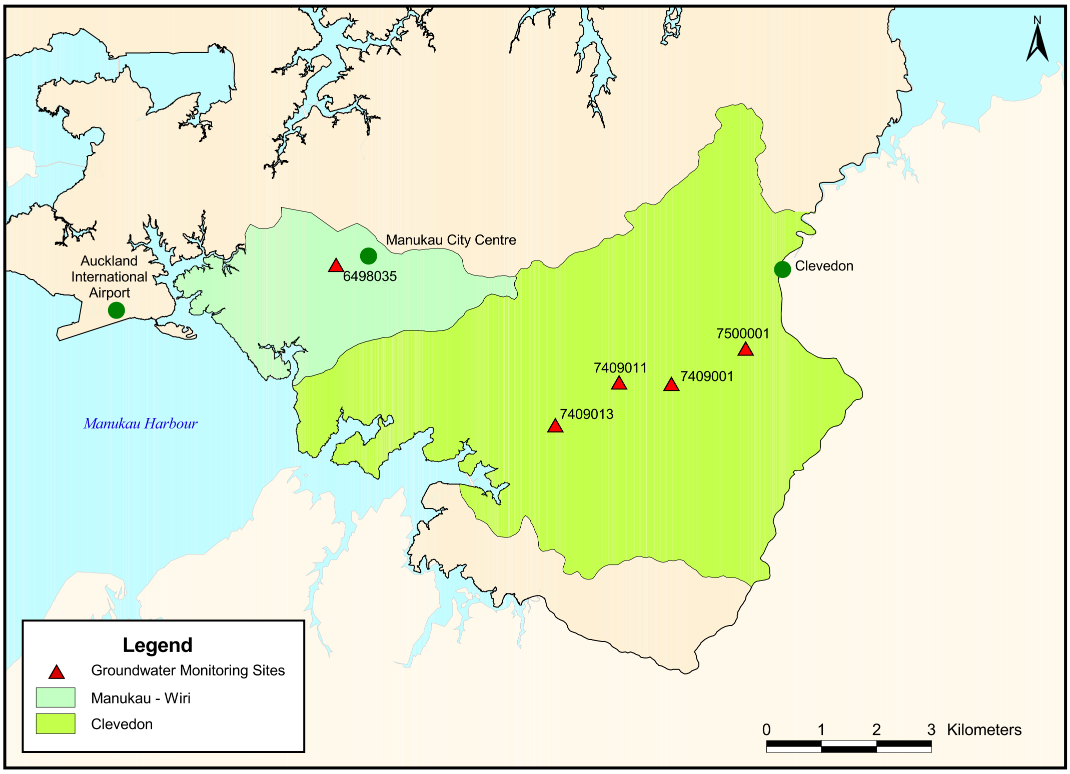

Figure 10.10: Groundwater monitoring sites and Waitemata Aquifers in Auckland Central

Clevedon Aquifer

The Clevedon Waitemata Aquifer has low transmissivities however most pumping tests have been carried out on bores that do not penetrate the full thickness of the aquifer. There is an upward hydraulic gradient from the Waitemata Aquifer to the overlying alluvial sand aquifer. Thus recharge to the Waitemata Aquifer is inferred to occur via sandstone outcrops in the hills to the north and south of the Clevedon Valley. Net recharge to the Clevedon Aquifer has been estimated using a soil water balance model as 93 mm/year over the 17 km^2-recharge area.

Bore water levels show that surface water divides are also groundwater divides in the hills to the north and south of the Clevedon Valley. The ARC groundwater monitoring bores between Ardmore and Clevedon show there is a groundwater divide in the Waitemata Aquifer in the vicinity of Burnside Road area. This coincides with the surface water divide. Groundwater levels in ARC Burnside Road monitoring (7409001) show seasonal fluctuations (fig. 10.11) similar to those in other Waitemata Aquifers in the region. Bores drilled to the Waitemata Aquifer in the Clevedon area are not particularly high producers (40-200 m^3/day from a 100mm diameter bore). Although bores that intercept the base of the Waitemata Aquifer in the Clevedon Valley tend to yield significantly higher production volumes and transmissivities are higher.

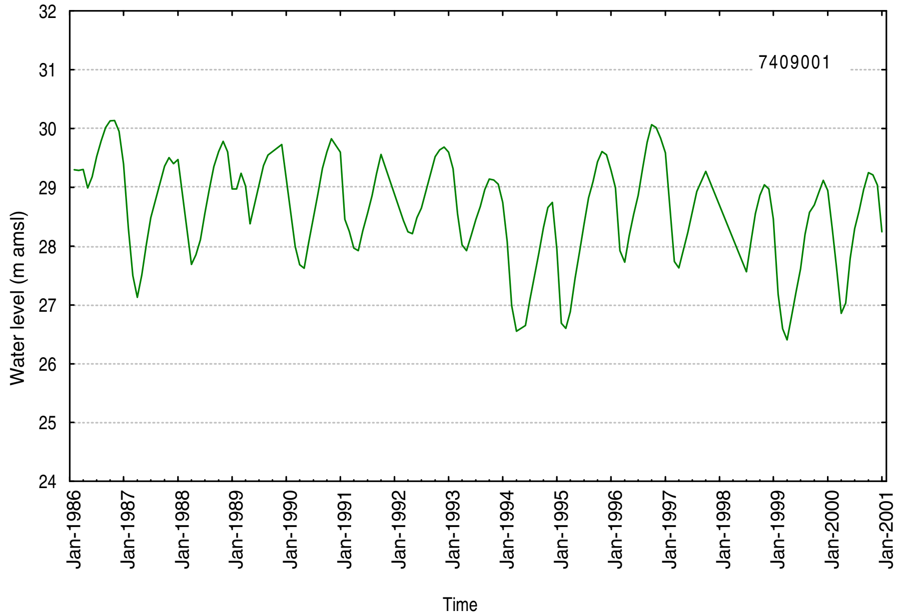

Figure 10.11: Groundwater level record at Burnside Road (7409001) monitoring bore.

10.4.3 Kaawa Aquifer

The Kaawa shellbed(s) is an important aquifer in the Manukau lowlands (see Section 12) and corresponding shell beds have been encountered in the Auckland Airport area north to the Mangere lagoon and again in the Middlemore area. Bores constructed in the Kaawa Aquifer are generally screened across coarse shell and/or sand beds. Typical well (100-150mm diameter) yields are between 800-1,200 m^3/d. Transmissivities range from 30-500 m^2/day and storativities from $1x10^{-2}$ –$1x10^{-5}$.

10.5 Water Management

10.5.1 Surface Water Management

Most surface water allocated within the Auckland Central area is used industrial purposes or for pastoral and horticultural irrigation. Water is principally extracted directly from springs and the stream channel, or from on-stream dams. The ARC monitors stream flow and abstraction closely to check that demand for water during summer months does not reduce stream flow below critical biological thresholds.

Springs and streams draining the Auckland Central Volcanics are managed conjunctively with groundwater resources. The One-Tree Hill-Onehunga groundwater management plan (Smaill, 1993) sets out the management objectives for both the aquifer and the springs (Bycroft, Captain and Grotto). Spring baseflow is linked to groundwater availability and abstraction in the aquifer. Watercare Services Ltd. has consent to take up to 30,000 m^3/day from their bore field up gradient of Bycroft Spring.

The largest user of surface water in the Auckland Central area is Colyer Mair Ltd., who have an allocation (AR962627) of 550 m^3/day and 100,000 m^3/year from Bycroft Spring. W Sutherland & Co Ltd. have consent (AR956831) to take 450 m^3/day and 80,000 m^3/year from this. Surface water allocations for high demand catchments are in table 10.4.

Surface water allocation and consent numbers in the Auckland Central surface water management areas is presented in table 10.5 and management areas are illustrated in figure 10.12. Note that the Taitaia is discussed with the Wairoa and Aroaro surface water management area in Chapter 11.

Table 10.4: Surface water consent numbers and allocations in high demand catchments in the Auckland Central area.

Catchment	Number of consents		Allocation from m^3/day		Total daily allocation from surface water m^3/day
	Stream	Dam	Stream	Dam	
Bycroft Stream	2	0	1,000	0	1,000
Captain Springs	2	0	3,289[1]	0	3,289
Puhinui	4	0	1,615	0	1,615
Waikopua Creek	0	3	0	1,586	1,586

1. this includes an allocation of 3,281 granted to Lichensteins to take from both groundwater and surface water.

Table 10.5: Surface water consent numbers and consent allocations in the Auckland Central area.

Management area	Number of consents		Allocation from m^3/day		Total daily allocation from surface water m^3/day
	Stream	Dam	Stream	Dam	
Auckland Isthmus	5	0	4,401	0	4,401
East Tamaki, Whitford, Beachlands	3	8	372	4,886	5,258
Manukau City	4	1	1,615	2,400	4,015
Upper Manukau	12	4	366	475	841
Total	24	14	6,754	7,761	14,515

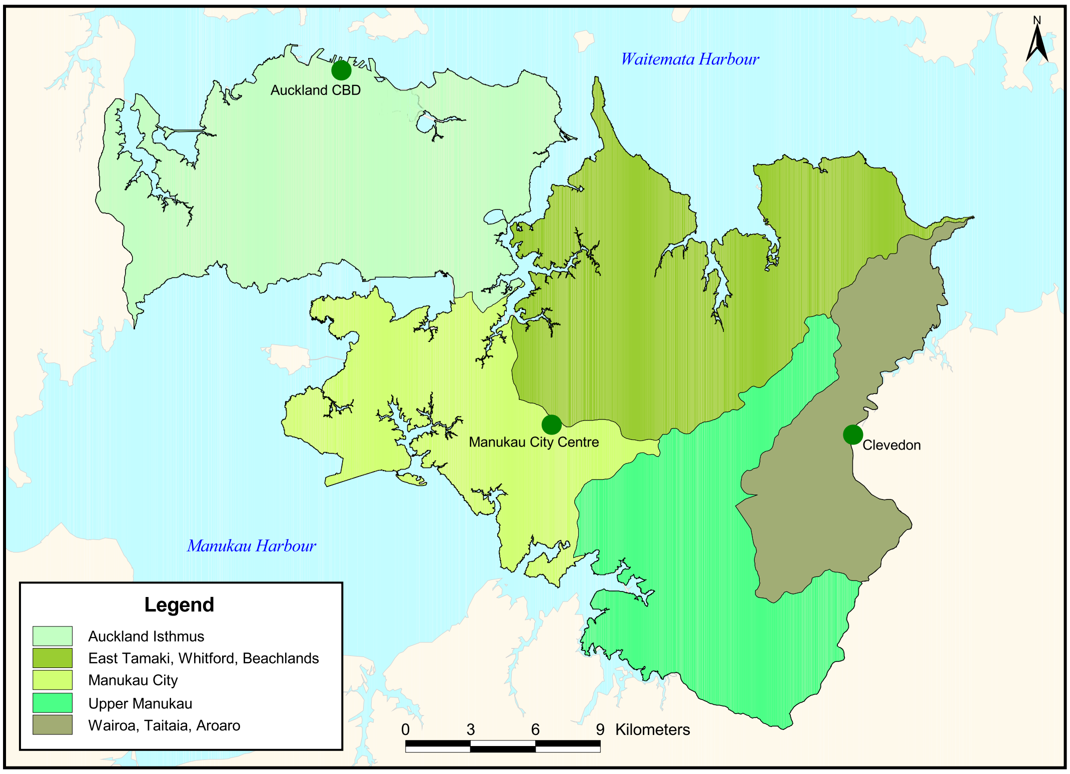

Figure 10.12: Surface water management areas in Auckland Central

The management strategy for the Puhinui Stream focuses on the extent to which abstractions from the lower reaches of the stream degrade stream water quality and result in increased stress on aquatic fauna. The largest abstractive demand in the Puhinui Catchment is toward the bottom of the catchment at Price Road. The largest allocations have been made to Perry's Berrys Ltd. (550 m^3/day), JMC Aarts Produce (500 m^3/day) and Vegmak Produce Ltd. (500 m^3/day). Milburn NZ Ltd. has an allocation of 65 m^3/day from a spring. The total quantity allocated, averaged over 24 hours is 70% of the one in five year low flow. When natural stream flow reduces below double the mean annual low flow, then two main irrigators must reduce their combined pumping rate. Priority is given to Perry's Berrys Ltd. who has the older consent.

10.5.2 Groundwater Management

There are 6 groundwater management areas within the Auckland Central area (fig. 10.13). A small part of the South Auckland groundwater management area overlaps with the Auckland Central reporting area. However, that area is discussed in Chapter 12. Groundwater allocations and consent numbers within the groundwater management areas are presented in table 10.6.

Groundwater availability figures have been estimated for key volcanic aquifers on the Auckland isthmus, the two Kaawa Aquifers and Waitemata Aquifers. Estimates of aquifer recharge and groundwater availability have been determined in response to geographic areas of relatively high groundwater demand. Areas for which groundwater availability figures have not been calculated indicate areas of relatively low demand.

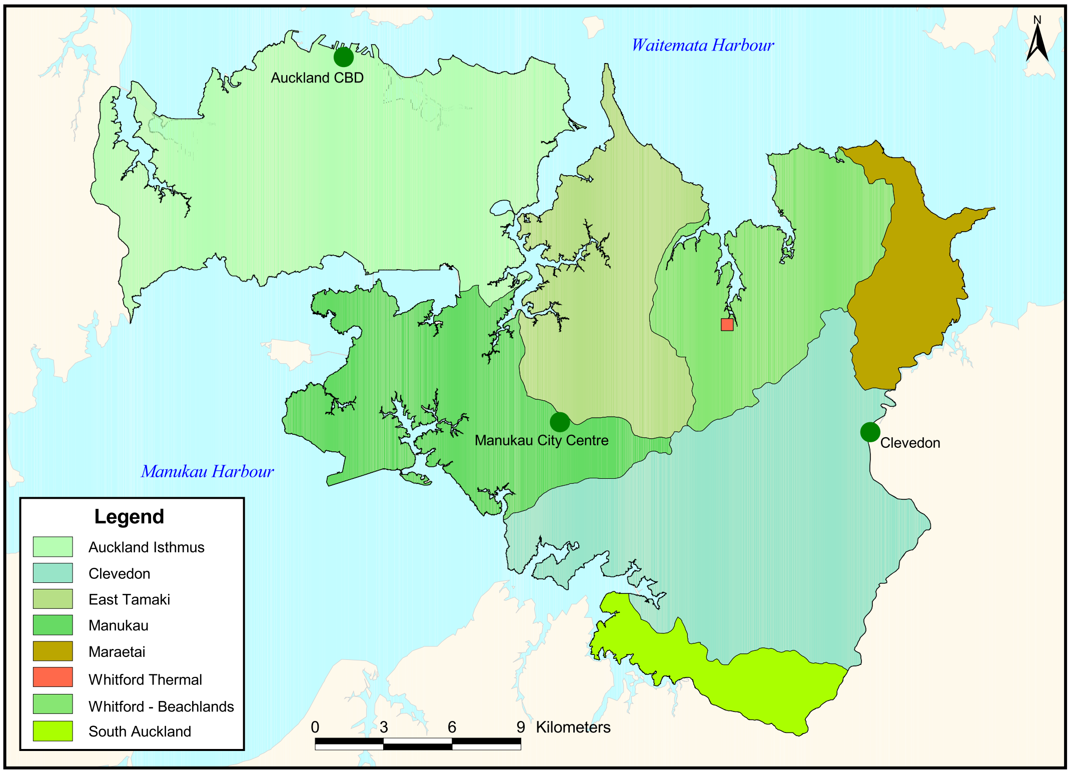

Figure 10.13: Groundwater management areas in Auckland Central

Table 10.6: Groundwater allocation and consent numbers in Auckland Central area.

Management Area	Water allocation m^3/year	Number of consents
Auckland isthmus groundwater	13,478,919	78
Clevedon	1,207,016	50
East Tamaki	98,000	10
Maraetai	5,750	5
Whitford-Beachlands	216,450	22
Manukau	1,467,835	44
TOTAL	16,473,970	209

Auckland Volcanic Aquifers.

The Auckland Volcanic Aquifers are managed for three main objectives: to maintain spring and stream baseflow, to maintain aquifer water quality, including preventing saline intrusion, and to use the aquifer for stormwater disposal without adversely affecting the aquifer.

The volcanic aquifers in Auckland Central Isthmus are managed separately (table 10.7). However, groundwater divides within the One-Tree Hill-Mt Wellington and Mt Richmond aquifers has allowed for further division of the aquifers for management purposes. A groundwater divide at Mt Smart enables the One-Tree Hill-Mt Wellington Aquifer to be split into One-Tree Hill-Onehunga and Mt Wellington-Mt Smart management zones. The Mt Richmond aquifer is split into Mt Richmond and McLennan’s Hill management zones.

Groundwater availability has been determined for each aquifer with the three management objectives in mind. The quantity available is based on aquifer recharge less 15% to ensure maintenance of spring flow and aquifer through flow to the coast. The total quantity of groundwater available for allocation from the separate management area is shown in table 10.7.

Table 10.7: Auckland Volcanic Aquifer groundwater availability and allocation in Auckland Central.

Management Area	Water availability m^3/y	Water allocation m^3/y
One Tree Hill-Onehunga	8.47M	7.35M
Mt Wellington-Mt Smart	4.74M	3.44M
Western Springs	9.60M	2.84M
McLennans Hill	585,620	0
McLaughlins Mtn / Wiri Mtn	1.45M	213,636
TOTAL	24.8	13.8

Despite the Auckland Volcanic aquifers vulnerability to contamination the groundwater quality is suitable for a wide range of uses. The highest use aquifer is Onehunga/Mt Wellington, where water is taken for municipal supply and numerous industries use groundwater for industrial processing. Watercare Services Ltd. has consent to take 7M m^3/year groundwater for municipal supply at Onehunga. Four consents are granted to take groundwater from Onehunga area for industrial purposes and the Ellerslie Bowling Club has consent for irrigation. Three consents to take spring water are managed conjunctively with groundwater allocations and the 180,960 m^3/year annual allocation to these users is included in table 10.7. The largest groundwater user in the Mt Wellington management zone is Winstone Aggregates Ltd., who take water for quarry dewatering and processing of aggregate at Lunn Avenue. Most other groundwater use in Mt Wellington is for industry and the ARC holds consent to take 8,000 m^3/year groundwater to irrigate fields at Mt Smart stadium.

Groundwater demand in the Western Springs Aquifer is not very high. However, during the 1994-1995 Auckland water crisis the Auckland City Council investigated part of the aquifer as a source of supplementary municipal supply water or wash water. No application was made to take water for this purpose. The Western Springs Aquifer is the main source of water to the Western Springs Lake. Applications to take groundwater in the vicinity of the lake are carefully managed to ensure that discharge to the lake is maintained at sufficient level for the lake to flush adequately.

The volcanic aquifers at McLaughlins Mountain, where Watercare Services Ltd. holds consent to take water, is within the Wiri Waitemata Aquifer Management area. The water availability of 1,445,000 m^3/year has been calculated from recharge over the volcanic area, with a 15% allowance for stream flow and outflow at the coast.

Waitemata Aquifer

Waitemata Aquifers underlie most of the Auckland Central region. However, groundwater demand from Waitemata Aquifers is limited in the isthmus but high in Manukau and Clevedon. Groundwater is also abstracted from bores in East Tamaki, although use is fairly limited due to the poor aquifer characteristics across much of East Tamaki. Groundwater availability and allocation in the Manukau and Clevedon groundwater management areas is in table 10.8.

Table 10.8: Waitemata Aquifer groundwater availability, allocation and use at 31 May 2001.

Aquifer	Water Availability m^3/year	Water Allocation m^3/year
Manukau (Wiri)	660,000	446,500
Manukau (Puhinui)	130,000	118,400
Clevedon east	379,400	115,620
Clevedon west	964,400	770,200
Clevedon others	NA	192,340

Manukau

The Waitemata Aquifer in the Manukau City area is managed in two areas, the Wiri Management plan area to the south and the Puhinui Management plan area. The Wiri Management plan area receives recharge from rainfall in the sandstone hills in the Redoubt Road area. Groundwater availability of 660,000 m^3/year allows for a water contribution to stream baseflow and through-flow at the coast to prevent salt-water intrusion. The Puhinui Management plan area is largely located north of Puhinui Road and is bounded by the Waiokauri Creek to the north-west. Water demand in the area is principally for horticultural uses along the western end of Puhinui Road. Water availability, determined from recharge infiltration rates, is 198,000 m^3/year.

Clevedon

Groundwater availability figures set in 1986 (ARWB, 1986) have since been superceded by information obtained in processing consent applications for Roberts Holdings Ltd. and NZ Dairy Foods Ltd. These applications are the largest in the Clevedon Aquifer area being allocated and 170,000 m^3/year and 400,000 m^3/year respectively. In total there are 53 issued consents allocated a total of 555,320 m^3/year groundwater in the Clevedon Aquifer.

Kaawa Aquifer

The lack of known continuity between Kaawa shell beds in the Middlemore area and those beds in the Mangere area has meant that annual groundwater availability estimates have been calculated separately for the two areas (table 10.9).

At Middlemore groundwater demand is for irrigation water for Auckland Golf Club and Grange Golf Club. Both golf courses have coastal boundaries and the greatest risk to the groundwater resource is from saline intrusion. However, the proximity to the coast also means that the golf club bores will be the first to detect salt-water intrusion and elevated chloride and sodium will have an adverse effect on the courses. It is in the best interests of the consent holders, therefore, to keep within the allocations granted.

Table 10.9: Groundwater availability and allocation figures for the Auckland Central Kaawa Aquifers

Aquifer	Groundwater availability m^3/year	Groundwater allocation m^3/year
Middlemore	1,106,606	170,800
Mangere	1,554,000	629,450
TOTAL	2,660,606	800,250

At Mangere groundwater demand has gradually changed from wholly irrigation to some commercial as landuse has changed. The aquifer has a long length of coastal boundary and must be managed to ensure that salt-water intrusion does not occur. As groundwater allocation is well within availability the risk of saltwater intrusion would appear low. The largest consent to take from the Kaawa Aquifer is for 1200 m^3/day and 414,800 m^3/year. This consent, granted to Manukau Wastewater Ltd. for a 2-year term, is to assist in processing sludge from the Mangere sewage treatment plant oxidation ponds.

10.6 References

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11 Hunua Water Resource Area

11.1 Introduction

The Hunua Ranges, formed from uplifted blocks of greywacke rock, are a significant topographic feature in the Auckland Region. Many faults dissect the Ranges and there is potential for earth movement along them. About 40% of the Hunua area (183 km^2) is regional parkland, within which are the Mangatangi, Mangatawhiri, Cosseys and Wairoa water reservoirs (fig. 11.1). Development within the parkland area is restricted to protect these water supplies and to protect native flora and fauna. Watercare Services Ltd., own and operate the water supply dams and have resource consent to dam and abstract water for municipal supply.

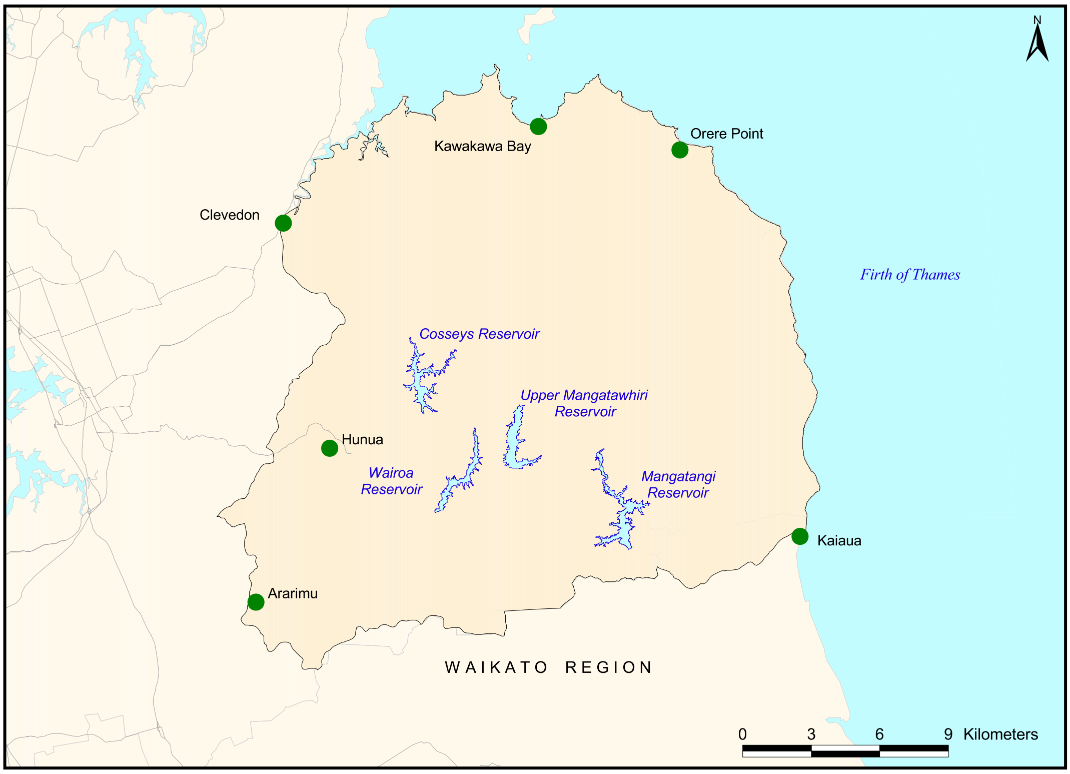

Figure 11.1: Location map for the Hunua water resource reporting area.

Outside regional parkland, land is used predominantly for farming. There are no large population centres, although there are numerous small settlements, mainly on the margins of the area. Water demand is for horticulture, small communities and lifestyle blocks, which is mostly supplied by surface water abstractions. Water management in the Hunua area has focused on surface water, particularly on the large water supply dams and related abstractions. The most recent investigations have been in the Wairoa Catchment, a project initiated at the time of the Cossey & Wairoa Dams consent renewal.

11.2 Rainfall

The ARC operates three automatic rainfall recorder sites. Two sites are located in the western sector of the Hunua Region: Hunua Nursery (750010) and Mangawheau weir (751019). On the Kaiaua Coast a site is operated at Waharau Regional Park (750213). Two manual sites provide additional information for the western sector. They are located at Frosts Road (750011), Clevedon and at Aldridge Road (751018) in the Mangawheau Catchment (fig. 11.2).

Elevation plays a major role in rainfall distribution across the Hunua Region. Mean annual rainfall isohyets (fig. 11.2) clearly define areas of high and low rainfall. Annual rainfall ranges from a maximum of over 1,600mm in the Orere Stream Catchment in the central Hunuas, to a minimum below 1,300mm along the Kaiaua Coast.

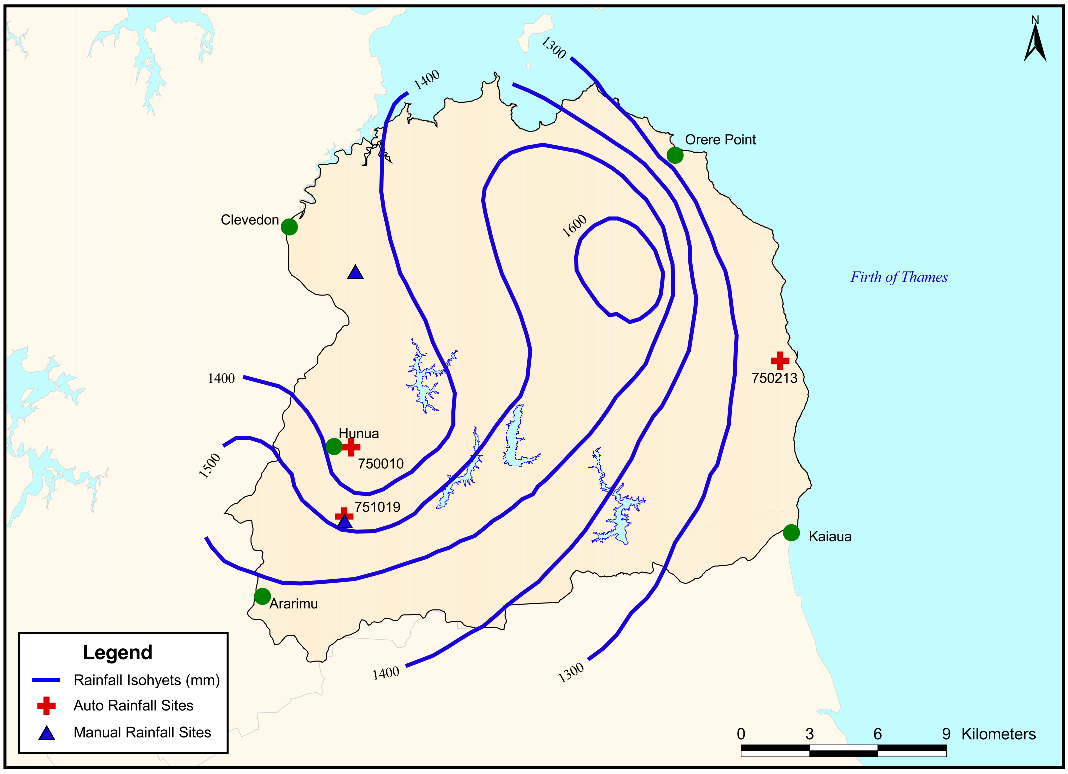

Figure 11.2: Hunua area rainfall monitoring sites and mean annual rainfall isohyets.

The rainfall record at Otau Mountain Road (750011) illustrates a general rainfall trend in the Hunua area over the last ten years (fig. 11.3). The record clearly shows the drier than average 1993-94 period that caused municipal water supply concerns in the Auckland Region.

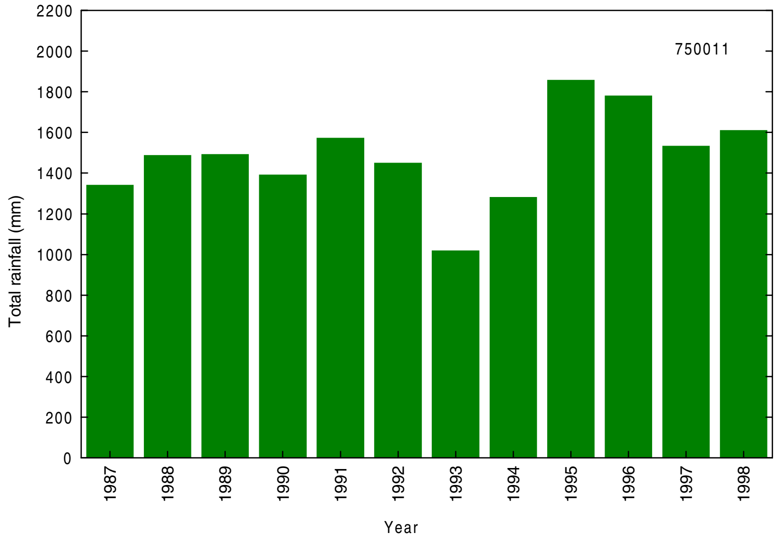

Figure 11.3: Annual rainfall record at Otau Mountain Road (750011).

11.3 Hydrology

The Hunua area comprises the Mangatangi, Mangatawhiri, Taitaia, Wairoa, Aroaro, Orere catchments and streams that drain east to the Firth of Thames. The ARC operates two automatic flow recorder sites in the Hunua area. Tourist Road (8516), on the Wairoa River has measured flows close to the outlet of the Wairoa catchment since 1979. A second flow recorder (8529) was installed at Aldridge Road, upstream of Tourist Road in 1988. This site measures flows from the Mangawheau sub-catchment of the Wairoa River. NIWA operates and maintains an automatic flow recorder site at Orere Road Bridge (8404), on the Orere stream. The location of flow monitoring sites is shown in figure 11.4.

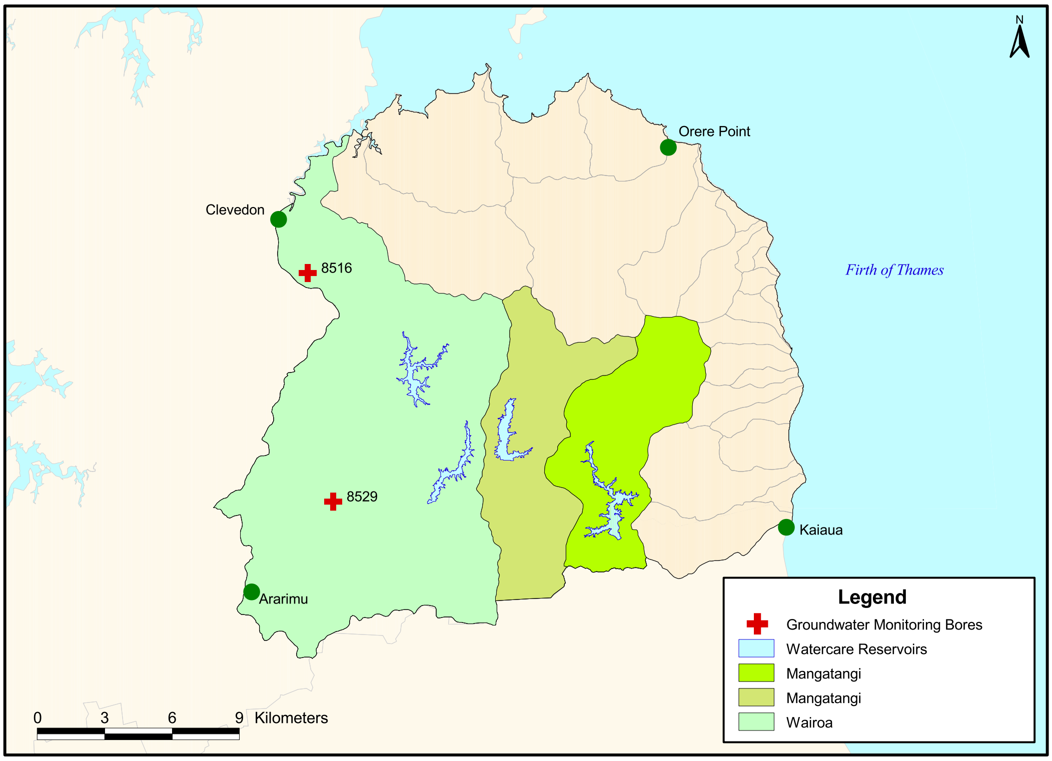

Figure 11.4: Surface water catchments, reservoirs and flow monitoring sites in the Waitakere area.

Surface water hydrology in the Hunua area has been significantly modified by the construction of the water supply dams in the Wairoa, Mangatangi and Mangatawhiri catchments. Stream flows in the Wairoa and Mangawheau catchments fluctuate in response to seasonal changes in rainfall. Mean monthly stream discharges show that stream discharges tend to peak in July and fall to a minimum in February (fig. 11.5).

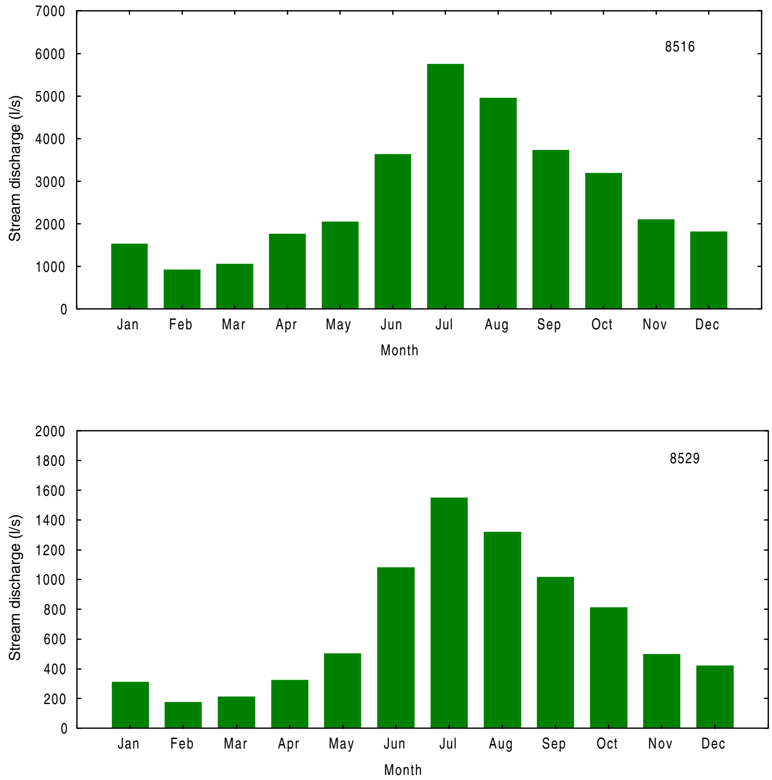

Figure 11.5: Mean monthly stream flows at Wairoa (8516) and Mangawheau (8529) flow monitoring sites.

Flow durations for Tourist Road and Mangawheau weir flow sites are consistent compared with two indicator sites. The flow duration curves in figure 11.6 show that stream flow is maintained by moderate groundwater sources. Flows are consistent across the percentiles except at the extremes (i.e., above the 98^{th} and below the 5^{th} percentile). The baseflow ratio ($90^{th}/50^{th}$ percentile) is an indicator of consistency. At Wairoa and Mangawheau the ratios are 0.34 and 0.32 respectively. These ratios are equivalent to Waitangi and Ngakoroa Streams in South Auckland which are known to have moderate baseflow sources.

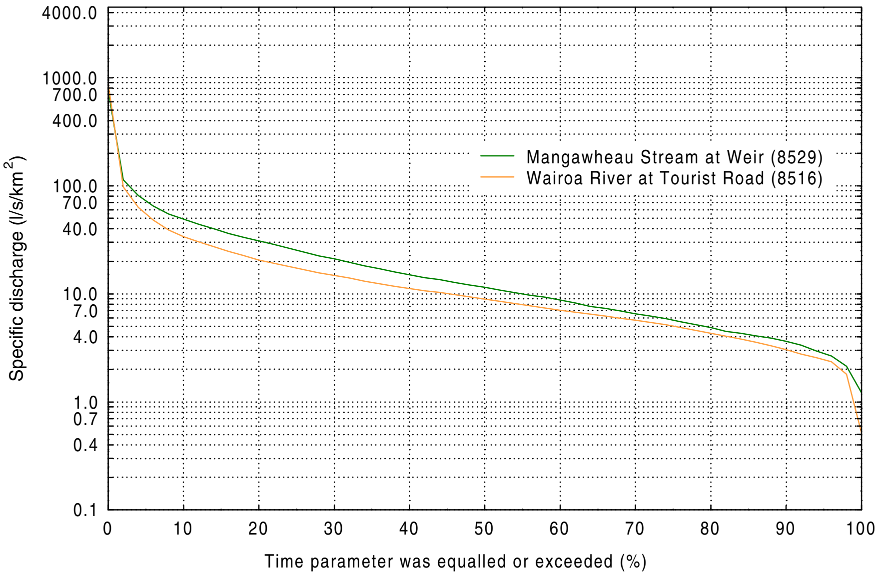

Figure 11.6: Flow duration curves for two Hunua area surface water catchments.

The Wairoa and Mangawheau low flow frequency curves in figure 11.7 shows an inflection point at 400 l/s for the Wairoa and no clear inflection for the Mangawheau. The inflection point is used to differentiate between normal and drought flows. That is, flows below 400 l/s are considered `drought' flows. The occurrence of drought flows is associated with extended periods of below normal rainfall, which generally coincides with summer months.

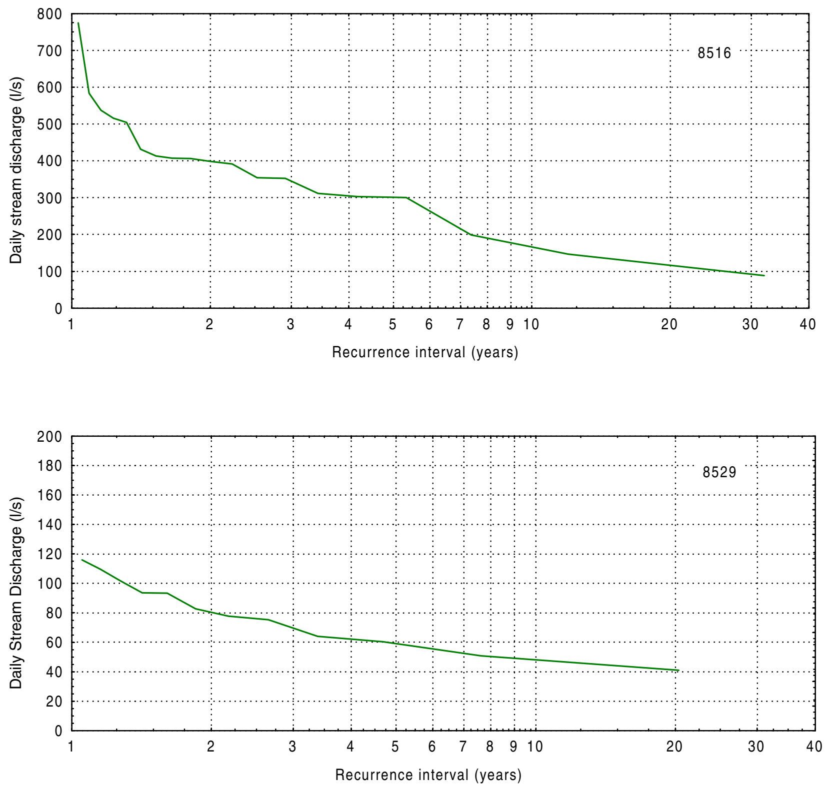

Figure 11.7: Low flow frequency plots at Wairoa (8516) and Mangawheau (8529) flow monitoring sites.

Low flows in Hunua area streams strongly reflect catchment area and rainfall. The 4 Watercare Services Ltd. water supply dams affect the duration of low flow events. The flow and specific discharges of mean annual and one in five year events are presented in table 11.1. The specific discharges for the Orere Stream are the highest of any flow recorder site in the Auckland Region, other than those on spring discharges. ARC has estimated flows for the Aroaro and Whakatiwai streams from gauging correlations with Orere stream site for consent application purposes.

Table 11.1: Low flow estimates for Hunua Region stream catchments.

Site number	Site name	Catchment area km^2	$Q_{2.3}$	Q_5	$SD_{2.3}$	SD_5
			l/s		l/s/km^2	
8516	Wairoa at Tourist Rd	116	380	300	3.27[1]	2.58[1]
8529	Mangawheau at weir	30.4	77	59	2.53	1.94
8604	Orere at bridge	40.4	272	210	6.73	5.20

Note 1:specific discharge are based on the catchment area at Tourist Rd less the Wairoa and Cossey dam catchments i.e. 116 km^2. No allowance is made for the 28 l/s minimum release flow conditions at Wairoa dam.

11.4 Hydrogeology

Greywacke rocks underlie most of the Hunua area. Greywacke is not generally a good aquifer. Most groundwater flow is through fractures in the rock and good producing bores need to intercept fracture zones that transmit water. Most bores drilled into greywacke in the Hunua area can produce adequate supplies for domestic, small community and small-scale horticultural use. A few bores produce much higher yields.

Small basaltic outcrops exist along the western boundary of the Hunua region, along the Drury Hills area. These small pockets are not significant aquifers due to their limited extent. However, some bores abstract adequate supplies from these materials.

Alluvial deposits in the valleys and along the coastal margins of the Hunua area form thin aquifers that in places can produce useful quantities of water. Some domestic bores obtain water from shallow bores drilled into alluvial material and one resource consent holder abstracts irrigation supply from the sands and gravels along the Kaiaua coast.

11.5 Water Management

Most water demand in the Hunua area is for surface water, very little is for groundwater. Apart from the large abstractions from the Watercare Services Ltd. reservoirs most water demand is met through run of stream abstractions.

11.5.1 Surface Water

There are three surface water management areas in Hunua: Eastern Hunua Streams, Mangatawhiri-Mangatangi and Wairoa (fig. 11.8). Watercare Services Ltd. has resource consents for four dams in the Hunua Region, and for the takes from those dams. The significance of the effects of the dams is principally due to the size of the catchment areas annexed by each dam. The dams and their catchment areas are Cosseys (22 km^2), Wairoa

(13 km²), Mangatawhiri (25.8 km²) and Mangatangi (39.4 km²) (fig. 11.4). There are no specific abstraction limits on the Watercare Services Ltd. resource consents to take and dam water. Consent conditions require mitigation including compensation flows from the dams to retain specific flow conditions downstream of the dams. Other than those consents issued to Watercare Services Ltd., there were 34 issued consents to take surface water in the Hunua area at 31 May 2001, comprising 30 takes directly from streams and four from dams (table 11.2). There are no takes from the Mangatangi/Mangatawhiri surface water management area other than Watercare Services Ltd. Pastoral, horticultural and recreation field irrigation is the main purpose of non-Watercare Services Ltd. surface water resource consents in the Hunua area.

Table 11.2: Surface water consent numbers and consent allocations in the Hunua Region, excluding Watercare Services Ltd.

Catchment	Number of take consents		Daily allocation m^3/d		Total allocation m^3/d
	Stream	Dam	Stream	Dam	
Wairoa[1]	11	2	1,021	3,628	4,649
Taitaia	5	0	1,432	0	1,432
Aroaro	9	0	2,347	0	2,347
Eastern Hunuas	5	2	1,865	2,700	4,565
TOTAL	30	4	6,665	6,328	12,993

Note 1: Wairoa includes takes from streams, which drain into the tidal Wairoa River estuary as well as those in the catchment of the freshwater Wairoa River.

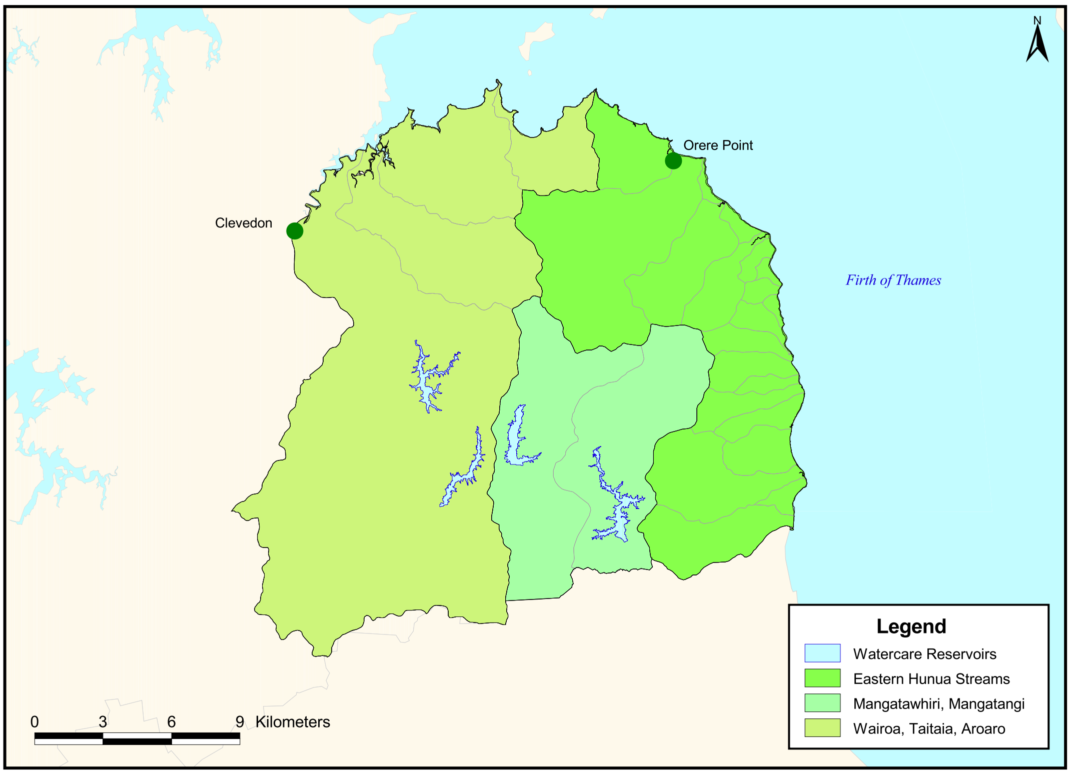

Figure 11.8: Surface water management areas in Hunua.

There are no WRAR's for surface water in the Hunua Region. However, there are Hearing reports for the Watercare Services Ltd. 1999 & 2001 Wairoa/Cossey/Mangatawhiri/Mangatangi dams suite of consents, and water permit reports for the Taitaia (1994) and Aroaro (1995) stream catchments.

On three river catchments, one large take consent comprises more than half the total allocated stream flow. These consents include HK Hattaway Ltd. (900 of a total 1,432 m^3/day) on the Taitaia Stream, Alpers Motel Ltd. (1,500 of a total 2,347 m^3/day) on the Aroaro Stream and JW & PN Wootten (1,340 of a total 1,865 m^3/day) on the Eastern Hunua Stream. All of these consents are for dairy farm pasture irrigation.

11.5.2 Ground water management:

There are no WRAR's for groundwater in the Hunua Region. This is principally because groundwater demand is low and bores tend to be low yielding. Water supplies are generally sought from surface water bodies and/or rainwater.

Groundwater is abstracted from the fractured greywacke, gravels or from discrete sand or basalt aquifers. The gravel aquifer on the eastern side of the region, along the Kaiaua coast is significantly higher yielding than any other the other aquifers in the region. However, current demand is from only 2 consents, one for pasture irrigation purposes and the other for gravel mining.

There were 16 issued resource consents to take groundwater from the Hunua region at 31 May 2001. Most were for the purpose of community supply (67%), with the remainder being for pastoral and plastic house irrigation, and as quarry wash water purposes.

Total water allocation to May 2001 was 349,400 and 3,093 m^3/day. Individual consent allocations range from 437 m^3/year to 300,000 m^3/year.

11.6 References

Water Care Services Ltd, 1999: Wairoa Catchment consents: Technical Report on River Hydrology, Ref 14048

12 South Auckland Water Resource Area

12.1 Introduction

The South Auckland area stretches from the Awhitu Peninsula to the Drury Fault, encompassing the Manukau lowlands, Waiuku, Pukehohe and Bombay (fig.12.1). While one of the dominant features on the South Auckland landscape is Pukekohe Hill (222m), the South Auckland Volcanic field comprises lava flows, scoria cones and tuff rings formed from at least 97 centres (Briggs *et al*. 1994). The basaltic soils that have developed on the volcanic materials have good structure and fertility and are well suited for horticulture. The Awhitu Peninsula protects and encloses the Manukau Harbour from the prevailing westerly winds. The Peninsula is formed from consolidated dune sands, which rise in places to over 250m.

Springs and streams drain the volcanic centres, flowing either to the Manukau Harbour or Waikato River. South Auckland streams are predominantly small, shallow first and second-order streams. Larger South Auckland streams derive their baseflow from volcanic material and lower reaches draining alluvial materials or Waitemata Group. Principally sands underlie streams draining the lowlands and Awhitu areas.

While market gardening in the Pukekohe and Bombay areas continue with a similar intensity to the last 20 years, other changes to land use have occurred over this period. Many kiwifruit orchards, established in the 1980's, have been removed. Market gardening is now occurring in Karaka, historically a pastoral farming area. While the soils may not be as well suited as those around Bombay and Pukekohe, endemic plant disease as a consequence of historical land use is not so prevalent.

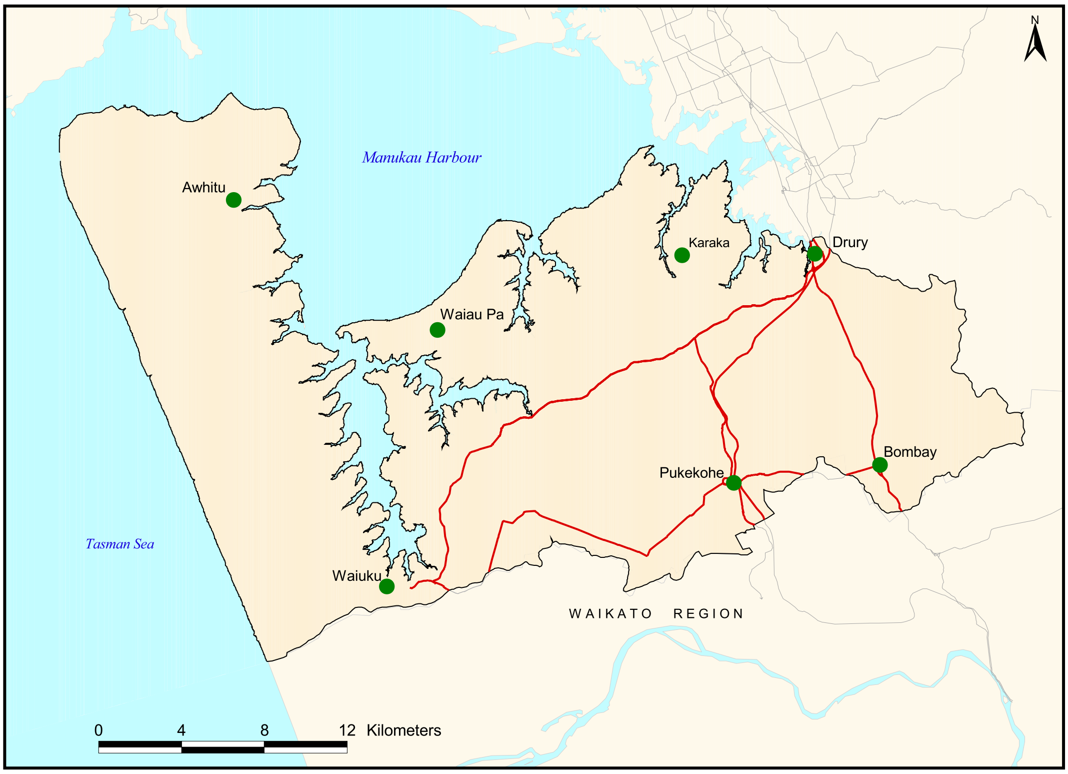

Figure 12.1: Location map for the South Auckland water resource reporting area.

Small-scale intensive glasshouse development has been a feature of the Drury area since the 1980's. Latterly, however, the horticultural industry is moving towards larger-scale development, with potential consequences on the viability of existing (small) growers. This trend also causes changes to the distribution of water demand. The new glasshouse development is often away from the established nodes, where the small land parcel size and potential for bore interference can limit opportunities.

There has also been an increase in rural-residential lifestyle lot development across the Manukau Lowlands, particularly in the Karaka area. Some development has occurred on the site of former orchards and existing irrigation bores can provide communal stock/domestic water supply. While some small scale water use is associated with these holdings, there is likely to be a net decrease in demand as a consequence of the landuse trend. Such developments are likely to increase in the future, with continued urban pressure for such land. There are issues of reverse sensitivity created by these changes, as effects from traditional rural activities does not always meet the expectations of former urban dwellers.

12.2 Rainfall

There are two long-term climate stations in South Auckland: Maioro Forest Station near Waiuku (743701) and, the Pukekohe Horticultural Research Station near Pukekohe (fig. 12.2). Both sites have the same mean annual rainfall (1,375mm), although Maioro has a higher monthly annual mean than Pukekohe (1,848mm compared to 1,678mm). The variation in mean monthly annual rainfall is due to higher summer rainfall at Maioro (271mm) than at Pukekohe (256mm). In late autumn-early spring Maioro receives comparatively less rainfall than (687mm compared to 669mm). Typically February is the driest month (66mm) and July is the wettest (151mm). The distribution of rainfall across South Auckland is variable (fig. 12.2).

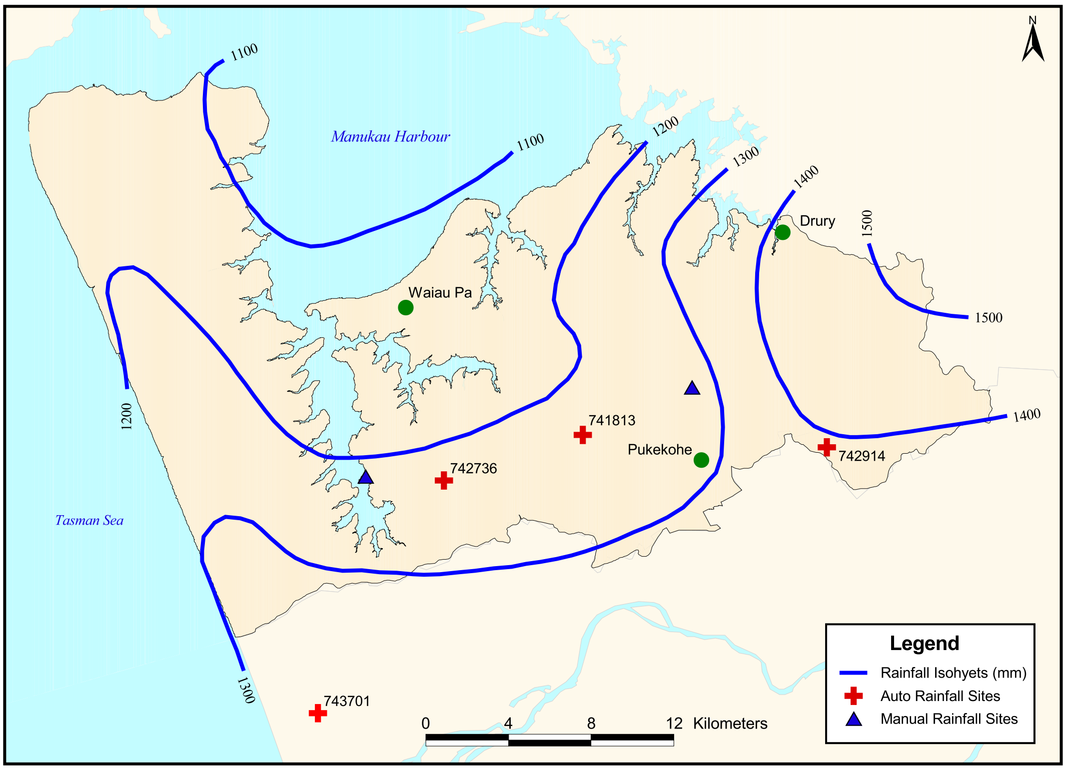

Figure 12.2: South Auckland area rainfall monitoring sites and mean annual rainfall isohyets.

Elevated regions of Awhitu Peninsula and Pukekohe volcanic plateau influence the pattern of rainfall and a distinct rainfall gradient exists between the Manukau Harbour coastline and Pukekohe volcanic plateau.

A comparison of rainfall at Kingseat (9m amsl)(C74182) and Tutaenui (50m amsl) (C74293) shows that the Pukekohe volcanic plateau experiences an additional 68mm for every 1,000mm rainfall recorded at Kingseat. A similar rainfall gradient occurs east of Awhitu Peninsula (119m amsl), where annual average rainfall is 1,000mm (C74261) while Waiuku Steel Mill (20m amsl) receives 908mm (742732).

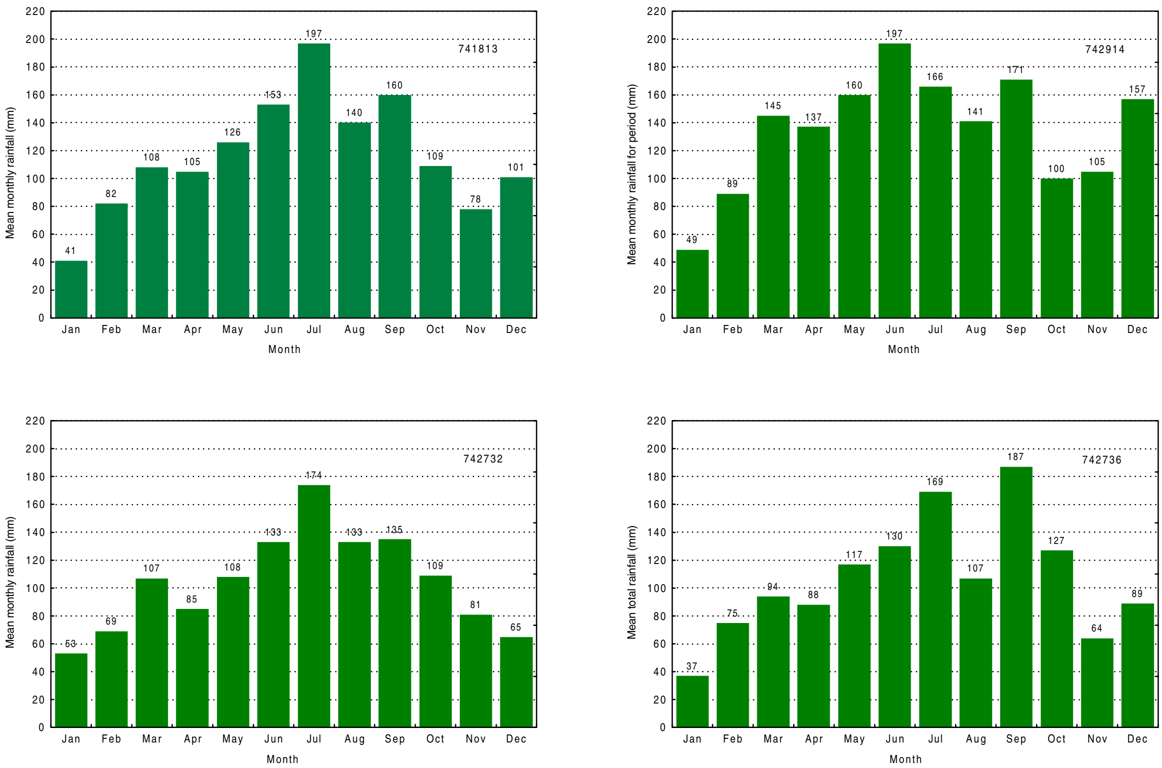

Figure 12.3: Rainfall variation comparison between four South Auckland rainfall monitoring sites.

The highest mean daily temperature of 19°C is recorded in February and the lowest in July of 10°C. The highest recorded daily temperature of 29°C occurred in both January and February. The three hottest months are January, February and March, averaging a mean daily temperature of 18.7°C. Relative humidity peaks in June and July with a mean monthly value of 86%. From July it drops incrementally to a low in February of 76%. Ground frosts occur on an average of 20 days per year between May and October, being most common in July.

12.3 Hydrology

There are several major streams in South Auckland Waitangi, Mauku, Whangamaire, Whangapouri, Ngakoroa and Hingaia (fig. 12.4). They experience amongst the highest demand for abstraction from stream flow in the Auckland Region.

Three automatic water level recorder sites are currently operating in South Auckland. State Highway 22 Bridge on the Waitangi Stream (43602) is considered to be the representative site for the area. The water level recorder has measured flows from an area of 17.6km^2 since 1966 and is maintained NIWA. The ARC maintains two sites, Patumahoe Weir (43811) and Mill Road (43829). Patumahoe Weir, located in the upper catchment of Whangamaire Stream, is considered to represent a groundwater catchment of approximately 10km^2 and a surface water catchment of 4.35km^2. The Mill Road site is on the upper Ngakaroa Stream. The ARC also manually monitors 19 additional sites during summer months.

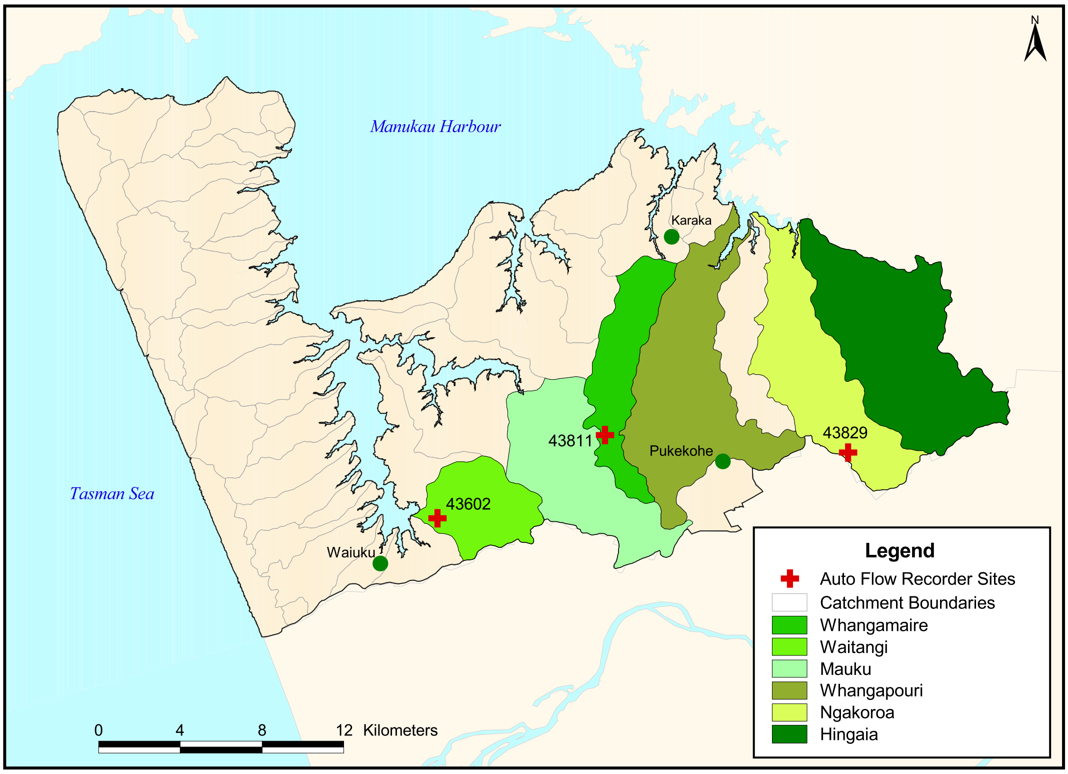

Figure 12.4: Surface water catchments and flow monitoring sites in the South Auckland area. The six key surface water catchments are indicated.

Flow duration curves for each of the automatic flow recorder sites are illustrated in figure 12.5. Each curve is adjusted in response to catchment area for the purpose of making comparisons between flow records. Flows at Patumahoe Weir are consistently higher per square kilometre than at the other two sites. The slope of the flow duration curve, except at the low and high extremes, represents the flow range. A common method for assessing baseflow contribution using flow duration curves is the ratio between the Q_{90} and Q_{50} percentiles. The ratios for each site are listed in table 12.1.

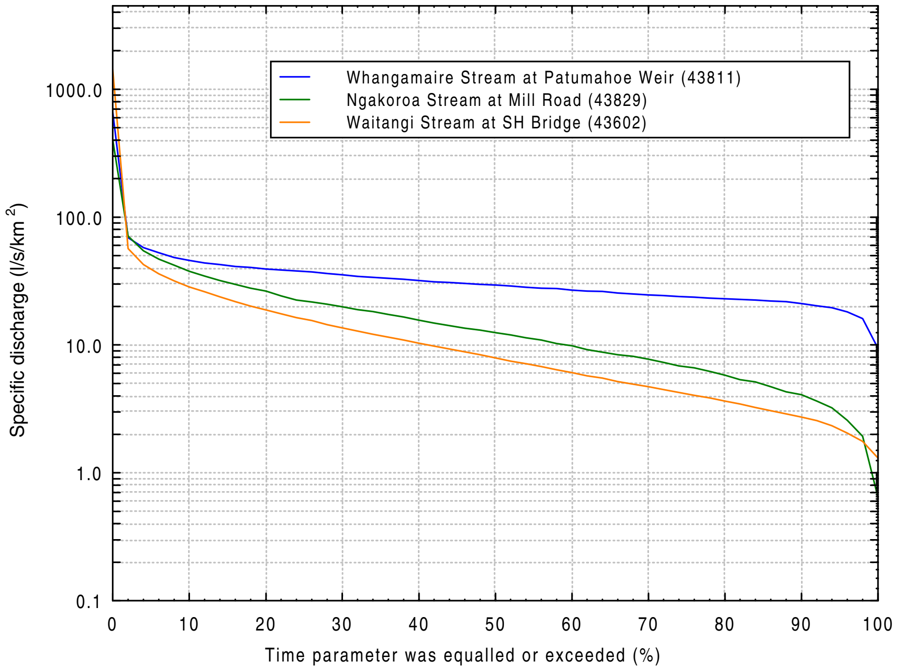

Figure 12.5: Flow duration curves for three South Auckland area surface water catchments.

Table 12.1: Calculated Q90, Q50 flows and baseflow ratios at SH2 Bridge, Patumahoe Weir and Mill Road.

Site	Catchment Name	Q_{90}	Q_{50}	Baseflow Ratio
43602	Waitangi	48	139	0.35
43811	Whangamaire	94	126	0.75
43829	Ngakaroa	19	60	0.32

Stream flows are seasonally variable in response to seasonal rainfall. Mean monthly stream flows for the three automatic flow recorder sites show greatest flows in July, August and September and smallest flows in January, February and March, with the exception of flows at Patumahoe Weir where peak flows are delayed by a month. This delay is due to the groundwater contribution to stream flow at Patumahoe Weir, which is slow to respond to seasonal weather changes i.e. there is a delay between water entering at the ground surface (rainfall) and it leaving the groundwater system via Patumahoe Spring.

Further evidence of a strong groundwater source is indicated by the consistent nature of monthly mean flows. A comparison between the wettest and driest months of the year suggests that a reliable and continuous source of spring water supports stream flow at Patumahoe Weir. There is a decrease of approximately 45% between the August mean flow of 190 l/s and the March mean flow of 105 l/s. In contrast, a decrease of approximately 85% occurs at Waitangi Weir between July and August mean flows. During summer months, minimum flows are of major concern in South Auckland. Low flow frequency curves (fig. 12.6) illustrate the role spring flow has on limiting low flow conditions in the Waitangi, Whangamaire and Ngakaroa stream catchments. While the Ngakaroa curves is flatter that the other two curves this is due to the location of the monitoring site in the upper catchment.

Flows and discharges for the automatic flow recorder sites and selected manual monitoring sites on South Auckland Streams are in table 12.2. A brief discussion of each catchment follows.

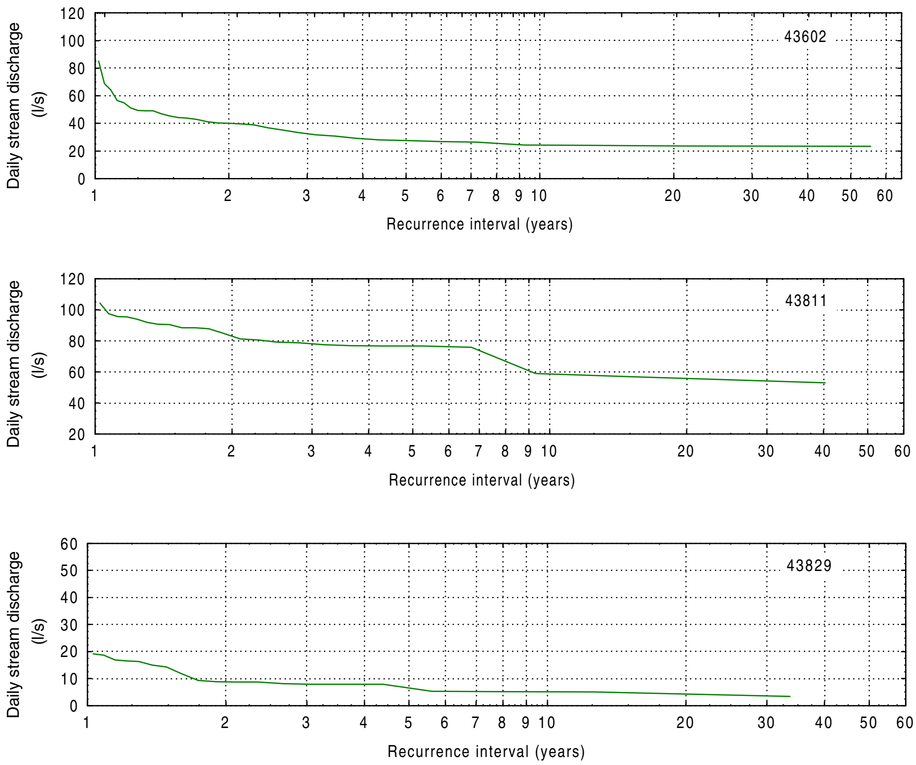

Figure 12.6: Low flow frequency plots for Waitangi (43602), Whangamaire (43811) and Ngakoroa (43829) flow monitoring sites.

Table 12.2: One-day duration return periods, natural flows and specific discharges for six South Auckland stream catchments.

Site Details			Return period					
			1:10		1:5		1:2.3	
Site Number	Name	Catchment Size km^2	Q l/s	SD $l/s/km^2$	Q l/s	SD $l/s/km^2$	Q l/s	SD $l/s/km^2$
Waitangi Stream								
43602	Bridge	17.6	28	1.59	30	1.7	40	2.27
Mauku Stream								
43705	Patullo Rd	31.4	76	2.42	80	2.54	100	3.2
43708	Titi Rd	16.8	53	3.18	55	3.27	70	4.16
43707	Aka Aka Rd	4.5	16	3.5	17	3.8	20	4.4
Whangamaire Stream								
43811	Railway Culvert	4.35	70	16.1	85	19.5	95	21.8
43814	Charles Rd	20.0			110	5.5	120	6.0
Ngakaroa Stream								
43829	Mill Rd	4.73	~9	1.9	9.5	2.01	12	2.54
43872	Runciman Rd	27	40	1.48	42	1.55	52	1.93
	Great South Rd	38	56	1.48	59	1.55	73	1.93
Hingaia Stream								
43851	Quarry Rd	44.4	150	3.38	160		200	4.50

Note that pumping effects have been removed for some streams and values here may differ from those in Appendix 3.

12.3.1 Waitangi Stream

The 18 km^2 Waitangi Stream catchment rises to an elevation of 147m at Bald Hill ridge. A key feature of the catchment is that almost all run-of-stream take water permits are downstream of the weir so there is little pumping effect on the flow record. There are no point source springs with large flows. The surface geology is undifferentiated fine to course grained basalt in the lower catchment with a volcanic centre at Sommerville Rd and two at Bald Hill. The upper catchment is largely tuff with three tuff rings. There is a large waterfall 100m upstream of where the stream discharges into the Waiuku estuary.

The control of the flow-measuring site is a compound weir, which gives additional flow sensitivity at lower flows. The one in five year return period specific discharge of 1.70 l/s/km^2 provides a "benchmark" against which flow in other catchments and sub-catchments of the Franklin lowlands can be compared. Because there is a very long-term record and little pumping effects at low flows, the Waitangi is useful record against which to correlate measurements of flows in other streams.

12.3.2 Mauku Stream

The Mauku stream catchment rises from the Taihiki River at Glenbrook Rd to an elevation of 180m at Middleton Rd close to Pukekohe Hill and covers 38km^2. The upper catchment has gently sloping topography on the western side of the Pukekohe volcanic plateau, with the lower catchment more undulating fluviatile and coastal sedimentary terraces north of Mauku. The surface geology influences stream flows, but there are no significant point source springs identified in the catchment. There is a large waterfall at Wrights Water Gardens at Mauku.

There are three sites in the catchment where manual flow gaugings have been carried out regularly: Patullo Rd (43705) near the bottom of the catchment, Titi Rd (43708), and Aka Aka Rd (43707) near the top of the catchment. Flows have been correlated with concurrent Waitangi weir flows and annual one-day duration low flows derived for various return periods at these three sites in the lower, mid and upper catchment (table 12.2).

The one in five year low flow increases from 55 to 80 l/s (an increase of 25 l/s) in the 14.6 km^2 lower catchment from Titi to Patullo Roads. This is a specific discharge of only 1.7 l/s/km^2 for this part of the catchment. This is similar to the overall value for the Waitangi Stream catchment given above, and less than half the 3.8 l/s/km^2 value for the upper Mauku stream catchment upstream of Aka Aka Rd. This suggests that there is a diffuse springflow contribution to flows in the upper Mauku catchment, due to the basalt surface geology.

12.3.3 Whangamaire Stream

The Whangamaire Stream falls from an elevation of 120m at Pollock Rd, Pukekohe, covers 23km^2 and discharges into Glassons Creek. The main stem begins on the Pukekohe volcanic plateau and drops sharply off the plateau in a cascading waterfall at Hunter Rd scenic bush reserve. Stream flow is dominated by Patumahoe Spring 1.8 km upstream of Hunter Rd.

There is an ARC flow-measuring weir at the Patumahoe railway line culvert just upstream of Hunter Rd (43811). The flow record begins in 1976 but early data is unreliable due to leaks in the wooden weir. A concrete weir was commissioned in May 1983. A comparison has been made between records of springflow, local rainfall and water levels in the nearby DSIR No. 2 groundwater monitoring bore (7428001), which taps a shallow volcanic aquifer 1.5 km from the spring. These records show a seasonal variation of 2 to 3m in the shallow aquifer water level, with a maximum level in Spring (October – November) and the lowest level in Autumn (March – May). Fluctuations in flow from the spring reflect seasonal water level variation in the shallow volcanic aquifer.

The surface water catchment area upstream of the flow weir is 3.8 km^2 giving a 1:5 year low flow specific discharge of 22 $l/s/km^2$. Minimum spring flow occurs in March to May which is generally later than seasonal minimum flows occurs in streams which are not fed by a point source spring.

12.3.4 Whangapouri Stream

The Whangapouri Stream comprises the main stem with two tributaries, which join on the northern side of Glenbrook and Karaka Roads, and discharge into Drury Creek at Blackbridge Road. It has a catchment area of 49km^2. The main stem arises to the east of Pukekohe Township. It receives a large input from three springs: Hickeys Spring in Dublin St, springs in a tributary upstream of Hickey Spring, and Lochview Springs near Lochview Rd. Franklin District Council intercepts flow from Hickeys Spring for municipal supply. The balance of Hickey Spring flow is measured with a V-notch weir. Natural flow from Hickey Spring (allowing for pumping effects) is estimated as contributing approximately 35-40% of the total flow from the suite of three springs at Pukekohe. Lowest flows from Hickey Spring occur in autumn (April-June) each year, not in summer. Hickey Spring low flows for different return periods are in table 12.3.

Table 12.3: Spring Low Flows at three sites on the Whangapouri Stream.

Site	Return period			
	1:20	1:10	1:5	1:2.3
	Q l/s	Q l/s	Q l/s	Q l/s
Hickey Springs	30	40	45	50
Pukekohe Springs	80	105	120	133
Blackbridge Road		150	170	200

12.3.5 Ngakoroa Stream

The Ngakoroa Stream catchment rises to an elevation of 376m at Puketutu Hill south of Paparata Road, Bombay, and covers 38 km^2. The main stem begins on the Bombay volcanic plateau, east of Razorback Road. It passes under State Highway 1 at an elevation of 170m, swings northward and drops off the plateau at Mill Road down to an elevation of 80m at Ingram Road with a low gradient over the 8 km to the estuary. The stream discharges into Drury Creek.

There is an ARC flow-measuring weir at Mill Road Bombay (43829). This is also the ARC long-term baseline freshwater quality-monitoring site for the Franklin area. The flows listed in table 12.2 were determined using the record from 1980 and removing the large effects of irrigation pumping upstream of the weir.

The area of greatest water demand, with a large number of dams, is the 6.2 km^2 Upper Ngakoroa Catchment Management area. Flows calculated from the Mill Road weir low flow specific discharge data for the Management area are: Q_5 12.5 l/s, $Q_{2.33}$ 16 l/s. The Mill Road weir lies above the main spring line for the Bombay volcanic aquifer, which occurs at 100-140m amsl. The flow duration curve for the Mill Rd weir is relatively flat except at both ends where it adopts a steeper angle indicating a strong groundwater input to the stream.

12.3.6 Hingaia Stream

The 55 km^2 Hingaia Stream catchment rises from Drury Creek to an elevation of 376m at Puketutu Hill at Bombay in the south. The main stream arises in the hills south of Paparata and flows west then skirts around the north-east flank of the Bombay hill volcanic plateau. At Stone Road there is a major spring-fed input from a tributary (from which FDC draws Bombay's municipal water supply). The Maketu Stream tributary arises in the hills between Ponga and Ararimu, and joins the Hingaia Stream near Maketu Road.

Springs discharge at 100-140m elevation from the Bombay volcanic aquifer into the main stem around the edge of the volcanic shield just downhill and north of Portsmouth Road. The Q_5 for these Portsmouth Road springs is approximately 70 l/s. Small springs discharge from the aquifer into the Ngakoroa Stream west of the motorway and north of Mill Road at an elevation of approximately 160m amsl. There is no long-term continuous flow record for the Hingaia Stream.

12.4 Hydrogeology

Aquifers in South Auckland include Waitemata Aquifer, Kaawa Aquifer, South Auckland Volcanics and Plio-Pleistocene deposits. Generally groundwater resources have been developed in shallower aquifers first (volcanic and sand aquifers), primarily due to the lower relative cost of drilling a shallow bore. However, where water quality in shallow aquifers is poor or the quantity is insufficient, deeper bores have been drilled. This is especially noticeable in the last 20 years, during which greater use of groundwater in the Kaawa Aquifer and deeper Waitemata Aquifers has occurred.

Unlike many parts of the region more than one aquifer underlies large parts of the South Auckland area. However the interrelationship between aquifers is important to understand in order to assess the potential impacts on these resources. Recent ARC investigations have looked at the relationship between the Kaawa Aquifer and the overlying Pukekohe Aquifer (fig. 12.7). The aims of this work was to quantify the volume of recharge to the Kaawa Aquifer gained from the Pukekohe Aquifer and to identify the interrelationship between groundwater and surface water on the Pukekohe Aquifer. This is discussed further in the following sections.

ARC groundwater monitoring bore locations are shown in figure 12.7. Although monitoring bores tap only one aquifer there are nests of monitoring bores that enable monitoring of shallow and deep aquifers at the same location. These bores have been useful in assisting with determining groundwater flows within and between aquifers. Appendix 4 provides site details for currently used monitoring bores, including the aquifer that each bore taps.

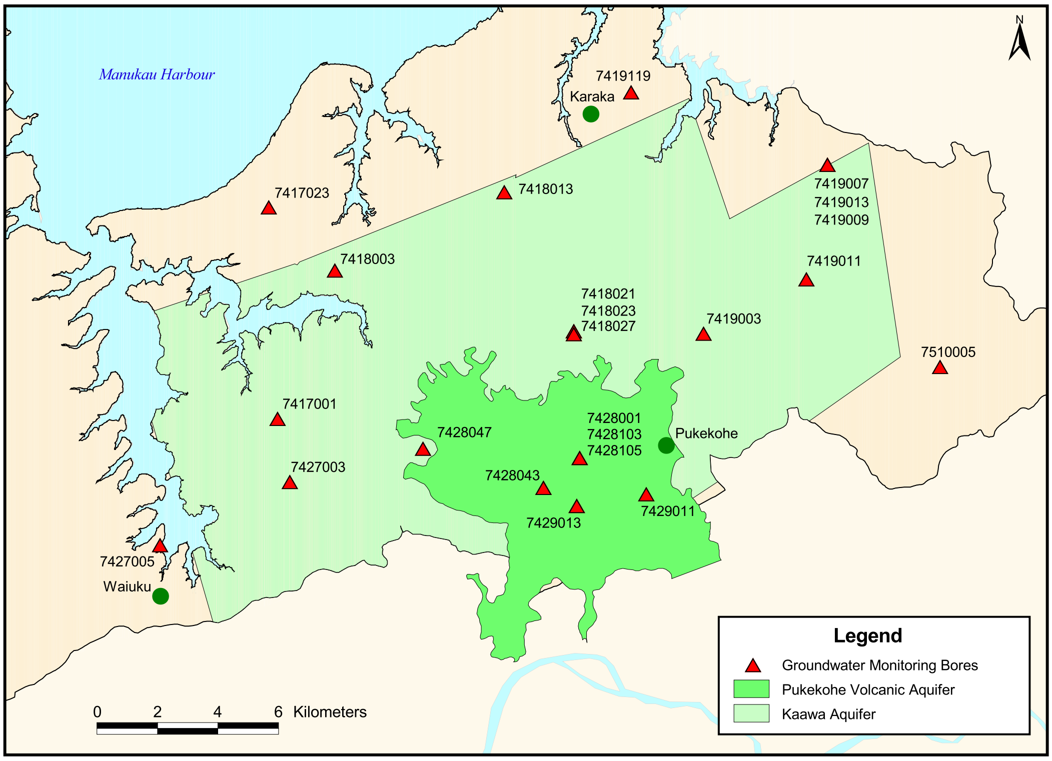

Figure 12.7: Groundwater monitoring sites and aquifers in South Auckland

12.4.1 South Auckland Volcanics

The South Auckland Volcanic Field extends from Papakura to Pukekawa and west to Waiuku. The field is predominantly comprised of lava flows, scoria cones and tuff rings formed through phreatomagmatic activity from at least 97 centres (Briggs *et al*. 1994). While the 0.51 - 1.59 Ma. year old field has been separated into Bombay and Franklin basalt based on age and location, they can not be clearly separated on the basis of hydrogeology. In low-lying areas such as around Drury, volcanics are mantled with Tauranga Group sediments.

Weathering of volcanic rocks has given rise to high quality soils, which have withstood repeated cultivation for more than 50 years. Irrigation water is generally abstracted from relatively shallow (30-60m deep) bores drilled into the fractured basalt. As a result of pumping, low summer groundwater levels have restricted yields from some shallow bores and deeper bores (60-120m) have been drilled.

Three main volcanic aquifers, Glenbrook, Pukekohe, and Bombay can be identified in the South Auckland Volcanic Field. The Pukekohe Volcanic Aquifers, which covers 55 km², is the largest and most important as a source of water supply and recharge to the underlying Kaawa Aquifer. Research by the Institute of Geological and Nuclear Sciences Ltd. indicates that approximately 50% of annual rainfall recharges the aquifer in the Pukekohe Hill area (Rosen et al., 2000). Use as a potable water supply is constrained by an elevated nitrate concentration as a consequence of land use. The hydrogeology of the Bombay basalt is significantly different from that of Pukekohe, with higher water levels and lower transmissivities. Transmissivities determined from tests on the ARC Wootten Road bore (7510005) ranged from 15 to 36 m^2/day. Groundwater recharge discharges as springs to the Hingaia Stream, and contributes to recharge to the Kaawa Formation.

Transmissivities in the South Auckland Volcanic Field vary from 13 m^3/day to as much as 5,600 m^2/day, although more typically transmissivities are in the order of 100 – 500 m^2/day. Storativities vary from $7x10^{-5}$ to $4.2x10^{-2}$. As a consequence of this large water abstractions from bores are possible without significant bore interference effects.

Groundwater levels are monitored in 7 bores at 2-weekly intervals. Levels respond rapidly to rainfall events, as would be expected in aquifers of such high transmissivities. This can be observed in the hydrograph for Revell Court (7429011), which demonstrates the effect of the droughts in 1982/83 and 1993/94, and the higher than normal rainfall of the early and mid 90's (fig. 12.8).

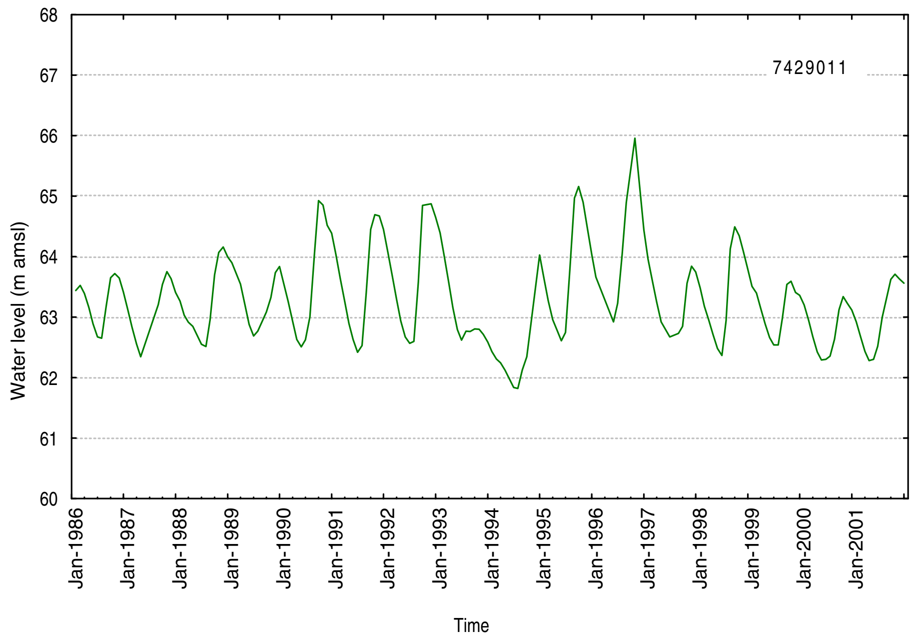

Figure 12.8: Groundwater level record at Revell Court (7429011) monitoring bore.

12.4.2 *Quaternary sediments*

These fine-grained sediments occur throughout the low-lying areas of the Manukau lowlands and are an important source of small water supply for farm holdings and rural domestic supply. Sea level changes, meandering of the ancestral Waikato River, tectonic faulting and local volcanism have produced a very complex depositional environment, which has resulted in highly variable aquifers.

Drury sands

The sand aquifer south of Drury is made up of a combination of Pleistocene (Quaternary) and Pliocene aged sediments. The hydrogeology and management of the system have been described in ARC TP 105 (Murphy, 1991).

Figure 12.9 shows the water level record from the Fielding Road sand bore (7419007) at Drury, which was established in 1989 as part of a resource investigation. Groundwater levels show a seasonal fluctuation of up to 4 metres, but are being maintained above 5m amsl.

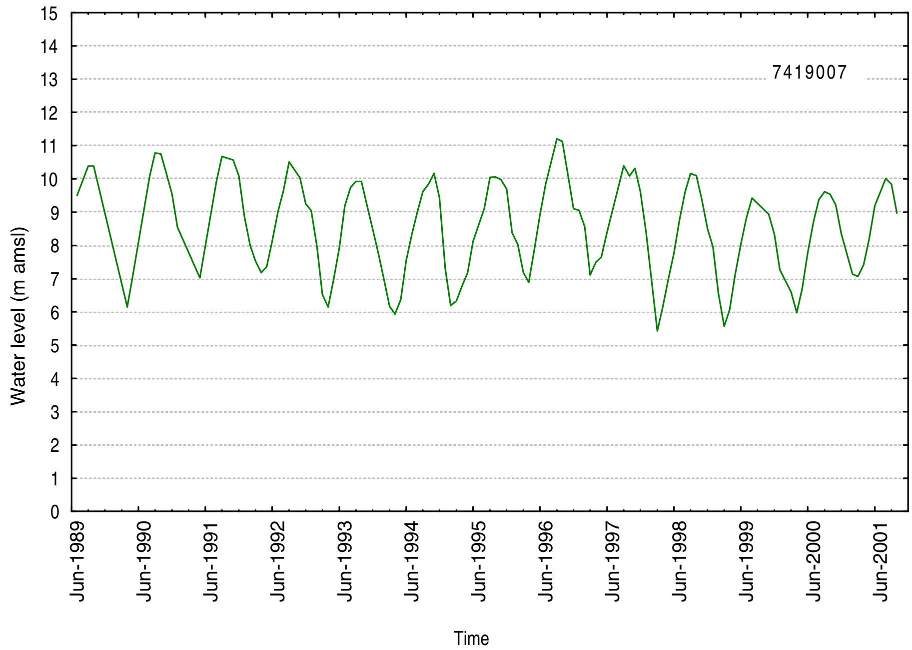

Figure 12.9: Groundwater level record at Fielding Road sand (7419007) monitoring bore.

South-east of Drury there is around 100 metres of sediments overlying the weathered upper surface of the Waitemata Group. Bores accessing this shallow sand aquifer are typically around 60 metres deep. The aquifer is relatively low yielding and could be susceptible to septic tank and saltwater contamination, or of poor quality due to elevated iron levels. However, sustainable yields of around 150m³/day are recorded from pumping tests carried out by ARC which show transmissivity of 6 m²/day and a storativity range of 10^{-4} to 10^{-5}. No leakage was observed from the overlying basalts.

Further south, around Ramarama, the sediments significantly thicken, grain size increases, and they become more like the Kaawa Formation in look and behaviour. It becomes difficult to determine the transition from Pleistocene to Pliocene origin, though this distinction is considered unnecessary for management purposes. Transmissivities increase to around 75m²/day with storativity of 2×10^{-4}.

12.4.3 Kaawa Aquifer

The Kaawa Aquifer is an important aquifer in the Manukau lowlands from Paerata to Glenbrook and, more recently with increased demand for water, south towards Pukekohe and Puni. While the Kaawa Formation comprises sands, shell and some gravel, the coarser shell beds are usually targeted for water supply. Faulting in the Manukau lowlands has impacted the Kaawa Aquifer, and underlying Waitemata Aquifer. Faults across the area have two orientations, north-south, and south-west to north-east. This has resulted in a series of uplifted and down-thrown blocks and discontinuity of sediments across the lowlands. In some uplifted areas e.g. Karaka, the Kaawa Aquifer has been eroded away and only the Waitemata Aquifer is available as a groundwater resource. Around Waiau Pa and Glenbrook the Kaawa Aquifer is fairly shallow (<100m bgl), while around Pukekohe and Puni the aquifer is much deeper (>200m bgl). In general the Kaawa Aquifer thickens and deepens southward. Aquifer transmissivities range from 10-500 m²/day and storativities from 10^{-2} to 10^{-5}.

Bores constructed in the Kaawa Aquifer are generally screened across coarse shell and/or sand beds. Well yields are typically between 800-1,200 m^3/d for a 100-150mm diameter bore. Extensive investigations of the Kaawa Aquifer were undertaken in the late 1980's. A total groundwater availability of 17,500 m^3/day (6.4M m^3/year) was determined for the Kaawa Aquifer from flow net analysis. This figure includes Glenbrook Volcanics and overlying sand aquifers in the Glenbrook/Waiuku area.

Work has recently been completed on the recharge mechanism to the Kaawa Aquifer (Viljevac et al., in prep.), which has lead to a review of water availability estimates. Groundwater is now believed to recharge the Kaawa Aquifer through the volcanic aquifers (e.g. Glenbrook, Pukekohe, and Bombay). Whereas recharge was also thought to occur outside these areas, it is now concluded that the mechanism by which groundwater reaches the underlying Kaawa aquifer is via the basaltic conduits associated with the volcanic cones of these volcanic fields.

A network of 9 groundwater level monitoring bores is currently monitored at monthly intervals. Groundwater levels respond to seasonal recharge fluctuations and to a lesser extent, seasonal pumping. Being recharged from the overlying volcanic aquifers, the water level plot in figure 12.10 shows a similar pattern to that in figure 12.8. Groundwater levels decrease from 40m amsl at Pukekohe to 10m amsl at Drury.

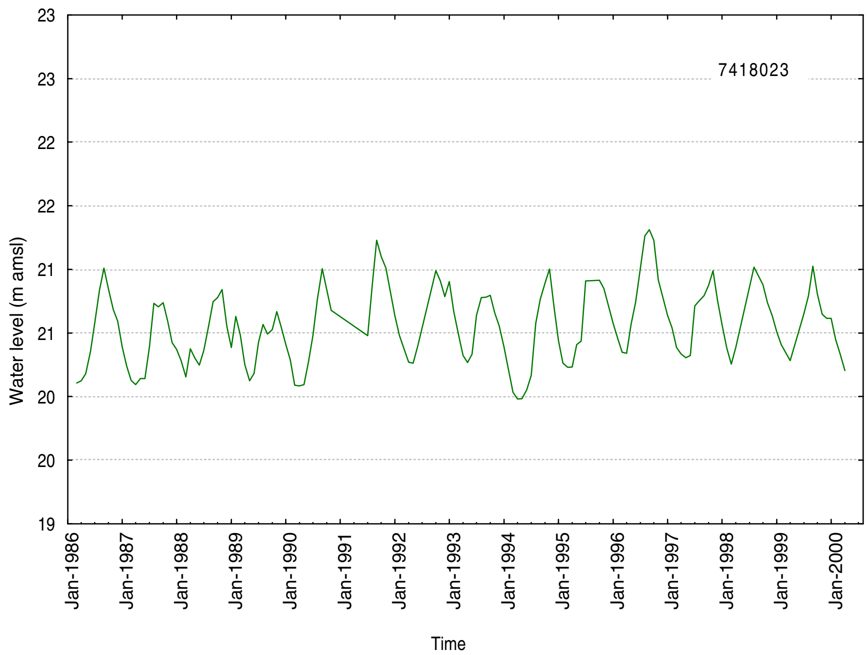

Figure 12.10: Kaawa Aquifer groundwater level record at Batty Road (7418023) monitoring bore.

12.4.4 Waitemata Aquifer

In South Auckland the Waitemata Group forms the surface topography from west of Papakura, where they are overlain by up to 40m of younger sediments, through Karaka, and across to Waiau Pa. They underlie other lithologies across the rest of the area, and outcrop near Bombay, where the St Stephens Fault has caused them to be up-lifted approximately 300 metres. The Waitemata Group has been extensively block-faulted and eroded, prior to deposition of later Pliocene and Pleistocene deposits. Faulting has resulted in Waitemata Group being uplifted in the northern parts of the south Auckland Region and deepening to the south and east of the region.

Groundwater flow though the Waitemata Aquifer is primarily through fractures and probably along faults. Groundwater flow is also through the sandstone matrix. Flow directions are controlled by surface topography and as a result groundwater gradients are relatively flat. Piezometric levels do not show a regional groundwater flow to the north as may be expected but tend to reflect local catchment topography and drainage. Recharge is primarily through vertical leakage rather than horizontal flow.

Groundwater levels are generally less than 10m amsl at Karaka-Waiau Pa and reflect seasonal variation in recharge and, to a lesser extent, pumping. Water level monitoring of private Waitemata bores indicates seasonal variation of up to 0.9m. Water level data collected automatically in 2 ARC monitoring bores up until 1999 indicate recharge peaks in December and falls to a low in April/May (fig. 12.11) (ARC, 1993).

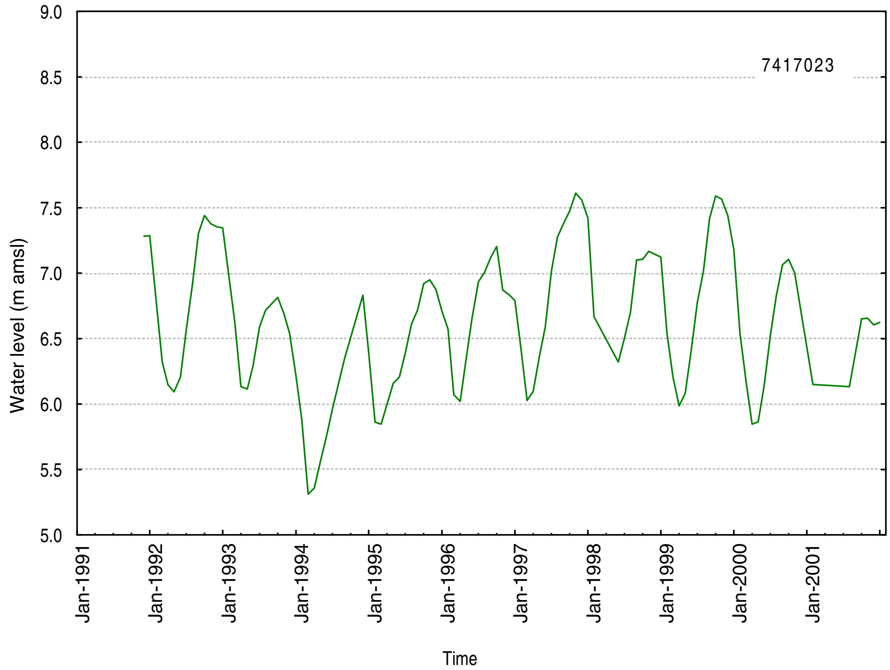

Figure 12.11: Groundwater level record at Seagrove Road (7417023) monitoring bore showing the strong seasonal variation in recharge to the Waitemata Aquifer.

Hydraulic parameters of the Waitemata Aquifer are variable across the region. Transmissivities range from 6 m^2/day to 62 m^2/day and storativities show that the aquifer is confined, values range from 0.035 to 0.00012 (ARC, 1993). The aquifer is generally low yielding and is strongly influenced by lateral variation in aquifer lithology and fracturing. Most modern Waitemata bores are drilled to around 200m depth with 90m of 100mm-diameter casing. Typical bore yields are 30-300 m^3/day.

Groundwater quality can generally be separated into two groups based principally on the ratio of total hardness to total alkalinity: High TH/TA ratio groundwater and low TH/TA ratio water (table 12.4). The hardness of groundwater decreases with depth hence shallower groundwater has a high TH/TA ratio than deeper groundwater. Waitemata groundwater is suitable for many uses without any pre-treatment. The main limiting elements in Waitemata groundwater are sodium, boron and iron.

Table 12.4: Waitemata Aquifer groundwater composition types (from ARC, TP 24).

	High TH/TA ratio groundwater	Low TH/TA ratio groundwater
TH/TA ratio %	>50	<12
pH	<8.3	>8.4
Silica (g/m^3 SiO_2)	>50	<35
Total iron (g/m^3 Fe)	>0.7	<0.1
Sodium (g/m^3 Na)	<40	>75

12.5 Water Management

12.5.1 Surface Water

The present demand, allocation and management of the six main Franklin Lowland catchments - Waitangi, Mauku, Whangamaire, Whangapouri, Ngakoroa and Hingaia - is strongly influenced by how the catchments have been managed in the past 30 years. Management strategies adopted by the ARWB in the 1980's were complicated by 'Existing Use' consents (ref. Chapter 4).

The Ngakoroa and Mauku Stream catchments have Water Allocation Plans that were prepared by the ARWB in 1980. Water Permit Reports, that dealt with the cumulative effects of all dams and takes on a catchment wide basis were prepared for the Mauku, Waitangi and Whangamaire catchments in 1982 and 1983. Consultation through Public meetings was an important part of having these Plans and Reports supported by the community of water users.

The Allocation Plans and Water Permit Reports adopted a common standard for the minimum flow. The "residual flow" for irrigation abstractions during the irrigation season 1 November to 30 April was set at 30% of Q_5. An allowance was made for pumping from streamflow for stock drinking requirements of 5 to 7% of Q_5. The allowance for stockwater plus the effect of dams, and water permit daily quantities (averaged over 24 hours) was restricted to a total 70% Q_5.

In September 1983 the ARWB adopted a policy, for the above four catchments that further applications to take from run-of-stream flow during the summer irrigation season be declined unless current allocations are reduced by future circumstances. A policy regarding dammings in catchments with surface water restrictions was also adopted. In particular dams for irrigation supply on perennial streams had to store a full seasons requirement, be capable of being filled from annual runoff and have a bypass installed that bypassed natural streamflow, up to three times $Q_{5.}$ The permit bypass condition was almost universally not complied with. Many illegal dams continued to be built without prior ARA authorisation.

More detailed Allocation and Management Plans were prepared for the six Franklin Lowland Stream catchments: Waitangi 1983, Ngakoroa 1986, Whangamaire 1987, Mauku 1990, Whangapouri 1990 and Hingaia 1991. All continued the use of 30% of Q_5 as the minimum stream flow.

A Resource Statement and Management Strategy is currently being prepared for the six Franklin Lowland Streams based on investigations completed in the six catchments over the period 1999-2002. Water quality and habitat indicator analysis has been made to establish the flows below which the life supporting capacity of streams in the Franklin Lowland Streams catchments may be affected. The analysis shows that, during most summers, flows in some parts of Franklin Lowland Stream catchments fall below 'environmental flows', and that dissolved oxygen, rather than temperature or habitat space, is the most limiting factor.

An alternative minimum flow, again in the main stem of streams in the lower catchment, would be 70% of the one in five year low flow Q_5 but only if significant riparian planting mitigation was completed in the mid-upper catchments (where such planting has most effect and benefit). Allocations could then be up to 30% of Q_5 and allow full exercise of permits all summer even in a one in five year drought. The appropriate minimum flow in the main stem or tributaries in the upper catchment could be less than 70% of Q_5, since water quality problems are less pronounced in the upper catchments.

At present the permit demand (averaged over 24 hours) to take from run-of-stream flow at the bottom of each catchment as a proportion of the one in five year low flow is: Ngakoroa 25% at Runciman Road, Mauku 77% at Patullo Rd, Waitangi 34% at weir (allowing for permit Ar4903 to take 10% of the flow), Whangamaire 32% at Charles Rd, Whangapouri 41% at Blackbridge Rd (allowing 3,000 m^3/day for permit Ar7159), and Hingaia 17% at Quarry Rd.

The present demand for surface water in the six individual Franklin Lowland streams is presented in table 12.5.

Table 12.5: Surface water consent numbers and consent allocations in the six key South Auckland Catchments.

Catchment	Number of consents		Maximum allocation m^3/day		Total daily allocation m^3/day
	Stream	Dam	Stream	Dam	
Hingaia	27	7	2,368	2,235	4,603
Ngakaroa	14	27	1,540	6,567	8,107
Whangapouri	12	3	8,090	415	8,505
Whangamaire	13	0	3,018	0	3,018
Mauku	13	13	5,322	8,460	13,782
Waitangi	4	3	1,192	2,440	3,632
TOTAL	83	53	21,530	20,117	41,647

For the Ngakoroa stream catchment, the demand in the upper 6.2 km^2 catchment, termed Area 1, is given separately. Demand for run-of-stream flow in Area 1 was 1,054 m^3/day in 1980, 787 m^3/day in 1986 and 645 m^3/day in 2001 (60% of the present 12.5 l/s estimate of Q_5 (1,080 m^3/day)). Demand for takes from dams in Area 1 in 2001 is 2,253 m^3/day. There are a further four permits for replacement consents in the mid-lower catchment totalling 325 m^3/day. There is only one permit to take from stream flow downstream of Runciman Road. Demand upstream of Runciman Road is 910 m^3/day or 10.5 l/s averaged over 24 hours. This is only 25% of the one in five year low flow of 42 l/s at Runciman Road.

For the Mauku stream catchment demand for run-of-streamflow has changed from 4,435 m^3/day in 1980 to 4,010 m^3/day in 1982 and now to 5,322 m^3/day (62 l/s averaged over 24 hours) in 2001. This is 77% of Q_5 at Patullo Road at the bottom of the catchment. The demand includes applications for replacements for Existing Uses which are being exercised, but also for some consents where there has been no use for several years.

For the Waitangi stream permit demand for run-of-streamflow has changed from 564 m^3/day in 1981, to 1,346 m^3/day in 1983 and 622 m^3/day in 2001. The values do not include consent Ar4903 to take up to 570 m^3/day from a weir with a catchment of 160 ha on a small tributary. The take reduces the stream flow by about 10% (260 m^3/day in a five year low flow). The effective total run-of-stream consent demand is therefore about 880 m^3/day or 34% of the 30 l/s (2,592 m^3/day) 2001 estimate of Q_5 at Waitangi weir.

For the Whangamaire stream catchment demand for run-of-stream flow was 7,338 m^3/day in 1981, 10,027 m^3/day in 1983, 10,009 m^3/day in 1987, and 3,018 m^3/day in 2001. The demand in 2001 represents 32% of the 110 l/s (9,500 m^3/day) one in five year low flow at Charles Rd. Demand upstream of Hunter Rd is 1,722 m^3/day (20 l/s averaged over 24 hours).

For the Whangapouri stream demand for run-of-streamflow was 6,691 m^3/day in 1990. This included permit Ar 7159 for Franklin District Council to take up to 5,000 m^3/day from Hickeys Spring but reducing to 3,000 m^3/day in one in five year low flow conditions. Demand is 8,090 m^3/day (including 5,000 m^3/day for FDC) in 2001. Allowing only 3,000 m^3/day for FDC in a one in five year event, the total allocation is 6,090 m^3/day or 70 l/s averaged over 24 hours, which is 41% of the 170 l/s Q_5 at Blackbridge Road at the bottom of the catchment.

For the Hingaia stream permit run-of-stream demand was 2,708 m^3/day in 1991 and 2,368 m^3/day in 2001. Greatest demand is in the small tributary fed by Stone Rd springs where demand is 1,150 m^3/day (13.3 l/s averaged over 24 hours) from 4 consents and the one in five year spring low flow is 30 l/s. Total run-of-stream demand in the catchment of 2,368 m^3/day is 27 l/s averaged over 24 hours or 17% of the 160 l/s one in five year low flow at Quarry Rd near the bottom of the catchment.

12.5.2 Groundwater

Early groundwater investigations and water management strategies in South Auckland targeted specific aquifers under demand pressure for irrigation water (e.g. Pukekohe Volcanics). Less consideration was taken of aquifer interrelationships such as groundwater movement between aquifers and to springs. Water management today makes use of greater investigation and monitoring information and enables better understanding of recharge and discharge processes.

Groundwater resources in the Manukau Lowlands have been developed since the horticultural boom in the early 1980's. Demand for groundwater resources in South Auckland has increased to the point where new applications for water permits have been declined in some aquifers (e.g. Pukekohe Aquifer).

Collectively consent holders use approximately 75% of the total regional groundwater allocation. The largest groundwater user is the Franklin District Council who supplies water to Pukekohe and Waiuku townships. There were 468 resource consents allowing the abstraction of groundwater in South Auckland as at 31 May 2001. Most groundwater is taken from the Kaawa Aquifer (174 consents), Waitemata Aquifer (95 consents) and Pukekohe Aquifer (73 consents). The remaining consents are to take groundwater from outside these aquifers such as the Drury Aquifer and Bombay basalt aquifer.

Pukekohe Aquifer Management

In July 1984 ARWB adopted an interim restriction on the granting of new consents to take groundwater from the volcanic aquifer. A horticultural boom had lead to increased demand for water and many streams had water allocation restrictions. The groundwater restriction was put in place in recognition of the hydrological connection between the volcanic aquifers and surface water springs.

A policy requiring that water meters be installed and water use recorded was put in place in 1989. A groundwater study was completed in 1991 (ARC, 1991). On the basis of aquifer sensitivity to pumping, prevailing climatic conditions, and observed groundwater level declines, the groundwater restriction was retained. An annual groundwater availability from the volcanic aquifer was first established in 1996, using results from a preliminary study into recharge to the

Pukekohe Aquifer (ARC, 1996). This availability figure was intentionally conservative, to ensure maintenance of the balance between aquifer water levels, spring flow and recharge to the deeper Kaawa aquifer until further research on the recharge mechanisms in South Auckland volcanic aquifers could be completed.

Consents issued in January 1997 had annual allocations for the first time. Allocations were determined with reference to water use records and research into crop water requirements, and in consultation with the newly formed Pukekohe Groundwater Users Group, made up of representatives from the various growers to assist in the management of the resource. The total annual allocation to all consent holders was just within the newly determined availability, and the groundwater restriction remained in place. Water use by the 73 consent holders is characterised by large allocations, with 25% of the allocations greater than 500 m³/day and 21% greater than 30,000 m³/year.

The results of investigations into the recharge processes of the underlying Kaawa Aquifer (Viljevac et al. in prep.) have revised the interim groundwater availability, and provided the technical support for a new management approach for both the Kaawa Aquifer and the Pukekohe Volcanic Aquifer. The Pukekohe Volcanic Aquifer is divided into 4 management areas, primarily on the basis of the direction of groundwater movement (fig. 12.12). Separate management of groundwater is to be practised within each area, controlling transfer of resource consents between sites.

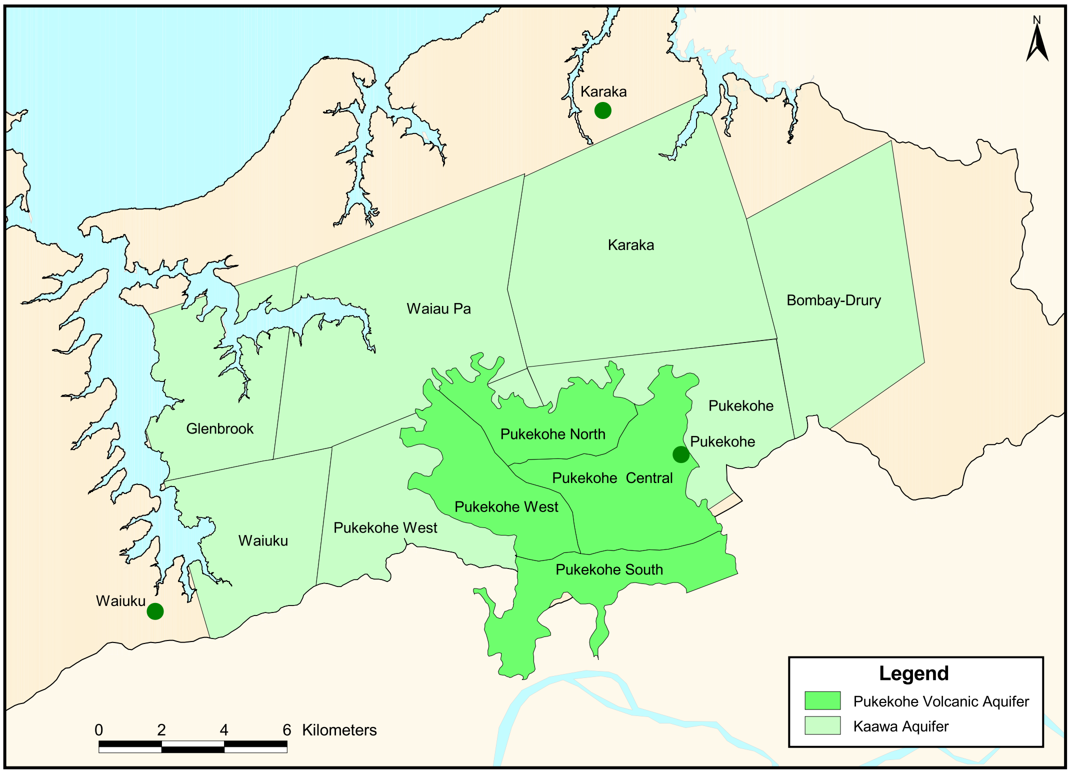

Figure 12.12: Pukekohe Volcanic Aquifer management zones and Kaawa Aquifer management zones.

On the basis of the groundwater availability and present allocation figures (table 12.6), groundwater is available for allocation in each management area. It should be noted that the Pukekohe South management area extends into the Waikato Region, and there is consequent co-management of the resource with Environment Waikato required in that area.

Table 12.6: Groundwater availability and consent allocations in the four Pukekohe Volcanic Aquifer Management zones.

Pukekohe Aquifer Management zone	Annual availability m^3/year	Annual allocation m^3/year
Central	856,000	474,000
South	650,000	90,000
West	420,000	243,000
North	420,000	138,000
TOTAL	2,346,000	947,000

Kaawa Aquifer Management

Kaawa Aquifer management has followed guidelines provided in the ARC TP 85 (ARC, 1989). These guidelines were retained when consents expired and were replaced in 1997. Results of the investigation into the recharge processes of the Kaawa Aquifer (Viljevac et al. in prep.) have re-configured the management zones within the aquifer, based on recharge, aquifer thickness, direction of groundwater flow, and faulting (fig. 12.12).

The new overall management area excludes the Awhitu Peninsula but extends through Ramarama to the Drury Fault and includes groundwater in the Glenbrook volcanics. Groundwater availability has been determined according to recharge estimates from the volcanic cones associated with the Pukekohe, Glenbrook and Bombay basalt fields. Groundwater allocation is managed to maintain a head of groundwater at the coast to avoid saline intrusion. Groundwater availability and allocation for each zone is presented in table 12.7.

The Kaawa Aquifer is the water supply source for towns including Pukekohe (in excess of 1M m^3/year), Patumahoe (60,000 m^3/year), and Waiuku (730,000 m^3/year). Waiuku has recently supplemented its supply with a new bore to the Kaawa Aquifer located across the regional boundary. Pukekohe augments its reticulated supply with surface water from Hickey Springs, which is fed from the Pukekohe Volcanic Aquifer and is the source of the Whangapouri Stream. The blending is necessary to address water chemistry constraints in both sources (elevated ammonia and nitrate).

The aquifer also supplies BHP NZ Steel at Glenbrook (250,000 m^3/year), the former Paerata Dairy Factory (Anchor Products 650,000 m^3/year), and several large water supply companies with allocations in excess of 100,000 m^3/year. Of the 174 consents, 11% are for allocations in excess of 30,000 m^3/year, and 12% in excess of 500 m^3/day.

Table 12.7: Groundwater availability and consent allocations in the six Kaawa Aquifer groundwater management zones

Management zone	Annual availability m^3/year	Annual allocation m^3/year
Pukekohe	1,860,000	1,247,000
Pukekohe West	1,780,000	357,000
Waiuku	2,450,000	882,000
Glenbrook /Waiau Pa	1,560,000	1,143,000
Karaka	617,000	799,000
Bombay-Drury	718,000	342,000
TOTAL	8,985,000	4,770,000

The new availability estimates indicate groundwater resources approaching full allocation east of the main hydrological divide, which runs approximately north/ south from Helvetia to Te Hihi (Pukekohe and Karaka management zones). Elsewhere there is surplus groundwater available for allocation. The over allocation in the Karaka management zone may be addressed by reviewing the under-utilised consent allocation to Anchor Products Ltd.

Drury Sand & Bombay Basalt Aquifers

The sand aquifer just south-east of Drury had a restriction on groundwater abstraction put in place in March 1990 (Drury Restricted Area). This policy acknowledged the intensity of all-year use, groundwater level decline in the sand aquifer, reports from growers of groundwater supply problems, and a lack of information on the resource. Groundwater availability was calculated in ARWB TP 105 (Murphy, 1991) using a flow net and water balance approach. The restriction continued from 1991 until the replacement of consents in 1998. At this time the same groundwater availability was retained, but reductions to the total consent allocation resulted in the restriction being lifted.

The results of work on recharge to the Kaawa Aquifer from the Plio-Pleistocene sands indicates sands should be integrated into Kaawa Aquifer management rather than managed separately. The Bombay-Drury Kaawa aquifer management zone (fig. 12.12) now includes the overlying sands and values for groundwater availability are presented in table 12.7.

The Bombay volcanic aquifer, like Pukekohe, is now assumed to be recharging the Kaawa Aquifer. However, recharge to the Kaawa Aquifer can only occur at Bombay if recharge rates to the volcanics are significantly higher than the measured discharge from the spring fed Hingaia Stream. This will be allowed for in future calculations of groundwater availability.

Until management guidelines are reviewed with regard to the new work on recharge to the Kaawa Aquifer, groundwater allocation from the basalt aquifer at Bombay will be managed conjunctively with surface water. A conservative approach assumes 30% of the surface water Q_5 (around 3 million m^3/year) equates to both ground and surface water availability for allocation, thereby preserving stream flow and groundwater recharge to the Kaawa aquifer. This varies from the approach taken in ARWB TP 105 (Murphy, 1991).

Groundwater availability for the Drury/Ramarama sand aquifer are also considered conservative, incorporating an error contingency and allowing for maintenance of a hydraulic head at the inferred discharge to the Drury Creek (table 12.8).

Only 2 of the 100 consent holders in the whole management area have allocations greater or equal to 30,000 m^3/year or 500 m^3/day.

Table 12.8: Groundwater availability and consent allocations in the Drury Sand and Bombay Basalt Aquifers.

Management area	Annual availability m^3/year	Annual allocation m^3/year
Drury sands[1]	198,560	109,000
Bombay volcanics	950,000	626,000[2]
TOTAL	1,645,000	1,097,000

1. Sand aquifer formerly the Drury restricted area
2. Surface water 511,000 & groundwater 115,000 m^3/year

Karaka Waitemata Aquifer

The Karaka-Waiau Pa groundwater management area extends broadly from Clarks Beach in the west to the Hunua foothills south east of Papakura. It includes the sandstone aquifer, which has been uplifted north of the Glenbrook fault. The Karaka–Waiau Pa Groundwater Study and Interim Management Plan (ARC, 1993) divided the aquifer, somewhat arbitrarily, into 4 management areas. Groundwater availability was determined using 2% infiltration of rainfall. This is considered a conservative estimate, since a flow net analysis carried out in the Karaka North Road area (where more data is available) indicated infiltration could be as high as 8%. The aquifer is managed to avoid excessive water level drawdown in pumped bores, and limit the potential for saline intrusion at the coast.

Groundwater availability has been estimated at 2.7M m^3/year, of which 928,000 m^3/year has been allocated to consent applicants. Pastoral farming is still a significant land use in this area and an allowance of 810,000 m^3/year has been made for that purpose. This means that the Karaka Waitemata Aquifer about 65% allocated.

It is, however, recognised that infiltration rates will vary across the area, and there are limitations to the amount of groundwater able to be accessed at any one location. Further work is intended on best practice for allocating groundwater from such aquifers. Until new guidelines are available ARC TP 24 (Arc, 1993) can still provide background information but large consent applications will be assessed on a case-by-case basis, not in relation to availabilities of the previously delineated smaller management areas.

Water use can be characterised mainly by smaller horticultural lots, with only 9% of the 80 consents being allocated more than 30,000 m^3/year and 6% greater than 500m^3/day. There is, however, a small number of large glasshouse and market garden developments, a chicken processing plant, and water supply bores operated by FDC for several townships. Allocation does not accurately reflect actual use, with United Water not exercising its consent for 81,000m^3/year to supply water to Papakura due to water quality issues. Deep sandstone bores tend to have elevated Boron concentrations, which pose problems for their suitability for potable water supply purposes.

12.6 References

ARC 1991: Pukekohe plateau groundwater resource report, water allocation and management plan. TP 109 ARC.

ARC, 1993: Karaka-Waiau Pa groundwater study interim management plan. TP 24 ARC.

ARC, 1996: A model of recharge to Pukekohe volcanic aquifers, South Auckland: preliminary study. TP 77. Auckland Regional Council.

ARWB, 1989: A study of the Kaawa formation aquifer system in the Manukau lowlands 1989. TP 85. ARWB.

Briggs, R.M., Okada, T, Itaya, T., Shibuya, H., Smith, I.E.M., 1994: K-Ar ages, paleomagnetism, and geochemistry of the South Auckland volcanic field, North Island, *New Zealand. New Zealand Journal of Geology and Geophysics, Vol. 37*: 143-153.

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Rosen, M.R., Bright, J., Carran, P., Stewart, M.K., Reeves, R., 2000: Estimating rainfall recharge and soil water residence times in Pukekohe, New Zealand, by combining geophysical, chemical and isotopic methods. Draft interim report prepared for the Auckland Regional Council.

Viljevac, Z., Murphy, G.K., Crowcroft, G. M., Smaill, S., Bowden, T.D., in Prep. : South Auckland Groundwater. A Conceptual Model of Groundwater System and Kaawa Formation Aquifer Recharge in Franklin District. South Auckland. ARC TP 133.

13 Looking Forward – Water Management to 2012

This statement has presented past and present water resource management information for the Auckland Region to 2001, 10 years after the implementation of the RMA. The last decade has been a period of adjusting to new legislation with a different set of tools for water management than those provided by the Water and Soil Conservation Act. While management area plans guided water management in Auckland prior to the RMA, the ARPS, ATRP and Water Resource Assessment Reports have been the tools used since then. The ATRP was required to be reviewed by 2001 and will be superceded by the PARP: ALWP when it becomes fully operative. The PARP: ALWP is the blueprint for water management in the Auckland Region for the next 10 years. The following section provides a brief outline of the future direction of water management under the PARP: ALW.

13.1 Proposed Auckland Regional Plan: Air Land and Water (PARP: ALW)

The ARC notified the Proposed Auckland Regional Plan: Air, Land and Water in October 2001. The Regional Plan contains objectives, policies, rules and other methods to govern the sustainable management of natural resources within the Auckland Region. The Plan includes rules on the taking, use, damming and diversion of the Region's water resources. Together with the Auckland Regional Policy Statement it (the Plan) establishes the direction for water allocation for the next ten years. Note that the provisions summarised below may change as a result of the statutory processes associated with a regional plan becoming operative.

The policy direction of the Regional Plan is to discourage taking water from streams in summer, to encourage taking in winter and storing water off-stream. The plan strongly discourages new dams on stream by making them non-complying activities. The plan also encourages the taking of groundwater, where available, in preference to surface water.

The plan sets out how much water can be allocated from a resource (the water availability). A methodology for setting minimum flows in streams is although actual figures for minimum flows are not yet included in the Plan. It is envisaged that they will be added after further work in the region is completed. The methods in the Plan can be used to determine a minimum flow which can be placed as a condition of a resource consent, either a consent to take surface water or, in the case of a dam, a minimum flow below the dam. The Plan provides a methodology for determining groundwater availability and sets water availabilities for some areas. In all cases the water allocated to users shall not exceed the water availability determined for that resource.

13.2 Future water resource information reporting

This Statement was produced to coincide with the 10th anniversary of the implementation of the RMA and the notification of the PARP: ALW. The 10-year period provided sufficient information to review our knowledge of the region's water resources and our management practices. While it is not possible to determine when the PARP: ALW will become operative a 10-year review and report of water management of that plan is anticipated.

Appendix 1: ARC rainfall site details

Site No.	Site Name	Easting	Northing	Monitoring
643510	Hoteo @ Oldfields	2646300	6538600	Automatic
643611	Waiwhui @ Goat Flat	2658900	6538600	Automatic
643713	Tamahunga @ Weir	2665700	6540900	Automatic
644211	Kaipara Heads @ Wallers	2621100	6529200	Automatic
644614	Mahurangi @ Walkway	2655900	6525200	Automatic
644616	Mahurangi @ Satellite Dish	2660000	6528500	Automatic
646619	Orewa @ Treatment Ponds	2660600	6510300	Automatic
647727	Oteha @ Rosedale Ponds	2663500	6493400	Automatic
647510	Ararimu @ Zanders	2649400	6498500	Automatic
647513	Kumeu @ Maddrens	2649800	6490800	Automatic
647601	Whenuapai @ Airbase	2655900	6489400	Automatic
647614	Rangitopuni @ Walkers	2655000	6494600	Automatic
648510	Swanson @ Pooks Road	2651700	6480300	Automatic
649723	Onehunga @ Rowe Street	2669700	6473700	Automatic
649820	Pakuranga @ Sunnyhills Village	2679400	6476100	Automatic
740815	Puhinui @ Botanic Gardens	2680400	6463800	Automatic
741813	Patumahoe @ Weir	2673700	6444000	Automatic
742736	Waitangi @ Diver Road	2667000	6441800	Automatic
742914	Ngakoroa @ Donovans	2685500	6443400	Automatic
750010	Wairoa @ Hunua Nursery	2694600	6455800	Automatic
750213	Waihihi @ Waharau Reg Park	2713900	6459700	Automatic
751019	Mangawheau @ Gorge	2694300	6452700	Automatic
642611	Hoteo @ Busbridge	2655300	6553000	Manual
642614	Poutawa @ Nolans	2659500	6552500	Manual
643704	Omaha	2666700	6538600	Manual
643709	Big Omaha	2665700	6540600	Manual
644410	Hoteo @ Kaipara Hills	2644800	6530700	Manual
644511	Hoteo @ Kaipara Flats	2649300	6531400	Manual
645613	Orewa @ Domant Crescent	2661600	6511200	Manual
647725	Glenfield	2664900	6489200	Manual
648693	Te Atatu Sth	2656900	6489200	Manual
648701	Auckland City @ Albert Pk	2667962	6482207	Manual
648812	Omaru Crk. @ University Park	2675300	6478300	Manual
648813	Remuera Golf Course	2673500	6478300	Manual
649515	Opanuku Upper Catchment @ 20 Turanga Rd	2648200	6476200	Manual
649626	Whau @ New Lynn	2661000	6476300	Manual
649720	Epsom @ Wapiti Av	2669200	6477700	Manual
649821	Pakuranga @ Pak. Village Man.	2679400	6476000	Manual
658011	Beachlands @ Anakena	2689200	6478100	Manual
741812	Whangapouri @ Paerata Dairy Co	2679000	6446300	Manual
742732	Glenbrook @ Steel Mill Nth	2663200	6442000	Manual
750011	Wairoa @ Otau Mountain Road	2694800	6463700	Manual
750012	Hunua @ Water Treatment	2689700	6456700	Manual
751018	Mangawheau @ Allridge Road	2694300	6452500	Manual

Appendix 2: ARC Automatic flow site details

Site Name	Site Number	Catchment	Site Commenced	Easting	Northing	Elevation	Catchment Area	River Number
Tomarata**	6302	Slippers Lake	16/12/1986	2657600	6557600		8.00	63305
Quintals Falls	6501	Tamahunga Stream	23/02/1978	2666200	6540000	5.37	7.97	65200
College	6806	Mahurangi Stream	11/06/1982	2658900	6531600	8.90	46.80	68300
Kowhai Rd	7202	Orewa Stream	20/06/1980	2658700	6510100	10.00	9.73	72100
Oak Hill	45407	Kaukapakapa Stream	18/04/1988	2647400	6506900		59.50	454000
Gubbs	45703	Hoteo River	10/06/1977	2646000	6534000		268.00	457000
Sandersons	45705	Waiteitei Stream	21/02/1996	2653100	6547300	50.00	80.60	457000
Donohue Rd**	45004	Lake Ototoa	29/02/1984	2621830	6519980	80.00	5.65	450200
Walkers	7805	Rangitopuni River	16/05/1975	2655000	6494600		81.50	78300
Bays Bridge	7811	Oteha Stream	13/12/1979	2661800	6495200		12.20	78040
Woodside Res.	7907	Swanson Stream	25/05/1993	2654300	6481600		22.60	79100
Millbrook Rd	7911	Oratia Stream	22/06/1999	2659900	6477900	4.48	22.88	79500
Vintage Res.	7912	Opanuku Stream	23/06/1999	2655100	6479000		26.50	79400
Waimauku	45311	Kaipara River	6/10/1978	2643800	6492100		155.40	453000
Maddrens	45315	Kumeu Stream	12/12/1983	2649700	6490800		47.60	453600
Old Nth Rd	45326	Ararimu Stream	14/12/1983	2645300	6494400		66.80	453406
Western Springs	8104	Motions Creek	27/03/1990	2664500	6480300		7.50	81350
Great Nth Road	8111	Meola Creek	29/11/1995	2663600	6480100		12.90	81300
Mooney Bridge	8207	Pakuranga Stream	20/09/1979	2680200	6476500		3.08	82010
Hills Rd Bridge	8208	Otara Stream	28/04/1992	2678056	6469762	10.00	18.90	82020
Great Sth Road	43803	Papakura Stream	16/06/1969	2680000	6461400	9.00	51.60	438040
Drop Structure	43807	Puhinui Stream	6/12/1978	2676800	6466100		11.60	438060
Lichtensteins**	44004	Captain Springs	30/08/1993	2670400	6473700	1.79	0.25	440400
Tourist Road	8516	Wairoa River	13/02/1979	2693100	6463300		161.00	85000
Weir	8529	Mangawheau Stream	15/06/1988	2694239	6453109	100.00	30.40	85200
S H Bridge	43602	Waitangi Stream	30/03/1966	2665500	6440000		17.60	436140
Patumahoe Weir	43811	Whangamaire Stream	29/09/1976	2673690	6444064	57.00	4.35	438000
Mill Rd	43829	Ngakoroa Stream	28/03/1980	2685576	6443227	143.00	4.73	438300

Appendix 3: Q5's for low flow sites

Site Name	Site Number	Catchment	Catchment Area	1 Yr Event (Q2.33) (l/s)	1-5 Yr Event (Q5) (l/s)	Spec. Dis. (SD2.33) (l/s/km2)	Spec. Dis. (SD5) (l/s/km2)
Tomarata**	6302	Slippers Lake	8.00	0.86	0.80	N/A	N/A
Quintals Falls	6501	Tamahunga Stream	7.97	4.00	2.22	0.50	0.28
College	6806	Mahurangi Stream	46.80	57.50	45.00	1.23	0.96
Kowhai Rd	7202	Orewa Stream	9.73	0.00	0.00	0.00	0.00
Oak Hill	45407	Kaukapakapa Stream	59.50	16.50	3.00	0.28	0.05
Gubbs	45703	Hoteo River	268.00	334.00	244.00	1.25	0.91
Sandersons	45705	Waiteitei Stream	80.60	103.00	74.00	1.28	0.92
Donohue Rd**	45004	Lake Ototoa	5.65	0.99	0.88	N/A	N/A
Walkers	7805	Rangitopuni River	81.50	10.00	3.00	0.12	0.04
Bays Bridge	7811	Oteha Stream	12.20	9.60	5.60	0.79	0.46
Woodside Res.	7907	Swanson Stream	22.60	16.00	12.68	0.71	0.56
Millbrook Rd	7911	Oratia Stream	22.88	#	#	#	#
Vintage Res.	7912	Opanuku Stream	26.50	#	#	#	#
Waimauku	45311	Kaipara River	155.40	104.00	70.00	0.67	0.45
Maddrens	45315	Kumeu Stream	47.60	29.30	21.50	0.62	0.45
Old Nth Rd	45326	Ararimu Stream	66.80	70.00	48.00	1.05	0.72
Western Springs	8104	Motions Creek	7.50	26.00	14.00	3.47	1.87
Grt Nth Road	8111	Meola Creek	12.90	5.50	1.60	0.43	0.12
Mooney Bridge	8207	Pakuranga Stream	3.08	3.63	3.11	1.18	1.01
Hills Rd Bridge	8208	Otara Stream	18.90	5.22	2.33	0.28	0.12
Grt Sth Road	43803	Papakura Stream	51.60	25.00	15.00	0.48	0.29
Drop Structure	43807	Puhinui Stream	11.60	13.00	11.32	1.12	0.98
Lichtensteins**	44004	Captain Springs	0.25	?	?	?	?
Tourist Road	8516	Wairoa River	161.00	380.00	301.00	2.36	1.87
Weir	8529	Mangawheau Stream	30.40	77.00	59.00	2.53	1.94
S H Bridge	43602	Waitangi Stream	17.60	38.60	27.70	2.19	1.57
Patumahoe Weir	43811	Whangamaire Stream	4.35	80.40	76.60	18.48	17.61
Mill Rd	43829	Ngakoroa Stream	4.73	8.67	6.55	1.83	1.38

Appendix 4: Groundwater monitoring bore site details

	Site Name	Aquifer	Purpose	Monitoring frequency	Quality Baseline Site	Easting	Northing	Elevation (m amsl)	Commencement date
6437005	Quintal Rd Bore 13	Waitemata	Long Term Baseline	Monthly	No	2666500	6540000	12.93	03-Feb-77
6437021	Omaha 25	Waitemata	Long Term Baseline	Monthly	No	2666800	6538800	7.01	07-Dec-77
6437087	Caroline Heights	Waitemata	Aquifer Management	Monthly	No	2669900	6539100	13.01	31-May-93
6456001	U. Orewa/Russell Rd 925/1	Waitemata	Aquifer Management	Monthly	No	2658300	6510800	39.94	03-May-96
6456005	Orewa South OS	Waitemata	Aquifer Management	Monthly	No	2662400	6510300	4.78	23-Jan-97
6456007	Orewa North	Waitemata	Long Term Baseline	Monthly	No	2661800	6512700	3.92	08-May-96
6457041	Waiwera	Thermal	Long Term Baseline	Automatic	No	2663400	6515900	3.21	30-Nov-76
6457097	Waiwera Beach	Waitemata	Aquifer Management	Automatic	No	2663400	6515800	3.17	10-Dec-97
6464007	Parakai	Thermal	Long Term Baseline	Automatic	No	2638900	6503600	4.37	13-Apr-84
6464009	Parakai #87	Waitemata	Aquifer Management	Automatic	No	2638900	6503700	3.68	03-Jul-84
6464089	Rimmers Rd	Waitemata	Long Term Baseline	Monthly	Yes	2635600	6500900	33.75	15-Apr-97
6467019	Stanmore Bay Res (RDC)	Waitemata	Aquifer Management	Monthly	No	2666300	6507000	2.80	03-May-96
6467021	Tindalls Hill WGP 3	Waitemata	Aquifer Management	Monthly	No	2669400	6508200	72.22	03-May-96
6467025	Chenery Rd RB 5	Waitemata	Long Term Baseline	Monthly	Yes	2662700	6508600	37.33	03-May-96
6474003	Waitakere Rd #2	Waitemata	Long Term Baseline	Monthly	Yes	2649400	6489700	33.20	05-Aug-98
6475003	Selaks, Kumeu	Waitemata	Long Term Baseline	Monthly	No	2651200	6489600	36.38	12-Feb-86
6475005	Trigg Rd (Obs 3)	Waitemata	Aquifer Management	Monthly	No	2646700	6490700	27.87	11-Jan-89
6475009	Lathrope Product. (Obs 5)	Waitemata	Aquifer Management	Monthly	No	2651400	6491200	38.07	29-Jun-88
6475015	Waitakere Rd	Waitemata	Long Term Baseline	Monthly	Yes	2649600	6489800	25.43	11-Jan-89
6475157	Short Rd, Riverhead	Waitemata	Aquifer Management	Monthly	No	2652300	6491300	31.08	10-Sep-96
6487001	Volcanic St.	Basalt - isthmus	Aquifer Management	2 Weekly	No	2665700	6477500	47.39	14-Nov-96
6487003	Bellevue Res.	Basalt - isthmus	Aquifer Management	2 Weekly	No	2666600	6479400	67.67	14-Nov-96
6487007	Selkirk	Basalt - isthmus	Long Term Baseline	Automatic	No	2664400	6478900	34.18	13-Nov-96
6487009	Leslie Ave	Basalt - isthmus	Aquifer Management	Automatic	No	2665200	6479000	39.61	13-Nov-96
6487011	Morven Rd	Basalt - isthmus	Aquifer Management	2 Weekly	No	2667600	6477100	84.25	14-Nov-96
6487015	Watson Ave	Basalt - isthmus	Long Term Baseline	2 Weekly	Yes	2665300	6478300	42.20	14-Nov-96
6487017	Motions BH 1	Basalt - isthmus	Aquifer Management	2 Weekly	No	2663100	6480900	4.99	14-Nov-96
6487021	Chamberlain Park OBS 1	Basalt - isthmus	Aquifer Management	2 Weekly	No	2664000	6479900	17.83	15-Jun-98
6488045	PD13-S	Basalt - isthmus	Aquifer Management	2 Weekly	No	2673800	6476800	41.39	11-Dec-89
6488047	PD13-T	Basalt - isthmus	Aquifer Management	2 Weekly	NO	2673800	6476800	41.30	11-Dec-89
6488049	PD13-B	Basalt - isthmus	Aquifer Management	2 Weekly	No	2673800	6476800	41.30	11-Dec-89
6497007	Alfred St	Basalt - isthmus	Aquifer Management	2 Weekly	No	1970300	6874400	28.88	06-Jun-89
6497011	OBC 8	Basalt - isthmus	Aquifer Management	2 Weekly	No	2669200	6474700	45.49	27-Nov-72
6497013	Cemetery	Basalt - isthmus	Aquifer Management	2 Weekly	No	2670300	6473200	4.59	21-Jun-93
6497015	Orakau Ave	Basalt - isthmus	Aquifer Management	2 Weekly	No	2668300	6476500	84.62	14-Nov-96
6497017	Amelia Earheart	Sand	Long Term Baseline	2 Weekly	Yes	2669100	6467500	11.87	25-Mar-97

	Site Name	Aquifer	Purpose	Monitoring frequency	Quality Baseline Site	Easting	Northing	Elevation (m amsl)	Commencement date
	Mt Richmond	Basalt - isthmus	Long Term Baseline	2 Weekly	Yes	#N/A	#N/A	#N/A	#N/A
6497019	Tiwai Rd	Basalt - isthmus	Long Term Baseline	2 Weekly	Yes	2668200	647500	70.16	08-Apr-97
6498003	Angle Street	Basalt - isthmus	Long Term Baseline	Automatic	No	2671300	6473400	4.79	06-Jun-89
6498005	Simpson Reserve	Basalt - isthmus	Aquifer Management	2 Weekly	No	2672700	6474000	6.94	17-Jul-89
6498007	Central Park	Basalt - isthmus	Long Term Baseline	Automatic	Yes	2671500	6476100	23.23	29-Aug-90
6498011	Tanner Reserve	Basalt - isthmus	Aquifer Management	2 Weekly	No	2671800	6475300	23.66	05-Jun-91
6498019	OBC 1	Basalt - isthmus	Aquifer Management	2 Weekly	No	2671000	6475300	28.55	27-Nov-72
6498029	Railway	Basalt - isthmus	Aquifer Management	2 Weekly	No	2671300	6474400	17.12	13-Apr-93
6498033	Te Papapa	Basalt - isthmus	Aquifer Management	2 Weekly	No	2670800	6474000	10.97	21-Oct-93
6498035	Puhinui, Lambie Dr	Waitemata	Long Term Baseline	Monthly	Yes	2676800	6466000	18.66	30-Jun-93
7409001	Burnside Rd	Waitemata	Long Term Baseline	Monthly	No	2688100	6462000	30.52	10-Jul-85
7409011	Bullens Rd	Waitemata	Long Term Baseline	Monthly	Yes	2686300	6460700	34.66	21-Jun-93
7409013	Hamlyn Rd	Waitemata	Aquifer Management	Monthly	No	2684200	6460600	23.80	11-May-94
7417001	Glenbrook Hall	Kaawa	Aquifer Management	Monthly	No	2666600	6443900	57.71	16-Mar-70
7417023	Seagrove	Waitemata	Long Term Baseline	Monthly	Yes	2666300	6450900	28.18	08-Aug-91
7418003	Waiau Pa	Kaawa	Aquifer Management	Monthly	No	2668500	6448800	0.00	18-Apr-80
7418013	Batty Rd	Kaawa	Aquifer Management	Monthly	No	2674100	6451500	35.45	20-Dec-85
7418021	Ostrich Road Prod	Kaawa	Aquifer Management	Monthly	No	2676400	6446800	24.30	20-Dec-85
7418023	Ostrich Road #2	Kaawa	Long Term Baseline	Monthly	Yes	2676400	6446800	24.35	20-Dec-85
7418027	Ostrich Road obs no1		Long Term Baseline	Monthly	Yes	2676400	6446700	23.11	00-Jan-00
7419003	Tuhimata	Kaawa	Aquifer Management	Monthly	No	2680700	6446700	28.90	03-Dec-86
7419007	Fielding Road	Sand	Long Term Baseline	Monthly	Yes	2684825	6452375	19.72	04-Apr-89
7419009	Fielding Road	B/D	Long Term Baseline	2 Weekly	Yes	2684800	6452300	19.99	04-Apr-89
7419011	Cooper Road	Sand	Aquifer Management	Monthly	No	2684100	6448500	48.60	16-Jan-90
7419013	Fielding Road	Waitemata	Long Term Baseline	Monthly	No	2684820	6452340	19.26	24-Apr-91
7419119	Karaka Nth Observ #2	Waitemata	Aquifer Management	Monthly	No	2678300	6454700	35.19	12-Mar-92
7427003	Divers Road	Basalt-Pukekohe	Aquifer Management	Monthly	No	2667000	6441800	52.29	27-Aug-85
7427005	Maraeorahia	Kaawa	Long Term Baseline	Automatic	No	2662700	6439700	5.00	05-Jan-87
7428001	DSIR No2	Basalt-Pukekohe	Aquifer Management	2 Weekly	No	2675480	6441670	84.22	09-Nov-73
7428043	DSIR Northern No. 2	Basalt-Pukekohe	Aquifer Management	2 Weekly	No	2675480	6441670	84.06	26-Apr-79
7428047	Mauku	Kaawa	Long Term Baseline	Monthly	No	2671400	6442900	0.00	17-Apr-85
7428103	Rifle Range Road (Deep)	Basalt	Long Term Baseline	2 Weekly	Yes	2676600	6442600	72.58	24-Apr-97
7428105	Rifle Range Road (Shallow)	Basalt	Long Term Baseline	2 Weekly	Yes	2676600	6442600	72.56	24-Apr-97
7429011	Revell Court	Basalt-Pukekohe	Aquifer Management	2 Weekly	No	2678800	6441400	86.83	14-Aug-79
7429013	Douglas Road	Basalt-Pukekohe	Long Term Baseline	2 Weekly	Yes	2676550	6441020	109.02	06-Jun-80
7429017	Douglas Road	Kaawa	Long Term Baseline	Monthly	No	2676550	6441020	109.02	30-May-80
7500001	Papakura Clevedon	Waitemata	Aquifer Management	Monthly	No	2690600	6463200	12.14	10-May-94
7510005	Wooten Road	Basalt-bombay	Long Term Baseline	2 Weekly	No	2688500	6445400	217.37	15-Dec-91

Appendix 5: Chapter 9 water conservation and allocation, Auckland Regional Policy Statement

Issues

9.2.1 Land use can affect the quantity of water in streams, lakes and aquifers, and largely influences the demand to take, divert or dam water.

9.2.2 Demand for surface water equals or exceeds availability in parts of the Auckland Region.

9.2.3 Demand for groundwater equals or exceeds availability in parts of the Auckland Region.

9.2.4 Competition for water between abstractive users has to be resolved where demand for water exceeds the quantity that the water body can sustain.

Objectives

9.3.1 To maintain water levels and flows sufficient to protect the:
- (i) natural character,
- (ii) cultural, amenity and intrinsic values, and
- (iii) aquatic habitats and ecosystems,

of streams, rivers, lakes and wetlands.

9.3.2 To maintain water levels and flows of aquifers in the long term so as to retain adequate spring flow, prevent seawater intrusion at the coast, and to maintain temperatures in geothermal aquifers.

9.3.3 To manage the use of water so as to enable people and communities to provide for their present and future social, economic and cultural wellbeing, and for their health and safety, while being consistent with Objectives 9.3-1 and 9.3-2.

Policies

9.4.1 Policies: Land use and water resources

1. Land use activities that affect the quantity of water contributed to streams, rivers, lakes, wetlands or aquifers shall be managed so as to:
   - (i) protect the quantity of water in water bodies which have high amenity, cultural or ecological values;
   - (ii) avoid or mitigate flooding and erosion;
   - (iii) enhance water quality;
   - (iv) protect highly used water bodies.

2. Planning for changes or intensification of land use shall have particular regard to current water availability and priorities for allocation of available water resources.

9.4.4 Policy: Water availability

The availability of water in water bodies and coastal water for taking, use, damming or diversion shall be determined on the following basis:

- (i) A precautionary approach shall be taken.
- (ii) The following matters shall be recognised and provided for:
  - (a) the ability of the water body to sustain the abstraction;
  - (b) the relationship of Tangata Whenua and their culture and traditions with their ancestral water, waahi tapu and other taonga;
  - (c) preservation of the natural character of the coastal environment, streams, rivers, lakes and wetlands and their margins;
  - (d) protection of indigenous vegetation and habitats of indigenous fauna in streams, rivers, lakes, wetlands and the coastal environment;
  - (e) maintenance of the natural flow variability in streams, rivers, lakes and wetlands.
- (iii) Particular regard shall be had to the following matters:
  - (a) kaitiakitanga;
  - (b) maintenance and enhancement of the recreational, scenic, amenity and intrinsic values of streams, rivers, lakes and wetlands;

(c) maintenance of water quality including sufficient capacity for streams, rivers, lakes and wetlands to assimilate contaminants;
(d) the security of a specific quantity of water being available in streams, rivers, lakes and wetlands during periods of low flow;
(e) estimates of aquifer recharge;
(f) maintenance of aquifer water levels adequate to ensure continued recharge between aquifers;
(g) maintenance of outflow from aquifers at the coast to prevent salt-water intrusion;
(h) retention of adequate spring flow from shallow aquifers which provide base flow for streams;
(i) avoidance of land subsidence and structural damage to aquifers;
(j) maintenance of geothermal aquifer water levels to prevent cold groundwater or seawater intrusion and reduction in aquifer temperatures;
(k) avoidance of long term decline of aquifer water levels;
(l) the extent of overlap, if any, of catchment and aquifers with regional council boundaries.

(iv) The principles of the Treaty of Waitangi (Te Tiriti o Waitangi) shall be taken into account.

9.4.7 Policies: Allocation and use of water

1. The conservation, efficient use and reuse of the Region's water shall be promoted.
2. Priority shall be accorded to uses of water which give effect to the RPS strategic direction and the regional development policies (see Chapter 2 of the ARPS).
3. The taking, damming, diversion and use of available water as determined by Policy 9.4.4 shall be controlled so that:

(i) Actual or potential adverse effects on the environment, including effects on other authorised water users, the water body, ecosystems, and amenity values, are avoided, remedied, or mitigated.
(ii) The relationship of Tangata Whenua and their culture and traditions with their ancestral water, waahi tapu and other taonga is recognised and provided for.
(iii) Particular regard is had to:

(a) kaitiakitanga;
(b) promoting efficient use of water;
(c) avoiding, remedying, or mitigating adverse effects of dams, weirs and other instream structures on the environment including but not limited to reduction in flows, obstruction to the passage and migration of any indigenous fauna; bank or bed erosion or aggradation; flooding or restricting the drainage of any property;
(d) providing, in the case of fresh water, for the individual's reasonable domestic needs and for the individual's animal's drinking water;
(e) providing, in the case of geothermal water, for tikanga Maori for the communal benefit of the Tangata Whenua of the area;
(f) encouraging multiple use of streams, rivers, lakes and aquifers.

(iv) The principles of the Treaty of Waitangi (Te Tiriti o Waitangi) are taken into account.

9.4.10 Policy: Significant resource management issues for Tangata Whenua

Maori cultural and traditional values shall be recognised and taken into account in the management of water conservation and allocation.

Note: Chapter 9 cannot be read out of context with the rest of the ARPS. Other particularly relevant chapters to water management include chapters 9 (Heritage preservation and protection), Chapter 8 (water quality) and Chapter 3 (matters of significance to Iwi).

Glossary of Terms

Aquifer	Saturated rock or soil material capable of transmitting and yielding water in quantities sufficient for abstraction.
Baseflow	Return flow from groundwater
Geothermal	Water heated within the earth to temperatures in excess of 30 degrees Celsius.
Head	Energy contained in a water mass, produced by elevation, pressure or velocity.
Isohyet	Contour line of equal rainfall
Kaitiakitanga	The exercise of guardianship; and in relation to a resource, includes the ethic of stewardship based on the nature of the resource itself. (RMA, 1994)
Permeability	The capacity of a rock, sediment or soil for transmitting fluid
pyroclastic	Volcanic material which has been blown into the atmosphere by explosive volcanic activity
Riparian	Land adjacent to a stream
Storativity	The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.
Tangata Whenua	In relation to a particular area, means the iwi, or hapu, that holds mana whenua over that area
Taonga	Something which is highly prized or treasured, tangible or intangible, that contributes to Maori well-being.
Tikanga Maori	Maori customary values and practices
Transmissivity	The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient.
Waahi Tapu	A place sacred to Maori in the traditional, spiritual, religious, ritual or mythological sense. (ALW)

Abbreviations

amsl	above mean sea level
ARC	Auckland Regional Council
ATRP	Auckland Transitional Regional plan
bgl	below ground level
PARP:ALW	Proposed regional plan: Air land and water
RMA	Resource management Act
WRAR	Water Resource Assessment Report